(No Model.)

2 Sheets—Sheet 1.

H. J. CONANT.

ELECTRICAL REGULATING APPARATUS.

No. 414,191. Patented Nov. 5, 1889.

Fig. 1.

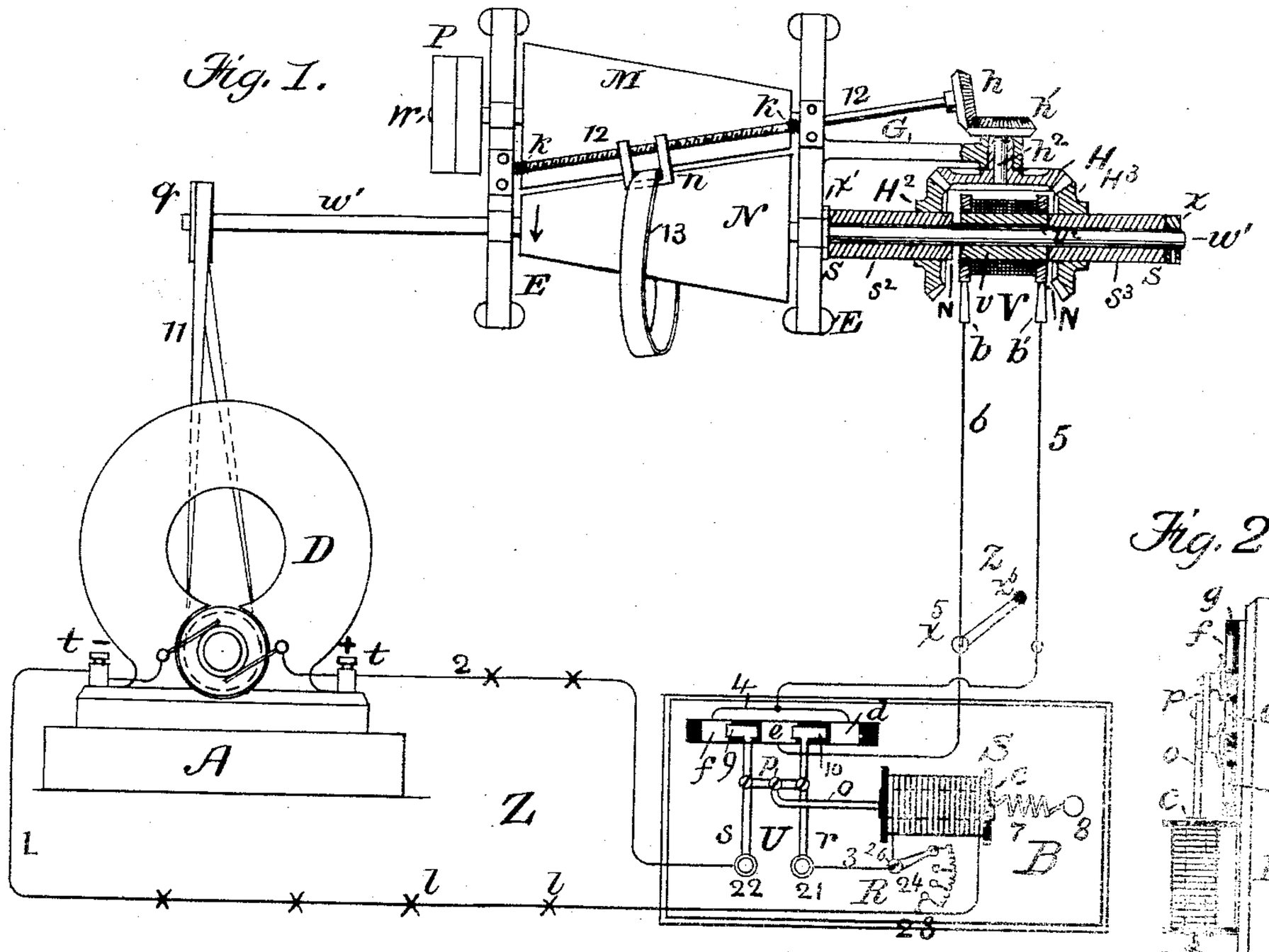


Fig. 2.

Fig. 4.

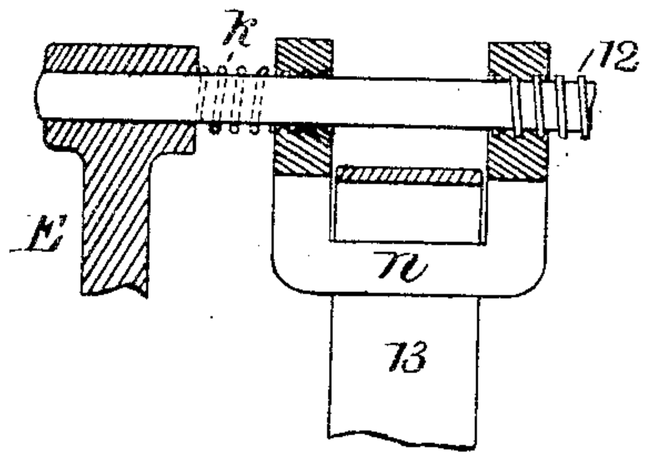


Fig. 1ª.

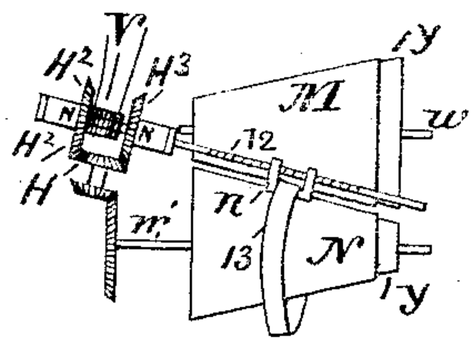
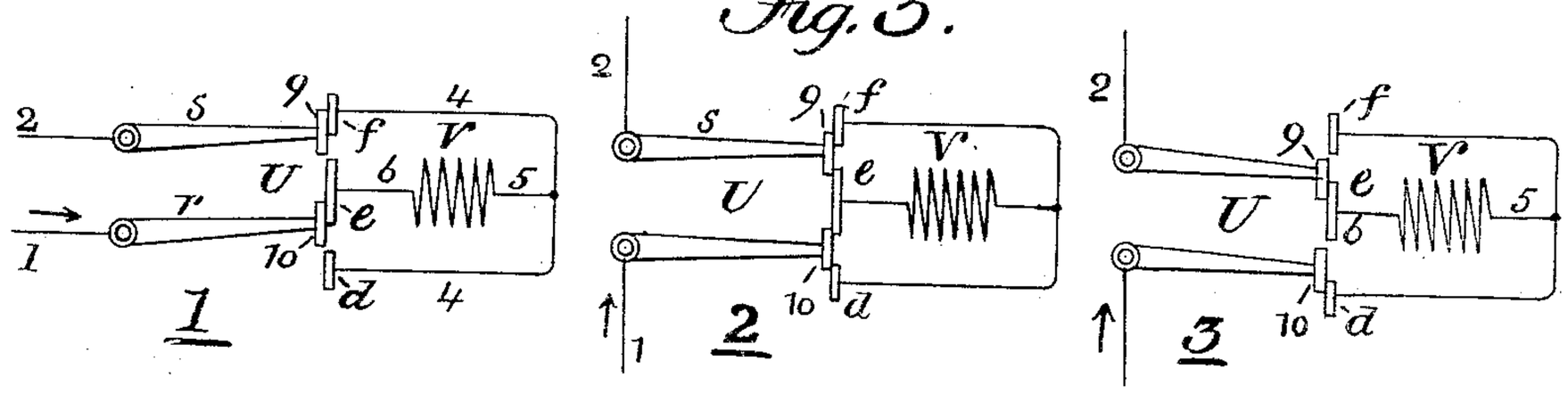


Fig. 3.



Witnesses.
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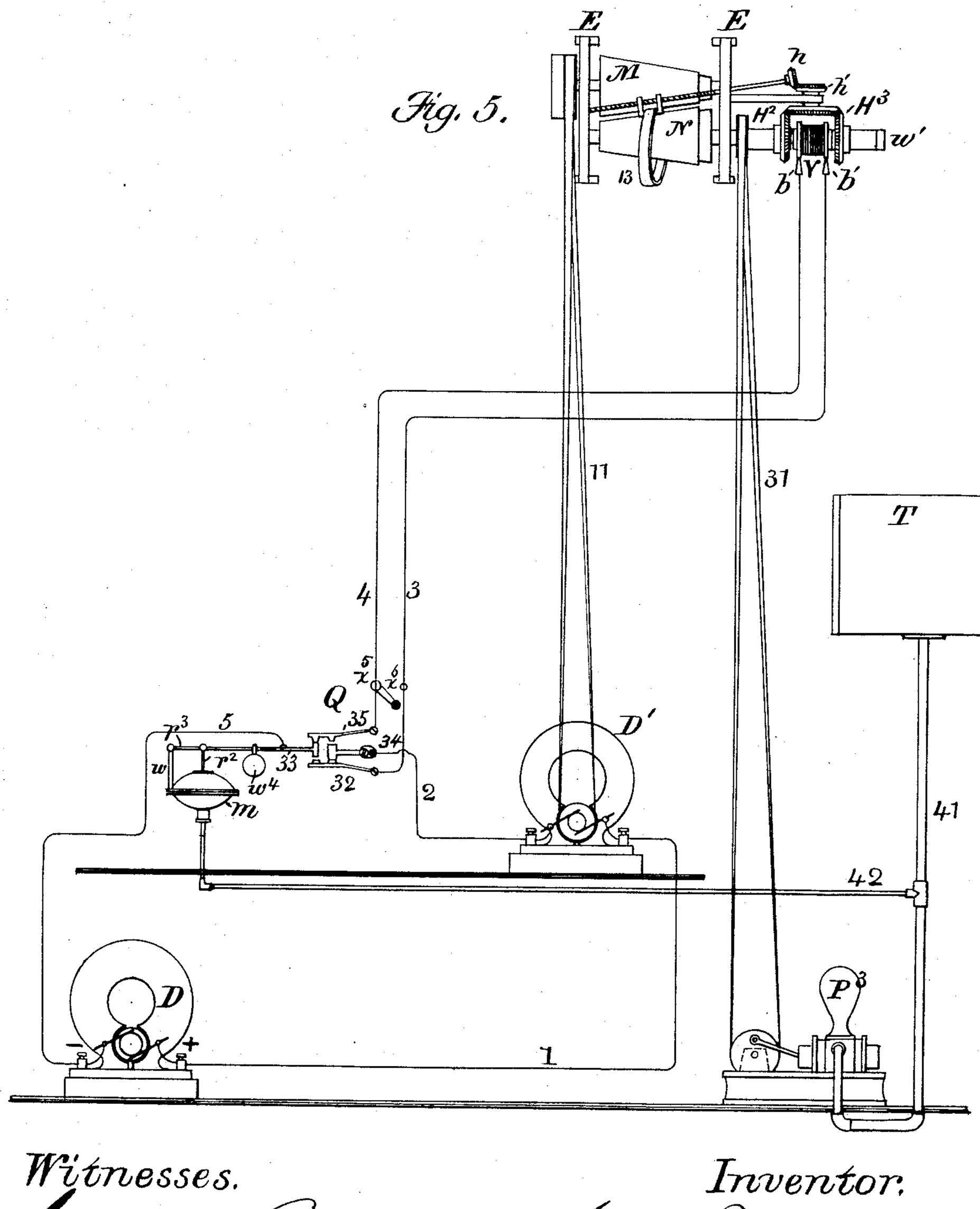
(No Model.) 2 Sheets—Sheet 2.

H. J. CONANT.

ELECTRICAL REGULATING APPARATUS.

No. 414,191. Patented Nov. 5, 1889.

Fig. 5.



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UNITED STATES PATENT OFFICE.

HENRY J. CONANT, OF WATERTOWN, MASSACHUSETTS.

ELECTRICAL REGULATING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 414,191, dated November 5, 1889.

Application filed February 6, 1889. Serial No. 298,790. (No model.)

To all whom it may concern:

Be it known that I, HENRY J. CONANT, residing at Watertown, in the county of Middlesex and State of Massachusetts, have invented certain Improvements in Electrical Regulating or Governing Apparatus, of which the following is a specification.

This invention relates to electric regulators or governors, and by it the fluctuations of a current traversing a main electric circuit are caused to automatically control, rectify, or modify the speed of mechanism, and this regulation of speed may finally be utilized directly upon the source of the said electric current, and thereby tend to maintain the uniformity of the same; or, if desired, other work performed by the energy of the said current, or even by any independent source of power, may be caused to react upon the said current and to effect changes therein corresponding to the conditions at any moment of the said work, which changes are, through the agency of suitable mechanism, made to control the speed of the engine, machine, or motor performing the work, the speed being thereby controlled and regulated automatically and promptly, so that when the work is progressing too fast or far, the speed of operation is retarded, while when the work is being done too sluggishly the speed, and consequently the rate of work, is accelerated. It will be seen, therefore, that my regulator is both a current and a speed regulator, since fluctuations of the current may produce corresponding fluctuations in speed, which act upon the original source of electrical energy, increasing or decreasing the electro-motive force, as the case may be, or may alternatively produce fluctuations or adjustments of speed affecting directly the work which is being performed.

More specifically, in one embodiment of my invention which I have shown and described, in which an electric-lighting circuit is shown as being energized by a dynamo, the main current is caused to traverse the helix of a solenoid, the core of which actuates a pole-changing switch. By means of this switch the current is directed in one direction or the other through an electro-magnetic helix operating a magnetic clutch, which controls the reversing-gear of a cone-pulley belt-shipper, and the changes of current in the main circuit are through the agency of this combination of mechanism enabled to act upon their source, and the current is thus constantly regulated, and the supply of current is caused to uniformly adjust itself to the demand. If, for example, certain lamps or motors in circuit and operated by the current flowing in the circuit are cut out, the current is momentarily increased, and the solenoid sucks in the core with increased vigor, the switch operated by the said core directs the current in a given direction through the clutch-helix, and the belt-shipping gear is operated in a direction to lower the speed. The velocity of the driven cone-pulley is thereby reduced, and the dynamo-armature driven thereby is correspondingly slowed up, with the final result that its delivery of current is materially lessened, the volume being at once lowered to the required point. So, also, should additional lamps be introduced, the current momentarily weakens, the solenoid-core is pulled outward by a retracting force—such as a weight or spring—the pole-changing switch reverses the current through the clutch-helix, the belt-shipper is reversed, and moves in a direction to increase the speed of the driven pulley and dynamo, and the delivered current rapidly rises in proportion to the increased work. When the current traversing the circuit is in exact proportion to the work, the solenoid-core occupies a medium or balancing position, and the poll-changing switch controlled thereby occupies also an intermediate position, and practically short-circuits the clutch-helix. The said clutch-helix under these circumstances is disengaged from the shipping-gear and the shipper remains in a constant position, the speed of the driven pulley and dynamo being exactly proportioned to the work and the current being normal. In practice the changes are quickly made and the regulator promptly responds to any change in the work, the solenoid-core, pole-changing switch, belt-shipper, and reversing-gear constantly making slight and brief changes to balance brief and practically inconsequent changes of current.

In another embodiment of my invention the condition of the work is caused to exercise

varying degrees of pressure upon a pressure-gage or an inclosed diaphragm, which acts through a suitable lever in the manner of a safety-valve upon a pole-changer. By means of this pole-changer the current from a suitable source of electricity is caused to traverse the helix of the clutch-magnet, and its direction therethrough is determined as in the former case, and to move the shipper in one direction or the other as the pressure upon the diaphragm is too strong, is normal, or is deficient. The variations of speed obtained by moving the belt between cone-pulleys in this manner may be caused to act directly upon the motor or engine immediately performing the work, in this case a pump being shown, and the speed of the motor may without regard to its character be thus modified; or, if the said motor be driven by electricity its speed may be varied by applying the pole-changer and electro-magnetic clutch to act upon the driving-pulleys of the dynamo, in which case the speed of the motor will be varied by increasing or decreasing the amount of current delivered to it by the dynamo. I prefer, however, the former method in such a case, as being more direct.

The invention consists, first, in an electrical current or speed regulator in which the necessary regulation of electrical currents or the adjustment of current-strength, or of power (electric or otherwise) to the work to be performed is accomplished by causing the fluctuations or changes of the electrical current to effect, through suitable mechanism, corresponding changes of speed in driving mechanism, which changes react upon the said current or upon the immediate motive power in such a way as to compensate for or to counteract the initial and undesirable character or conditions of current or speed, maintaining a proper and uniform adjustment of current or power to the work which at any moment is to be or is being performed.

It also consists in an apparatus for regulating, governing, or adjusting electric currents by causing changes in the said currents to actuate speed-regulating mechanism, whereby the speed of the dynamo, and consequently the electro-motive force, can be varied and regulated independently of the speed of the prime mover; and this apparatus consists in certain combinations and subcombinations of mechanism and electrical appliances and circuits more fully specified hereinafter, and comprising a circuit-changing switch actuated by a solenoid included in the circuit and responsive to changes of current occurring therein, a polarized clutch device governed and controlled by the said switch, and cone-pulleys provided with suitable reversing-gear operated by the said clutch, whereby the speed of the driven cone-pulley may be automatically varied, as required by variations of work.

It further consists in the special form of electro-magnetic clutch adopted by me and herein described, in which a hollow electro-magnet is alternately attracted and repelled in either direction, being in all cases repelled from one side while it is attracted to the other, and vice versa, whereby the electro-magnetic attraction and repulsion are made to coincide or unite in the accomplishment of the work to be done.

In the drawings which illustrate and form a part of this specification, Figure 1 is a diagram exhibiting the electrical and mechanical arrangements of the first embodiment of my invention in its utilization as a current-regulator, the clutch device being in section. Fig. 1ª is a detail showing a modified arrangement of the cone-pulleys, reversing-gear, and shipper, in which the reversing clutch and gear are mounted upon the shipper screw-shaft, instead of upon the shaft of the driven pulley, as in Fig. 1. Fig. 2 is a side view, partly in section, of the pole-changing switch. Fig. 3 comprises a series of diagrams illustrative of the three positions of the pole-changing or current-reversing switch shown in Fig. 2. Fig. 4 is an enlarged view of the end of the reversing-screw and belt-shipping device, showing means for preventing the shipping-nut from being totally disengaged from the said screw; and Fig. 5, Sheet 2, is a diagram illustrating the embodiment of my invention in an apparatus adapted to directly control the speed of a pump or other machine or motor, and to adjust the same to the varying character and condition of the work to be done, the said adjustment being, as in other cases, reached through the instrumentality of cone friction-pulleys, wherein the speed of the driven pulley is varied through the agency of changes produced in a current of electricity, in accordance with the varying demands of the work.

I will first describe the instrumentalities illustrated by the figures upon Sheet 1.

D represents a dynamo supplying current for an electric-lighting circuit Z, the outgoing and return wires 1 and 2 being connected with the machine-terminals *t*. *l l* are lamps serially connected in the said circuit. The rotating armature of the dynamo is shown as being driven by a belt 11, actuated from a pulley *q* on the shaft *w'* of a driven friction cone-pulley N. The motion of this pulley N is derived from another and similar cone-pulley M, mounted in close proximity, as shown, this in turn being controlled and actuated or stopped by ordinary fast and loose pulleys P, operated by a belt from any prime motor in the usual way. The friction cone-pulleys are not in contact with one another, but are separated a short space, within which a short endless ring or belt of leather or like material 13 is compressed. The motion of the driving-pulley M is imparted by friction through the instrumentality of this belt to the driven pulley N, and it is obvious that by moving the said belt toward one end or the other the speed of the driven pulley may

be varied within limits of considerable extent. This type of cone-pulley arrangement or friction-gearing is of course not new, and various means, automatic and otherwise, have been suggested and adapted for the longitudinal movement of the cone-pulley belt 13. I propose to provide mechanism for the automatic traverse of the said belt which shall be operated by the fluctuation of the current in the dynamo-circuit. One way to effect this is shown in the drawings. The shafts of the two cone-pulleys are supported in bearings on the brackets or pedestals E, and the shaft w' of the lower pulley extends out a suitable distance to one side and carries upon it bevel-wheels H^2 and H^3, which are keyed or otherwise secured to steel or cast-iron sleeves s^2 and s^3, these being bored out smoothly and adapted to rotate either upon or with the pulley-shaft w'—that is, the said shaft w' is loosely fitted to rotate within the said sleeves, and the sleeves will not rotate with it unless clutched thereto in a manner well understood. A bevel-wheel H engages with both of the wheels H^2 and H^3 and participates in the motion of that one of the two which at the moment may be engaged by and moving with the shaft w'. This is mounted on a short vertical shaft h^2, and is supported in a bracket G. The said short shaft, by means of bevel-gear h and h', is enabled to rotate the shaft of a screw 12, having a belt-shipping nut n, which clasps the belt 13, moving it one direction or the other, and varying the speed of the driven pulley according as the motion of the pulley-shaft w' is conveyed to the screw-shaft by the wheels H^2 or H^3.

I will now describe the apparatus whereby the changes in position of a clutch determining the direction of rotation of the shipper-nut screw are effected and controlled by the variation of current in the main circuit. The cast-iron or steel sleeves s^2 and s^3, to which are secured the bevel-gear H^2 and H^3, are permanently magnetized, so that both will present like poles to the space between the bevel-wheels. I have shown the magnets as presenting their N poles to one another; but it is of course not material, provided that the poles of the two magnets facing one another are of like character. The central space between the wheels H^2 and H^3 is filled up by an electro-magnetic helix V, having a hollow soft-iron core v bored true, so that it fits loosely but snugly upon the shaft w'. This is secured to the said shaft by a feather-key v^2, so that it necessarily and at all times participates in the motion of the said shaft, but is capable of sliding longitudinally in either direction thereon. The terminals of the helix are led out to conducting-surfaces upon the flanges of the spool, and are included in the electric circuit z by means of brushes or contact-springs b and b', which are connected with the said circuit and which press upon the spool-flanges. The hollow core of the helix V thus is strongly magnetized when the helix is traversed by the electric current flowing in the circuit z, and its polarity is determined by the direction of the said current. Thus when the current flows in a given direction through the said helix one end of the hollow core acquires a north magnetic polarity, the other in like manner becoming a south pole. Since both of the permanent magnets s^2 and s^3 are of like polarity—say N—it follows that the pole of the central core, which also is N, will be repelled by the like pole of the permanent magnet nearest to it, while the S pole at the other end will be attracted by the opposite polarity of the permanent magnet on that side, and the result is that the permanent magnet carrying the bevel-wheel is compelled by magnetic attraction to participate in the motion of the hollow helix and its core. The drawings show the central core v as being attracted to and actuating the magnetic sleeve s^3, so that if we assume the driven pulley to be moving in the direction of the arrow the nut-shipping screw is caused to move in the same direction, and the nut will move the belt in a right-hand direction and the speed of the driven pulley will be reduced. Suppose, however, that the direction of the current through the helix V be reversed, the polarity of the core v will also be reversed, the magnet s^3 and the adjacent pole of said core will now be alike, and will vigorously repel each other, while attraction will be set up between the permanent magnet s^2 and the adjacent hollow-core pole, and the repulsion at one end co-operating with the attraction at the other the helix V will be shifted sharply over, the wheel H^3 will cease to move, and the wheel H^2 will be compelled to participate in the motion of the shaft w' and helix V, and the motion of the screw 12 will be reversed in direction, tending now to move the shipping-nut to the left, and thus to increase the velocity of the driven pulley.

To counteract any tendency of the magnet-poles to stick when in contact, I prefer to face the ends of the permanent magnets with a very thin plate of copper or brass, whereby sticking, due to residuary magnetism is prevented. It will be seen, therefore, that the device I have described is practically an electro-magnetic clutch, to be operated by changes in the direction of current traversing the longitudinally-movable helix. These changes in the direction of the current I effect by interposing in the electric circuit and between the main circuit and the loop leading to the clutch-helix V an automatic current-reversing switch actuated by a solenoid. This is symbolically indicated in the diagram as being adapted to work horizontally.

B is a suitable base-board. S is a solenoid or hollow helix mounted thereon, having an iron plunging-core c pulled constantly in one direction by a counter-spring 7 (which may be adjustable, as by the screw 8) or equivalent weight, and which, when the current

passes through the helix, is sucked thereinto to a greater or lesser extent, depending upon the strength of the said current. To one end of the core *c* is attached a rod *o*, pivoted to the strap *p*, uniting the two bars *r* and *s* of a double switch U, these moving on pivots 21 and 22. At the free ends of these switch-bars are contact-pieces 9 and 10, which slide over a surface *g* of non-conducting material, into which is let conducting-plates *d e f*. One of the main circuit-wires 1 is united to one of the solenoid terminals, and the other main wire 2 is connected with the switch-bar *s* at 22. The remaining solenoid terminal is connected by wire 3 with the other switch-bar *r* at 21. The central switch-plate *e* is united by the wire 6 with one terminal *b* of the clutch-helix, and the upper and lower plates *d* and *f* are united together by the wire 4 and both by wire 5 with the other terminal *b'* of the said clutch-helix.

In order that the solenoid S may be kept under more perfect control, I prefer to shunt it with an adjustable resistance R, extending from the point 23 through a series of resistances of any suitable character, and by way of the switch 24 to point 26 on wire 3. The switch 24 can be so placed as to include any or all of the resistances in the shunt-circuit, and thereby to regulate the amount of electricity which passes through the solenoid. I have stated that the solenoid is in this instance placed horizontally. It may, however, readily be arranged in several ways, and its position is not material to my invention. If desired, it may be mounted vertically and the core so arranged that it will be sucked in a downward direction as the helix is energized, and in such a case the core would require to be suspended above and supported and controlled by a counter-weight or spring, whereby it might regain its position when the helix ceased to attract; or, on the other hand, it might be so arranged that the core should be sucked upwardly, in which case its own gravity, preferably modified, however, by a spring, could be employed as a retractor. If desired, also, a dash-pot may be associated with this solenoid and switch in a manner well understood. It is also evident that the reversing-switch, solenoid, and clutch-helix can be placed at any point of the circuit where most convenient, and that the several lamps *l* are shown in circuit between the said switch and the dynamo purely for convenience in illustration.

To prevent any possibility of forcing the traversing or shipping nut against the bearings E, I provide at each end of the shipper-screw, as shown in Fig. 1 and more clearly in Fig. 4, that a portion of the screw-thread shall be removed, and that a helical spring *k* shall be caused to surround the screw-rod close to the said bearings. By this device the said spring is caused to act as a buffer or elastic cushion and jars are prevented, and, furthermore, a constant pressure is exercised upon the nut when it has so far traversed the screw as to come into contact with the spring, and thus if the nut leaves the screw entirely the spring comes into operation and assists it once more to engage the screw as soon as the reverse operation begins.

In Fig. 1ª I have shown that the reversing-gear and clutch-magnets may be with equal facility placed directly upon the screw-shaft 12 instead of upon the shaft *w'* of the driven pulley N. This view also shows the pulleys M and N reduced in size, as at *y*, so that by moving the belt 13 over to this point the friction will cease to exist, and the driven pulley may be thereby stopped.

The three plans, 1, 2, and 3, of Fig. 3 indicate the three positions of the solenoid-actuated switch U. That marked 1 shows the switch in its uppermost position, in which a current entering by wire 1 passes into the clutch-helix by way of the central plate *e* and out by the wires 5 and 4 and the uppermost plate *f*. That marked 2 shows the switch in the central or intermediate position, the clutch-helix being short-circuited and the current normal. That marked 3 shows the switch in contact with plates *e* and *d*, and the current entering the clutch-helix by way of wire 5 and leaving by wire 6.

In the operation of my regulating apparatus let it be understood that the solenoid is so constructed and adjusted that when the current is normal and of proper working strength the core is sucked thereinto to such a degree that the switch occupies the central position and the clutch-helix is short-circuited. Under these circumstances the shipper-screw is at rest. If from any cause the current becomes too strong, the solenoid at once becomes more active, the core is drawn farther in, and the switch assumes the position shown in the drawings. The current is thus directed through the clutch-helix V in a given direction and magnetizes the hollow core with such a polarity as causes it to be attracted by the magnetic sleeve of that one of the bevel-wheels which will operate the shipper-screw in the direction of decreased speed. The clutch-helix core will at once, by virtue of the said attraction, cause the said wheel to participate in its motion, and the said motion, propagated to the screw, will cause the nut to traverse in the direction adapted to decrease the speed of the driven pulley, and the dynamo being thus driven at a lower rate of speed will develop a lower electro-motive force and consequently a weaker current. Thus the variations of current are caused to react upon the speed of the dynamo and to automatically correct themselves, while the speed of the prime motor may remain unchanged. Conversely, should the current weaken, the solenoid-core will be partly retracted by the counter force, and the arms of the reversing-switch will as-

sume the position in which the arm *s* will rest upon the plate *e* and the arm *r* upon the plate *d*. The current through the clutch-helix is thus reversed, the attractions and repulsions are also reversed, the helix slides over and engages with the opposite bevel-wheel, and the screw will change its direction of rotation and will cause the nut and belt to traverse the pulleys to the left, whereby the dynamo speed will be accelerated. In the intermediate position of the switch the clutch will tend toward an intermediate position also, its core being practically demagnetized, and in any event it will not retain sufficient strength to hold the wheels. The nut will in consequence remain substantially stationary and the speed constant until the next variation of current occurs. In practice brief and rapidly-succeeding changes of solenoid, switch, clutch, and shipper are constantly occurring, which prevent any material or sudden change of speed or current governing the said current and maintaining substantial uniformity therein.

To prevent a continual effort on the part of the speed-regulating mechanism to maintain a uniform speed while the entire mechanism is being designedly stopped, I provide a switch x^6, which may be located so as to short-circuit the clutch-loop only, as shown at x^5, or which may be located at x^2, so as to short-circuit the solenoid also. This switch will (when the machine is to be stopped) be turned, and the belt will thus be prevented from accomplishing an unnecessary traverse.

Fig. 5 shows in diagram the adaptation of my invention to a control of the speed of mechanism, the prime motor, as before, maintaining an invariable velocity. In this case D is the dynamo, and D′ an electromotor in circuit therewith and driven thereby. This electromotor, by the belts 11 and 31 and the cone-pulleys M and N, with their system of shafting, in turn is made to drive a pump P^3, which may be employed to raise water through the pipe 41 into a tank T. The pump is in this instance the motor or machine immediately performing the work. A pressure-gage or inclosed diaphragm *m* is operated by means of the branch pipe 42, and through the vertical rod r^2 controls a lever r^3, fulcrumed to the upright *u* and provided with the counter-weight w^4. The end of the said lever r^3 actuates a circuit-changing switch Q, and the hammer-headed end thereof 33 is one of the elements of the said circuit-changer, which takes the place and is an equivalent of the current-reversing switch of Fig. 1. The speed-regulating mechanism is also identical with that shown in Fig. 1, and is in like manner controlled by the electro-magnetic helix V and the permanently-magnetic sleeves to which the bevel-wheels H^2 and H^3 are attached.

The electric circuit may be traced as follows: From the plus-pole of the dynamo by wire 1 to the motor, thence by wire 2 to fixed element 34 of the circuit-changer, thence (in the condition shown) to circuit-changer spring 32, and by way of wire 3 to contact-spring *b*′, clutch-helix V, spring *b*, and wire 4 to spring 35 of pole-changer Q, movable element 33 thereof, and wire 5 to the minus-pole of dynamo. The extension 33 of the pressure-gage lever is insulated from the main stem r^3, and as it moves upward under increased pressure raises spring 35 from the fixed element 34, at the same time letting go of the spring 32 and permitting it to make contact with the anvil. When the pressure relaxes, the reverse operation is performed, the spring 32 being detached from 34 and depressed by 33 and the spring 35 released from 33 and allowed to rest on 34.

The operation of this application of my regulator is identical with that already described, except that the said regulation does not extend to the dynamo or current, the electric current in this instance being simply utilized as an intermediary, whereby the condition of the work is automatically enabled to control the speed of the mechanism performing the said work—that is to say, the condition of the work is caused to determine the action of a pole-changer, which controls by means of a suitable electro-magnetic device adapted to govern and adjust the speed of the driven pulley, the speed of the prime motor, dynamo, electromotor, and the strength of current remaining substantially unchanged.

I have stated some of the uses and functions of my regulator, and desire to mention, in conclusion, that one of its most important features, in addition to those which are hereinbefore recited, is its capability to automatically rectify and compensate for changes in current or work resulting from changes in the speed of the prime mover. It will be evident that it has a special adaptation to this exigency, and that should the prime motor vary in either a faster or slower direction the regulator, acting through the cone-pulleys and their electro-magnetically-actuated reversing-gear, will in a brief period of time respond thereto and counteract the said change. My governing apparatus is thus equally efficient in cases where the variations are in the prime mover, the work remaining the same as in cases where the variations are chiefly in the work and due to external causes, the operation of the prime mover remaining uniform.

Having now fully described my invention, I claim—

1. The hereinbefore-described electric-current and speed regulating apparatus, comprising a driving cone-pulley running at a uniform speed, a driven cone-pulley actuated thereby and driving a dynamo, the velocity thereof being dependent upon the position of a friction-belt interposed between the said pulleys, belt-shipping apparatus comprising a rotat-

ing screw and a traversing belt-shipping nut, the said screw being driven by the driven pulley, reversing-gear whereby the direction of rotation of the said screw and the longitudinal traverse of the nut may be at any point reversed, an electro-magnetic clutch controlling the said reversing-gear, and a reversing-switch operated by a solenoid responsive to changes of current in the main circuit, the said switch being adapted to reverse the said main current through the helix of the said clutch or to short-circuit the said helix, whereby changes of current in the circuit are enabled to actuate speed-regulating mechanism controlling the speed of the dynamo, and thereby to regulate the electromotive force and current developed by said dynamo independently of the speed of the prime mover.

2. The combination, in an automatic electric regulator or governor, of a system of friction cone-pulleys provided with a rotary screw and traversing-nut belt-shipper, and with suitable reversing-gear for reversing the direction of rotation of the said screw for the purpose of changing or regulating the speed of the driven cone-pulley, of an electro-magnetic polarized clutch comprising a hollow helix, a soft-iron hollow core therein feathered upon the shaft of the driven pulley or shipper-screw and capable of longitudinal movement thereon, and two permanently-magnetic sleeves presenting like poles to the two ends of the said core, the said sleeves being connected with the reversing-gears, as described, a main electric circuit, a loop thereof including the said hollow helix, and a circuit-changing switch operated by a solenoid included in the said main circuit and adapted to direct the current in the main circuit through the loop and clutch-helix in either direction or to short-circuit the same, whereby the said clutch-helix and core are made to move longitudinally upon the shaft to actuate the belt-shipper, and thereby to vary the speed of the driven pulley responsively to changes in the strength of the main current, substantially as and for the purposes specified.

3. The combination, substantially as hereinbefore described, in an electric regulating or governing mechanism, of a circuit-changing or current-reversing switch actuated by a solenoid included in the main electric circuit and responsive to changes occurring therein, a polarized clutch device governed and controlled by the said switch and responding to reversals of current through its helix, and cone-pulleys provided with suitable reversing-gear operated by the said clutch, whereby the speed of the driven cone-pulley may be automatically varied, as required by variations of work.

4. In a bevel-wheel-reversing gear, the combination of the two facing bevel-wheels, each provided with a permanently-magnetized sleeve constituting the hub of said wheel and revolving loosely upon the shaft, the like poles of said magnetized sleeves being presented toward one another, with an electro-magnet having a hollow soft-iron core keyed loosely upon the same shaft between the said two bevel-wheels and adapted to slide longitudinally upon the said shaft, the said magnet being responsive to changes in the direction of an electric current and to be attracted by one of the wheel-magnets and repelled by the other, according to the direction of the said current through its helix, and thereupon to cause the wheel at any period exercising attraction to participate in the motion of the shaft and electro-magnet, substantially as described.

5. The combination, with friction cone-pulleys and belt-shipping devices therefor, comprising a belt-shipping nut, a screw traversed thereby and adapted to rotate in either direction, and reversing-gear for the said screw, consisting of bevel-wheels running loose on a working shaft, facing one another and engaging with a third, as shown and described, of a polarized clutch consisting of an electro-magnet having a hollow soft-iron core, which core is keyed to the said working shaft and adapted to slide longitudinally into contact with the face of either bevel-wheel on the same shaft, and of two hollow permanent magnets, each forming the center of one of the said bevel-wheels, and both presenting a like pole to the end of the said electro-magnet, which is adapted to be repelled by one and attracted by the other, according to the direction of the current traversing its helix.

6. The combination, with an electric circuit, a loop thereof, and an electro-magnetic helix included in said loop, acting as a clutch for a reversing mechanism, provided with a hollow soft-iron core and adapted to slide on a shaft between similar permanently-magnetic poles, of a solenoid in the main circuit, and a current-reversing or circuit-changing switch actuated by said solenoid and adapted to determine the direction of the main-line current through the loop and clutch-magnet, according to its position, whereby the said clutch-magnet will be attracted to one side or the other, according to the direction in which the said main-line current traverses its helix, substantially as described.

7. The combination, substantially as hereinbefore described, of the cone-pulleys M and N, the automatic belt-shipper therefor, comprising the rotary screw 12 and nut *n*, the said screw being deprived of its threads at a portion of its surface near each end thereof, and a helical spring encircling the said stripped screw ends, for the purpose specified.

8. In an electrical regulator or governor, a main electric circuit, a loop thereof, an electro-magnetic clutch included in said loop and responsive to changes in the direction of the current traversing its helix, a pole-changing or current-reversing switch included in the

main circuit at the junction therewith of the said loop, and determining by its position the direction of the main-circuit current through the said clutch-helix, and an actuating device for the said switch responding to variations in the work performed by the main current and operating the said switch in accordance therewith, substantially as described herein.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 4th day of February, 1889.

HENRY J. CONANT.

Witnesses:

GEO. WILLIS PIERCE.

JOHN F. MARTIN.