E. R. CLIFF.

CONSTANT CURRENT REGULATOR.

APPLICATION FILED AUG. 21, 1908.

988,312.

Patented Apr. 4, 1911.

2 SHEETS—SHEET 1.

Fig. 2.

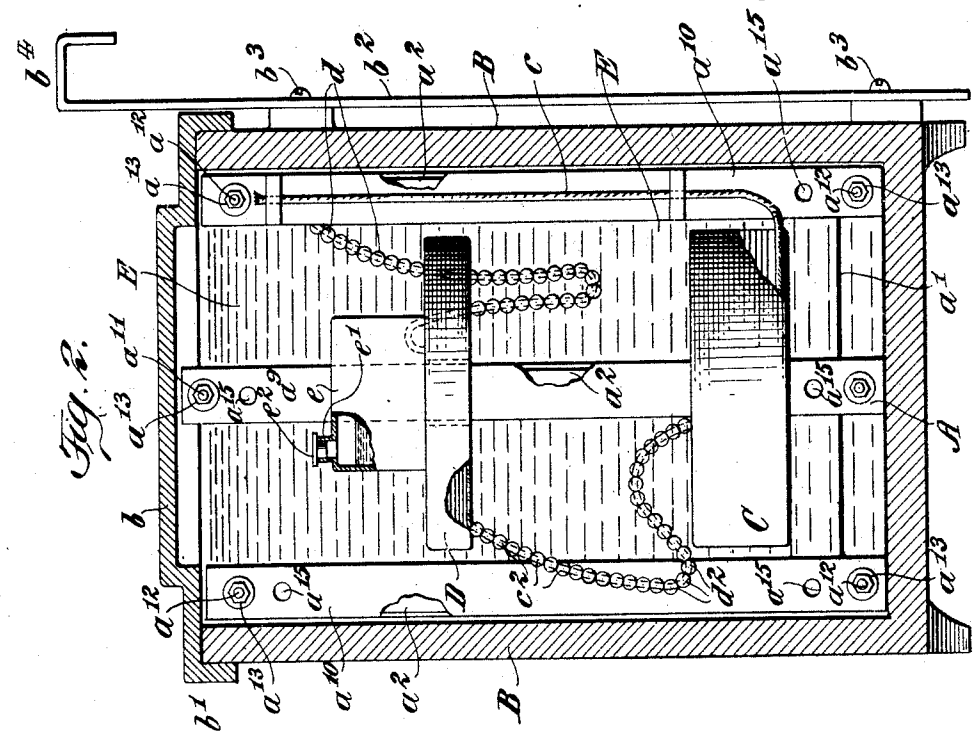
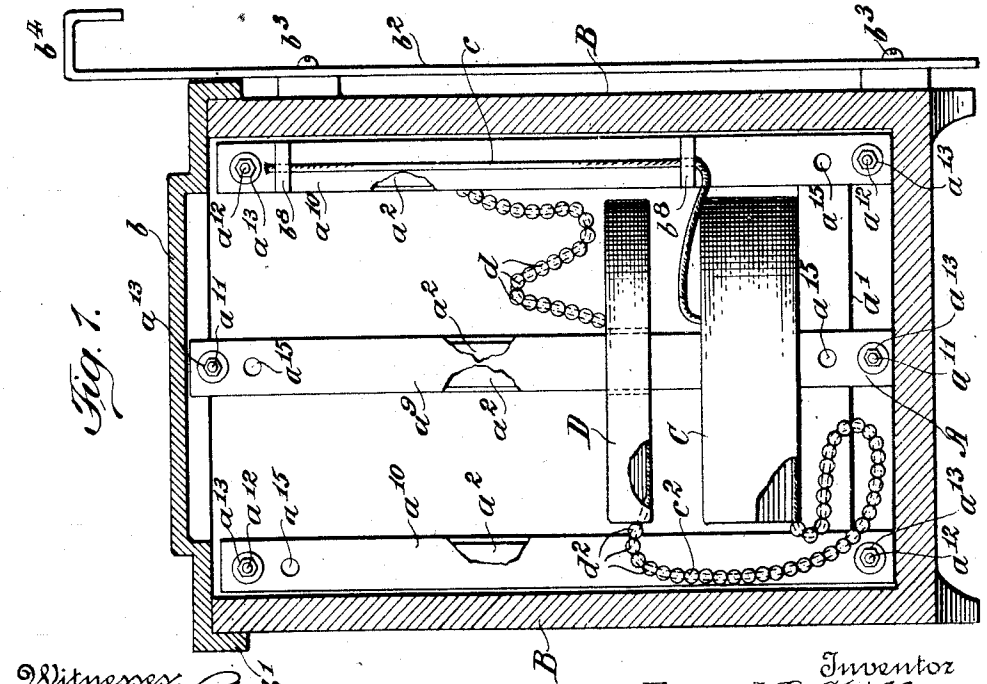


Fig. 1.



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2 SHEETS—SHEET 2.

Fig. 3.

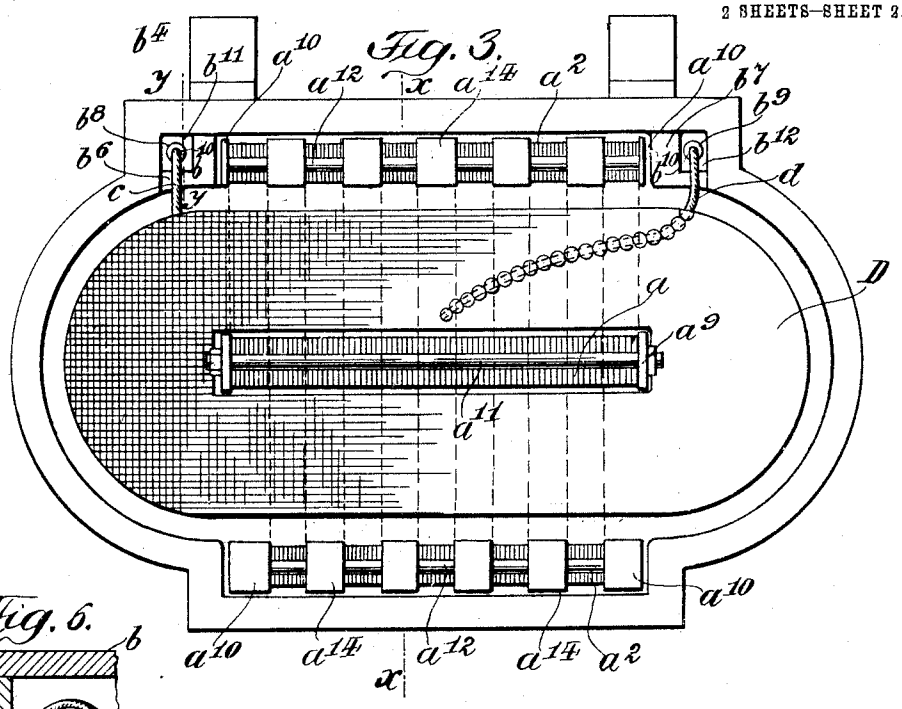


Fig. 6.

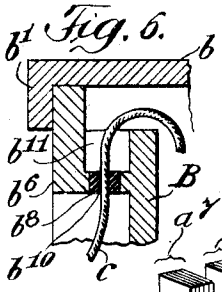


Fig. 4.

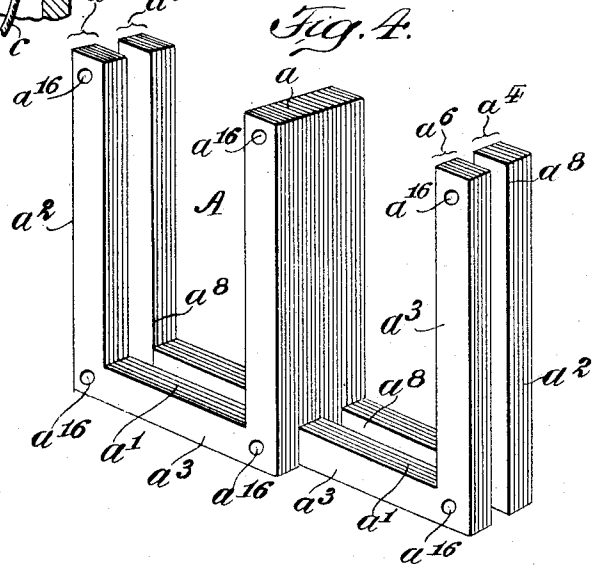
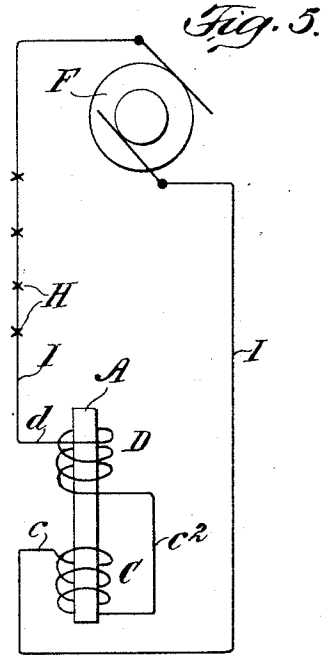


Fig. 5.



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UNITED STATES PATENT OFFICE.

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CONSTANT-CURRENT REGULATOR.

988,312. Specification of Letters Patent. Patented Apr. 4, 1911.

Application filed August 21, 1908. Serial No. 449,740.

To all whom it may concern:

Be it known that I, EDWARD R. CLIFF, a citizen of the United States, and a resident of Port Richmond, in the borough and county of Richmond and city and State of New York, have invented certain new and useful Improvements in Constant-Current Regulators, of which the following is a specification.

My invention relates to that class of electric regulators which is employed in alternating current circuits to maintain a constant and uniform current, whether the entire number of the electrically operated units is in operation, or a greater or less number of them withdrawn therefrom; the object of the invention being to provide a regulator of this class, which, while simple in construction and not liable to get out of order, shall at the same time be more efficient and reliable in operation than those heretofore in use.

To these ends, the invention consists, first, in the construction of the magnetic circuit; second, in the peculiarities of construction of the serially connected stationary and movable coils, and in their arrangement in connection with the magnetic circuit, and third, in various other constructions and combinations of parts, all as will hereinafter more fully appear.

Referring to the accompanying drawings, which form a part of this specification, Figure 1 represents a vertical transverse section on line x—x of Fig. 3 of a current regulator embodying one form of this invention, the coils being in elevation with parts broken out for the purpose of illustration. Fig. 2 represents a similar vertical transverse section of the current regulator embodying this invention in another form, the coils being submerged in oils or other suitable liquid and the movable coil being provided with a buoyant chamber of varying capacity, parts being broken out for better illustration. Fig. 3, a plan view of the regulator, with the cover of its containing case removed; Fig. 4, an isometric view of a portion of the core detached; Fig. 5, a diagrammatic view, showing the arrangement of the regulator in connection with the parts with which it is designed to coöperate, and Fig. 6, a sectional detail of the inclosing case taken in the plane y y of Fig. 3.

In all the figures, like letters of reference are employed to designate corresponding parts.

A indicates a magnetic circuit core, which is or may be constructed in various forms. It is preferred however to construct it in the form shown in the drawings, with an elongated central member a, having arms a^1 extending outwardly in opposite directions from its lower end and provided at their outer extremities with upwardly extending portions a^2, which are disposed in approximately parallel relationship to each other and to the central member a, and constitute elongated side members of the core. In the construction of this magnetic circuit core soft cast-iron or wrought-iron may be employed. It is preferred however to construct it of wrought-iron and to build it up from open rectangular U shape plates a^3 of that material. When this form of construction is adopted the plates a^3 are conveniently arranged in groups a^4, a^5, a^6, a^7, etc., of the required number of plates in each group, and the groups thus formed disposed in two end to end series, in which groups a^4, a^6, etc., are included in one series, and a^5, a^7, etc., in the other, with the inner ends of the groups of one series overlapping and alternating with the inner ends of the groups of the other series. As thus arranged the overlapping portions of the oppositely placed groups form the central elongated member a of the core, which is made up from a solid mass of parallelly disposed plates a^3, without any spaces therein, while the portions of the groups extending outwardly in opposite directions therefrom constitute its outwardly extending arms a^1 and the upwardly extending portions a^2 at their extremities constitute the elongated side members of the core. These outwardly extending arms, with the upwardly extending portions at their extremities however, instead of being made solid and continuous throughout, are, in consequence of the alternate arrangement of the oppositely disposed series of groups of plates a^3, formed with a space a^8 between each two groups of plates, whereby each of these outwardly extending arms with its up-

wardly extending portion is made up of an alternate series of groups of plates and spaces, as shown. With the magnetic circuit core thus built up its constituent plates a^3 are firmly bound together and held from displacement by strips a^9 and a^{10}, which are preferably constructed of wood, and are respectively applied to the opposite edges of the central core portion a, and to the opposite edges of the upwardly extending portions a^2, against which they are firmly clamped by bolts a^{11} and a^{12}, which, passed through suitable apertures formed in the upper and lower ends of the respective strips, and extending across from one fellow strip to the other, above and below the metal portion of the core, are provided on their ends with suitable nuts a^{13}. In being thus clamped together, the constituent plates, as will be seen, are firmly bound together in a composite whole; and in order to prevent the portions of the groups of plates a^4, a^5, a^6, a^7 etc. that form the outwardly and upwardly extending portions a^1 and a^2 of the core from yielding under the strain of the bolts a^{12}, as the strips a^{10} are clamped against their edges by such bolts, the spaces a^8 in these portions are preferably filled with some unyielding non-magnetic material. It is preferred to employ wood for this purpose, which is constructed in the form of strips a^{14} of the proper dimensions to closely fit between them throughout their lengths, and to project both above and below, as well as inwardly and outwardly slightly beyond, the upwardly extending portions a^2, whereby to not only engage with the bolts a^{12} that extend across the upper and lower ends of those portions, from one strip a^{10} to the fellow strip cooperating with it, but also to prevent either the coils from coming in contact with the core, or the core from contacting with the interior of the inclosing case. In most instances the clamping strips a^9 and a^{10}, with their coöperating bolts and nuts will be found sufficient to hold the constituent parts of the core together and prevent their displacement. It is preferred however to supplement these means with pins a^{15}, which, constructed of wood or other non-magnetic material, are passed through suitable orifices formed in the strips a^9 and a^{10} and through the plates a^3 at the points a^{16}, as shown. In thus building up a core from oppositely arranged and alternately disposed U shape plates of the character explained, the number of groups of these plates that may be availed of may be varied within reasonable limits, and in Fig. 3 I have shown one construction thereof. This construction however is merely illustrative, and a greater or less number of groups in each series may be adopted as the exigencies of the work to be performed or the judgment of the constructor may dictate.

With the core constructed as above explained, it is preferably arranged within an inclosing case B, which may be constructed in various forms and from a variety of materials. It is preferred however to construct it of metal, and in the shape of a closed bottom receptacle of the form shown in the drawings, with a cap or cover b fitted thereto and provided with a downwardly extending flange b^1, which is adapted to extend down around and embrace the upper end of the receptacle, whereby to closely cover it and exclude the entrance of moisture and other objectionable substances from its interior. As thus constructed the cover b may be held in place upon the receptacle by any appropriate means, and the case, as a whole, with its inclosed parts, suspended from any appropriate support by any suitable appliances. In the form of the invention which I have selected for purposes of illustration however, the cover is held in place by the action of gravity, it being constructed of a weight sufficiently great for that purpose; while the suspension of the case is effected by means of straps b^2, which are secured to its rear by bolts or screws b^3, and may have their upper ends overturned in the form of hooks b^4, that are adapted to engage with the cross-bars of an electric light pole, or otherwise.

With the core A arranged within the inclosing case B, it receives a stationary coil C and a movable coil D. These coils, which are connected in series by a conductor c^2, are arranged around the central core portion a, with the stationary coil C resting upon the outwardly extending arms a^1 to which it may be fixedly secured by cords or otherwise, and with the movable coil D disposed above the stationary coil in such a manner as to be capable of movement up and down along the core portion a. As thus arranged, the movable coil D is preferably constructed of a wire that possesses a greater power of resistance to the passage of the current than does the wire of which the stationary coil is formed. When both coils are made up from wire of the same material, as, for instance, from copper, this difference in the resistance will be produced by constructing the movable coil from a finer wire than is employed in the construction of the stationary coil. It is preferred however to construct the stationary coil from wire of one material, as, for instance, of copper, and the movable coil from wire of a different material, as, for instance, of aluminum, as thereby not only is the increased resistance to the passage of the current through the movable coil attained, but the weight of such movable coil very much reduced. The coil constructed of aluminum wire is extremely sensitive to the action of the currents and quickly adjusts itself under the influence

thereof. With the coils constructed and connected as thus explained, and applied in connection with a core, whenever an electric current is passed through them the movable coil will be either attracted and drawn toward the stationary coil, or repelled and forced away from the same, as the winding of the coils is such that the current in passing through them travels in the same or in the opposite direction.

In Fig. 1 I have shown the coils so wound that the current in passing through them travels in the opposite direction, and in that case a mutual repulsive action between the two coils is effected when they are energized, the amount of this repulsive action depending upon the strength of the current and varying with it. In Fig. 2, on the other hand, I have shown these coils as so wound that the current in passing through them will travel in the same direction, and in this case a mutual attractive action between the coils will be produced when they are energized, the amount of which attractive force, as was the case with the repulsive force in the construction shown in Fig. 1, depending upon the strength of the current and similarly varying with it. As thus operating, whenever the construction shown in Fig. 1 is employed, the weight of the movable coil D will be so graduated to the strength of the current in connection with which it is to be used, that, when the entire number of electrically operated units are in operation, the repulsive action between it and the stationary coil will be such that it will only be raised slightly from such stationary coil, and in that position it will be held stationary by such repulsive action so long as the entire number of these electrically operated units are in operation and the strength of the current remains uniform and constant. When however one or more of these units are withdrawn from operation and the strength of the current in the circuit thereby increased, as it will be under those circumstances, then the repulsive action between the two coils will be increased in correspondence therewith, with the result that the movable coil D will be moved upward thereby along the central portion *a*, until, by its impedance, it tends to reduce the strength of the current to that possessed by it at the outset, when the further upward movement of the coil will be arrested and the same held stationary in the position thus attained until one or more of the other units are withdrawn from operation, when it will again start on its upward travel and continue therein until, by its impedance to the passage of the current, it again tends to reduce the strength of the same to that originally possessed by it, when it will be again arrested in its movement, and so on, each withdrawal of a unit, as it increases the strength of the current, causing an upward travel of the coil D, and thereby, through its governing action, maintaining a uniform and a constant current. On the other hand, when the coil D has been forced upward from its original position by the withdrawal of a portion of the electrically operated units from operation, and one or more of the units thus withdrawn is or are returned into operation, when a reverse in these results will follow, and the strength of the current will be reduced by their return, when the coils will have their repulsive actions reduced thereby and the movable coil D, under the action of gravity, will travel downward along the core portion *a* toward the stationary coil A, until it reaches a point where it restores the current to its normal condition and strength, when it will be arrested in its movement and there held until the current is further reduced, when it will again start downward in its movement, to be arrested when the strength of the current has been again restored, and so on, repeating these downward movements and stoppages as each succeeding unit is brought into operation. Similarly with the construction shown in Fig. 2, whenever that construction is employed. Instead however of the movable coil D in this construction being forced upward away from the stationary coil C, as one or more of the electrically operated units in the circuit is or are withdrawn from operation, it is moved downward toward it by the mutual attraction of the two coils. To permit of this movement therefore, it is necessary to suspend the movable coil D at its upper limit of travel along the core portion *a*, by means that will permit of its moving downward toward the stationary coil when the attractive force between these two coils is sufficiently great to cause such movement, and to so graduate the suspending forces, that, when the entire number of electrically operated units are in operation, the coil D will be held stationarily at the highest point of its travel. As thus suspended whenever one or more of the electrically operated units is or are withdrawn from action and the strength of the current thereby increased, the attractive power possessed by the coils will be similarly increased, and the movable coil D thereby moved downward toward the stationary coil until the original strength of the current, by the impedance offered by the coil, is restored, when the further downward movement of the coil will be arrested and the coil there retained until one or more of the remaining units are withdrawn from action, when it will be again moved downward until, by its impedance, the strength of the current is a second time restored, when it will be again arrested, and so on, each withdrawal of a unit causing a further

downward movement of the movable coil and a consequent restoration of the strength of the current. The coil D having been thus moved downward along the core portion *a*, whenever one or more of the electrically operated units are returned into operation, the reverse of the results thus specified will follow and the movable coil D, in consequence of the reduction in the attractive forces between the two coils, due to a reduction in the strength of the current, will rise under the action of its suspending means until, through the impedance offered by it, the current is restored to its original strength, when the coil will be a second time arrested in its movement, to be again moved upward or downward as another unit is brought into or carried out of, operation, and so on, each withdrawal of a unit from, or its restoration to, operation, causing the movement of the coil D in the appropriate direction and thereby, through such coil, maintaining, as is the case with the coil D in the construction shown in Fig. 1, a constant and uniform strength of current in the circuit, by automatically cutting in or cutting out the necessary resistance to accomplish that result.

For yieldingly suspending the coil D, in the construction shown in Fig. 2, whereby to permit of its up and down movements away from and toward the stationary coil C as the requirements of the current may demand, various means may be employed. It is preferred however to employ for this purpose a column of liquid E, in which the coil is submerged, and, to that end, a liquid of greater specific gravity than aluminum is preferably supplied to the interior of the inclosing case B. As thus submerged, the coil, by reason of its buoyant character, will have a tendency to rise within the liquid, especially when the coil is constructed of aluminum or other light material, and to thereby normally move away from the stationary coil C, unless restrained by the attraction superinduced in the coils by the electric current passing through them. In some instances the buoyant capability of the coil D may be sufficient in itself in some liquids, such as a solution of borotunstate of cadmium or a solution of bromoform or a solution of nitro bromoform to resist the attraction exerted between the two coils, when the current is not of too great a strength, and to raise it against the same when the strength of the current is reduced. It is preferred however to supplement this coil with a buoyant chamber *e* the capacity of which may be varied to suit the weight of the coil or the density of the liquid in which it floats, as thereby the buoyancy of the coil may be adapted to the strength of the current whatever that may be. These air chambers, while capable of various embodiments, are here shown as constructed in the form of closed rectangular vessels, and, applied to the upper surface of the coil, are provided in their tops with suitable orifices or nozzles e^1, through which liquid or other weighting material may be supplied to their interior to graduate the buoyancy of the coil to the strength of the electric current to be employed, a suitable plug or stopper e^2, being fitted to each, whereby to close it when access to the interior of its chamber is not required. By these means as will be seen provision is made for the ready and accurate adjustment of the buoyancy of the coil to any strength of current that may be employed. The liquid made use of for suspending or aiding in the suspension of the coil B above the coil C may be of various kinds, it only being essential, that, whatever its character, it be such as will be unaffected by the action of the cold. It is preferred however to employ oil for the purpose, although glycerin, alcohol, and other similar liquids may be employed in lieu if so desired. With the stationary and movable coils thus arranged they are respectively provided with conductors *c* and *d*, whereby to be adapted for connection in circuit with the source of electric supply and with the units to be operated. To permit of this connection being effected the inclosing case B is preferably constructed with two rearwardly extending projections b^6 and b^7, which are respectively provided in their bottoms with insulating nipples b^8 and b^9 that are formed with orifices b^{10} extending through them and respectively connecting with the interior of the case through suitable passage-ways b^{11} and b^{12}. As thus equipped the conductors *c* and *d* extend upward from their appropriate coils to their respective passage-ways b^{11} and b^{12}, thence along these passage-ways to the nipples b^8 and b^9, and thence downward through these nipples to the exterior of the case where they are ready for connection with any other conductors with which the governor may be employed. Instead of the conductors *c* and *d* extending directly from their respective coils C and D to their appropriate passage-ways b^{11} and b^{12}, however, it is preferred to conduct them from the coils to the passage-ways through suitable keepers b^8, which are secured to the outer sides of the coöperating members of one of the pairs of clamping strips a^{12}, with the conductor *d*, and the conductor c^2 which extends between and connects the coils C and D, constructed of sufficient lengths to permit of the requisite up and down movements of the coil D, without in any way interfering with them. As thus arranged the conductors *c*, *d*, and c^2, may be insulated if so desired, and the means for accomplishing this result may be of various kinds. It is preferred however to insulate them, and to employ for the purpose insu-

lating beads d^2 which may be strung upon them, as shown. In some instances the coils C, D, may be used without covering, except as may be required to bind their constituent parts together. It is preferred however, to wrap them with cords or tapes, and to thoroughly coat this covering with varnish or shellac, but this is not essential, and the coils may be left without such covering or coating and operate with efficiency.

Although capable of use in circuit with series of electric motors and other electrically operated devices, the governor herein shown and described is especially applicable for use in circuits with electric lights, and wherever the words "electrically operated units" are employed herein, it is with the understanding that they not only include such motors and other devices, but electric lights as well.

With the parts constructed and organized as above explained, a governor is produced, which, while extremely simple in construction, is, at the same time, sensitive in operation and capable of maintaining with great accuracy uniformity in the strength of a current that is liable to fluctuations, or otherwise.

When employed in practice, the governor will preferably be applied in circuit with the source of electric supply and with the units to be operated, whereby the current operating such units will pass through it, and in Fig. 5 I have shown one form of its application, in which F indicates an alternating current electric generator, H a series of electric lights, A the core, C the stationary coil, D the movable coil, c^2 the conductor by which the stationary and movable coils are connected in series, and I, c and d the conductors by which the parts are connected in circuit. This particular arrangement however, is simply illustrative, and is merely designed to show one of the different arrangements in which the governor may be employed.

While in the foregoing the best means contemplated for carrying the invention into practice has been described, it is to be understood however that the invention is not limited thereto, as it is obvious that modifications may be made therein without departing from the spirit of the invention.

Having now described the invention and specified certain ways in which it is or may be carried into effect, the following features are claimed,—

1. The combination of a core comprising a central solid member and two side members disposed apart from the central member on opposite sides thereof and connected therewith, said side members being composed of legs spaced apart from one another, a stationary coil disposed on said central member between said side members, and a movable coil disposed on said central member between said side members and adjacent to said stationary coil.

2. The combination of a core comprising a central solid member and two side members disposed apart from the central member on opposite sides thereof and connected therewith, said side members being composed of legs spaced apart from one another and the legs of one side member alternating with the spaces of the other side member, a stationary coil disposed on said central member between said side members, and a movable coil disposed on said central member between said side members and adjacent to said stationary coil.

3. A core for a magnetic circuit, having a central core portion with outwardly extending arms at its lower end and upwardly extending portions at their extremities, composed of oppositely disposed and alternately arranged groups of U shaped plates firmly bound together, substantially as described.

4. The combination, with a core for a magnetic circuit having a central core portion with outwardly extending arms and upwardly extending portions at their extremities, composed of oppositely disposed and alternately arranged groups of U shaped plates, of clamping strips applied to the edges of both the central core portion and the upwardly extending portions at the extremities of the arms, and bolts for firmly clamping the parts together, substantially as described.

In testimony whereof I have hereunto set my hand in the presence of two witnesses this 17th day of August, 1908.

EDWARD R. CLIFF.

Witnesses:
EDWARD WIESNER,
GRACE T. DIPOW.