No. 646,308.

Patented Mar. 27, 1900.

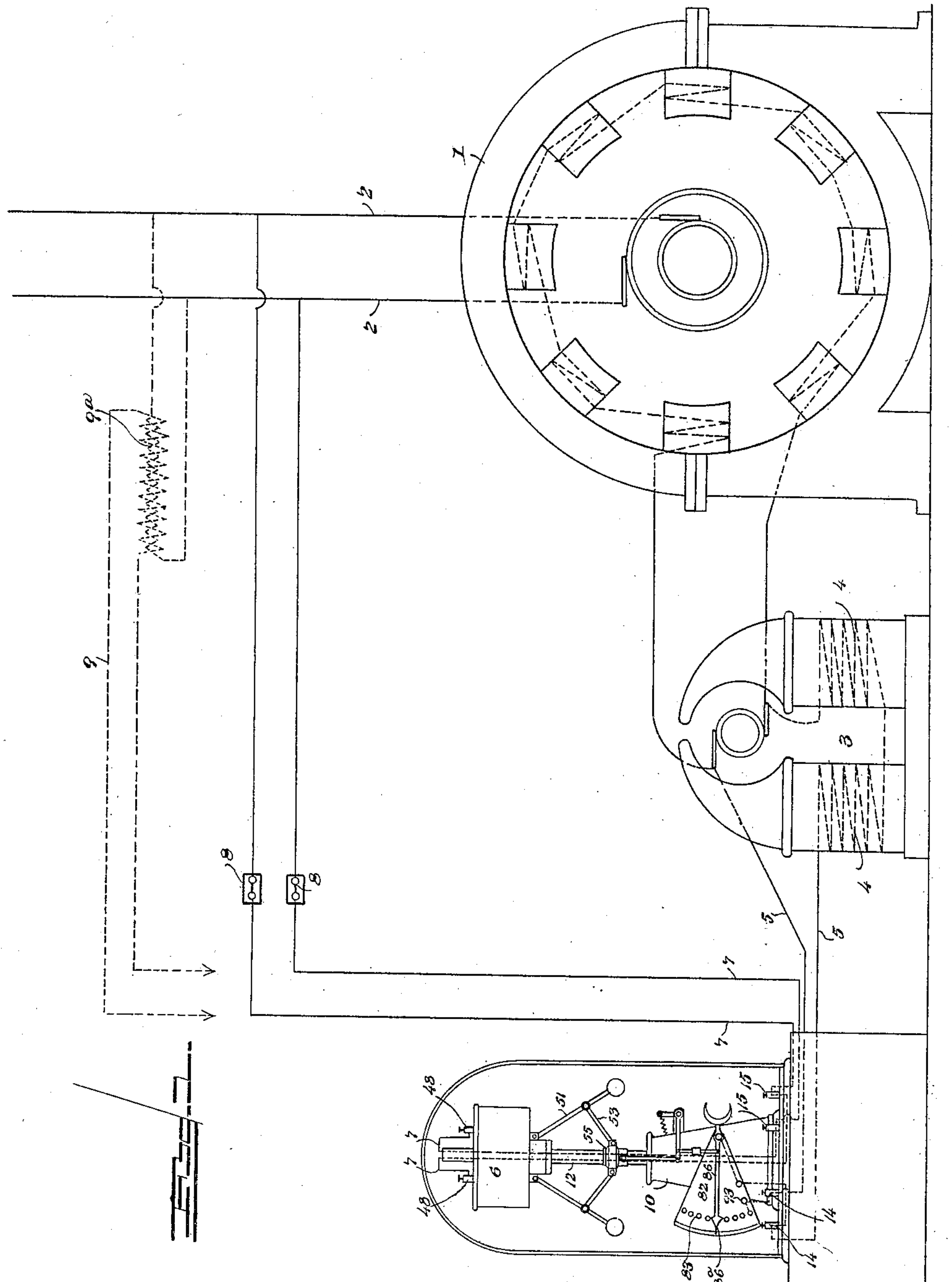
G. S. NEELEY.

AUTOMATIC REGULATOR FOR ALTERNATING DYNAMOS.

(Application filed June 7, 1898.)

(No Model.)

4 Sheets—Sheet 1.



Witnesses
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No. 646,308. Patented Mar. 27, 1900.

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(No Model.) 4 Sheets—Sheet 2.

Fig. 2.

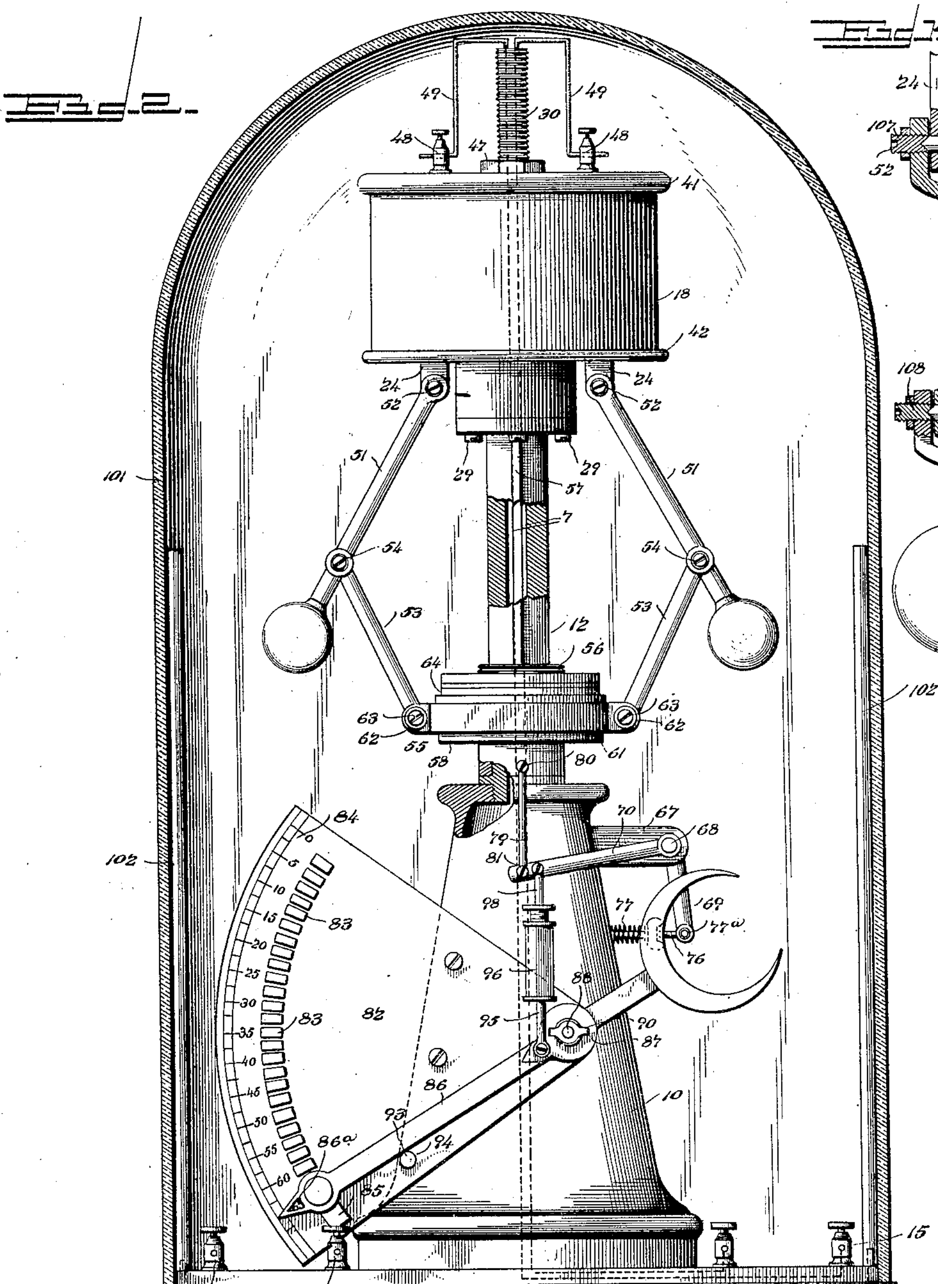
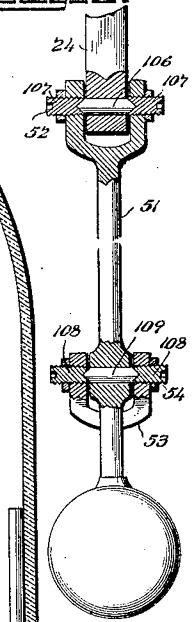


Fig. 19.



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AUTOMATIC REGULATOR FOR ALTERNATING DYNAMOS.

(Application filed June 7, 1898.)

(No Model.) 4 Sheets—Sheet 3.

Fig. 3.

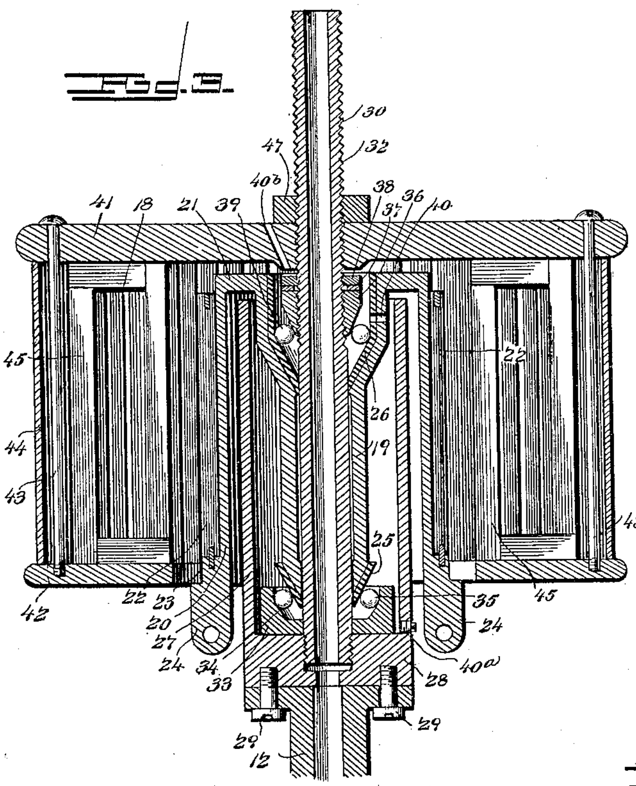


Fig. 5.

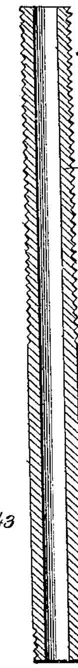


Fig. 6.

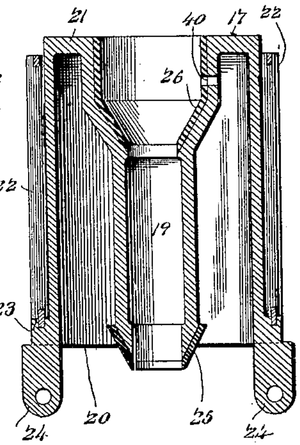


Fig. 8.

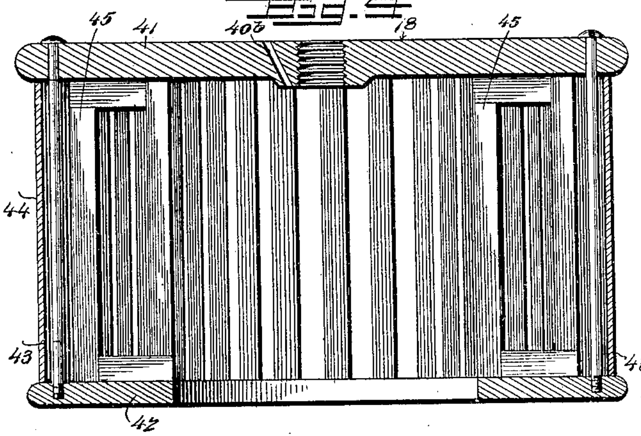


Fig. 9.

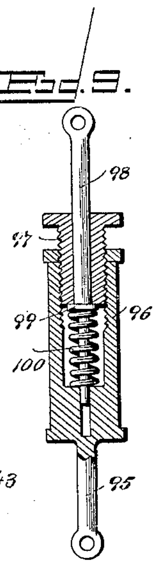
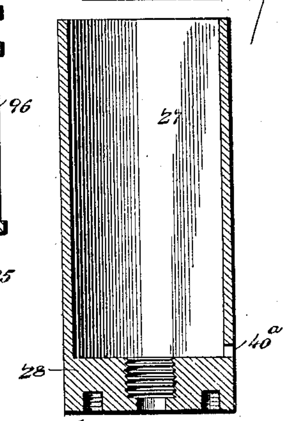


Fig. 7.



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AUTOMATIC REGULATOR FOR ALTERNATING DYNAMOS.

(Application filed June 7, 1898.)

(No Model.) 4 Sheets—Sheet 4.

Fig. 9.

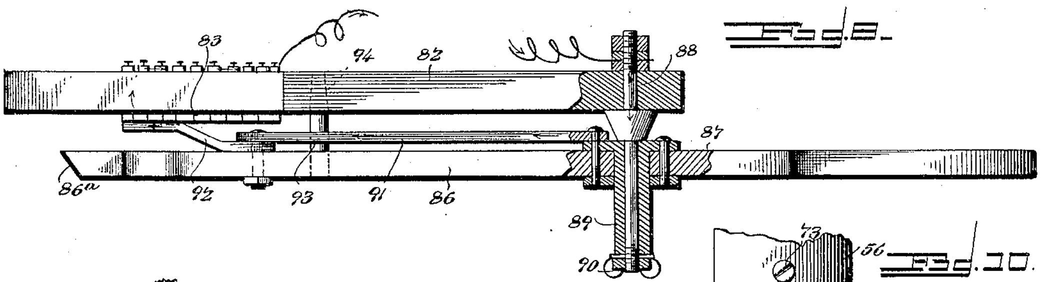


Fig. 10.

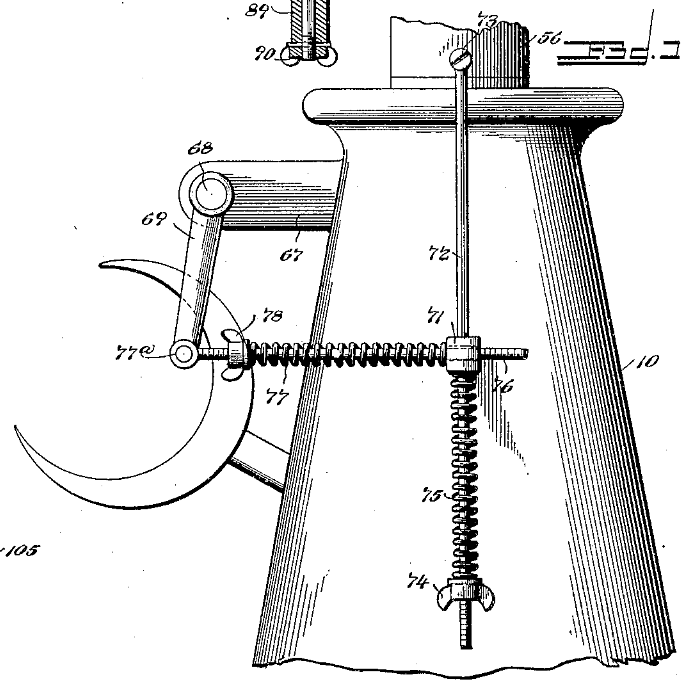


Fig. 13.

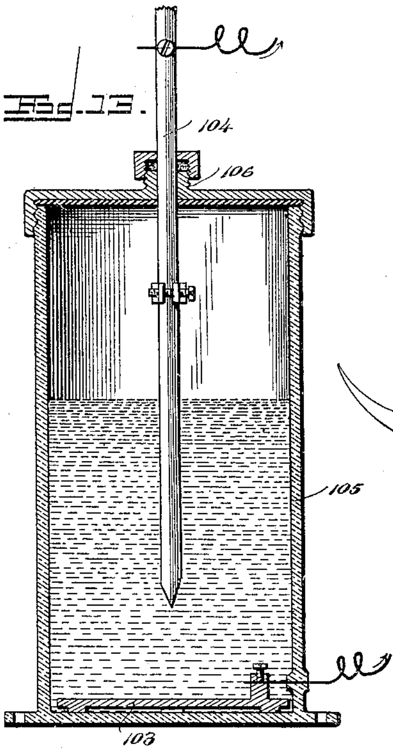


Fig. 12.

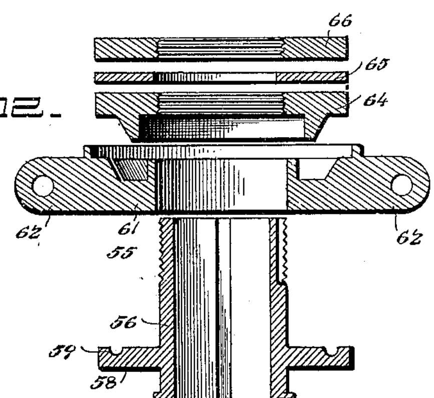
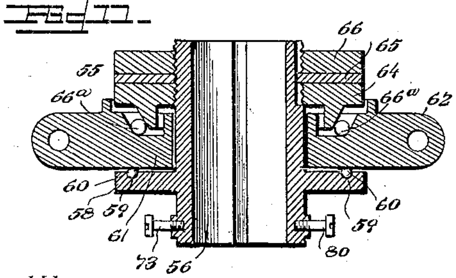


Fig. 11.



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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

GEORGE S. NEELEY, OF PACIFIC, MISSOURI, ASSIGNOR OF ONE-HALF TO ALBERT KOPPITZ, OF SAME PLACE.

AUTOMATIC REGULATOR FOR ALTERNATING DYNAMOS.

SPECIFICATION forming part of Letters Patent No. 646,308, dated March 27, 1900.

Application filed June 7, 1898. Serial No. 682,849. (No model.)

To all whom it may concern:

Be it known that I, GEORGE S. NEELEY, a citizen of the United States, residing at Pacific, in the county of Franklin and State of Missouri, have invented a new and useful Automatic Regulator for Alternating Dynamos, of which the following is a specification.

This invention relates to improvements in automatic regulators for alternating dynamos of the class disclosed in my prior application for Letters Patent, filed in the United States Patent Office on July 28, 1897, Serial No. 464,202, in which I disclose a system embracing the induction-motor included in shunt with the primary working circuit and a motor-controlled centrifugal governor which is mechanically connected with the commutator-brushes of an auxiliary exciting-generator that supplies the primary dynamo, whereby an increase in the electromotive force of the primary dynamo and the working circuit accelerates the speed of the induction-motor to shift, through the centrifugal governor, the brushes of said auxiliary exciting-generator in a manner to restore the primary alternating dynamo to its normal working condition.

In my present invention I have improved the system disclosed by my prior application by including therein a rheostat which is controlled mechanically by the centrifugal governor actuated by the induction-motor and electrically connected in series with the shunt-field winding of the auxiliary exciting-generator, whereby an exceedingly-small percentage of the current from the auxiliary generator is required to pass through the rheostat for the successful operation of the entire lighting or power system and which is designed to indicate at all times the total amount of work performed by the alternating dynamo and does not indicate the amperage of the current from the auxiliary exciting-generator. This employment of the rheostat between the centrifugal governor and the field of the auxiliary generator is advantageous, because the rheostat may be maintained in a cooled condition at all times, and it requires a minimum amount of current to pass through it for the successful operation of the system, and the rheostat may be made quite simple and compact.

A further object of the invention is to construct and arrange the several parts of the rheostat to the end that they may work with great freedom and enable the same to be adjusted by hand to the working position in event of the disability of the induction-motor or disarrangement of the working parts of the centrifugal governor.

With these ends in view the invention consists in the system to be hereinafter described and in the novel combination of elements and in the construction and arrangement of parts, which will be hereinafter fully described and claimed.

To enable others to understand the invention, I have illustrated the preferred embodiment thereof in the accompanying drawings, forming a part of this specification, and in which—

Figure 1 is a diagrammatic view illustrating the circuit and showing by dotted lines an arrangement of shunt or derived circuit, including a transformer, which may be employed between the regulator and the primary working circuit of an electrical distribution or lighting system. Fig. 2 is an enlarged sectional elevation of the stand, the induction-motor, and the rheostat. Fig. 3 is a vertical sectional elevation through the induction-motor, showing its parts properly assembled. Figs. 4 to 7 are detached views of the several parts composing the induction-motor. Fig. 8 is an enlarged detail view looking at one edge of the rheostat. Fig. 9 is a detail sectional elevation of the extensible spring-link connection between the rheostat-lever and the shiftable connection for the rotary and slidable swivel of the centrifugal governor. Fig. 10 is an enlarged detail elevation of the regulating-screws forming a part of the connections between the centrifugal governor and the rheostat-lever. Fig. 11 is a detail sectional elevation of the rotary and shiftable swivel, showing its parts assembled in proper relation; and Fig. 12 is a similar view of the parts of said swivel detached or separated one from the other. Fig. 13 is a sectional elevation of a special form of rheostat employing a liquid resistance. Fig. 14 is a detail sectional elevation of the governor arms and links, showing my preferred form of pivotal connection between the parts.

Like numerals of reference denote like and corresponding parts in each of the several figures of the drawings.

1 designates an alternating dynamo of any construction, which supplies the current of electrical energy to the external working circuit 2. The auxiliary generator 3 has its brushes electrically connected by suitable conductors with the field-coils of the alternating dynamo, and the shunt-wound field-coils 4 of the auxiliary generator are in circuit with the shunt-circuit 5 to the rheostat, forming a part of the automatic regulator of my invention. The induction-motor 6 is included in a derived or shunt circuit 7, the conductors of which are electrically connected with the leads or mains of the primary working circuit 2. In this derived or shunt circuit 7 for the induction-motor of the regulator are included the ordinary fuse-blocks 8, which are adapted to protect the field-coils of the motor 6 and conductors 7 in the event of an undue discharge of electrical fluid into the derived or shunt circuit 7—as, for example, a discharge of lightning would fuse or melt the fuses 8, and thereby interrupt the continuity of the derived circuit. I do not, however, confine myself to the employment of the shunt-circuit having the fuse-blocks connected with the induction-motor and the external working circuit, because I am aware that the derived circuit 9, including a transformer 9^a, as indicated by dotted lines in Fig. 1, may be employed between the working circuit 2 and the fields of the induction-motor 6.

My improved regulator mechanism embraces a vertical stationary column 10, which is of substantial construction and is preferably cast in a single piece of metal, and said column is rigidly secured in any suitable way to a base 13, preferably of insulating material. To the upper end of this stationary column is rigidly and detachably secured a vertical tubular standard 12, and on the base 13 are provided two sets of binding-posts 14 and 15. One set of the binding-posts is adapted for the attachment of the conductors forming the shunt-circuit 5 to the rheostat; but the other set of binding-posts 15 receives the conductors forming the derived or shunt circuit 7 to the induction-motor 6.

I employ a novel construction of induction-motor, (represented by Figs. 2 to 7, inclusive, of the drawings,) and the rotary element of this induction-motor is fitted or mounted upon the upper extremity of the tubular standard 12, while the fixed member of said induction-motor is rigidly secured on the rotary member in a peculiar manner for the purpose of adjusting the relatively-stationary member in relation to the rotary element to the end that the speed and rotative strength of the motor may be regulated without involving disarrangement of the working parts of the regulator system. The rotary element of the induction-motor is embodied in the form of an armature-spider, which is rotatably fitted to a tubular spindle on the standard 12, while the stationary element is embraced in a field-carrier attached to said spindle to remain normally in fixed stationary relation to the rotative armature-spider and adjustable endwise in relation thereto. The rotative armature-spider 17 is of peculiar construction for the purpose of using the same in connection with bearings which insure great freedom of rotation to said armature-spider and provide for the proper and constant lubrication of its rotary element. Said spider consists of a tubular hub 19 and a cylindrical shell 20, which are joined together at one end by a web or head 21, all of said parts being preferably made in a single piece of metal—as, for instance, by casting the same. The form of this armature-spider is represented by Fig. 6 of the drawings, in which the web 21 is shown as closing the space between the upper end of the sleeve-like hub 19 and the cylindrical shell 20; but the space at the opposite end of said armature-spider is open for the accommodation of a lubricating-reservoir 27. To the external surface of the cylindrical shell 20 of the armature-spider is applied a series of short-circuited copper bars, which are set close together and constitute a closed circuit around the entire external diameter of the cylindrical shell 20. These bars have grooves formed in their ends to snugly receive the copper bands or ribbons 23 23^a, which bands serve to hold the circuit or series of copper bars against the periphery of the cylinder 20, forming a part of the armature-spider. The external shell 20 is further provided with the depending short arms 24, that lie below the stationary field-carrier 18 of the motor for the purpose of properly attaching the weighted lever-arms of the centrifugal governor to the rotary armature-spider forming a part of the induction-motor. The sleeve-like internal hub 19 of the armature-spider 17 is constructed with two conical bearings, one of which, at the lower end of the sleeve 19, is external thereto, while the other bearing, at the opposite end of the sleeve-hub, is internal thereto. Both of these conical bearings are faced with a metal designed to reinforce the surface and increase the durability of the armature-spider, and with the hard-metal conical bearings are combined certain ball-bearings that reduce the friction to a minimum and insure great freedom of rotation to the rotary element of the induction-motor. The external conical bearing at the foot of the rotary armature-spider is indicated by the numeral 25; but the internal conical bearing at the upper end of the sleeve-like hub 19 is formed by flaring the said hub

19 and lining the same with the hard metal to produce the internal conical bearing 26. With this rotary element of the induction-motor is combined a lubricant-reservoir 27, which is introduced into or through the lower open end of the armature-spider, and this reservoir 27 is of a length to supply the lubricant to the upper as well as the lower conical bearings 26 and 25. The oil-reservoir consists of a cylindrical shell which is open at its upper end and is closed at the lower extremity by a head 28, preferably integral with the shell, and this head 28 is fitted to an enlargement or disk on the upper extremity of the tubular standard 12, so that the reservoir may be fixed to the standard by the screws 29 or other suitable fastening devices. The cylindrical reservoir 27 is thus arranged to fit loosely into the armature-spider between the sleeve-like hub 19 and the external shell 20 thereon, and the upper extremity of this reservoir 27 terminates close to the web 21, which closes the head of the armature-spider. The reservoir 27 being fixed rigidly to the upper extremity of the tubular standard 12, it serves as the support for a tubular standard 30, which serves as the axis around which the rotary spider may travel with ease and freedom. This spindle 30 is externally threaded at its lower end for the purpose of screwing it into and fastening it rigidly to the bottom 28 of the fixed reservoir 27, and said tubular spindle extends vertically through the sleeve-like hub 19 of the spider and through the field-carrier 18 of the motor. The upper part of this fixed spindle 30 is externally threaded at 32 for a considerable distance, so as to allow of the proper vertical adjustment of the field-carrier 18 thereon, and said spindle is thus adapted to serve in a twofold capacity, in that it provides the axis of rotation for the armature-spider and as the support for the field-carrier in its relation to the armature-spider. A lower bearing-cup 33 is arranged above the fixed reservoir 27 in operative relation to the lower external conical bearing 25 of the armature-spider, and between the faces of the bearing-cup 33 and the hardened conical face of the bearing 25 is interposed a series of bearing-balls 35. These bearing-balls are adapted to travel against the external conical bearing 25, and they are housed or contained within the ball-race 34, which is provided in the upper face of the bearing-cup 33, that rests upon the bottom 28 of the fixed reservoir 27. The upper cone-bearing 36, which coacts with the internal conical bearing-face 26 of the armature-spider, is secured rigidly to the threaded part 32 of the tubular spindle 30. This upper bearing 36 is in the form of a cone which is provided with a central threaded opening adapted to be screwed on the threaded part 32 of the spindle 30 to occupy a position within and concentric with the internal bearing-face 26, thus disposing the bearing-cone 36 in a position for its conical face to oppose the similar face on the bearing 26, and between the opposing faces of the cone 36 and the bearing-face 26 is interposed the series of bearing-balls 39, adapted to ride against said faces. This bearing-cone 36 is adjustable lengthwise on the tubular fixed spindle 30 by rotating it on the threaded part 32 of said spindle for the purpose of compensating for any wear which may take place on the upper and lower conical bearings for the rotatable armature-spider, and the upper cone 36 is held securely in its adjusted position by means of a washer 37, which is fitted loosely around the threaded part of the spindle 32 to rest upon the cone 36, a jam-nut 38 being also screwed on the spindle for the purpose of holding the cone 36 and the washer 37 firmly in their adjusted positions. The upper end of the reservoir-shell 27 terminates on the horizontal plane of the upper bearing-cone 36, and communication is established between the reservoir and the tubular hub of the armature-spider by a port 40, which is formed in the flared upper part of said hub 19, thus permitting the lubricant from the reservoir to pass freely into the space between the fixed spindle 30 and the hub of the armature-spider. A port 40^a is provided in the lower part of the reservoir-shell 27 for the extraction of the lubricant from the reservoir, and a similar port 40^b is provided in the upper head of the field-carrier 18 for introducing the lubricant into the reservoir and the hub 19 of the armature-spider, the lower port 40^a being closed by a suitable plug, as shown by Fig. 3.

The stationary field-carrier 18 of my improved induction-motor consists of a head 41, a base-ring 42, the bolts 43, and the casing or shell 44. The head 41 and base-ring 42, respectively, are parallel to each other, and between said parts is interposed the cylindrical casing 44, all the parts of the field-carrier being bound firmly together by the tie-bolts 43, suitably attached to the head and the base-ring. This field-carrier sustains a series of laminated sheets 45, which constitutes the iron core, which are surrounded by the starting and field coils of the induction-motor, and the core-sheets and the field and starting coils are arranged between the head and base-ring of the carrier so as to be confined rigidly within the latter. The field and starting coils of the induction-motor surround the laminated sheets 45, and these field-coils and laminated-iron core on the adjustable field-carrier surround the copper bars 22 on the armature-spider. The field-coils and their cores are thus mounted within the annular carrier 18 for the purpose of being movable therewith in the endwise adjustment of said carrier on the fixed spindle 30 of the motor, whereby the area of the coils and core exposed to the copper bars on the armature-spider may be varied by the vertical adjustment of the field-carrier. Said field-carrier has its upper head 41 provided with a central threaded opening, into which is screwed the upper threaded length 32 of the spindle 30, and this threaded connection between the spindle and the head of the field-carrier enables the carrier to assume a stationary position in relation to the armature-spider; but at the same time the annular carrier is held firmly in its adjusted position on the spindle 30 by a jam-nut 47, which is screwed on the threaded spindle and binds against the upper head 41 of said carrier. This field-carrier supports the binding-posts 48, to which are attached the insulated conductors 49, that are connected with the binding-posts 15 of the shunt or derived circuit 7, and in order to compactly dispose these conductors in relation to the other working parts of the system I prefer to carry or extend them through the tubular spindle 30, the tubular standard 12, and the hollow column 10. The tubular spindle, the column, and the standard are in vertical alinement with each other to provide for the proper passage of the conductors from the binding-posts 48 of the induction-motor to the binding-posts 15 of the shunt or derived circuit 7, which leads from a regulator mechanism to the primary working circuit 2.

My improvements in the induction-motor are not directed to the construction of the operating elements of the motor, *per se*, nor do they relate to the theory or principle on which the motor becomes operative through the inductive effects of the alternating current. On the other hand, my improvements relate more particularly to the means for supporting the rotative element, (the armature,) by which the latter may revolve freely with a minimum friction, to the means by which the motor is rendered regulatable as to the strength and speed by enveloping more or less of the armature within the magnetic field of the coils, which is due to the adjustment of the relatively-stationary carrier by the agency of the threaded end of the spindle and the nuts thereof, and to the provision of means by which the parts can be adjusted to compensate for wear on the motor. It will also be evident that the field-coils of the motor can be interchanged readily to suit the different potentials without disturbing the motor-armature.

The induction-motor hereinbefore described constitutes the subject-matter of a separate application filed by me November 18, 1899, Serial No. 737,521, and therefore I do not claim herein the induction-motor, *per se*. It is to be understood, however, that this motor is useful in my regulator system because the rotative strength and speed of the motor may be varied by adjusting the field-carrier and the field-coils to more or less envelop the armature without disturbing the operative relation of the induction-motor to the centrifugal governor mechanism.

I will now proceed to describe the improved centrifugal governor which I have provided for use in my improved regulator system, but this governor is of the same general type as the structure described in my prior application, to which reference has been made.

The governor has its weighted levers 51 pivoted in a suitable way at 52 to the short arms 24 of the rotary armature-spider, and to the weighted levers are connected the outer ends of the links 53 by suitable pivots 54. The inner ends of the links 53 are operatively connected with a swivel having a compound movement on the standard 12 of the regulator, and this swivel 55 is in two parts, one of which is a slidable sleeve 56 and the other a rotary collar 61. The slidable sleeve 56 is loosely fitted to the standard 12 to move freely in a vertical direction thereon, and it is prevented from rotating by means of a rib or key 57 on the standard, which is loosely fitted in a keyway or groove provided on the inner face of the sleeve 56. Said sleeve is constructed with an external annular bearing-flange 58, in the upper face of which is formed a ball-race 59, containing a series of bearing-balls 60. The rotary collar 61 is loosely fitted around the slidable sleeve 56 to travel therewith vertically in its play on the standard, and said collar rests loosely upon the ball-bearings 60, which reduces to a minimum the friction and wear between the working parts constituting the swivel. This rotary collar 61 is provided with outwardly-extending lugs or ears 62, and to these ears are pivotally attached the inner ends of the governor-links 53 by pivots indicated at 63. The rotary collar is properly confined on the slidable sleeve by an adjusting-cone 64, which is secured to a threaded upper part of the slidable sleeve 56, and this adjusting-cone is held in its proper position by a washer 65 and a jam-nut 66, the latter being screwed on the upper threaded part of the slidable collar 56 to bind firmly against the washer and the adjusting-cone. The upper face of the rotary collar 61 is constructed with a ball-race to receive a series of bearing-balls 66^a, against which the adjusting-cone 64 is adapted to bear, and as the cone is rigidly and adjustably attached to the slidable sleeve the rotary collar is properly confined between the cone and the bearing-flange of the collar. It will be observed that the rotary collar has ball-bearing engagement on both sides or faces thereof with parts of the slidable sleeve, and the adjusting-cone may be rotated on said sleeve for the purpose of taking up wear between the working parts and maintain them in a position to insure great freedom of rotation to the collar.

Projecting laterally from one side of the fixed column 10 is a horizontal arm 67, which serves as the bearing for a rock-shaft 68, the latter being suitably mounted in the arm to rock or turn freely therein. To one end of this rock-shaft is secured a vertical arm 69, while to the other end of the shaft is attached a horizontal arm 70, both of said arms being fast with the shaft to turn therewith and arranged in different vertical planes to lie on opposite sides of the column 10. On one side of the column is provided a fixed guide-lug 71, through which passes two tension-rods, which are controlled by springs. One of these tension-rods 72 is arranged in a vertical position to move freely through a fixed guide-lug 71, the upper end of said rod 72 being pivoted, as at 73, to the slidable sleeve 56. The lower end of the vertical tension-rod is externally threaded to receive an adjusting-nut 74, and between the nut and the fixed lug 71 is interposed a coiled spring 75, the tension of which may be varied by adjusting the nut. The other tension-rod 76 occupies a horizontal position and at right angles to the rod 72, and this horizontal rod 76 plays freely in an opening in the lug 71, the outer end of said rod 76 being pivotally attached at 77ª to the free end of the depending vertical arm 69 on the rock-shaft. A pressure-spring 77 is loosely fitted on this horizontal tension-rod 76, so as to have one end seated against the lug 71, and on said rod 76 is fitted an adjusting-nut 78, which bears against the spring 77 to vary the tension thereof.

The horizontal arm 70 of the rock-shaft 68 is operatively connected with the vertically-slidable governor-sleeve 56 by means of a link 79, which is pivoted at its upper end at 80 to said sleeve and has its lower end attached at 81 to said horizontal arm 70, and this horizontal arm 70 is in turn connected by an extensible spring-link, hereinafter to be described, with the lever of a rheostat, whereby the centrifugal governor is mechanically connected with the rheostat, which in turn is electrically connected in series with the shunt field-coils of the auxiliary exciting-generator. The described arrangement of the spring-controlled tension-rods, which are operatively connected with the arms of the rock-shaft, enables the operator to correct at will any discrepancy which may be found to exist in the electromotive force of the dynamo when the latter attains its normal speed and working conditions, and as two of these spring-controlled tension-rods are employed and said rods lie at right angles to each other a nicety of adjustment of the resistance to the upward movement of the slidable governor-sleeve may be attained.

I will now proceed to a description of the rheostat which I employ.

The rheostat has an insulating sector-shaped base 82, of slate, fiber, or any other insulating material, rigidly fastened in a suitable way to the column 10, and to this base is applied the series of resistance-blocks 83. The base carries a scale 84, the indications of which are coincident with the resistance-blocks, and this scale is intended to show at all times the total output in amperes of the alternating-current dynamo, but it does not show the amount of exciting-current which passes through the rheostat. The scale should be calibrated by an ammeter of known accuracy while the regulator is in operation. At one end of the series of resistance-blocks 83 is a "dead-segment" or insulated plug 85, which lies in the path of the rheostat-lever 86 and is entirely independent of any electrical connection with the shunt-circuit 5 to the field-coils of the auxiliary generator. The lever 86 is hung on the insulated base to traverse the face of the series of resistance-blocks, and said lever is equipped at its free end with a pointer 86ª, which may indicate on the scale 84 the particular block with which the contact-shoe of said lever has electrical connection. The lever 86 is made of wood, fiber, or any other insulating material, and it is provided with a metallic hub 89 for the reception of a spindle or pivotal bolt 88. This pivotal bolt is mounted in the insulated base 82, and to it is attached one of the conductors forming a part of the shunt-circuit 5 to the auxiliary generator, and as the metallic hub 89 is in electrical connection with the spindle of the pivotal bolt 88 a conductor-bar 91 on the lever is in electrical connection with the circuit which is attached to the pivot 88 for the lever. This conductor-bar 91 is suitably fastened to the insulated body of the lever and is electrically connected with the metallic lever-hub 89, and to the free end of the conductor-bar 91 is electrically connected a yieldable contact-shoe 92, which may traverse the resistance-blocks 83. The spindle 88 of the bolt, which serves as the fulcrum for the lever 86, is extended beyond the hub 89 of said lever, and to the protruding threaded end of said spindle 88 is fitted a clamping-nut 90, which is suitably insulated from the hub and is adapted to bind against the latter for the purpose of holding the lever 86 from coming off the spindle 88 and whereby the lever of the rheostat may be adjusted by hand and clamped in position.

93 designates a removable stop which is fitted in a socket 94 of the rheostat-base 82, and this stop 93 lies in the path of the lever 86 at a point to intercept any contact of the lever with the insulated block or dead-segment 85 of the rheostat.

The lever 86 is mechanically connected with the arm 70 of the rock-shaft by the extensible spring-link. (Shown more clearly by Fig. 9 of the drawings.) This extensible link consists of a shell or casing 96, which is internally threaded for a part of its length to receive an externally-threaded bushing 97, and through this bushing passes the stem 98, which is slidably fitted at its lower end in a socket of the shell or casing 96. The slidable stem 98 is provided at a point intermediate of its length with an annular collar 99, and around this stem is loosely arranged a coiled spring 100, which is contained within the shell 96, to have one end thereof seated upon the shell, while its other end bears against the collar 99.

Under normal conditions the contact-shoe of the rheostat arm or lever does not rest on the insulated segment 85. The sleeve 56 rests securely on the flanges on the bottom of the column, and the total weight of the arms 51

53 is imposed on the column through the medium of the sleeve 56. Removing the guard-pin 94 allows the rheostat arm or lever 86 to descend through the expanding action of the spring 100 in the link 96, so that the contact-shoe 92 will rest squarely on the insulated segment 85. This lever or arm, with its contact-shoe, is not intended to reach the insulated segment until the regulator or any of its parts becomes deranged in such manner as to render it inoperative, thus rendering the regulator automatic in its action, as by this arrangement the exciting-current is automatically interrupted in case of accident or stoppage of the rotary elements, and thus overcoming increase in the potential of the dynamo to a dangerous degree on a light load. It should also be understood that the stop-pin 94 should be removed as soon as the arm or lever is raised to its normal working condition and should be replaced before it is desired to throw the dynamo out of action. The link 96 allows the weight of the arms 51 53, with the pressure of the springs 77 71, to be borne by the sleeve 56 and the flange of the column 12, and were it not for the contracting action of the joint 96 the weight of these parts would rest upon the guard-pin 94, the stud 88, the pivot-screw 80, and the links 79 and 96; but as the link 96 is contractive and expansive in its action a minimum fraction of the weight is borne by the different parts, in fact only so much of the weight as is necessary to contract the spring 100. This spring is of sufficient strength to keep the links 95 and 98 pressed apart at all times against the resisting action necessary to move the lever 86 back and forth over the contacts 83. The screw 97 serves to lengthen or shorten the link 96, to the end that the contact-shoe 92 may rest squarely on the segment 85 when the lever-arms 51 53 are at rest and the guard-pin 94 is removed. Assuming that this adjustment by the screw 97 has been effected, the lever or arm 86 should be elevated sufficiently for the guard-pin 94 to be inserted into position, as indicated by Fig. 2, because, as hereinbefore indicated, the dynamo will not generate the current if the lever 86 is on the segment 85. Hence it is apparent that the guard-pin should be placed in position before shutting down the dynamo in order to prevent the lever 86 from descending to the segment 85 when the centrifugal governor mechanism comes to rest.

At the present time there is danger in the employment of instruments for the automatic regulation of the electromotive force from direct or alternating current dynamos for the reason that voltage-regulators, whether controlled by centrifugal force or solenoid-coils, operate to increase the electromotive force of the dynamo toward its maximum limit as the speed of the regulator decreases, and vice versa. Should any of the working parts of the regulator become deranged—as, for instance, by an accidental discharge of lightning, which in all probability would either burn out the field-coils of the induction-motor or would melt the fuses 8—the regulator would cease to operate, as it would automatically slacken in speed or stop running entirely. In the latter event the entire resistance of the rheostat is thrown off the field-coils of the auxiliary exciting-generator, and this result affects the alternating dynamo so as to increase its electromotive force to the maximum limit. We will suppose, for example, that the dynamo is generating an alternating current of sixty-five amperes at one thousand volts, while in all probability at the moment of interruption to the regulator the external or working circuit would require about ten or twelve amperes. It will thus be seen that on a light load of the working circuit and with the electromotive force of the dynamo and external working circuit at a high point great danger to life would result, and the increase is liable to injure the insulation of the armature-winding. My regulator system is equipped with means to automatically prevent any sudden increase in the electromotive force of the working circuit due to any sudden failure of the induction-motor or the centrifugal governor, and this end is in part attained by the employment of the removable stop-pin 93, which is attached to the insulated base of the rheostat, and also to the employment of the automatic link connection 95 between the lever of the rheostat and the centrifugal governor. This safety-pin should always be removed when the dynamo and regulator have attained their normal working positions, and it should be replaced before stopping the engine and the dynamo. In case of an accident to the electrical regulator the governor-arms will drop, thus allowing the lever 86 of the rheostat to pass below the series of resistance-blocks 83 and make contact with the insulated section or dead-segment 85 on the rheostat, thereby interrupting the shunt-circuit 5 and cutting the field-coils of the auxiliary exciting-generator out of circuit. Assuming that the dynamo in the external working circuit has a capacity of sixty-five amperes and one thousand volts electromotive force, that the regulator and dynamo are working normally without indication of trouble, and the pointer on the rheostat-lever indicates on the scale 84 that the load on the external working circuit is only five amperes, a discharge of lightning blows either one or both of the line-fuses 8 in the shunt-circuit between the primary working circuit and the regulator; but the lightning-discharge may succeed in passing the fuse-blocks and burn out the primary or field coils of the induction-motor. Should either of these contingencies occur, the rotation of the induction-motor and the centrifugal governor would be instantly arrested, and as the centrifugal force decreases the governor-arms will have a tendency to lower, thus depressing the slidable sleeve and through the described connections will shift the lever 86 downwardly past the resistance-blocks 83 until the contact-shoe on said lever 86 finally reaches the insulated section 85. All possibility of danger will end when the lever is in contact with this insulated section, because the electric circuit to the field-coils of the auxiliary exciting-machine will be broken, and this renders impossible any generative action by the alternating dynamo.

In my regulating system an induction-motor is employed which has its field-coils connected by a shunt-circuit with the primary circuit, so that the variations in the electromotive force of the primary current will be transmitted to the field of the induction-motor without interruption or resistance by a set of gummy brushes or by an irregular commutator.

It has generally been the practice to employ a motor of that class using a brush and commutator, and, as is well known, any sparking at the commutator increases or decreases the speed of the motor-armature in proportion to the length of the arc, the effect of which variation in the speed is to vary the resistance to the current utilized for the operation of the motor. The causes for the sparking are various, and among them may be mentioned a dirty or gummy set of brushes and irregular service of the commutator and improperly-adjusted brushes, which conditions, taken as a whole, render it difficult for the successful operation of a centrifugal governor for any appreciable length of time by a motor of this class. By employing an induction-motor substantially such as herein indicated, which is free from brushes, in connection with the commutator and the employment of a rheostat which is mechanically controlled by a governor mechanism actuated from the induction-motor I am enabled to effect the automatic regulation of the auxiliary exciting-generator and the primary dynamo in a practical and constant manner.

It will be understood that my improved regulating system is especially designed for an alternating dynamo; but the improved induction-motor that I have devised can be operated in the primary or secondary circuit of a transformer by substituting a field-coil of less resistance when used in the secondary transformer-circuit, all as clearly represented by dotted lines in Fig. 1.

One of the important features of my improved system is the inclusion of the operative elements forming a part of the rheostat in the shunt-circuit leading to the field-coils of the auxiliary exciting-generator and the mechanical connection of the centrifugal motor-driven governor with the shiftable arm or lever of the rheostat, which is adapted to indicate on the scale the load in amperes of the working primary circuit supply from the dynamo. This organization of the elements effects the operation of the rheostat by a very small percentage of the current from the auxiliary exciting-generator, the rheostat is kept in a cooled condition by the passage of the minimum amount of the electrical energy through the circuit from said auxiliary generator that will successfully control the entire output of electrical energy from the alternating dynamo, and the rheostat itself may be constructed of comparatively-small dimensions.

In my regulator only one adjustment of the parts to attain the electromotive force is necessary and the elements act positively after such adjustment has been attained. The regulator operates as a safeguard to the dynamo against sudden overloading thereof and there are no electrical contacts necessary to be made or broken, as with solenoid devices. The regulator requires a minimum amount of attention, and all its working parts are adjustable to compensate for wear. In case of accident to any of the rotative elements of the regulator or burning out of the field-coils of the induction-motor the rheostat may be adjusted by hand, thus avoiding an interruption of the service. In case it becomes necessary to adjust the rheostat member, as in the event of the disability of the induction-motor or the centrifugal governor, the extensible spring-link 95 should be disconnected from the shiftable arm or lever of the rheostat and the clamping-nut 90 should be tightened on the spindle of the fulcrum 88 sufficiently to hold the shiftable arm or lever in any position to which it may be adjusted, thus preventing the arm or lever from being jarred out of position and affecting the service. This is important, because the lever or arm is mounted to traverse the face of the resistance-box and the scale with minimum of friction between the parts. It will thus be evident that the induction-motor may be arrested at any time independent of the dynamo and the current in the working circuit if it is necessary, owing to disarrangement of the automatic elements of the regulator system, and this action does not involve any interruption to the service.

The shiftable arm or lever, which traverses the face of the rheostat and the scale thereon, indicates at all times the total amount of work performed by the alternating dynamo, and my regulator is applicable to all systems and voltages employing alternating currents.

To protect the working parts of the automatic regulator, I employ a transparent inclosing case 101, preferably of glass and arranged to rest upon the base 13, and when it is necessary to lift this inclosing case for access to the parts of the regulator system said case is guided by the guard-rods 102, which are suitably attached to the base.

In Fig. 13 of the drawings I have represented another type of rheostat, in which a liquid resistance is employed between the cathode 103 and an anode 104, to which are connected, respectively, the two conductors of the shunt-circuit leading to the field-coils of the auxiliary generator. The anode 104 is preferably in the form of a carbon pencil, which is attached to a vertically-adjustable and non-corrosive carrier that is designed to be mechanically connected with the arm 70 forming one of the connections to the centrifugal governor. The cathode is in the form of a flat metallic plate arranged on the bottom of a glass jar or vessel 105, which is adapted to contain the liquid resistance, and to the upper head of this vessel is secured an insulating stuffing-box 106, through which the anode-carrier is adapted to play vertically.

In Fig. 13 of the drawings is represented the preferred form of the joints between the weighted governor-arms and the rotary motor-armature and the links and weighted arms of the governor. The lugs 24 of the armature-spider each has a conical-pointed steel pin 106 to fit in conical recesses of bushings 107, that are secured in the arms of a forked extremity of each governor-arm 51. The links 53 of the governor are forked to sustain the bushings 108, that receive the conical ends of the steel pins 109, which are shrunk or otherwise secured in the governor-arms 51. This form of the joint reduces the friction to a minimum, and said joint retains the lubricant for a considerable length of time.

Changes may be made in the form of some of the parts while their essential features are retained and the spirit of the invention embodied. Hence I do not desire to be limited to the precise form of all the parts as shown, reserving the right to vary therefrom.

Having thus described the invention, what I claim is—

1. In an automatic dynamo-regulator, the combination with a main working circuit, an auxiliary exciting-generator in circuit with the fields of the dynamo, and an induction-motor in a shunt from the main circuit, of a rheostat having its resistance and shiftable element in circuit with the fields of the auxiliary exciting-generator, and a governor mechanism connected with the induction-motor and the shiftable element of the rheostat, said governor mechanism and the rheostat arranged to break the regulator-circuit to the auxiliary exciting-generator under abnormal load of the main circuit, substantially as described.

2. In an automatic dynamo-regulator, the combination with a main working circuit supplied from the dynamo, an auxiliary exciting-generator in circuit with the fields of said dynamo, and an induction-motor in a shunt from the main circuit, of a regulator-circuit connected in series with the fields of the auxiliary exciting-generator, a rheostat having its resistance and the shiftable element in said regulator-circuit, and a governor mechanism having its revoluble element carried by the motor-armature and its slidable element connected mechanically with the shiftable element of the rheostat, said governor mechanism and the rheostat arranged to break the regulator-circuit to the auxiliary exciting-generator under abnormal load of the main circuit, substantially as described.

3. An automatic dynamo-regulator embracing an induction-motor in a shunt from a working circuit, a rheostat having an insulated segment and arranged with its resistance and shiftable element in a circuit including an auxiliary exciting-generator, a centrifugal governor mechanism controllable by the induction-motor, and a sectional link having its members controlled by a spring and connected respectively with a slidable element of the governor mechanism and the shiftable element of the rheostat, substantially as described.

4. In an automatic dynamo-regulator, the combination with an induction-motor, a centrifugal governor mechanism and an auxiliary exciting-generator, of a rheostat having its resistances and shiftable arm in circuit with the field-coils of the exciting-generator and also provided with an insulated section in the path of the shiftable arm, and with a removable device for arresting the movement of said shiftable arm before it reaches the insulated section in said rheostat and suitable mechanical connections between the governor mechanism and the shiftable arm of the rheostat, substantially as described.

5. An automatic dynamo-regulator embracing an induction-motor in a shunt from a working circuit, a centrifugal governor mechanism, a rheostat provided with an insulated segment and having its resistance and shiftable element in a circuit with the field of an auxiliary exciting-generator, a rock-shaft having yieldable link connections with a slidable element of said governor mechanism, and a sectional spring-actuated link between the shiftable element of the rheostat and the rock-shaft and operable by the expansive action of its spring to normally force the rheostat element toward the insulated segment, substantially as described.

6. In an automatic dynamo-regulator, an induction-motor comprising a relatively-stationary carrier which sustains the field-coils, and a revoluble armature, said carrier being adjustable with the field-coils relatively to said armature, in combination with an auxiliary exciting-generator, and a governor mechanism controlled by the armature of the induction-motor, substantially as described.

7. In an automatic dynamo-regulator, a brushless induction-motor comprising a rotatable armature and a carrier which sustains the field-coils concentric with said rotatable armature and is adjustable relatively thereto for varying the area of the field-coils exposed to the revolving secondary element on said armature, in combination with a shunt-circuit connected with said field-coils of the induction-motor and with a primary circuit supplied with energy from a dynamo, a governor mechanism, an auxiliary exciting-gen-

erator, and a rheostat controlled mechanically by said governor mechanism and included in circuit with the auxiliary exciting-generator, substantially as described.

8. In an automatic dynamo-regulator, the combination of a tubular column supporting a tubular motor-spindle, an induction-motor having its rotary armature sleeved upon said spindle and its stationary field-carrier supported on the spindle in operative relation to said armature, a shunt-circuit having certain lengths of its conductors carried through the hollow column and spindle and attached to the field-carrier for connection with the coils of said induction-motor, a governor mechanism, a rheostat mechanically connected with said governor mechanism, and an auxiliary exciting-generator having its field in circuit with the resistances of the rheostat, substantially as described.

9. In an automatic dynamo-regulator, the combination with a column, an induction-motor supported thereby and a governor mechanism having its weighted arms carried by the rotary element of the induction-motor and a slidable collar guided by the column, of the rock-shaft having a link connection with the slidable governor-collar, an arm attached to said rock-shaft and a spring-controlled tension-rod operatively connected with the governor-collar, another spring-controlled tension-rod connected with the arm of the rock-shaft, and a rheostat having its shiftable arm or lever mechanically connected with the rock-shaft, substantially as described.

10. An automatic dynamo-regulator embracing an induction-motor in a shunt from a working circuit, a rheostat included in a circuit with the field of an auxiliary exciting-generator, a centrifugal governor mechanism controllable by the induction-motor, a rock-shaft having arms, spring-rod connections between one arm of the rock-shaft and a slidable element of the governor mechanism, and a sectional spring-controlled link connecting the shiftable element of the rheostat with said rock-shaft, substantially as described.

11. An automatic dynamo-regulator embracing an auxiliary exciting-generator, a rheostat in circuit with the field of said generator, an induction-motor comprising an armature revoluble on a fixed axis and a shiftable field normally in a stationary operative relation to the armature, and said motor included in a shunt from a working circuit, and a governor mechanism controllable by the motor and connected with the shiftable element of the rheostat, said motor having its field shiftable relatively to the armature without derangement of the elements of the regulator system, substantially as described.

12. In an automatic dynamo-regulator, a rheostat comprising a base carrying a series of resistance-blocks and an insulated or dead segment at one end of said resistance-blocks, a shiftable arm mounted pivotally on said base and provided with manually-operative means by which it may be clamped firmly in its adjusted position, and a contact-shoe supported by the shiftable arm to traverse the resistance-blocks and electrically connect with the fulcrum of said shiftable arm, in combination with an auxiliary generator having its fields connected in circuit with the resistance-blocks and fulcrum of the shiftable arm, an induction-motor and a governor operatively connected with the induction-motor and the shiftable arm of the rheostat, substantially as described.

In testimony that I claim the foregoing as my own I have hereto affixed my signature in the presence of two witnesses.

GEO. S. NEELEY.

Witnesses:

WM. BRAZEALE,
HELEN J. BOOTH.