(No Model.) 3 Sheets—Sheet 1.

J. J. WOOD.

CURRENT REGULATOR FOR DYNAMO ELECTRIC MACHINES.

No. 418,303. Patented Dec. 31, 1889.

FIG. 1.

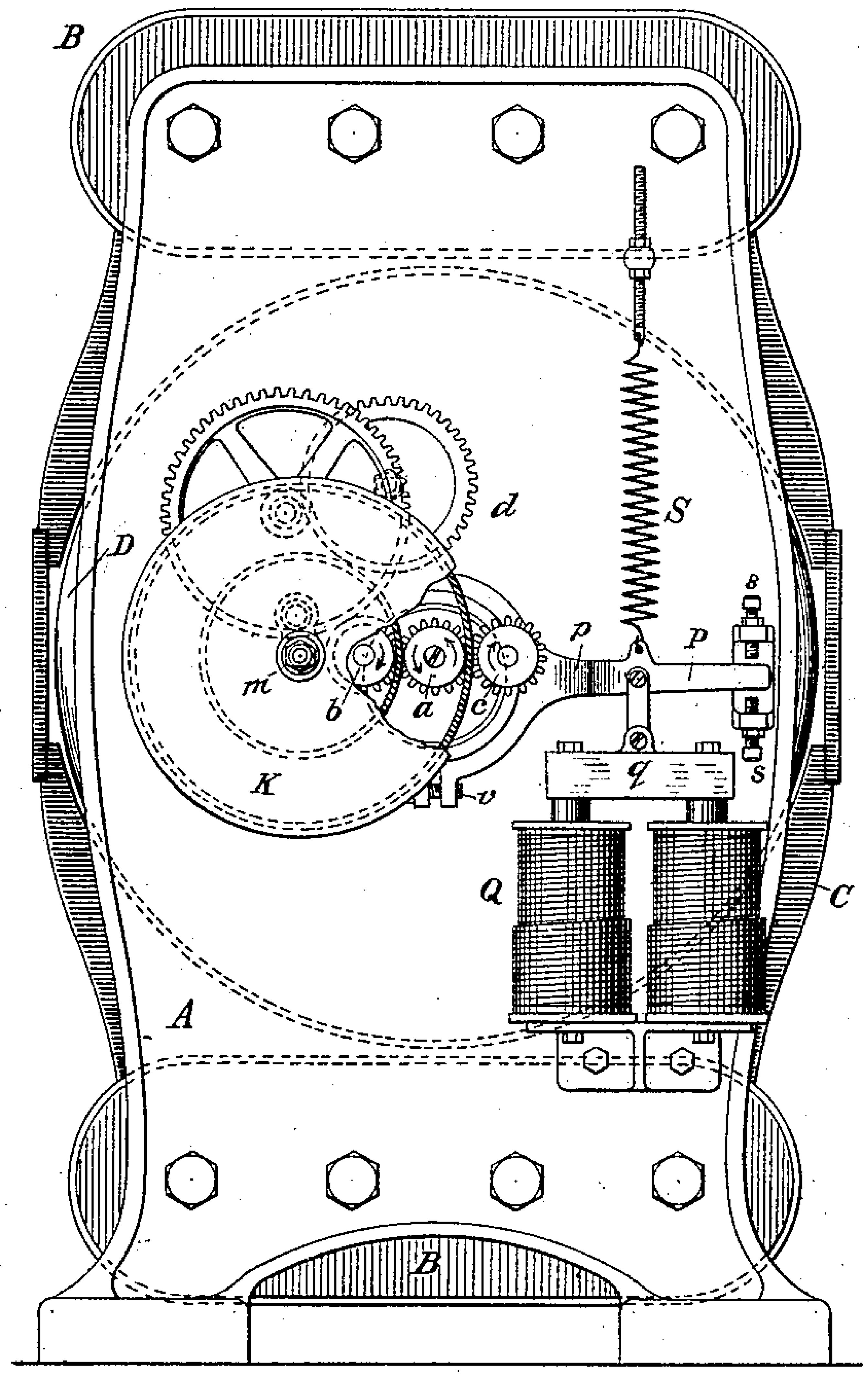


FIG. 2.

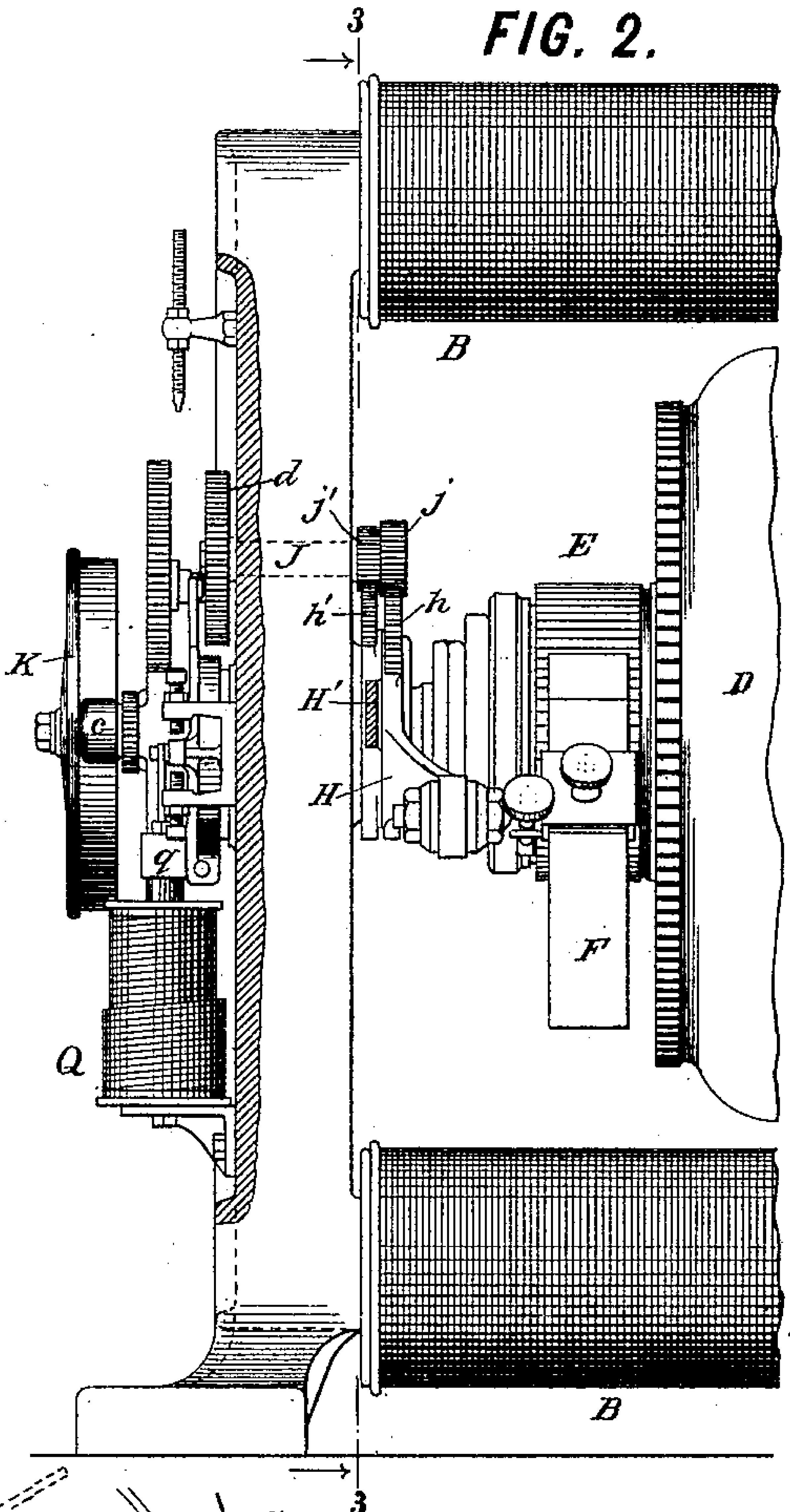
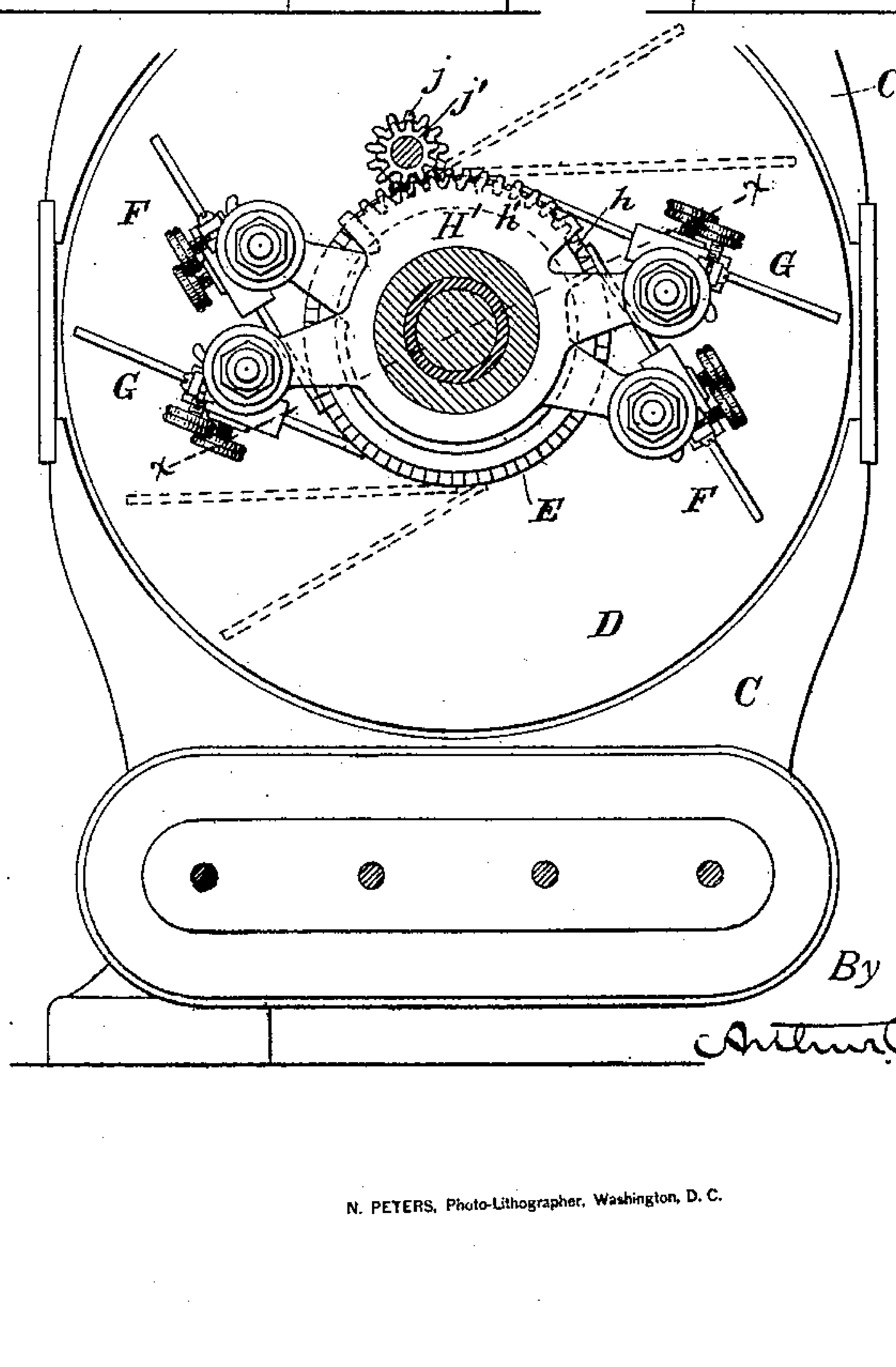


FIG. 3.



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(No Model.) 3 Sheets—Sheet 2.

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FIG. 4.

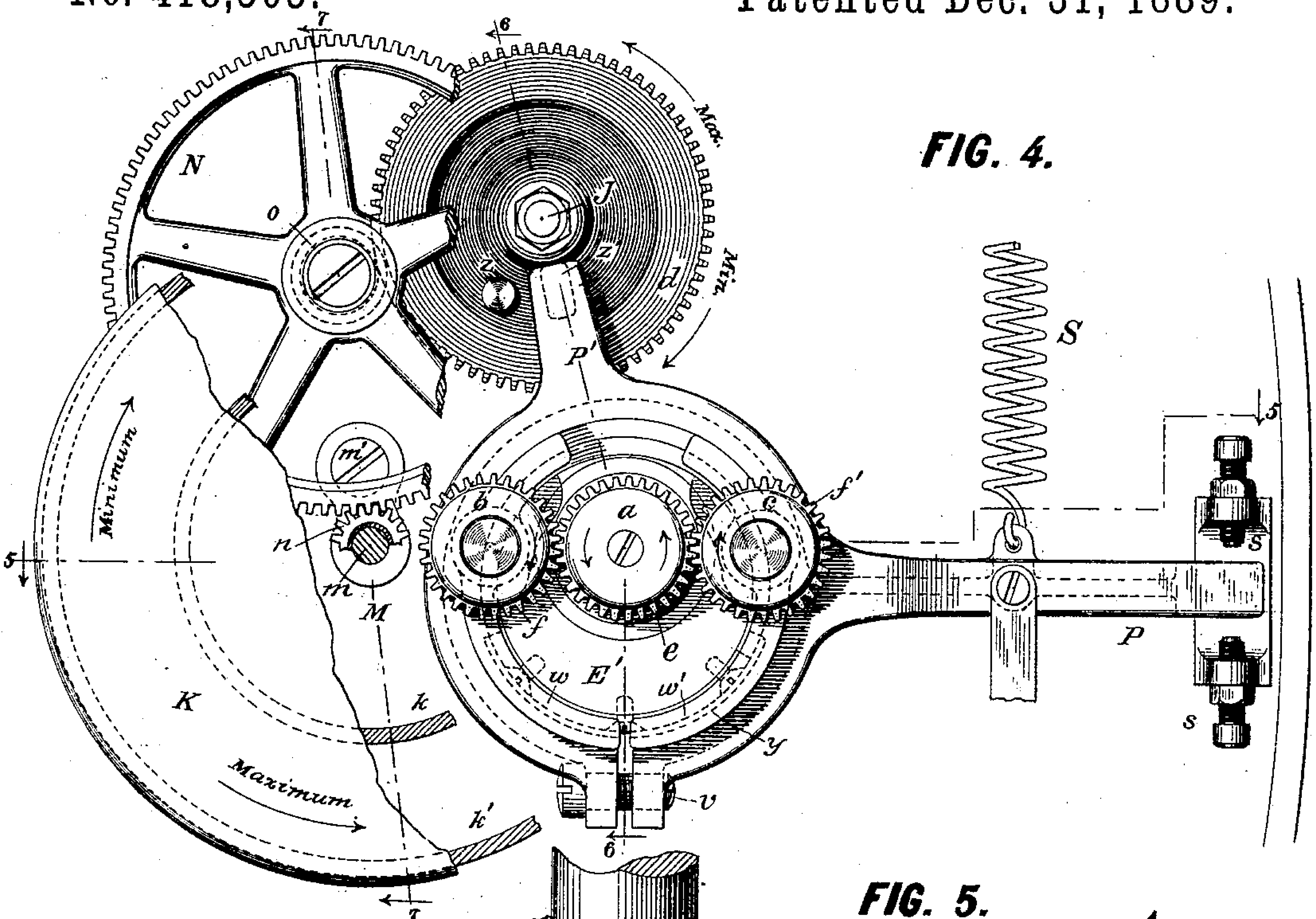

FIG. 5.

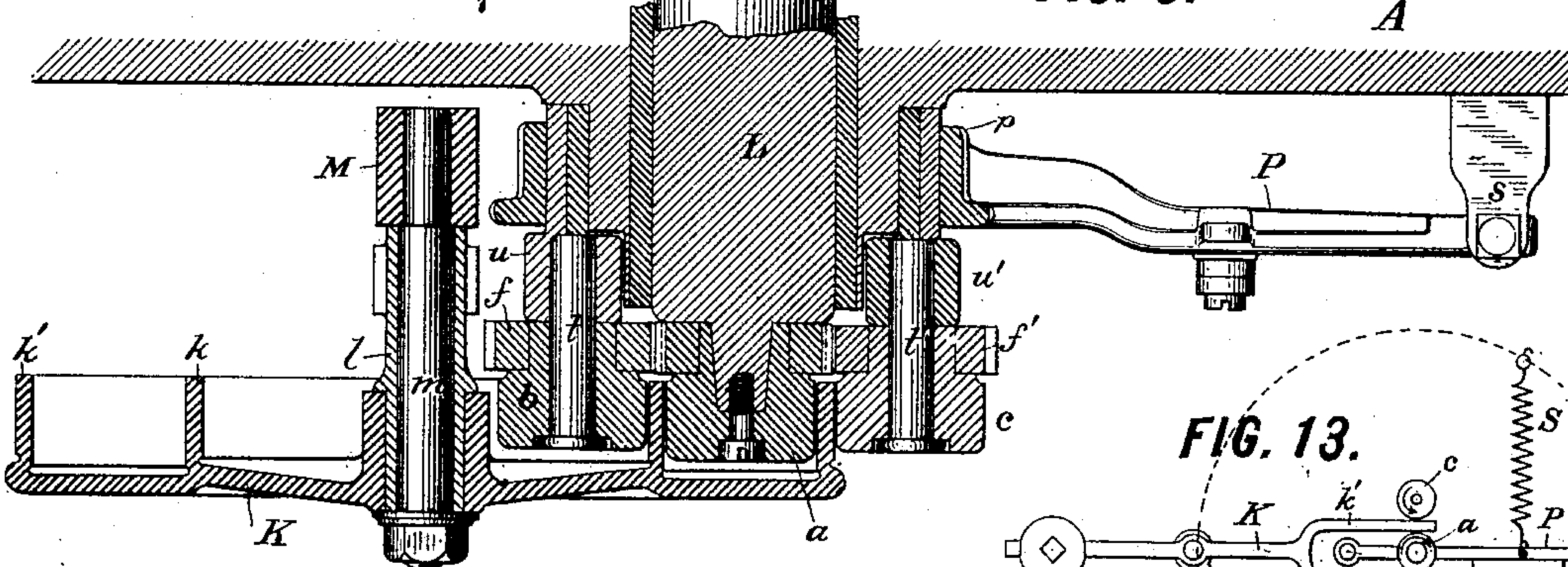

FIG. 13.

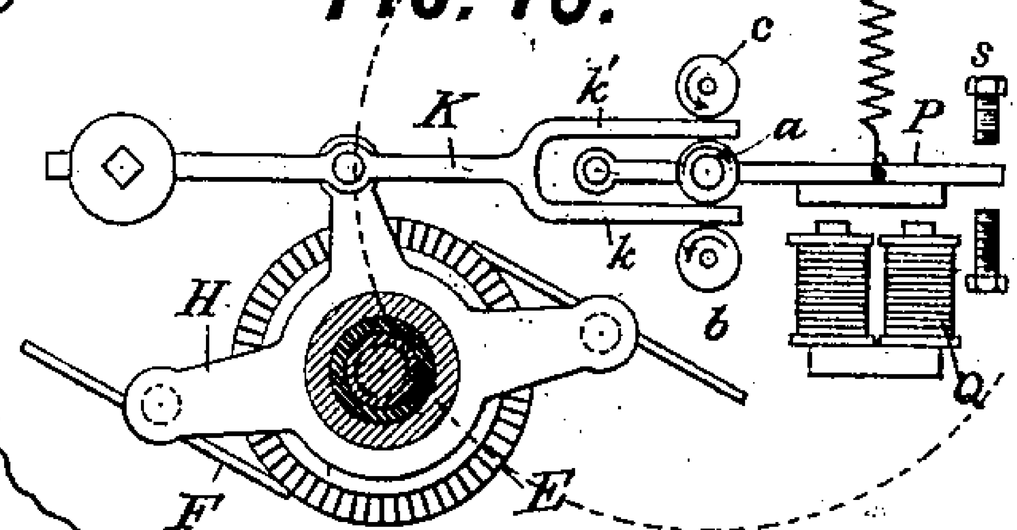

FIG. 11.

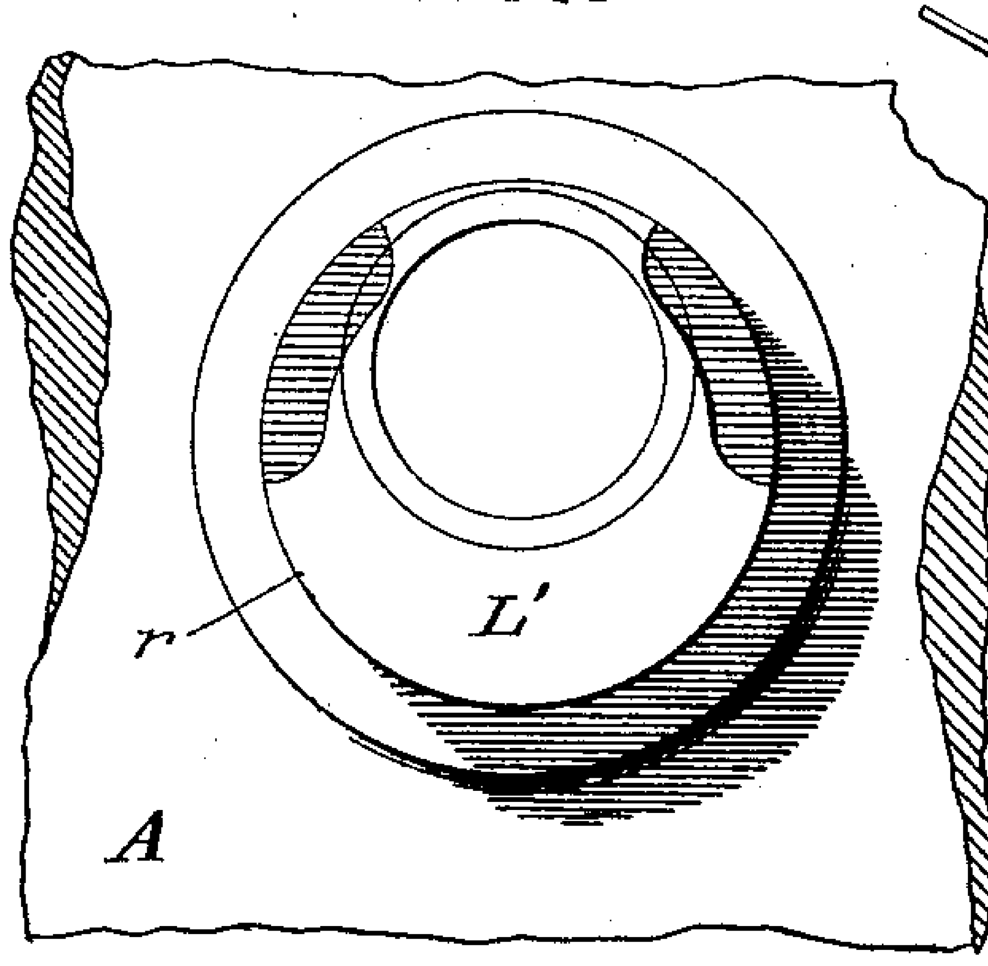

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FIG. 7.

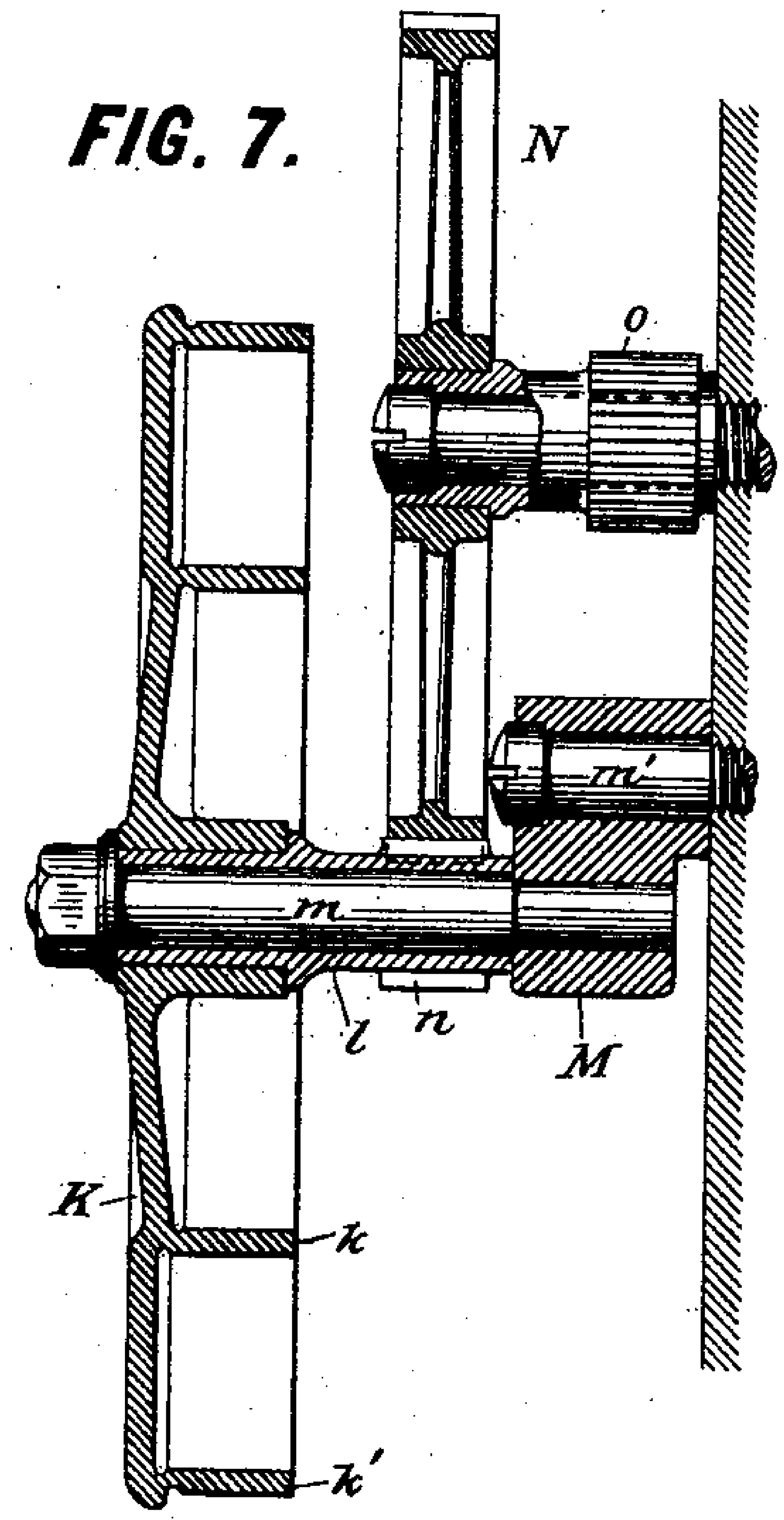


FIG. 6.

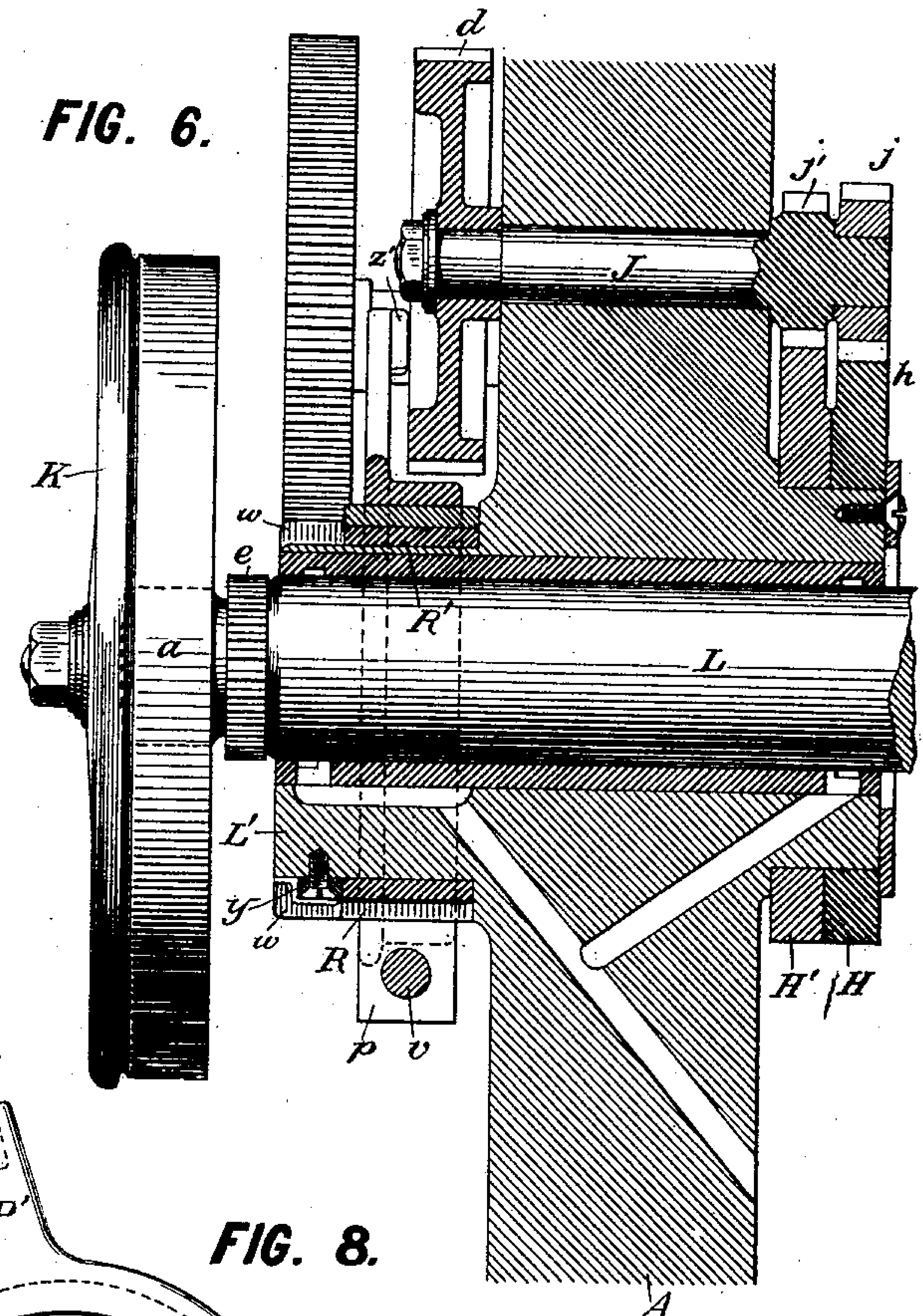


FIG. 9.

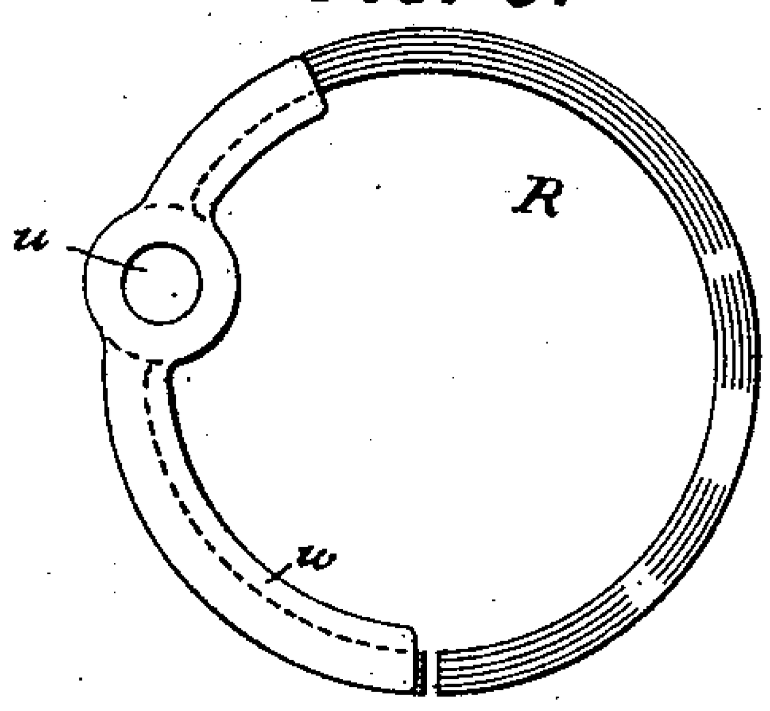


FIG. 8.

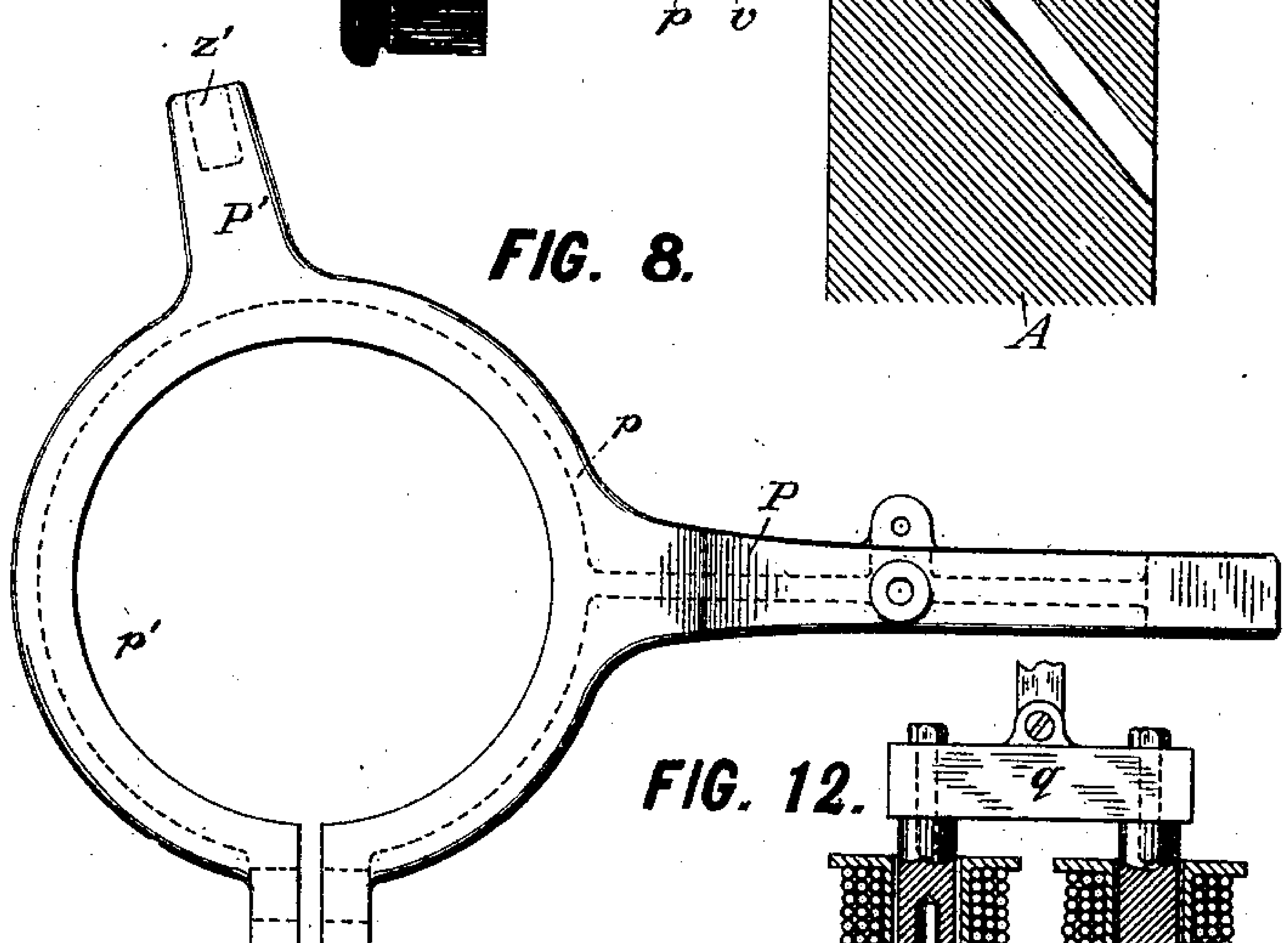


FIG. 12.

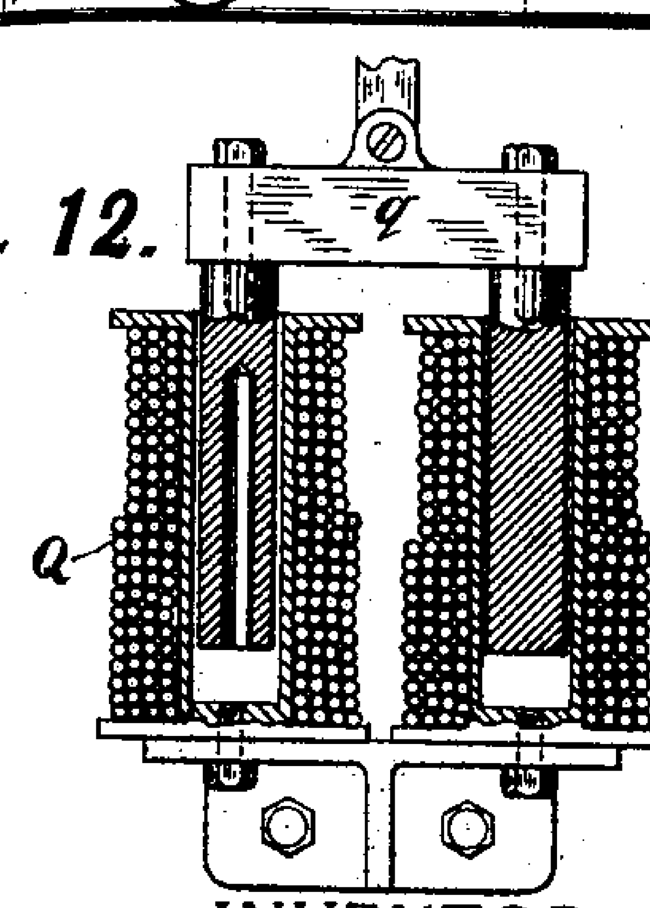
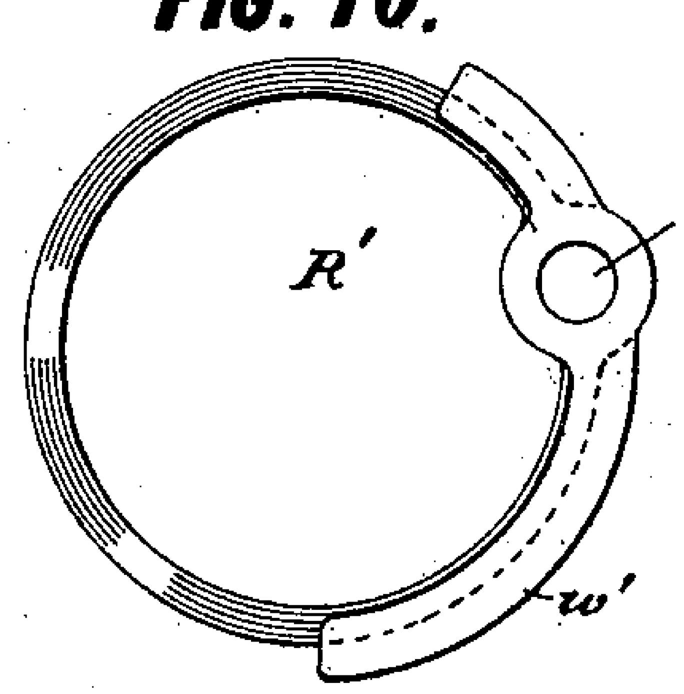


FIG. 10.



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UNITED STATES PATENT OFFICE.

JAMES J. WOOD, OF BROOKLYN, NEW YORK.

CURRENT-REGULATOR FOR DYNAMO-ELECTRIC MACHINES.

SPECIFICATION forming part of Letters Patent No. 418,303, dated December 31, 1889.

Application filed November 22, 1888. Renewed September 3, 1889. Serial No. 322,853. (No model.)

To all whom it may concern:

Be it known that I, JAMES J. WOOD, a citizen of the United States, residing at Brooklyn, Kings county, New York, have invented certain new and useful Improvements in Current-Regulators for Dynamo-Electric Machines, of which the following is a specification.

This invention relates to that class of regulators in which the strength of the current is regulated by the shifting of the collecting-brushes of the commutator toward or from the position of maximum difference of potential, the movement of the brushes being effected by electrically-controlled mechanism corresponding to changes in the current and imparting a movement to the brushes in such direction as to compensate for such changes in the current, thereby keeping the current as nearly constant as is practically possible.

My present invention is in part an improvement upon the current-regulator disclosed in my Patent No. 326,894, dated September 22, 1885, and it is in part an improvement applicable to automatic regulators generally of the class wherein the brushes are shifted toward and from the positions of maximum current. It also involves an improvement in electro-magnets or solenoids for operating automatic current-regulators. My said patent discloses a current-regulator consisting of adjustable commutator-brushes and mechanism for shifting the same toward or from the position of maximum current, with a clutching device for connecting said mechanism to a source of power in either of two directions, in order to shift the brushes backward or forward, the clutching device being operated by an electro-magnet arranged with its coils in the working-circuit and by a retracting spring or device acting in opposition to said magnet. In case of an increase of current the attraction of the electro-magnet increases and overcomes the retraction of the spring, thereby throwing the clutch into engagement in such direction as to cause the shifting mechanism to carry the brushes away from the position of maximum current until by such movement of the brushes the current is thereby reduced to the normal. In case of a decrease in the current the electro-magnet relaxes and permits the retracting-spring to throw the clutching device into action in the contrary direction, so that the shifting mechanism is caused to move the brushes toward the position of maximum current, and consequently to increase the current given out by the machine until the normal current is again restored. In my said patent the clutching device consists of a friction-clutch operating by the bearing of a friction-wheel against a continuously-revolving roller, the friction-wheel having two flanges on opposite sides of the roller, one of which is brought into contact therewith to drive it in one direction and the other of which is brought into contact therewith to drive it in the opposite direction. The frictional contact being due solely to the pressure with which the friction-wheel was pressed against the periphery of the driving-roller, and this pressure being due to the variation in the attractive effect of the regulating electro-magnet, the apparatus was not as sensitive to slight changes in the current as is desirable, since the inertia of the parts at starting retarded the compensating action of the apparatus. My present invention aims to improve upon the former mechanism in this respect. To this end the flange on the friction-wheel, instead of being merely thrust against a single friction-roller, is gripped between two friction-rollers, both acting upon it in the same direction after the manner of a pair of drawing-rolls, whereby the tractive effect of the frictional contact is greatly increased without necessarily increasing the pressure derived from the variations in the magnetic attraction.

My invention also provides an improved construction whereby the perfect and convenient adjustment of the working parts is effected, all the adjustments required in the initial position of the parts or to compensate for wear being made by a single operation.

In dynamo-machines wherein the current-regulation is effected by the movement of the collecting-brushes toward or from the neutral line or position of maximum difference of potential on the commutator it is practically necessary whenever the machine is constructed to generate currents of high electromotive force that the positive and negative brushes be constructed in pairs in order to bridge over or short-circuit a portion of the commutator, as otherwise there is an excessive sparking and burning at the commutator.

In addition to the ordinary main brushes employed with machines of low electro-motive force supplemental brushes are provided, arranged in advance of the main brushes and adjusted to a greater or less distance therefrom, in order to bridge over a greater or less number of intermediate commutator-segments. When the main brushes are in the position of maximum current, the supplemental brushes should be at the farthest distance from them, and as the main brushes are moved toward the position of minimum current the supplemental brushes should be drawn toward them in order to shorten the portions of the commutator which are bridged over or short-circuited. In practice these adjustments of the supplemental brushes have heretofore been effected by hand, although it has been proposed to apply an automatic adjustment for similar brushes, but in connection with machines of a different class—namely, those having armatures of the "open-coil" type—wherein in order to avoid sparking it is essential to shift the main and supplemental brushes simultaneously in opposite directions, instead of at differential speeds in the same direction, as is required in the case of armatures of the Gramme or "closed-coil" type, to which my invention applies.

To avoid the necessity for the adjustment of these brushes from time to time by the attendant, my present invention provides an improved means for effecting their adjustment automatically and in correct proportion to the adjustment of the main brushes.

It is preferable with automatic regulators to mount the regulating magnet or solenoid upon the main frame of the machine; but as this frame forms a portion of the magnetic circuit the cores of the magnet are strongly polarized therefrom by magnetic induction, and the sensitiveness of the magnet is correspondingly reduced. My present invention compensates for this polarization and restores the sensitiveness of the magnet by reducing the mass of the pole of the iron core which is of preponderating polarity relatively to the mass of the opposite pole, which is of diminished polarity.

In the accompanying drawings, Figure 1 is an end elevation of a Wood dynamo-electric machine provided with a regulator constructed according to my present invention. Fig. 2 is a fragmentary side elevation of the same, showing only the end of the machine to which the regulator is applied, the view being partly sectional. Fig. 3 is a vertical section looking in the same direction as Fig. 1 and cut in the plane of the line 3 3 in Fig. 2. Fig. 4 is a front elevation of the regulating mechanism, partly broken away in order better to show the construction. Fig. 5 is a horizontal section cut in the plane of the line 5 5 in Fig. 4. Fig. 6 is a nearly-vertical section cut in the plane of the line 6 6 in Fig. 4. Fig. 7 is a nearly-vertical section cut in the plane of the line 7 7 in Fig. 4. Figs. 8, 9, and 10 are front views of the parts of the operating-lever detached. Fig. 11 is a front view of the projecting boss on which the operating-lever turns, the moving parts being removed. Fig. 12 is a sectional view of the solenoid by which the regulating mechanism is controlled. Fig. 13 is a section answering to Fig. 3, and showing a modification.

In the drawings, A designates the frame of the machine; B B, the field-magnet coils; C C, the field-magnet pole-pieces; D, the armature; E, the commutator; F F, the main commutator-brushes, and G G supplemental commutator-brushes. The main commutator-brushes F F are carried in holders mounted on opposite arms of the brush-carrying yoke or lever H, which is mounted to turn on an inward prolongation or boss formed on the inner side of the end frame A, Fig. 6, and as usual. The supplemental brushes G G are carried by holders mounted on the opposite arms of a supplemental carrier-yoke H′, mounted in the same way as the yoke H, and inside thereof, as shown in Fig. 6. The brush-carriers H and H′ are formed, respectively, with gear-teeth h and h', which mesh, respectively, with pinions j and j', fixed on a shaft J, which passes through the main frame A, as shown in Fig. 6, and has fixed on its front end a gear-wheel d. By imparting motion to the shaft J through the gear-wheel d the brush-carriers H and H′ are moved around the axial center, so as to advance or retract the respective brushes relatively to the neutral line or line of maximum difference of potential of the commutator, which line is indicated by $x\,x$ in Fig. 3.

The armature-shaft L carries on one end, as usual, a pulley, (not shown,) through which it is driven, and on the other end a friction-roller a. This friction-roller may be formed integrally with the shaft, but is preferably a separate piece fastened thereto in the manner shown in Fig. 5. On opposite sides of the roller a and on axes parallel therewith are two other friction-rollers b and c. The roller a carries a small gear-wheel e, which meshes with two other like gear-wheels $f\,f'$, fixed, respectively, to the rollers b and c. The roller a, which partakes of the continuous rotary motion of the shaft L, thus communicates like rotary motion to the rollers b and c, but in the opposite direction. The rollers a, b, and c are all of the same size, or very nearly so, so that their adjoining peripheral portions travel in the same vertical direction and at the same or substantially the same surface speed. A friction-wheel K, having two concentric annular flanges $k\,k'$, is arranged with these flanges entering the spaces between the friction-rollers $a\,b\,c$, the flange k entering between the rollers a and b and the flange k' entering between the rollers a and c, as shown in Fig. 5. The friction-wheel K is geared to the brush-carriers H H′ through the medium of the shaft J and its pinions and any suitable intermediate train. The train shown consists of a pinion *n* on the sleeve or hub *l* of the wheel K, meshing with a gear N, carrying a pinion *o*, which meshes with the gear *d* on the shaft J. The friction-rollers *b* and *c* are carried by an operating-lever P, which is connected to the armature *q* of a solenoid or electro-magnet Q, by which the regulating mechanism is controlled. A retracting-spring S is arranged to pull against the lever P in the opposite direction to the attraction of the magnet Q. The free end of the lever P works between adjustable stop-screws *s s*, mounted on the fixed frame to limit its motion. The lever P is mounted on an eccentric boss L′, (shown best in Fig. 11,) the center of which is somewhat below the axial center of the shaft L and roller *a*. The lever thus turns around this eccentric center, so that as its free end is raised or lowered by the variations in the attraction of the magnet Q it moves the rollers *b* and *c* around this center, and consequently toward the left or right, by reason of the fact that their pivotal axes are above the center on which the lever P turns. When the attraction of the magnet increases and the lever P is pulled down, the rollers *b c* are moved toward the right, thus bringing the roller *b* closer to the roller *a*, and consequently nipping between them the flange *k* of the wheel K. On the contrary, when the magnetic attraction relaxes and the retarding-spring S pulls up the free end of the lever P the rollers *b c* are moved toward the left, so that the roller *c*, approaching the roller *a*, nips between them the flange *k′* of the friction-wheel K. A very small movement of the lever P is sufficient to cause either of the rollers *b c* to pinch the corresponding flange between itself and the intermediate roller *a*, and the tractive force thus exerted against the flange of the friction-wheel is very considerable and far greater than would result from the mere bodily pressing of the wheel K itself against the roller *a* in one direction or the other by the equally energetic action of the magnet or retracting-spring on the lever P. By noting the arrows on the rollers *a b c* in Figs. 1 and 4 it will be seen that when the flange *k* is nipped between the rollers *b* and *a* their action will be to propel it downwardly from between them, thus rotating the wheel K toward the right, while when the outer flange is nipped between the rollers *c* and *a* their effect will be to propel it upwardly, thereby revolving the wheel K toward the left. In the former case the rotation of the wheel K will impart a motion to the commutator-brushes toward the position of minimum load or away from the neutral line, while in the latter case they will be moved toward the neutral line or position of maximum load.

In order to enable the friction-wheel K to be freely engaged between either of the friction-rollers *b a* or *c a*, it should be so mounted as to be free to move in horizontal direction for a short distance. To this end I mount it on a crank M, (best shown in Figs. 4 and 7,) which crank is hung to the frame of the machine by a stud *m′* and carries a wrist-pin *m*, on which the hub or sleeve *l* of the friction-wheel K turns freely.

The lever P is built up of three parts (shown in Figs. 8, 9, and 10)—viz., the lever proper *p* and two rings R and R′, the former of which fits inside the annular hub portion *p′* of the lever P, and the latter of which fits inside the former. The ring R has a socket *u*, into which is driven the pin *t*, on which the friction-roller *b* turns, and the ring R′ is formed with a socket *u′*, into which is driven the pin *t′*, on which the friction-roller *c* turns. The ring R′ fits on the eccentric bearing-face *r* of the projecting boss L′, Fig. 11, which boss is formed on the outer side of the main frame A, and through which boss the shaft L passes. The ring R′ is an easy-working fit on the eccentric bearing-face *r*. Over it is placed the ring R, which is open or slitted at one side, as shown in Fig. 9, and over this ring is placed the annular hub *p* of the lever P, which also is slitted. This hub portion is then drawn together at its slitted part by a screw *v*, Fig. 4, so that it is closed tightly upon the lever R and the latter is compressed and closed tightly upon the ring R′, thus clamping together firmly the three parts or members of the lever P.

The proper adjustment of the working parts is effected in the following manner: After the several parts of the lever P are put together and applied on the eccentric hub L′, and before the screw *v* is tightened, the friction-wheel K is applied in place, and pieces of some thin material, as paper, are placed on opposite sides of its flanges *k k′* where these flanges come in contact with the friction-rollers *a b c*, in order to insure proper separation of the rollers from one another relatively to the flanges. The lever P is then held in its mid-position equally distant from two stop-screws *s s*, which in operation is its normal position of rest, and while so held the rollers *b* and *c* are moved toward each other until they come into close contact with the flanges *k k′* where the latter are thickened by overlaying with paper. This adjustment of the rollers *b c* is effected by imparting a rotary movement to the rings R R′, which carry these rollers. To facilitate this operation, these rings are provided with thickening-flanges *w* and *w′*, respectively, projecting toward the front and extending around the respective rings in the form of circular arcs for somewhat less than half a revolution. By preference the two flanges *w w′* project both to the same vertical plane and are equally distant from the center, so that they constitute segments of a mutilated ring. They approach each other closely at the bottom, as shown in Fig. 4, leaving, however, a narrow gap between them. A screw-driver or other flat instrument is inserted in this gap and twisted, in order to open the gap and press the flanges w w' apart, whereby a rotary displacement of the rings R R′ is effected. As the sockets u u' are considerably above the center of the ring, this displacement results by reason of moving the two sockets farther upward in bringing them closer together, and consequently bringing the rollers b and c toward each other. This movement is continued until the rollers b and c are pressed into firm contact with the paper overlays on the flanges k k'. The screw v is then tightened, thereby maintaining the adjustment that has thus been secured. On removing the paper overlays, if the latter have been of the proper thickness, the adjustment is then to be accurately made. This adjustment is thus effected with great ease and accuracy and very quickly.

Whenever it is found that the rollers a b c or flanges k k' have worn away, so that a new adjustment is necessary, the screw v is loosened and the rings R R′ are again displaced rotatively to bring the rollers b c again to the correct position, paper overlays having previously been inserted against the flanges to determine the proper clearance. Thus as the machine continues in use and is adjusted from time to time to take up wear the rings R R′ are gradually rotated upon one another until the bared ends of their flanges w w' approach each other and render further adjustment impossible. At this time the wear has become so great that the rollers a b c or friction-wheel K, or both, require to be renewed. If it is desired to remove the rollers b c farther apart instead of closer together, this is done by inserting any suitable tool between the upper ends of the flanges w w', in order to spread them apart and rotate the rings R R′ in the contrary direction.

In order to compensate for the slight inequalities in workmanship, it is desirable to be able to adjust the lever P toward or from the frame A, in order to bring it properly in line with the solenoid and stop-screws s s. To this end I make the hub portion P′ of less width than the rings R R′, so that the lever may be adjusted toward the front or rear relatively to the rings R R′. This adjustment is effected at the same time as the other adjustments referred to, so that the tightening of the screw v clamps the parts together and preserves this adjustment. Thus the rings R R′ constitute together a hub for the lever P, on which the latter is adjustable in direction longitudinally of the axis. The displacement of the lever P as a whole in direction front or back is prevented by the abutment of the rear side of the rings R R′ against a turned shoulder at the base of the boss L′ and by an arc-shaped strip or segmental ring y, (shown in section in Fig. 6 and in dotted lines in Fig. 4,) which is fastened by screws to the under side of the boss L′, being applied after the ring R′ is applied and before applying the ring R. The adjustment of the retracting-spring S to proportion its tension properly to the attractive action of the magnet or solenoid Q is effected by adjusting-nuts in the usual manner, as shown. The adjustments of the screws s s are also obvious. The proportions of the solenoid Q should be such that when the current is normal the core of the solenoid will be balanced against the retracting-spring in any position that the lever P may assume between the adjusting-screws s s; but upon the perceptible strengthening or weakening of the current the core shall be instantly strongly attracted or strongly relaxed, so as to move the lever P instantly to either limit of its stroke and hold it there with maximum pressure in order to throw the clutching mechanism into positive action in one direction or the other.

It will be understood that the clutching mechanism in my present construction differs from that shown in my said patent in this respect, that the operating-lever P is wholly independent of the friction-wheel K, instead of the friction-wheel being carried by the lever, as formerly. The action of the lever P is merely to close together one or the other pair of friction-rollers upon one or the other flanges of the friction-wheel K, the latter being mounted quite independently of the lever P.

A regulating mechanism of this kind acts to maintain an approximately-uniform current in compensation both for variations of the current caused by varying resistances on the circuit and for variations of current caused by variations in the speed of the dynamo. In the latter case if the speed increases the regulator perfectly compensates for the new condition; but if the speed decreases below that which will furnish the normal current after the brushes have been shifted to the maximum position it is impossible to compensate for this decrease. The action of the retracting-spring S is, however, to hold the clutch in engagement in a continual effort to carry the brushes farther in the same direction in which it has moved them—an action which if not corrected would result in tearing off the teeth from the gear-wheels of the train or in otherwise breaking or injuring the regulator. This result is avoided by the provision of a stop-pin z on one of the wheels of the train, preferably the terminal wheel d, which pin, when the brushes reach the position of maximum current and attempt to move beyond that position, encounters the stop-tooth z' on an upwardly-projecting arm P′ of the lever P, which tooth is shown in full lines in Fig. 6 and in dotted lines in Figs. 4 and 8, and thereby displaces the lever P in such direction as to throw the clutch out of engagement. Thus the regulator is thrown out of action when the conditions become such that regulation is impossible.

In the regulator shown in my former patent only one pair of commutator-brushes is shifted.

In all machines generating a high electromotive force it is necessary to employ supplemental brushes in order to short-circuit a portion of the armature-coils, as otherwise sparking or burning will occur. The number of coils to be thus short-circuited varies as the position of the main collecting-brushes is varied, the number being greatest in the position of maximum current and least in the position of minimum current; hence the supplemental brushes must recede from the main brushes as the latter are moved toward the point of maximum current, and vice versa.

In practice heretofore in machines of the closed-coil type the supplemental brushes have been carried by the same carrier as the main brushes, but adjustable thereon independently of the main brushes, and the attendant has had to slide them forward or back by hand from time to time to correct any undue sparking observable at the commutator. I provide for the automatic adjustment of these supplemental brushes and in correct ratio to that of the main brushes by means of differential gearing, as best shown in Figs. 3 and 6. The pinion *j*, gearing with the sector *h*, is of larger diameter than the pinion *j'*, gearing with the sector *h'*; hence a given rotative movement of the shaft J imparts a more rapid angular movement to the main brush-carrier than to the supplemental brush-carrier H'. The speeds are so proportioned as to give the correct proportionate movements to the main and supplemental brushes.

In the Wood dynamo shown in the drawings, and in most other dynamos, the frame of the machine forms a part of the magnetic circuit, and consequently is polarized. The electro-magnet or solenoid Q should be arranged as near as it conveniently can to the neutral portion of the field-magnet frame in order that its core may be as little polarized by induction therefrom as possible. In practice, however, it is impossible to entirely avoid this inductive polarization. Its effect is disadvantageous in that it reduces the sensitiveness of the magnet or solenoid, and consequently renders the regulating mechanism sluggish in correcting variations in the current. My present invention eliminates this disturbing influence by compensating for the inductive polarization of the core of the regulating magnet or solenoid. The two poles of this core should be capable of responding equally to the inductive action of the inclosing-coil, so that they shall be of equally opposite polarity. If, however, the adjoining field-magnet has a preponderating north polarity, it induces in the core a preponderance of south polarity. This preponderance I correct by reducing the mass of the limb of the core in which the preponderating polarity manifests itself, this reduction of mass being proportional to the preponderation, so that the attractive effect of the two poles of the core relatively to the inclosing-coil is restored to equality. The preferred method of accomplishing this result is shown in Fig. 12, where one limb of the core is bored out tubularly, while the other limb is left solid. The precise extent of reduction of mass by which to accomplish the proper result must be determined experimentally in each instance, more or less metal being removed by boring out until the two poles become properly balanced and the solenoid is given the requisite sensitiveness. This part of my invention is equally applicable to solenoids, wherein the core is movable within the coils, and to the ordinary type of electro-magnets, in which the core is fixed in place within the coils.

It must not be inferred from the particular description of the details of construction which I have adopted in the practical embodiment of my invention that my invention is necessarily limited to such details. On the contrary, the principle of my invention may be utilized through the medium of very different mechanism, which, however, may be readily devised by any mechanic or electrical engineer, since the principle of my invention has been communicated to the public.

It should be understood that the train of gears intervening between the friction-wheel K and the brush-carrier is employed for the purpose of reducing the speed in order to gain mechanical advantage, and thereby render the instrument sensitive to slight current changes. The wheel K is driven at high speed by reason of the fact that the rollers *a b c* are revolved at the same speed as the armature-shaft. These rollers might, however, be driven at a speed so much slower that no gearing down between the wheel K and the brush-carrier would be necessary, (as I will presently show with reference to Fig. 13.) In such case the wheel K (or its equivalent, as will presently be shown) might be directly connected to the brush-carrier or even made integral with it. Furthermore, it is to be observed that the tractively-driven part upon which the rollers *a b c* act need not be in the form of a wheel having flanges, but may be a reciprocating part or an oscillating part, or be constructed in any shape, provided that it has a traction flange or flanges or equivalent traction-surfaces entering between the respective pairs of friction-rollers to be driven in one or the other direction thereby.

While it is highly preferable that the friction-rollers be geared together, so that all shall revolve positively at the same speed, yet it is sufficient if only the intermediate roller be driven positively, the two outer rollers serving to press the traction flange or surface into tractive contact with the middle roller and deriving rotation therefrom, or the two outer rollers might be positively driven and the intermediate roller be merely an idler.

Instead of the intermediate roller being mounted on a fixed axis and the two outer rollers being moved simultaneously to bring one or the other toward it, the two outer rollers might be mounted on fixed axes and the intermediate roller be connected with the electro-magnet to be moved toward one or the other of the outer rollers.

As an illustration of these modifications I have introduced Fig. 13. In this view the supplementary brushes G G are omitted and the brush-carrier H has an upwardly-projecting arm, which is pivoted to a reciprocatory bar K, which takes the place of the friction-wheel K in the previous figures. This bar K constitutes a tractively-driven moving part, since it has two arms or plates k k', which enter between the friction-rollers b a c. The intermediate roller a is driven at a slow rate of speed by being geared from the armature-shaft or otherwise. The rollers b c are on fixed axes, while the roller a is pivoted on a lever P, which carries the armature of the electro-magnet Q and is engaged by the retracting-spring S, so that as the magnetic attraction varies the roller a is moved up or down. When the current strength exceeds the normal, the armature is drawn down and the roller a pinches the arm k between itself and the roller b, so that this arm is driven toward the left and the commutator-brushes are moved toward the point of minimum current. When the current diminishes, the magnet relaxes and the retracting-spring S pulls up the lever, producing the contrary effect.

Instead of an electro-magnet or solenoid acting against a retracting-spring, any other known kind of electro-motive device responding to changes in the current may be used.

I claim as my invention the following-defined improvements in current-regulators for dynamo-electric machines, substantially as hereinbefore specified, viz:

1. In a current-regulator operating by the shifting of the collecting-brushes on the commutator, the combination, with the brushes, of a pair of friction-rollers revolved in opposite directions from a source of power, a tractively-driven moving part entering between said rollers and connected to the shifting brushes, so that its movement shall shift them, and an electro-motive device responding to changes in the current and connected to said rollers, whereby by its movement in one direction said rollers are closed together in tractive engagement with said moving part and by its movement in the opposite direction said rollers are released therefrom.

2. In a current-regulator operating by the shifting of the collecting-brushes on the commutator, the combination, with the brushes, of a tractively-driven moving part connected to the shifting brushes, so that its movement shall shift them, and oppositely-revolving friction-rollers arranged to act in pairs, the two rollers of one pair arranged to engage said moving part between them and revolving in such direction as to tend to move it in the direction to shift the brushes toward the maximum position, and the two rollers of the other pair also arranged to engage said moving part between them and revolving in such direction as to tend to move it in the direction to shift the brushes toward the minimum position, and an electro-motive device responding to changes in the current and connected to said rollers, so that by its movement in one direction or the other the rollers of one or the other pair are closed together in tractive engagement with said moving part.

3. The combination, with a dynamo-commutator and its shifting brushes, of a tractively-driven moving part connected to the brushes, so that its movement shall shift them, three friction-rollers arranged to act in pairs, the intermediate one revolving in one direction and the outer ones revolving in the opposite direction and the two rollers for each pair arranged to engage said moving part between them, and an electro-motive device responding to changes in the current and connected to said rollers, so that by its movement in one direction or the other the rollers of one or the other pair are closed together in tractive engagement with said moving part.

4. The combination, with a dynamo-commutator and its shifting brushes, of a tractively-driven moving part or friction-wheel having two traction-flanges, three friction-rollers arranged to act in pairs and geared together, so that they revolve in successively-opposite directions at approximately equal surface speeds and receiving said flanges between the respective pairs of rollers, and an electro-motive device responding to changes in the current and connected to said rollers, so that by its movement in one direction or the other the rollers of one or the other pair are closed together in tractive engagement with the intervening flange.

5. The combination, with a dynamo-commutator and its shifting brushes, of a tractively-driven moving part connected to the shifting brushes, so that its movement shall shift them, three friction-rollers arranged to act in pairs and revolving in alternately-opposite directions and the two rollers of each pair arranged to engage said moving part between them, the intermediate roller mounted on a fixed axis and the two outer rollers mounted so as to be capable of movement toward and from the intermediate roller, and an electro-motive device responding to changes in the current and connected to the two outer rollers, so that by its movement in one direction or the other one or the other of said rollers is pressed toward the intermediate roller, whereby the two rollers of one or the other pair are closed together in tractive engagement with said moving part.

6. The combination, with a dynamo-commutator and its shifting brushes, of a tractively-driven moving part connected to the shifting brushes, so that its movement shall shift them, three friction-rollers arranged to act in

pairs driven successively in opposite directions and the two rollers of either pair arranged to engage said moving part between them, an oscillating lever connected to said rollers and constructed by its vibratory movement to reciprocally approach or recede the rollers of either pair toward or from one another, and an electro-motive device responding to changes in the current and connected to said lever, so that its movement is imparted through the lever to the rollers.

7. The combination, with a dynamo-commutator and its shifting brushes, of a tractively-driven friction-wheel having two traction-flanges and gearing connecting it to the brushes, so that its rotary movement shall shift them, three friction-rollers arranged to act in pairs upon the respective flanges of said friction-wheel and revolving in successively-opposite directions, an electro-motive device responding to changes in the current and connected to said rollers, so that by its movement in either direction the rollers of one or the other pair are closed together upon the intervening flange, and a yielding support upon which said friction-wheel is hung, constructed to allow the friction-wheel to move toward or from said rollers to admit of their engaging and releasing movements.

8. The combination, with a dynamo having shifting brushes, of a friction-roller fixed on the end of the armature-shaft, two friction-rollers arranged on opposite sides thereof and revolving in the opposite direction thereto, a lever on which said two friction-rollers are mounted, arranged by its vibration to move either of said rollers toward or from the intermediate roller, an electro-motive device responding to changes in the current and connected to said lever, and a friction-wheel having traction-flanges projecting between the pairs of rollers, and gearing connecting said friction-wheel to the shifting brushes, so that its rotary movement shall shift them.

9. The combination, with a dynamo, of a friction-roller and gear-wheel fixed to the end of the armature-shaft, two other friction-rollers on opposite sides thereof, and gear-wheels fixed thereto and meshing with said gear, whereby the two outer rollers are driven in the opposite direction to the intermediate roller, a lever upon which said outer rollers are mounted, an electro-motive device connected to said lever, and a friction-wheel having traction-flanges entering between the pairs of rollers and connected to the shifting brushes, so that its rotary movement shall shift them.

10. The combination, with a dynamo, of a friction-roller fixed to the end of its armature-shaft, two other friction-rollers on opposite sides thereof, an eccentric fixed boss through which the armature-shaft projects, a lever having an annular hub turning on said eccentric boss and carrying said two outer friction-rollers, an electro-motive device connected to said lever, and a friction-wheel having traction-flanges entering between the respective pairs of friction-rollers and connected to the shifting brushes, so that its rotary movement shall shift them.

11. In a current-regulator, the combination, with a friction-roller having a fixed axis and a bearing-boss eccentric thereto, of a lever having an annular hub turning on said eccentric boss, and friction-rollers arranged on opposite sides of said roller, mounted on said lever, and constructed to be adjustable relatively thereto in such direction as to bring them closer to or farther from the intermediate roller.

12. In a current-regulator, the combination, with a friction-roller revolving on a fixed axis and a bearing-boss eccentric thereto, of two friction-rollers arranged on opposite sides of said roller, a lever carrying said two rollers and turning on said eccentric boss, and intermediate parts on which said rollers are mounted, fastened to said lever, and adjustable relatively thereto in an angular direction around the center of said eccentric boss.

13. In a current-regulator, the combination, with a friction-roller turning on a fixed axis and a bearing-boss eccentric thereto, of a lever mounted on said boss, and comprising a ring fitting over said boss and an annular hub embracing said ring and adjustably fastened thereto, and a friction-roller mounted on said ring, whereby by the adjustment of said ring the position of said roller may be adjusted relatively to the lever in order to move it nearer to or farther from said first-named roller.

14. In a current-regulator, the combination, with revolving friction-rollers, of an operating-lever connected thereto and constructed with a wide ring fitting over its bearing-boss and a narrower annular hub fitting over said ring and fastened thereto, whereby said hub may be adjusted forward or back on said ring to bring the lever-arm to the correct position.

15. In a current-regulator, the combination, with a friction-roller turning on a fixed axis with a bearing-boss eccentric thereto, of two friction-rollers arranged on opposite sides thereof, and an operating-lever carrying said outer rollers and consisting of an inner ring fitting over said eccentric boss and on which one of said outer rollers is mounted, a second ring fitting over the first and on which the other of said outer rollers is mounted, and an annular hub fitting over said second ring and fastened adjustably thereto.

16. The combination, with friction-roller *a* and eccentric boss L′, of the friction-rollers *b* and *c* and operating-lever P, constructed with an inner ring R, fitting over said boss, a slitted ring R′, fitting over said ring R, a slitted annular hub *p′*, fitting over said ring R′, and a clamping-screw *v*, for closing together said slitted hub and slitted ring upon the ring R to clamp the parts of the lever together.

17. In a current-regulator, the combination,

with friction-roller *a* and eccentric boss L′, of friction-rollers *b* and *c* and the operating-lever P, carrying said rollers and constructed of two concentric rings R R′, formed, respectively, with segmental flanges *w w′*, and said rings carrying the rollers *b c*, and an annular hub portion *p*, constructed to be clamped adjustably on said rings, whereby said rings may be adjusted by prying apart their flanges *w w′*.

18. In a current-regulator operating by the shifting of the collecting-brushes on the commutator, the combination, with the brushes, of positively-revolving friction-rollers arranged to act in pairs, a friction-wheel having traction-flanges entering between the respective pairs of rollers, a train of gearing connecting said friction-wheel with the shifting brushes, an electro-motive device responding to changes in the current, a lever for transmitting the movements of said electro-motive device to said friction-rollers, and reciprocal stops on said lever and on some part of said train, respectively, arranged to abut when the collecting-brushes have reached the limit of their movement and by such abutment to displace the lever and throw the regulator out of operation.

19. In a current-regulator operating by the shifting of the collecting-brushes on the commutator, the combination, with an automatic current-regulator comprising a shifting mechanism having differential driving-pinions, of the main commutator-brushes and their carrier connected to and driven by the larger of said pinions, and supplemental brushes and a carrier therefor connected to and driven by the smaller of said pinions, whereby the movement of the shifting mechanism communicates differential movements to the respective pairs of brushes, causing the main and supplemental brushes to relatively approach each other when moving from and separate from each other in moving toward the position of maximum current.

20. The combination, with a dynamo, of an automatic current-regulator and an electro-magnet connected operatively to and controlling said regulator, arranged with its iron core in inductive proximity to the field-magnet of the dynamo, whereby its core is polarized by induction and one pole thereof is given a preponderating polarity, and constructed with the pole of preponderating polarity reduced in mass to compensate for such preponderance and restore the normal balance of attraction between the opposite poles.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

JAMES J. WOOD.

Witnesses:
ARTHUR C. FRASER,
JNO. E. GAVIN.