

(No Model.)

8 Sheets—Sheet 1.

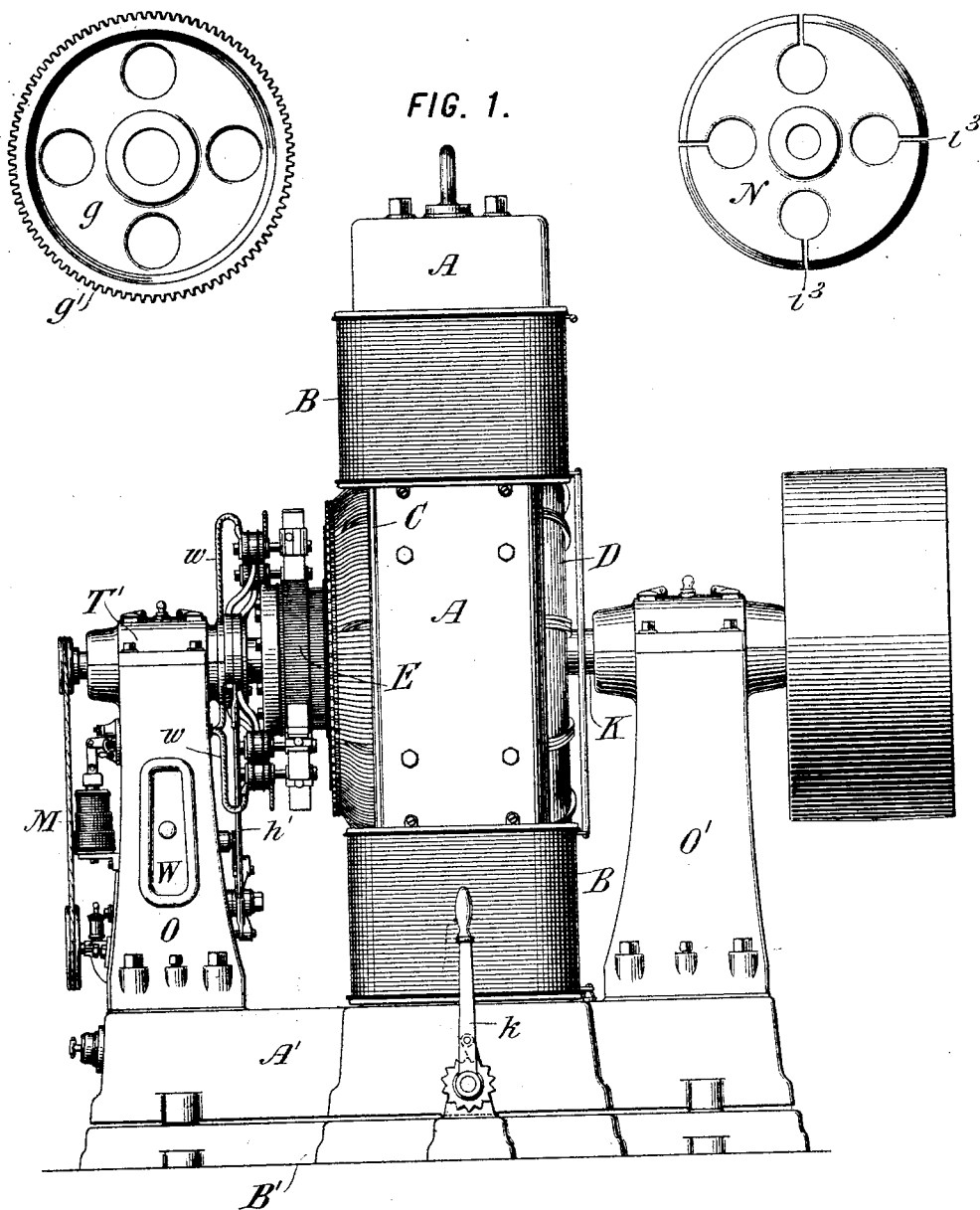
J. J. WOOD.
CONSTANT CURRENT DYNAMO.

No. 531,821.

Patented Jan. 1, 1895.

FIG. 12.

FIG. 13.



WITNESSES:

C. E. Ashley
H. W. L. Lloyd.

INVENTOR:

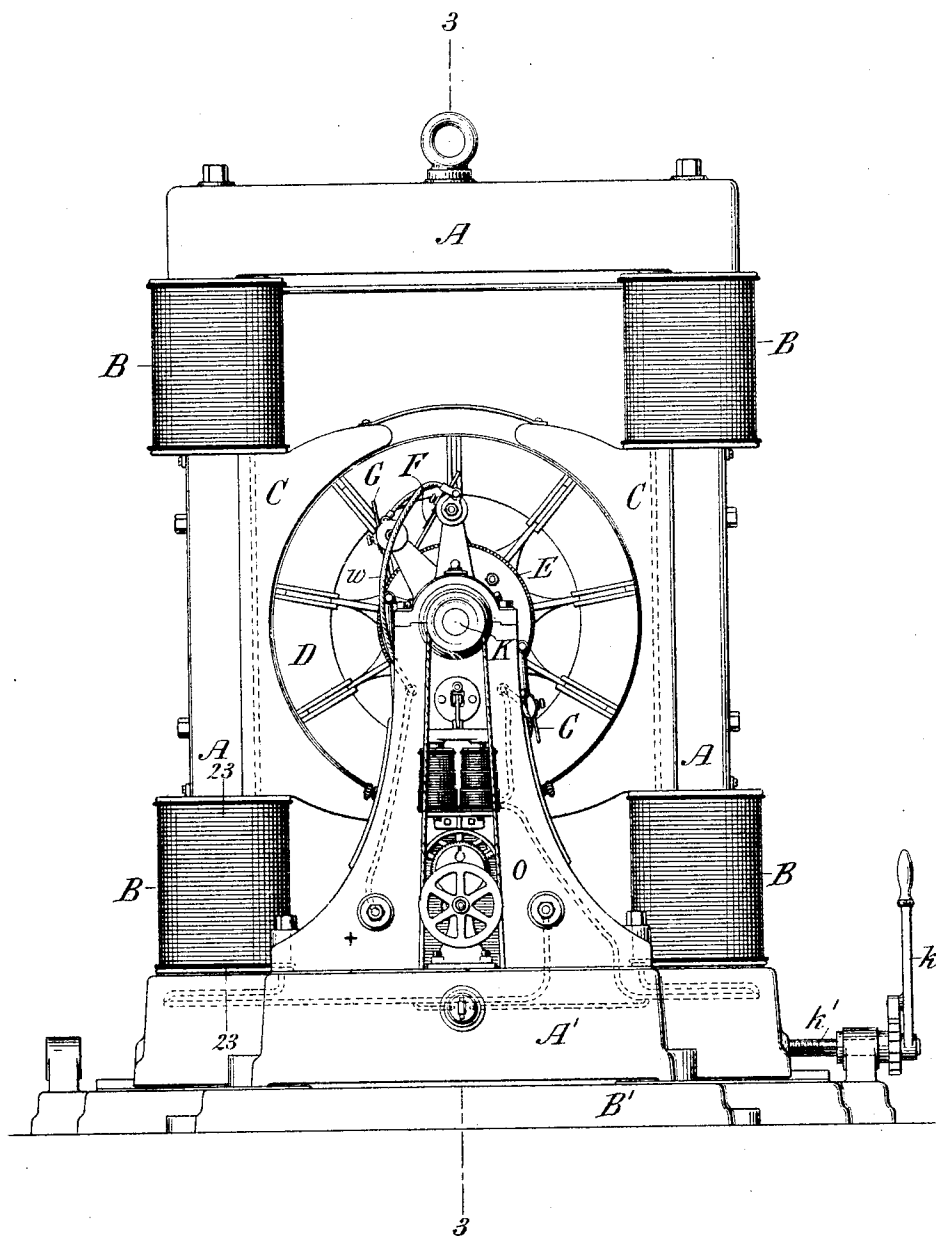
James J. Wood,
By his Attorneys,
Arthur G. Draper & Co.

J. J. WOOD.
CONSTANT CURRENT DYNAMO.

No. 531,821.

Patented Jan. 1, 1895.

FIG. 2.



WITNESSES:

C. E. Ashley
H. W. Lloyd.

INVENTOR:

James J. Wood,
By his Attorneys,
Arthur C. Orson

J. J. WOOD.
CONSTANT CURRENT DYNAMO.

No. 531,821.

Patented Jan. 1, 1895.

FIG. 22.

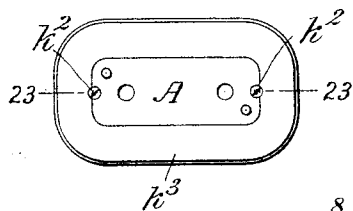


FIG. 3.

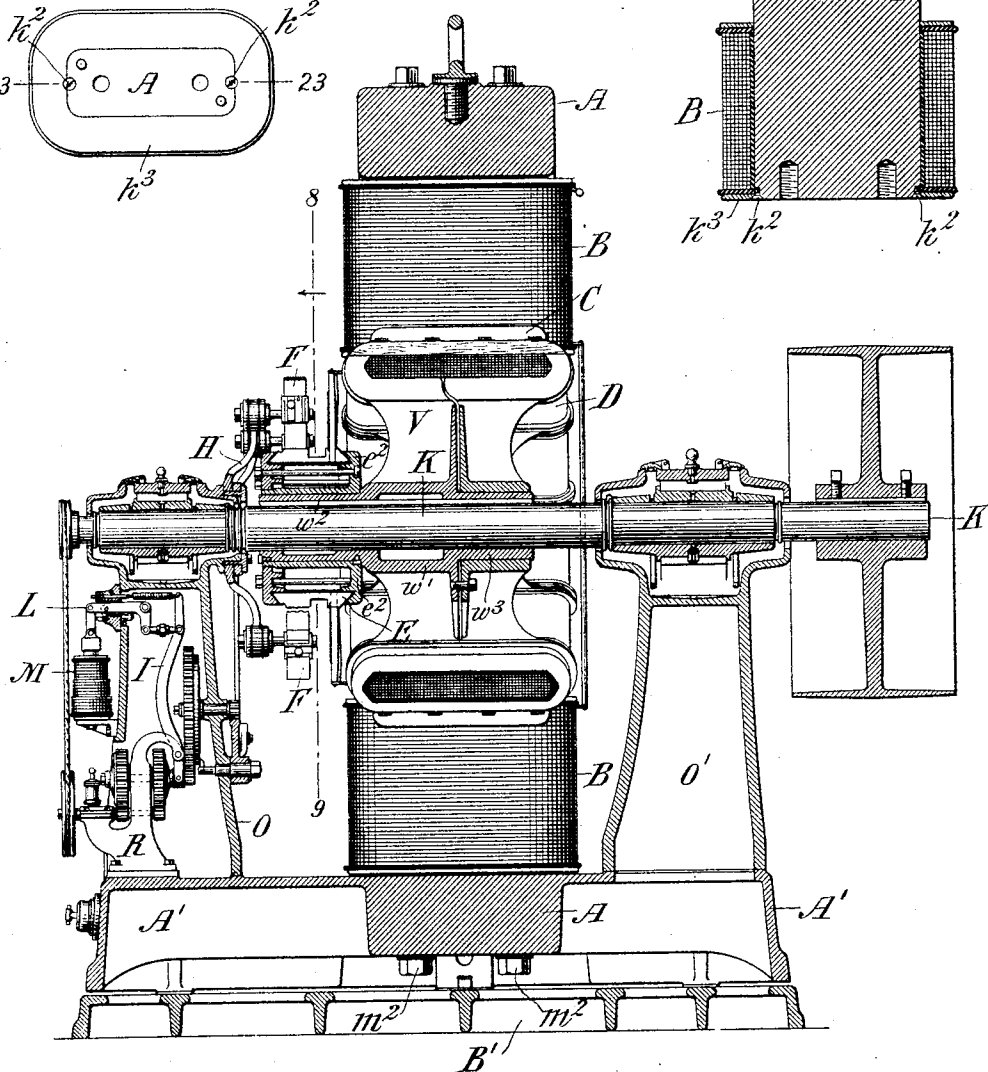
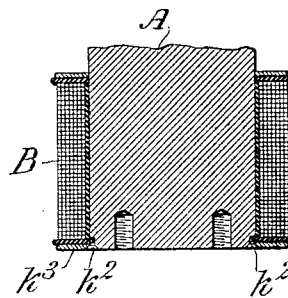


FIG. 23.



WITNESSES:

C. E. Ashley
H. W. Lloyd

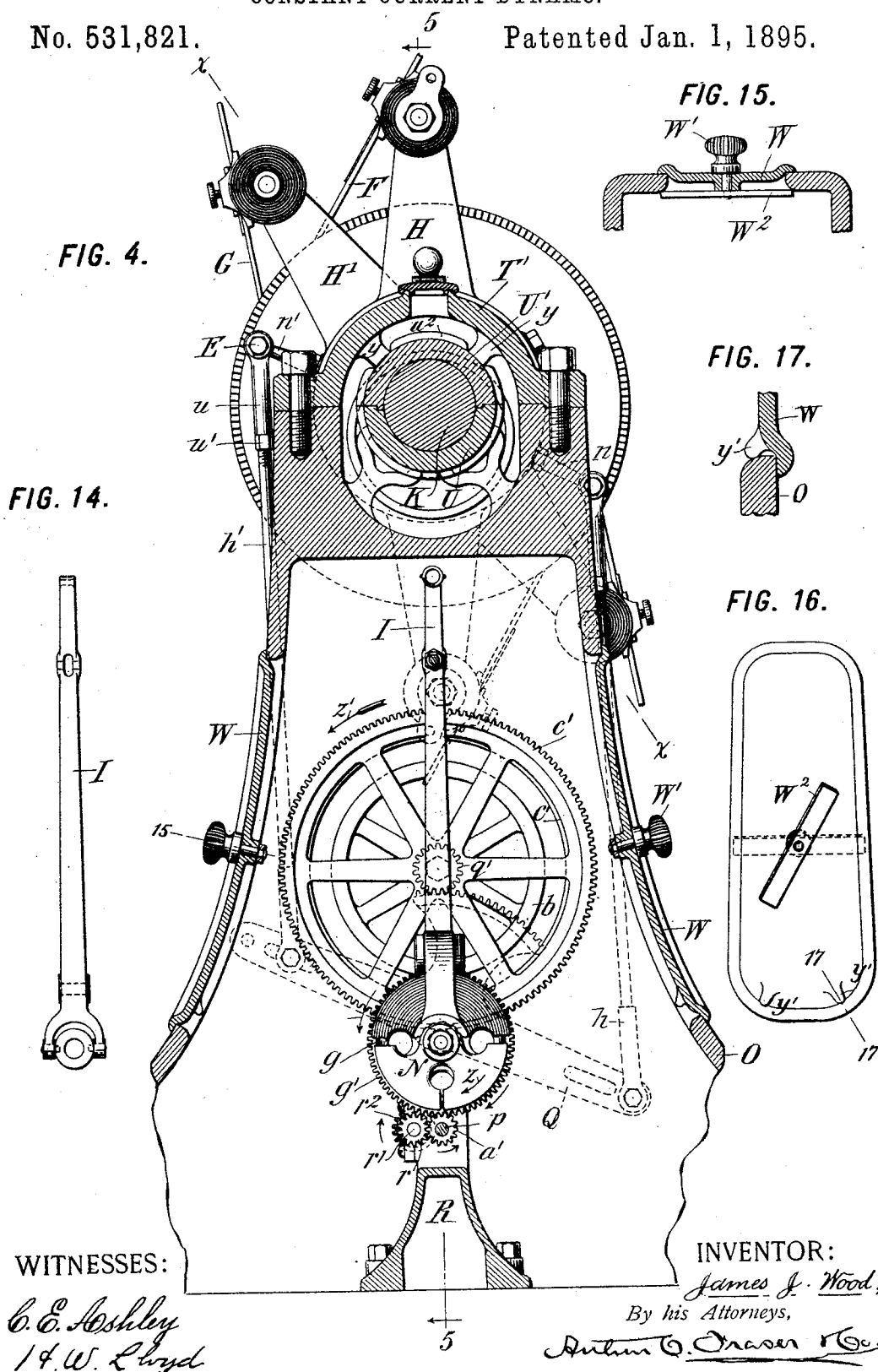
INVENTOR:

James J. Wood,
By his Attorneys,
Arthur C. Orason & Co.

J. J. WOOD.
CONSTANT CURRENT DYNAMO.

No. 531,821.

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WITNESSES:

C. E. Ashley
W. W. Lloyd

INVENTOR:

James J. Wood,

By his Attorneys,

Arthur C. Orason & Co.

J. J. WOOD.
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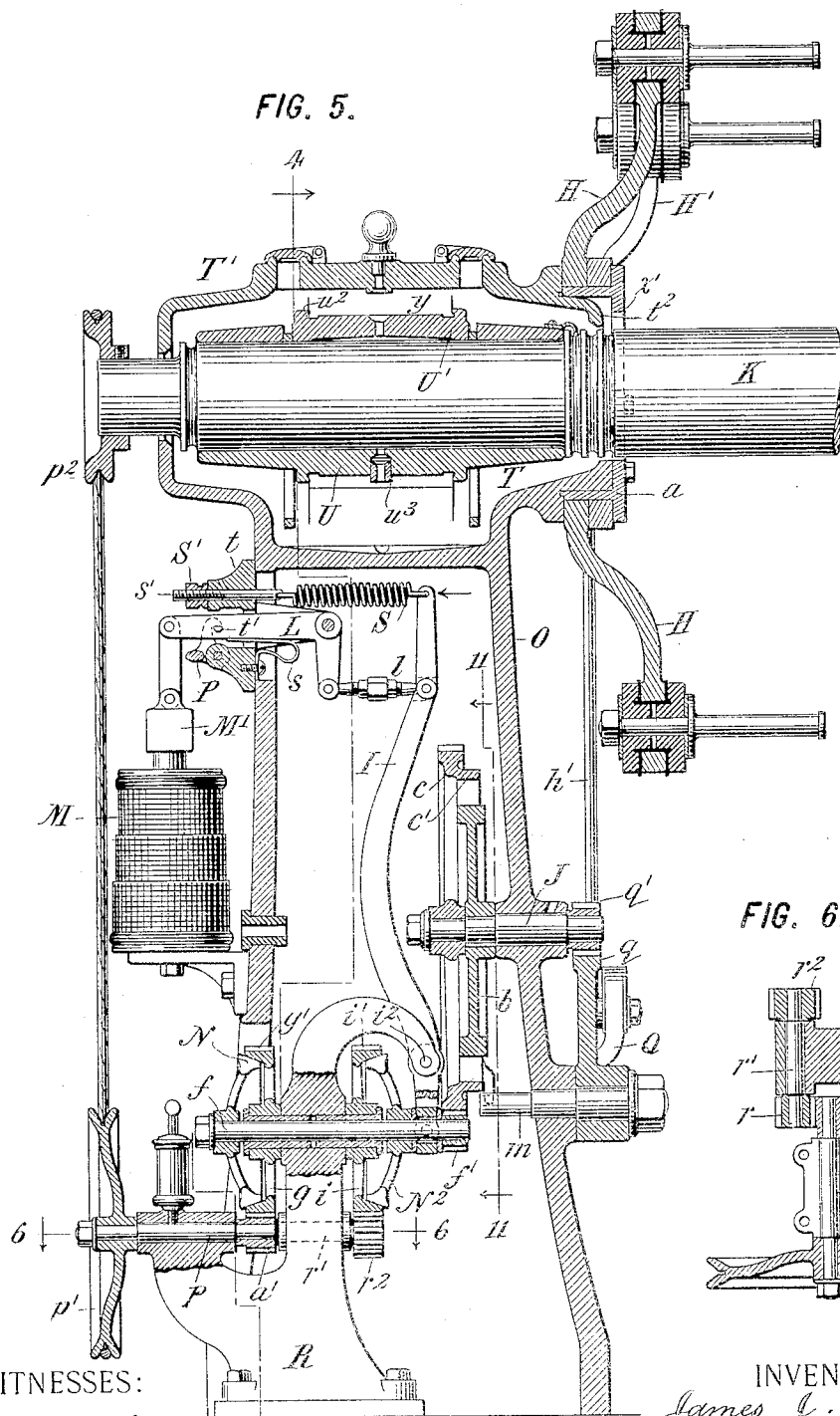
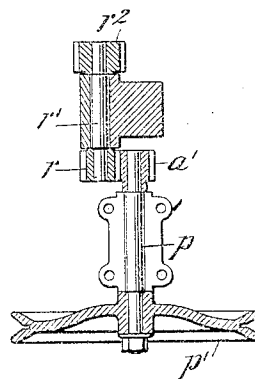


FIG. 6.



WITNESSES:

C. E. Ashley
H. W. Lloyd.

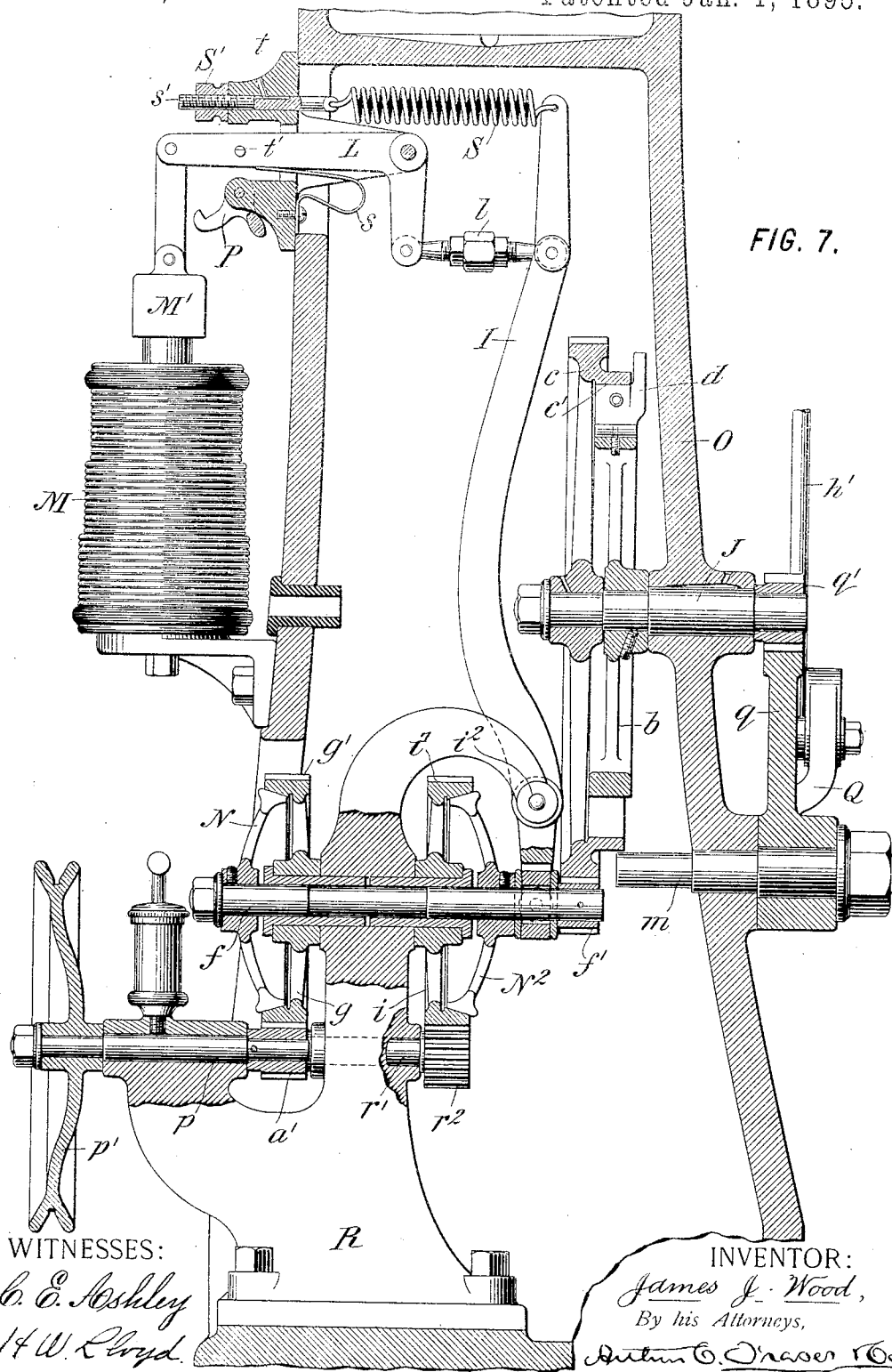
INVENTOR:

James J. Wood,
By his Attorneys,
Arthur C. Overton & Co.

J. J. WOOD.
CONSTANT CURRENT DYNAMO.

No. 531,821.

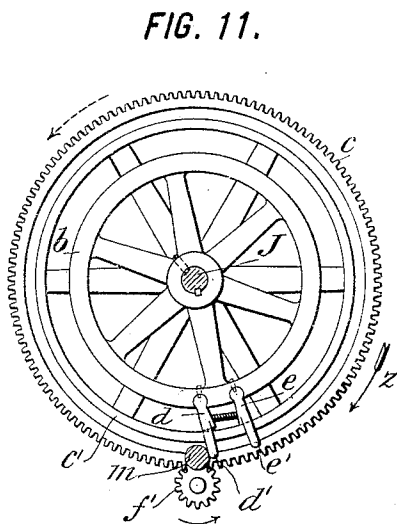
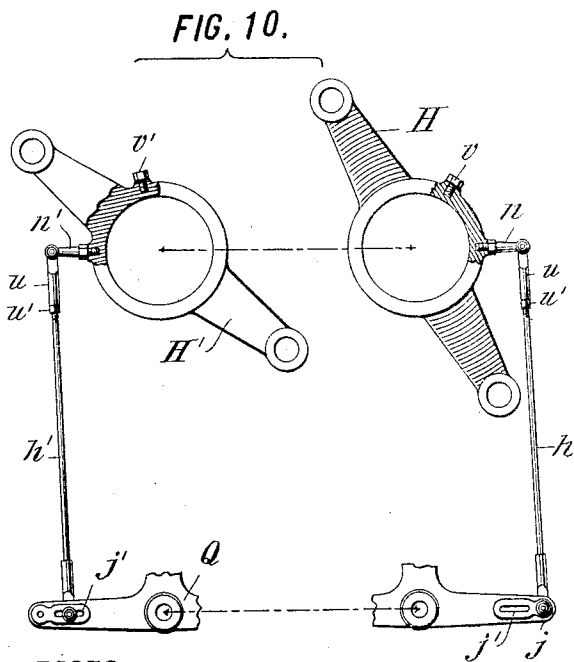
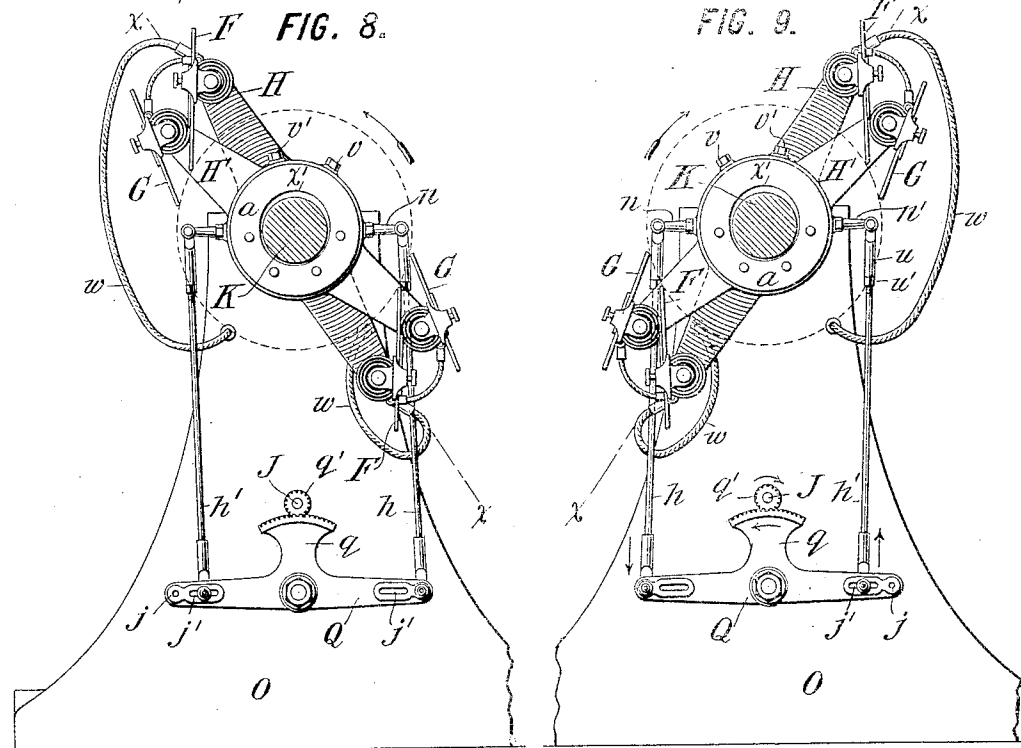
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J. J. WOOD.
CONSTANT CURRENT DYNAMO.

No. 531,821.

Patented Jan. 1, 1895.



WITNESSES:

C. E. Ashley
W. W. Lloyd.

FIG. 10^a



INVENTOR:

James J. Wood,
By his Attorneys,
Arthur C. Orser & Co.

J. J. WOOD.
CONSTANT CURRENT DYNAMO.

No. 531,821.

Patented Jan. 1, 1895.

FIG. 18.

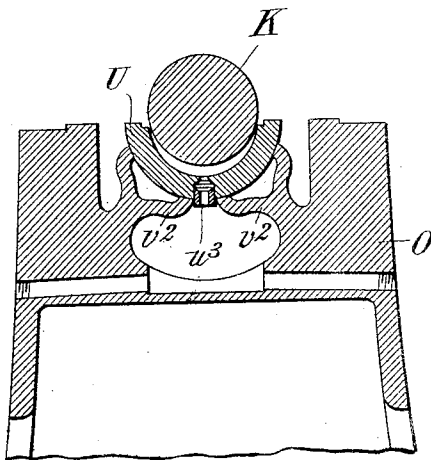


FIG. 19.

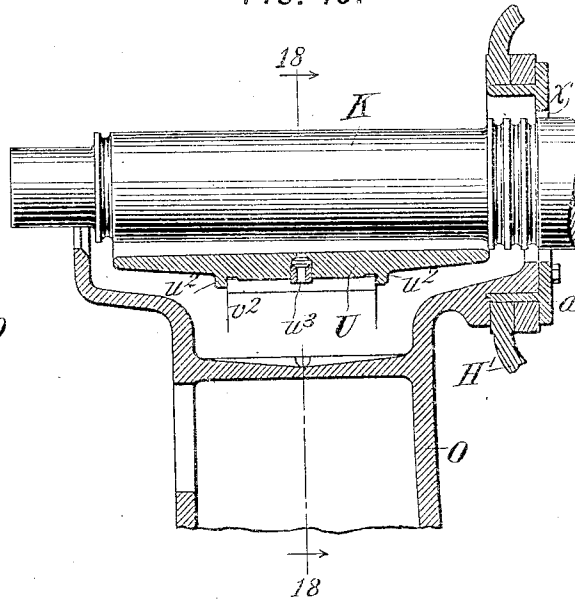


FIG. 20.

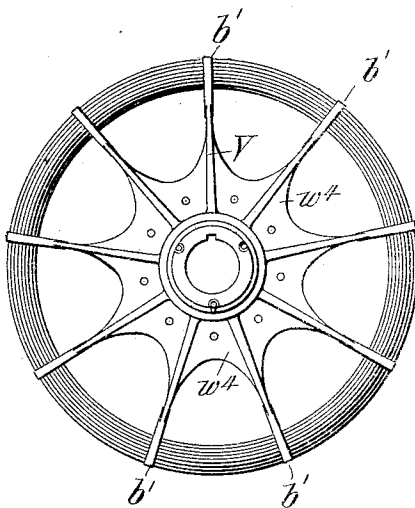
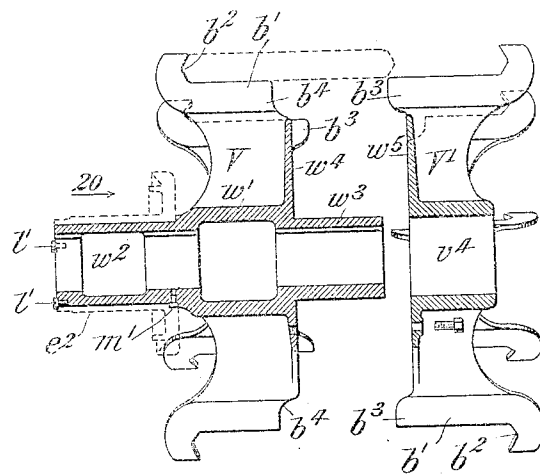


FIG. 21.



WITNESSES:

C. E. Ashley
W. Lloyd.

INVENTOR:

James J. Wood,
By his Attorneys,
Arthur C. Draper & Co.

UNITED STATES PATENT OFFICE.

JAMES J. WOOD, OF FORT WAYNE, INDIANA.

CONSTANT-CURRENT DYNAMO.

SPECIFICATION forming part of Letters Patent No. 531,821, dated January 1, 1895.

Application filed July 3, 1894. Serial No. 516,412. (No model.)

To all whom it may concern:

Be it known that I, JAMES J. WOOD, a citizen of the United States, residing at Fort Wayne, Allen county, Indiana, have invented certain new and useful Improvements in Constant-Current Dynamos, of which the following is a specification.

This invention relates to dynamo electric machines designed to generate a constant current against a varying line resistance, or what are commonly called arc light dynamos, and usually employed for feeding a circuit of arc lamps.

The machine produced by my present invention is a development of the well known Wood arc dynamo with automatic regulator as disclosed in my Patents No. 418,302, dated December 31, 1889, and No. 420,138, dated January 28, 1890. The construction of machine shown in those patents has been embodied in dynamos of varying sizes adapted for feeding from one to eighty or one hundred arc lamps of two thousand candle power.

My present invention is more particularly designed for dynamos of larger capacity, such as those feeding from one hundred and twenty-five lamps upward, although applicable to smaller sizes if desired.

My present construction retains in essential particulars the more important features of the current regulator shown in my Patent No. 418,302, but the particular construction of the regulating mechanism has been greatly varied, with a view to rendering it more perfect and enduring in its operation.

My present invention also renders the regulator "dead beat" in its action, without recourse to any retarder or fan such as is claimed in my said Patent No. 420,138.

My invention also relates in parts to other features of dynamos, all as will be fully hereinafter set forth.

I will now proceed to describe the preferred embodiment of my invention as illustrated in the accompanying drawings, wherein—

Figure 1 is a side elevation of the dynamo. Fig. 2 is an end elevation thereof looking from the commutator end and showing part of the regulator. Fig. 3 is a vertical mid-section thereof cut on the line 3—3 in Fig. 2. Fig. 4 is a vertical section on a larger scale cut through the bearing pedestal at the com-

mutator end, the plane of the section being on the line 4—4 in Fig. 5. Fig. 5 is a vertical section through the same pedestal and adjacent parts on nearly the same plane as Fig. 3, of which it is mainly an enlargement, the section being on the line 5—5 in Fig. 4. Fig. 6 is a fragmentary horizontal section in the plane of the line 6—6 in Fig. 5. Fig. 7 is a similar section to Fig. 5 and in substantially the same plane but on a larger scale to show the regulating mechanism more in detail. Figs. 8 and 9 are vertical transverse sections on a scale intermediate of Figs. 3 and 5, and on line 8—9 in Fig. 3, the commutator being removed. Fig. 8 shows the machine arranged to be driven to the left, and Fig. 9 to the right. Fig. 10 shows the brush yokes and their connections in Fig. 8 separated. Fig. 11 is a fragmentary section on the line 11—11 in Fig. 5, being on the same scale as Fig. 5. Figs. 12 and 13 are face views of the two parts of one of the friction clutches. Fig. 14 is a face view of the clutch operating lever looking in the same direction as Fig. 4. Fig. 15 is a transverse section through part of the pedestal on the line 15 in Fig. 4. Fig. 16 is an elevation of the inner side of the pedestal door or handle cover. Fig. 17 is a fragmentary section of the latter on the line 17—17 in Fig. 16. Figs. 18 and 19 are respectively vertical transverse and longitudinal sections through one of the shaft bearings showing the shaft partly raised, both these being on the same scale as Fig. 5, and Fig. 19 being a section in the same plane as Fig. 5, while Fig. 18 is a section on the line 18—18 in Fig. 19. Fig. 20 is an end elevation of the armature spider and core. Fig. 21 is a diametrical section of the two parts of the armature spider separated. Fig. 22 is a bottom view of one of the lower field-magnet coils; and Fig. 23 is a vertical section thereof on the line 23—23.

In Figs. 1, 2 and 3, A designates the main frame or fixed metallic circuit of the field-magnet, B B the field-magnet coils, and C C the field-magnet pole-pieces. D is the armature mounted on the armature shaft K. E is the commutator. F F are the main commutator brushes, and G G are the supplemental brushes.

As for the general arrangement of the principal parts of the machine, the field-magnet

is a quadrangle with consequent poles as in my previous arc machines, differing from them only in being mounted on its end instead of its side, the lower end being made integral with a machine base A' , and the upper end being a cross yoke. The shaft K instead of extending in the same plane as the quadrangle, is turned so that its axis is perpendicular thereto, and to support it two bearing pedestals are provided lettered O O' , these pedestals rising from the base A' . This base rests upon a sub-base B' , which is fastened down to the foundation. The main base A' has a sliding connection with the sub-base so that it may be slid in either direction in order to tighten or loosen the driving belt, as is usual with dynamos, the means shown for this purpose consisting of an operating lever k (Figs. 1 and 2) acting through a pawl upon a ratchet wheel fixed upon a screw k' turning in fixed bearings on the sub-base B' and engaging a threaded hole in the main base A' in a well known manner.

In their general features the armature and commutator are the same as heretofore constructed, and call for no description. The armature has a Gramme ring winding upon a wire wound core.

The main commutator brushes F F are carried as usual in insulated holders mounted on opposite arms of the main brush carrying yoke H . The supplemental brushes G G are in like manner carried in opposite arms of a supplemental carrier yoke H' . The yokes H H' , best shown in Fig. 10, turn on a bearing ring a (Fig. 5) constituting an inward prolongation or boss fixed to the inner side of the shaft bearing on the pedestal O . The two brush yokes are confined on this bearing ring between opposite flanges, and are loosely mounted so that they can turn or slide around on the bearing ring independently of each other. Instead of these brush yokes being formed with toothed sectors engaged by differential pinions revolved through a friction clutch by the regulating mechanism as in my former construction, they are operated in different manner by the mechanism which I will now proceed to describe.

Each yoke has screwed or otherwise fastened to it an arm lettered n for the yoke H , and n' for the yoke H' . (See Fig. 10.) To these arms are jointed rods h h' which extend downward (see Fig. 8) and are jointed at their lower ends to opposite arms of a lever or tilting beam Q . For a reason hereinafter stated, one of these rods is connected in a hole j in the end of one arm of this lever, while the other end is connected in a slot j' in the other arm of the lever, so that the effective portions of the lever arms are of unequal length, and differential movements are imparted to the two rods and their connected yokes by the oscillations of the lever. The lever Q in addition to its two opposite arms each with a hole j in its end and a slot j' nearer the center, is formed with a toothed sector q with

which meshes a pinion q' fixed on the end of a revolving shaft J having a suitable bearing formed in the pedestal O . On the opposite portion of this shaft within the hollow of the pedestal, is fixed a disk or wheel b , and on the end portion of the shaft so that it may freely turn thereon, is mounted a wheel c . The disk b and wheel c are normally locked together so as to necessarily turn as one. The wheel c has external gear teeth which mesh with a pinion f' which is fixed on a revolving shaft f , on which also are fixed two friction clutch cones N N^2 which engage frictionally with interior coned flanges on clutch wheels g and i respectively. The shaft f turns freely in bushings fixed in a small bearing frame or pedestal R , and the clutch wheels g i turn freely on the outer surfaces of these same bushings. The wheels g i are revolved constantly in opposite directions, the wheel i turning at a somewhat faster speed than the wheel g . The wheel g has peripheral gear teeth g' with which mesh the teeth of a pinion a' (see Fig. 4) which pinion is fixed on a short shaft p (see Figs. 5 and 6) which turns in a bearing formed on a bracket of the pedestal R , and on which shaft is fixedly attached a belt pulley p' by means of which it is driven by a belt from a smaller pulley p^2 fixed on the armature shaft K . The shaft p is thus driven preferably at a somewhat slower speed than the armature shaft. The pinion a' in addition to driving the clutch wheel g , also meshes with and drives a pinion r (see Figs. 4 and 6) fixed on a short shaft r' , on the other end of which shaft is fixed a pinion r^2 which meshes (see Fig. 7) with gear teeth i' formed on the periphery of the clutch wheel i , by which the latter wheel is driven. The shaft r' is with the proportions shown rotated at the same speed as the shaft p , but by the pinion r^2 being larger than the pinion r' , the wheel i is driven at a slightly more rapid rate than the wheel g .

The shaft f is capable of a short longitudinal sliding movement in its bearings, being controlled by a clutch lever I , pivoted at i^2 to an overhanging arm on the pedestal R , and extending thence upward within the pedestal O . At its end it is connected to a spring S , which exerts a constant tensile stress in the direction of the arrow in Fig. 5, this tension being adjustable by means of the nut S' . The lever I is also connected by means of the link l (adjustable in length) to one arm of an elbow-lever L , the opposite arm of which projects through the pedestal and is connected by a link to the armature or movable member M' of the regulating magnet or solenoid M . This magnet is of the same construction as in my previous machines, and its coils are connected in the same way in the outside or main circuit or line, so that its magnetization varies with the current. Its attraction for its armature is resisted by the tension of the spring S as formerly. For sustaining the weight of the ar-

mature M' and its cores, the horizontal arm of the lever L and the intervening link, independently of the spring S , a separate leaf-spring s is introduced pressing upwardly against the horizontal arm of the lever L . For convenience in construction and mounting, a bearing block t is provided fastened against the side of the pedestal O' , and having bracket arms extended inwardly between which the lever L is fulcrumed, its horizontal arm projecting out through a hole in the bearing block t , the opposite margins of which serve as stops to limit the opposite movements of the lever, and consequently of the armature M' . The spring s is attached to the same bearing block. For adjusting the spring S it is connected to a sliding screw-rod s' passing through a hole in the block t and receiving on its threaded end an adjusting nut S' which bears against the face of the block.

Before describing the operation of the regulator, I will remark that it is not essentially changed from that in my aforesaid Patent No. 418,302. The regulation is effected by an automatic adjustment of the brushes around the commutator to move them toward or from the position where they take off the maximum current. This position with reference to the main brushes $F F$ is indicated approximately by the dotted line $x-x$ in Figs. 4, 8 and 9. When the main brushes touch the commutator on this line with the supplemental brushes $G G$ touching at certain distances in advance of them, the maximum current is delivered to the line. To cut down the current the brushes are moved forward (that is, in the direction of rotation of the commutator) until the main brushes $F F$ touch the commutator at a position of minimum current where the least current is delivered to the line. As the main brushes are thus advanced toward the minimum position, it is essential in order to prevent sparking or arcing at the commutator, that the supplemental brushes $G G$ shall be advanced at a slower rate, so that in the position of minimum current each supplemental brush G shall be closer to its main brush F , or shall bridge or short-circuit a less number of commutator segments, than when in the position of maximum current. To accomplish this a differential motion is necessarily given to the main and supplemental brushes respectively. These essentials are fully set forth in my aforesaid patents, as well as in my Patent No. 418,303, dated December 31, 1889.

The operation may now be understood.

I will start with the assumption that the dynamo is running normally at the proper speed and generating its normal current. Under these circumstances the attraction of the magnet M will be exactly balanced by the retractive stress of the spring S , so that the clutch-lever I will be in equilibrium and will occupy substantially a mid position. In this position the two clutch cones N and N^2 are both out of contact with the friction surfaces of the clutch wheels g and i , and consequently

neither of them is driven, the shaft f therefore remaining stationary, and the lever Q and brush yokes being likewise at rest. The only moving parts of the regulator under these circumstances are the shafts p and r' with their attached pulley and pinions, and the clutch wheels g and i , all of which parts revolve continuously. If the current should decrease in volume (caused either by increasing the resistance of the line by turning in more lamps, or by a lowering of the speed of rotation of the dynamo) the attraction of the magnet M would become less, and the tension of the spring S would preponderate, thereby drawing the clutch-lever I toward the left in Figs. 5 or 7, so that its forked lower arm slides the shaft f toward the right and forces the clutch cone N into frictional engagement with the clutch wheel g . Instantly the shaft f is rotated in the same direction as the wheel g , that is, in the direction of the arrow z in Fig. 4, and this rotation is communicated to the wheels c and b , which are turned in the direction of the arrow z' in Figs. 4 and 11, and consequently the pinion q' is turned in the direction of the arrow in Fig. 9, thereby rocking the lever Q , pushing up the rod h' , and pulling down the rod h , thereby causing both the main commutator brushes $F F$ and the supplemental commutator brushes $G G$ to travel backward over the commutator toward the position of maximum current. This travel of the brushes will continue until the increase of the current restores it to the normal ampereage, or until the position of maximum current is reached. In the former case the magnet M regains its normal power and thrusts back the clutch-lever sufficiently to disconnect the clutch $N g$ and stop the regulating mechanism. In the latter case (which occurs only when the machine is overloaded or under-speeded) the regulator would strive to carry the brushes beyond the position of maximum current, and to prevent this the brush propelling mechanism is thrown out of engagement in the manner shown in Fig. 11, that is to say by precisely the same means as that claimed in my said Patent No. 418,302, the parts shown in Fig. 11 being lettered the same as in that patent. Briefly described, the loose wheel c is connected to the wheel b by two opposite friction pawls $d e$ pressed apart by a spring, so that normally the wheel c drives the wheel b in either direction until either limit of movement of the brushes is reached, whereupon arm d' (or e') projecting from the pawl d (or e) strikes a fixed stop m and tilts the pawl sufficiently to throw it out of action and stop the rotation of the wheel b , and consequently the movement of the brushes, while permitting the wheel c to continue to revolve idly in obedience to the continued tendency of the regulating mechanism. The pawl d is thrown out of action in the manner described when the brushes reach the position of maximum current, while on reaching the opposite limit of movement or position of minimum

current, the pawl *e* is thrown out of action. If the current should increase in volume (owing to a decrease of the resistance in the circuit by cutting out one or more lamps, or to the dynamo being driven at too high a speed) the attraction of the magnet *M* will increase and its stress will preponderate over the tension of the spring *S*, whereby it will exert a thrust through the link *l* against the clutch lever *I*, thereby moving this lever so that its forked lower arm thrusts the shaft *f* toward the left in Fig. 5, thereby pressing the clutch cone *N*² into frictional engagement with the clutch wheel *i*. Immediately upon this engagement the shaft *f* is revolved in the opposite direction to that last described, but somewhat faster, and through the pinion *f'* it revolves the wheels *c b* in the direction of the dotted arrow in Fig. 11, consequently causing the lever *Q* to tilt in the opposite direction so as to pull down the rod *h* and push up the rod *h'*, thereby causing the brushes to advance along the commutator toward the position of minimum current. This movement will continue either until the current is reduced to the normal, whereupon the equilibrium between the magnet *M* and spring *S* is restored, and the clutch *N*² *i* is thrown out of engagement, and the brush propelling mechanism stopped; or until the position of minimum current is reached, whereupon the pawl *e* will be disconnected on striking the stop *m* as already described, so as to stop the further movement of the brushes. Because of the risk attending an excessive current the movement for thus reducing the current is made more rapid than that for increasing it.

It is at times desirable to throw the regulator out of action temporarily, as for example when the dynamo is running below its normal speed, or when it is working against a higher resistance on the line than constitutes its normal load. Under these circumstances the magnet *M* being weak, the superior tension of the spring *S* would keep the brush shifting mechanism in action after carrying the brushes to the maximum position, and after the disconnection of the clutch pawl *d* (see Fig. 11), the regulating mechanism revolving thus continuously (as long as the machine is operating under such conditions) in a fruitless effort to carry the brushes to a position where a larger current would be taken off. To provide for throwing the regulator out of action under such circumstances, I adopt essentially the same movable stop as the stop *P* claimed in my said Patent No. 420,138. This stop *P* I now construct as a hook which is pivoted to a boss formed on the bearing block *t*, and the hooked end of which is adapted upon turning the stop up by hand to engage a pin *t'* projecting from the lever *L*. When the machine is under-speeded or overloaded, the operator will turn up the hook and engage it with the lever in the manner shown in Fig. 5. Upon the cessation of the abnormal condition, that is, upon

the restoration of the normal current, the magnet *M* by reacquiring its normal strength, pulls down the lever *L*, and thereby relieves the hook *P* of the strain of holding this lever, whereupon the hook falls down by its own weight to the position shown in Fig. 7. Thus the stop automatically removes itself, and does not interfere with the necessary action of the regulator in case it becomes necessary for it to act to reduce the current.

To insure the absolute sparklessness of the commutator, it is essential that the brushes shall be adjusted exactly to the correct position, and that the main and supplemental brushes shall be given exactly the differential movement necessary to maintain them properly spaced in all positions to which they may be adjusted. It is customary to set the brushes in their brush holders by a gage with a certain uniform projection. This being done, it is necessary to bring the brush carrying yokes to such positions as to cause the brushes to bear at the proper places upon the commutator. To provide for this adjustment I make the rods *h h'* extensible in length in any suitable manner, preferably by constructing each rod with a tubular or socket portion *u* into which the screwthreaded end of the rod screws, being fastened in place therein by a set-nut *u'*, as shown in Figs. 8, 9 and 10. This adjustment may be made by swinging the lever *Q* to either limit of its movement, and then elongating or shortening each of the rods *h h'*, as may be necessary to bring the respective brush carrying yokes to the proper positions to cause the brushes to bear in the proper places upon the commutator.

The adjustment of the relative speeds of the main and supplemental brushes, or their velocity ratio, is effected by means of the elongated slot *j'*. The main brush yoke *H* being connected by the rod *h* to the hole *j* in the end of the lever *Q*, is moved with a certain invariable speed relatively to the brush driving mechanism; but the supplemental brush yoke *H'*, which is necessarily moved at a slower speed, being connected by the rod *h'* to the slot *j'* in the lever *Q*, its velocity ratio is adjustable by setting its connecting stud to different positions in the slot *j'*. If it is found that for the conditions of any particular machine the supplemental brush yoke requires to be moved at a slower velocity ratio, the connecting stud is set nearer the axial center of the lever; and vice versa. By means of these adjustments the slightly varying conditions peculiar to each dynamo may be compensated for, and each machine thereby rendered entirely sparkless under all normal conditions of regulation.

Another novel feature introduced by my present invention, is the construction of the machine so that it may be adapted to be driven in either direction. The conditions as to location and source of power under which the dynamo is erected often dictate the direction of rotation which is most desirable or

convenient, and it is therefore advantageous to construct the machine so that by an easily effected adjustment it may be set up so as to revolve either to the right or to the left. To this end my invention introduces the features of construction shown best in Figs. 8, 9 and 10. Fig. 8 shows the machine mounted to revolve to the left, while Fig. 9 shows it revolving toward the right, as is shown also in Figs. 1 to 5.

Each yoke H and H' is constructed with two screw sockets, into either of which the arm n or n' may be screwed, the other socket being closed by screwing in a tap-screw or filler v or v' , as shown in Fig. 10. The lever Q has the hole j and slot j' duplicated upon each of its horizontal arms, as shown. When a machine is to revolve toward the right, the parts are connected up in the manner shown in Fig. 9, and as shown also in Fig. 4. If the machine is to be driven in the opposite direction, the maximum line $x-x$ of course swings to the opposite side of the center, and the brushes and brush holders have to be turned on their studs to the opposite side. These changes necessitate that the yokes H H' shall be swung to the position shown in Fig. 8. To make this change the two arms $n n'$ are unscrewed from the yokes, as also are the filling screws $v v'$. The brush holders being removed, the yoke H is swung around by carrying its right hand arm in Fig. 9 downward past the right-hand arm of the yoke H', and then swinging the two yokes together until they are brought to the position shown in Fig. 8. The conducting cables $w w$ are given ample slack to admit of this movement. The yokes having been brought to this new position, the arms $n n'$ are screwed back into the yokes, but in the opposite holes, that is to say, in the holes which previously were occupied by the filling screws $v v'$; and the other holes now left vacant are filled by screwing in the screws $v v'$ in order to exclude dirt. The rods $h h'$ are then connected to the arms $n n'$ at their upper ends, and at their lower ends they are alternated in position relatively to the lever Q, that is to say, the arm which formerly was connected to the hole at the end of the lever is now connected in the slot, and vice versa, the new connections thus made being as shown in Figs. 8 and 10. It will be understood that the screw arm n' at the right in Fig. 9, which before the change connects with the yoke H', is connected after the change to the yoke H, and consequently it thereby becomes the arm n , it being to compensate for this reversal of its action that the right hand rod which in Fig. 9 connects with the slot j' , is disconnected therefrom and connected to the hole j , so that it becomes the rod h as shown in Fig. 8. The effect is the same as though the rods $h h'$ and arms $n n'$ were wholly disconnected and reversed in position from right to left, or vice versa, and again reconnected. These connections are easily and quickly made in the original set-

ting up of the machine, it being ordinarily then known in which direction the machine is to revolve; and the adjustments of length of the rods $h h'$ to bring the brush yokes to position, and the adjustment in the slot j' to impart the proper velocity ratio are afterward made.

Instead of constructing the lever Q with duplicate holes j and slots j' , it might be constructed so as to turn it around end for end in effecting the change of direction of rotation just described.

In my present construction the bearing ring or collar a for the brush yokes, instead of being applied against a solid frame, is fixed against the inner end of the bearing box T formed on the pedestal O (Fig. 5). As this box has a removable bearing cap T', the collar a is fastened only to the lower half of the bearing box, in order that the bearing cap may be removed independently of the collar a . The bearing cap T' is fastened to the pedestal by four screws, by removing which the cap may be slid outwardly away from the commutator sufficiently to get its inner end b^2 out from under the upper half of the collar a , after which the cap may be lifted off. This removal of the cap does not disturb the brush yokes, which remain guided and held in place on the collar a by the semicircular abutting face of the lower half of the bearing box T. To enable the cap T' to be thus slid outward, the outer collar u^2 (Fig. 5) on the upper half U' of the bearing brass or bushing U, is cut away as shown in Fig. 4 at two points opposite the inwardly projecting ribs $y y$ on the bearing cap, by which the bushing is held in place. After thus removing the bearing cap T', the upper half U' of the bushing may be taken off by removing the screws which unite it to the lower half of the bushing, and lifting it out. This may be necessary in order to get at the bearing in case it be found that any persistent heating occurs indicating a want of smoothness in the bearing. If the difficulty is not found in the upper half U' of the bushing, it is presumed to exist in the lower half U, and for removing this the shaft K may be lifted in the manner shown in Figs. 18 and 19. It is to provide for thus lifting the shaft that the inner margin or opening of the collar a is made eccentric, as shown at x' in Figs. 5, 8 and 9. This eccentricity should be such as to permit the shaft to be thus lifted high enough so that by lifting up the lower half of the bushing U against the shaft journal, a tubular downward projection u^3 from this half bushing which projects between the two supporting ribs $v^2 v^2$ may be carried above these ribs, so that by then turning the half bushing around against the journal it may be carried out of the box. The upper supporting arms may be notched, if necessary, to more easily permit the passage of the projection u^3 . Either end of the shaft may be lifted in this manner, while the other end remains journaled in its bearing,

the mounting of the bearing bushings being sufficiently flexible to permit of this slight tilting movement of the shaft, and the clearance around the armature being also sufficient for this purpose. The armature may be easily removed. To do this the pulley p^2 is removed from the armature shaft, the driving pulley being preferably also removed. The pedestal O' is then detached from the base and removed, whereupon the armature, commutator and shaft can be drawn out on the axial line without disturbing the field-magnet or the regulator.

The line circuit is connected with positive and negative binding posts fixed to the pedestal O , as shown in Fig. 2. From these posts all the electrical connections of the machine are made within the pedestal O and the base A' , except where the flexible cables $w w$ pass out of the pedestal to connect with the commutator brushes, as shown in Figs. 1, 8 and 9. The electrical circuit connections are thus so protected as to be safe from injury, while reducing to a minimum the risk incurred by the attendant.

The armature is supported upon a two-part spider $V V'$, as shown in Figs. 20 and 21. The spider V is formed integrally with a hub w' formed on opposite sides with sleeves w^2 and w^3 . This hub is mounted on the shaft K , being keyed thereto by a long key or spline. The spider V' is formed with a hub v^4 which fits over the sleeve w^3 . The two spiders have their flattened spokes formed with seats b' for carrying the wire wound core of the armature, these seats being provided with overhanging ends or hooks b^2 (Fig. 21) as usual. The two spiders $V V'$ are formed on their abutting faces with webs $w^4 w^5$ respectively, and when drawn together are fastened by passing screws through one web into the other, as shown in Fig. 3. The seats b' on each spider are alternately constructed to project and recede, the projections being indicated at b^3 and the recesses at b^4 . By this construction the joints in the seats where the two spiders come together are alternated so as to "break joints" instead of coming all in one plane as heretofore. The disadvantage of the old construction is that some of the wires of the core are liable to be unsupported and to drop into the space between the two spiders, an accident which is rendered impossible by my improved construction.

The commutator E is self-contained, all its parts being mounted on a shell e^2 formed with an internal sleeve which sleeve slides over and fits upon the sleeve w^2 of the armature spider, as shown in dotted lines in Fig. 21. The commutator is keyed to the armature spider so as to rotate therewith, by means of an inserted key or block m' , and is held thereon so as to prevent its slipping off longitudinally by screws l' screwing into the material of the sleeve w^2 with their heads overlapping the ends of the commutator sleeve e^2 . By means of this relative construction of the ar-

mature spider and commutator base, the armature and commutator after being connected together are practically self-contained, so that they may be together removed from the armature shaft and shipped away for repairs. The circuit connections between the commutator segments and the armature coils are not affected by the act of either removing the armature and commutator from the shaft, or replacing them upon the shaft. The segments and coils may thus be connected up before the armature is mounted upon the shaft, which is an important advantage for large and heavy armatures.

The improved regulator provided by my present invention has proved itself in practical use to operate to great perfection, the clutches $N g$ and $N^2 i$ being found to operate more perfectly as their frictional surfaces become worn down by use, instead of being impaired by wear as has been the case with previous regulators employing friction clutches or gearing. A practically important detail of these clutches consists in the formation of radial slots or grooves i^3 in the frictional surfaces of the cones $N N^2$, as best shown in Fig. 13, whereby any particles of grit or dust that may find their way between the frictional surfaces are caused to work out, escaping through these slots.

Almost the entire regulator mechanism is inclosed within the pedestal, where it is protected against injury and tampering, only those parts requiring examination or attention being arranged upon the outside of the pedestal, such as the magnet M , the adjusting nut S' , the stop P , and the driving belt and pulleys. In case it becomes necessary to get access to the inclosed parts, it is only necessary to remove one or both of two hand-hole covers $W W$ which are applied on opposite sides of the pedestal O . One of these covers is shown in cross-section in Fig. 15, and an inside view of the cover removed is shown in Fig. 16. Each cover is formed with two bottom lugs y' which are adapted to engage and partly overhang the margins of the hand-hole, as shown by the oblique section Fig. 17. These lugs serve to properly position the hand-hole covers in applying them, and when put in place they are locked fast by turning a knob W' , the spindle of which passes through the cover, and has fixed upon its inner end a cross-bar or bolt W^2 (Fig. 16) which is thus turned to a transverse position, as shown in dotted lines in that figure, so that its ends engage the inner surfaces of the wall of the pedestal at the margin of the hand-hole, as shown in Fig. 15.

My improved regulator is found in practice to be absolutely "dead beat"—that is, it brings the brushes each time to the exact position on the commutator required to compensate for any variation from the normal current, without at any time carrying them too far, or causing any see-saw back and forth across the correct position. This desirable

result is attained without any sacrifice in the rapidity of action of the regulator, which is found to operate with the same quickness as the regulators of my former arc machines.

5 In case it becomes necessary to take the field-magnet apart, the side bars or cores may be disconnected from the base A' by removing the screws m^2 (Fig. 3) which enter the threaded holes in the lower end of the core
10 shown in Figs. 22 and 23. The armature and shaft having previously been removed, the field-magnet cores and upper cross head may now be lifted off. In so doing the lower coils B B would remain resting on the base, were
15 not some special means provided for fastening them to the cores. This means consists of the construction shown in Figs. 22 and 23. Two (or more) screws k^2 are screwed into the opposite sides of the core so that their projecting heads shall on the outer sides project
20 beyond the sides of the core, and in so doing shall underlie the lower head or plate k^3 of the spool supporting the lower coil.

It must not be inferred from the particularity of detail with which I have described the preferred form and construction in which my present invention is embodied that my invention is necessarily limited to such details, since in fact the construction may be considerably varied without departing from the essential features of my invention. Those
30 parts or features of my invention which I believe to be new and essential are hereinafter defined in the claims.

35 It will be understood that my invention is not confined to the use of an electro-magnet or solenoid as the device for controlling the current regulator, but that any electro-motive device responding to current changes
40 may be employed. It will also be understood that in lieu of the particular mechanism for communicating motion from the clutches to the brush yokes which I have shown and described, any other suitable or equivalent
45 brush shifting mechanism may be substituted. It is not absolutely essential to my present invention that this brush shifting mechanism shall be divided by the disconnecting device consisting of the wheels $c b$
50 and interposed pawls d and e (which constitute the subject of one of my aforesaid patents) or by any other equivalent separating device, such separation forming no part of my present invention. The brush shifting
55 mechanism is that portion of the mechanism between the driven members of the clutches and the brushes or brush yokes by which movement is communicated from the clutches to the brushes. As part of this mechanism
60 the rods $h h'$ may be substituted by any other equivalent connectors. It will be understood that as for the lever Q, its operation and capabilities would be the same if the slot j' in each arm were extended into the hole
65 or socket j , as indicated in Fig. 10^a, making one long slot in each arm instead of a shorter slot and separate hole. The lever Q might

be variously otherwise arranged, it not being strictly essential that its arms shall project in opposite directions as shown, provided
70 otherwise the same essential movements are imparted to the brush yokes, and the same essential capabilities of adjustment and in some cases of reversal are attained. Other purely structural or mechanical modifications
75 in great number might be suggested.

I claim as my invention the following-defined novel features, substantially as hereinbefore specified, namely:

1. The combination in a dynamo having
80 movable commutator brushes, of a current regulator consisting of a clutch driven shaft f , a brush shifting mechanism connecting said shaft to the brushes to move the latter, the driven members N N² of two clutches
85 fixed on said shaft, driving clutch-wheels $g i$, a continuously revolving shaft p having a pinion a' driving the clutch-wheel g , a secondary shaft r' having a pinion r driven from the shaft p , and a pinion r^2 driving the other
90 clutch-wheel i , said pinions being relatively proportioned to drive the clutch-wheel i more rapidly than the clutch-wheel g .

2. The combination in a dynamo having commutator brushes carried by a movable
95 yoke, of a current regulator consisting of an electro-motive device responding to current changes, and a brush-shifting mechanism controlled by the electro-motive device, and comprising a driven shaft, a lever geared to said
100 shaft to be oscillated thereby, and a mechanical connector between said lever and brush yoke, by which the movement is communicated to the latter, said connector constructed to be longitudinally adjustable, whereby to
105 vary the position of the brushes on the commutator.

3. The combination in a dynamo having main and supplemental commutator brushes carried by two movable yokes, of a current
110 regulator consisting of an electro-motive device responding to current changes, and a brush-shifting mechanism, controlled by the electro-motive device, and comprising a driven shaft, a lever geared to said shaft to
115 be oscillated thereby, and mechanical connectors between the opposite arms of said lever and the respective brush yokes.

4. The combination in a dynamo having main and supplemental commutator brushes
120 carried by two movable yokes, of a current regulator consisting of an electro-motive device responding to current changes, and a brush shifting mechanism, controlled by the electro-motive device, and comprising a
125 driven shaft, a lever geared to said shaft to be oscillated thereby, and mechanical connectors between the opposite arms of said lever and the respective brush yokes, connected to the respective arms at different distances
130 from the lever axis to communicate differential movements to the two yokes.

5. The combination in a dynamo having main and supplemental commutator brushes

carried by two movable yokes, of a current regulator consisting of an electro-motive device responding to current changes, and a brush-shifting mechanism, controlled by the
 5 electro-motive device, and comprising a driven shaft, a lever geared to said shaft to be oscillated thereby, and two rods jointed at one end to the opposite arms of the lever, and at their opposite ends to the respective brush
 10 yokes.

6. The combination in a dynamo having main and supplemental commutator brushes carried by two movable yokes, of a current regulator consisting of an electro-motive device responding to current changes, and a
 15 brush-shifting mechanism, controlled by the electro-motive device, and comprising a driven shaft, a lever geared to said shaft to be oscillated thereby, and two rods jointed at one end to the opposite arms of the lever, and at their opposite ends to the respective brush
 20 yokes, and the lever constructed to admit one of the rods to be adjusted relatively to the other to varying distances from the lever axis, whereby the speed ratio of the respective
 25 yokes may be varied.

7. The combination in a dynamo having main and supplemental commutator brushes carried by two movable yokes, of a current
 30 regulator consisting of an electro-motive device responding to current changes, and a brush-shifting mechanism controlled by the electro-motive device, and comprising a lever Q, and two rods jointed to the opposite arms
 35 of the lever and connected to the respective brush yokes, the lever constructed with a socket j in one arm for connection with the rod leading to one brush yoke, and with a slot j' in the opposite arm for adjustable connection with the rod leading to the other yoke.
 40

8. The combination in a dynamo having main and supplemental commutator brushes carried by two movable yokes, of a current
 45 regulator consisting of an electro-motive device responding to current changes, and a brush-shifting mechanism controlled by the electro-motive device, and comprising a lever Q, and two rods jointed to the opposite arms of the lever and connected to the respective
 50 brush yokes, the lever constructed with duplicate slots in its opposite arms adapted to admit the connection of the respective rods at unequal distances from the lever axis to communicate differential movements to the yokes,
 55 while permitting the adjustment of one connection relatively to the other for varying the speed ratio of the yokes, and to admit the reversal of the connection of the rods with the respective arms, the one connected farthest
 60 from the axis being adjusted inwardly and the other outwardly to reverse the differential movements.

9. The combination in a dynamo having main and supplemental commutator brushes
 65 carried by two movable yokes, and a current regulator comprising an electro-motive device

and brush-shifting mechanism for imparting differential movements to the respective yokes, of means for enabling the direction of rotation of the armature to be reversed at will,
 70 consisting of detachable and reversible connectors forming part of the brush-shifting mechanism, and constructed to permit the brush yokes to be disconnected and swung to opposite positions corresponding to the opposite rotation of the armature, and to be then
 75 reconnected with the brush-shifting mechanism in inverse order so as to maintain after reversal the same relative differential movements of the respective yokes.

10. The combination in a dynamo having main and supplemental commutator brushes carried by two movable yokes, and a current
 80 regulator comprising an electro-motive device and brush-shifting mechanism for imparting differential movements to the respective yokes, of means for enabling the direction of rotation of the armature to be reversed at will, consisting of detachable arms $n n'$ connected to the respective yokes, and rods $h h'$
 85 constituting part of the brush-shifting mechanism, and the yokes constructed to admit of the attachment of said arms to them in different positions, whereby the arms may be detached from the yokes, the yokes swung to opposite positions, and the arms reattached.
 90

11. In a dynamo, having main and supplemental commutator brushes carried by two movable yokes, and a current regulator comprising an electro-motive device and brush-shifting mechanism for imparting differential
 100 movements to the respective yokes, the combination of the yokes $H H'$ each constructed with two screw sockets, detachable arms $n n'$ adapted to screw into either of said sockets, and filling screws $v v'$ for closing the unoccupied sockets.
 105

12. In a dynamo having a base and bearing pedestals mounted thereon, having bearings for the armature shaft, a current regulator
 110 for shifting the commutator brushes comprising opposite clutches and connecting gearing housed within one of said pedestals, and mechanical connections between the driven members of such clutches and the brush-yokes,
 115 carried by said pedestal.

13. In a dynamo having a base A' and bearing pedestals $O O'$ mounted thereon, a current regulator for shifting the commutator brushes comprising opposite clutches housed
 120 within the pedestal O , and mechanical connections between the driven members of such clutches and the brush yokes comprising gearing and a shaft J having bearings in said pedestal, and a lever Q having a bearing upon
 125 the exterior of said pedestal.

14. In a dynamo having a base A' and bearing pedestals $O O'$ mounted thereon, a current regulator for shifting the commutator brushes comprising opposite clutches housed
 130 within the pedestal O , and mechanical connections between the driven members of such

clutches and the brush yokes carried by said pedestal, and a separate pedestal R within the pedestal O affording bearings for the clutches.

15. In a dynamo having a base A' and bearing pedestals O O' mounted thereon, a current regulator for shifting the commutator brushes comprising shafts *p* and *r'*, two opposite clutches, a driven shaft *f*, housed in the hollow pedestal O and mechanical connections between the latter shaft and the brush yokes, and a pedestal R within the pedestal O, and providing bearings for said shafts *p* *r'* and *f*.

16. In a dynamo having a base A' and bearing pedestals O O' mounted thereon, a current regulator comprising opposite clutches and connecting gearing housed within the pedestal O, a clutch-lever I for operating said clutches also housed within said pedestal, a controlling magnet M outside the pedestal, and mechanical connections between said magnet and clutch lever passing through the pedestal.

17. In a dynamo having a base A' and bearing pedestals O O' mounted thereon, a current regulator comprising opposite clutches and connecting gearing housed within the pedestal O, a clutch lever I for operating said clutches also housed within said pedestal, a controlling magnet outside the pedestal, an elbow-lever L passing through said pedestal, and a link *l* for connecting with said clutch lever.

18. In a dynamo having a base A' and bearing pedestals O O' mounted thereon, a current regulator comprising opposite clutches and connecting gearing housed within the pedestal O, a clutch lever I for operating said clutches also housed within said pedestal, a controlling magnet M mechanically connected to said clutch lever, a retracting spring within the pedestal connected to said clutch lever, and an adjusting device for said spring outside the pedestal.

19. In a dynamo having a base A' and bearing pedestals O O', a current regulator comprising opposite clutches and connecting gearing housed within the pedestal O, a clutch lever I within the pedestal, a controlling magnet M outside the pedestal, mechanical connections between said magnet and lever, comprising a lever L passing through the pedestal, and a bearing block *t* fastened to the pedestal formed with opposite stops to limit the movement of said lever L, and formed with bearings to which said lever L is pivoted.

20. In a dynamo, a current regulator comprising opposite clutches and brush-shifting mechanism driven thereby, a clutch-lever I for operating said clutches, an adjustable retracting spring S controlling the magnet M having an armature M', mechanical connections between said armature and lever I, said connections comprising a lever L, and a spring *s* pressing upwardly against said lever L to counterbalance the weight of the lever and armature.

21. In a dynamo, the combination with a current regulator of the class wherein a shifting mechanism is connected to a source of power by the action of an electro-motive device against a retractile force, of a movable stop constructed as a hook P adapted to engage a projection *t'* connected with the electro-motive device, and thereby to resist the retractile force to hold the dynamo out of action, and unbalanced so as to fall out of engagement when the electro-motive device overcomes the retractile force.

22. In a dynamo, in combination with a current regulator for shifting the commutator brushes wherein the brush-shifting mechanism is controlled by an electro-magnet acting against a retractile force, a lever L connected to said magnet having a projection *t'*, a bearing block *t*, and a gravity hook P pivoted to said bearing block, and adapted when turned up to engage said projection.

23. In a dynamo, a current regulator comprising opposite clutches consisting each of a driving and driven part, the one constructed as a wheel with an internal coned flange and the other as a disk with an external cone fitting in said flange, said externally coned disk being formed with radial slots *v*³.

24. In a dynamo having a current regulator partly housed within one of the bearing pedestals, the pedestal O constructed with opposite hand holes combined with hand-hole covers W for closing said holes, and means for fastening them to the pedestal.

25. In a dynamo having a current regulator partly housed within one of the bearing pedestals, the pedestal O constructed with opposite hand holes combined with hand-hole covers W for closing said holes, each constructed with lugs *y'* projecting into the hole, and with a fastening device consisting of a bar W² adapted to be turned to engage the margins of the hole.

26. In a dynamo having the armature shaft K mounted on bearing pedestals O O', the combination of the brush yokes, a concentric bearing ring *a* on which said yokes are mounted, and the lower half T of the bearing box on the pedestal O to which said ring is attached independently of the bearing cap, whereby the bearing cap T' may be removed without disturbing the brush yokes.

27. In a dynamo wherein the armature shaft K is supported on bearing pedestals O O', the pedestal O formed with the lower half T of the bearing box, the upper half or bearing cap T' thereof removably attached thereto and formed with internal ribs *y*, an inclosed bearing bushing in two halves U U' supported within the bearing box, and the upper half U' formed with its thrust collar *w*² cut away in line with the ribs *y* on the bearing cap T' to admit the removal of the latter by sliding it endwise.

28. In a dynamo having the armature shaft K mounted on bearing pedestals O O', the combination of the brush yokes, a concentric

bearing ring *a* on which said yokes are mounted, and the lower half T of the bearing box on the pedestal O to which said ring is attached independently of the bearing cap, 5 whereby the bearing cap T' may be removed without disturbing the brush yokes, and the said ring *a* having the opening through it upwardly enlarged at *x'* to permit the lifting of the shaft as described.

10 29. An armature comprising a wire wound core and supporting spiders V V' having their spokes formed with seats *b'* for supporting the inner surface of the core, and the respective

spiders formed on their spokes with alternate projections *b*³ and recesses *b*⁴, the projections 15 of each fitting into the recesses of the other, and thereby breaking joints to prevent the wires of the core falling into the space or joint between the spiders.

In witness whereof I have hereunto signed 20 my name in the presence of two subscribing witnesses.

JAMES J. WOOD.

Witnesses:

ARTHUR C. FRASER,
GEORGE H. FRASER.