June 29, 1937. A. A. EMLEN ET AL 2,085,255

VOLTAGE REGULATOR

Filed Dec. 26, 1935 4 Sheets-Sheet 1

Fig. 4

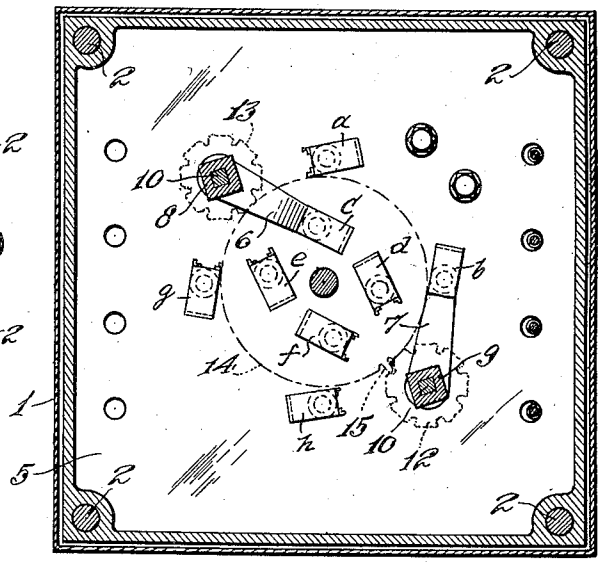


Fig. 3

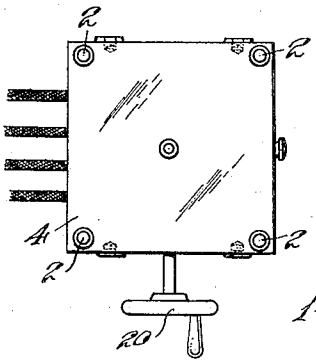
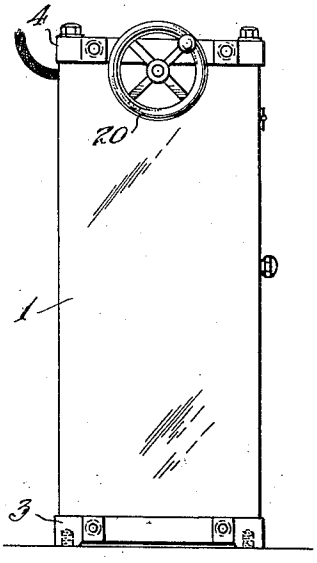


Fig. 1



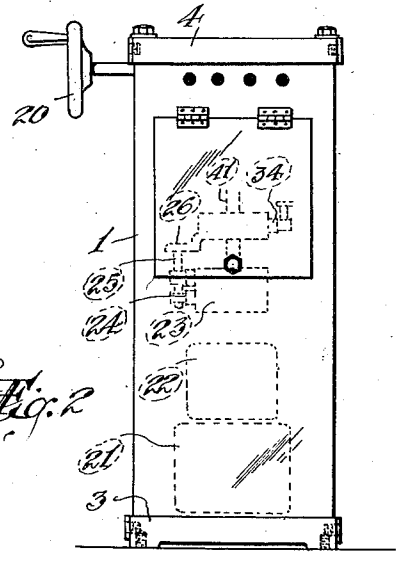


Fig. 2

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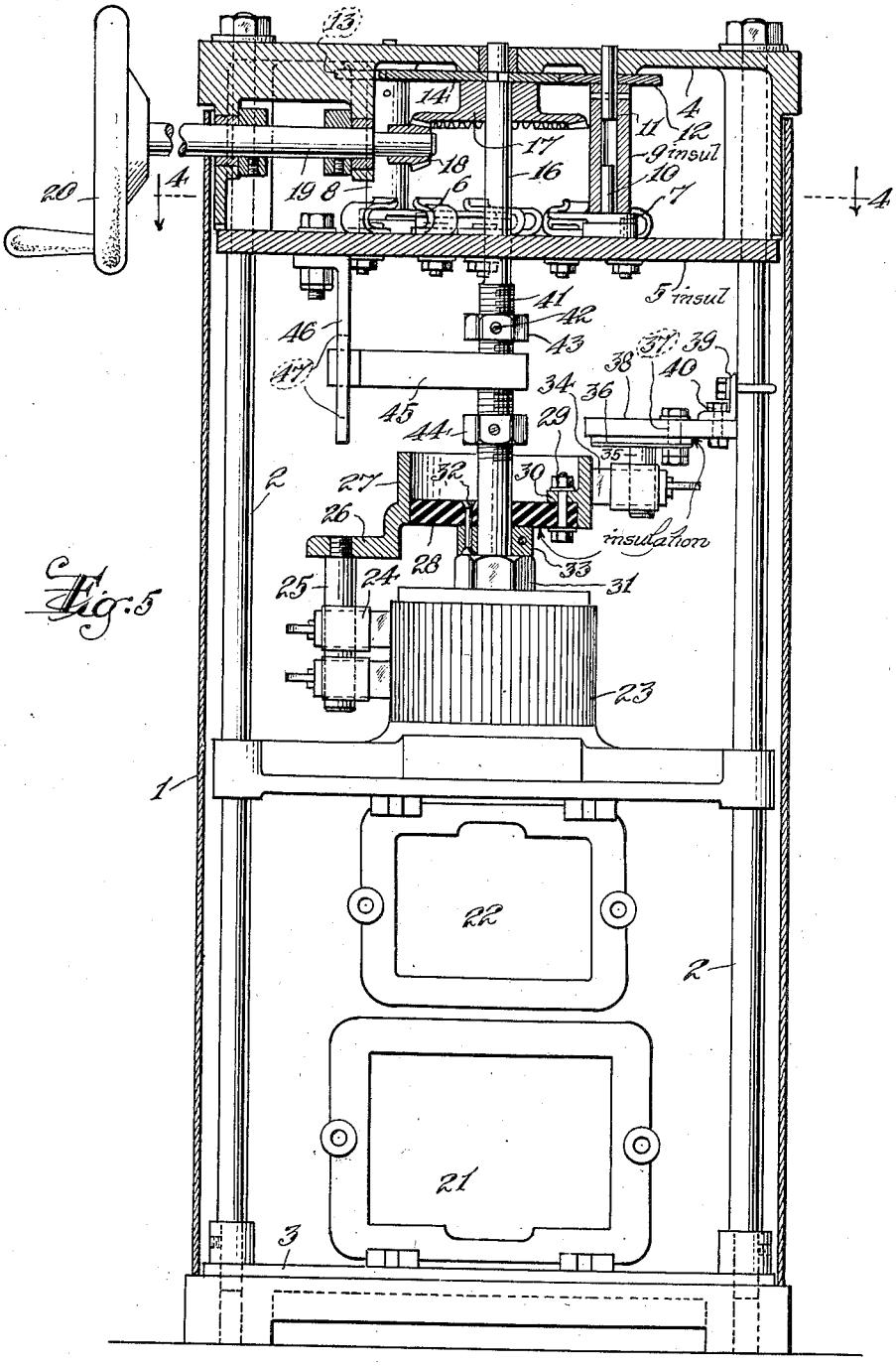

Fig. 5

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VOLTAGE REGULATOR

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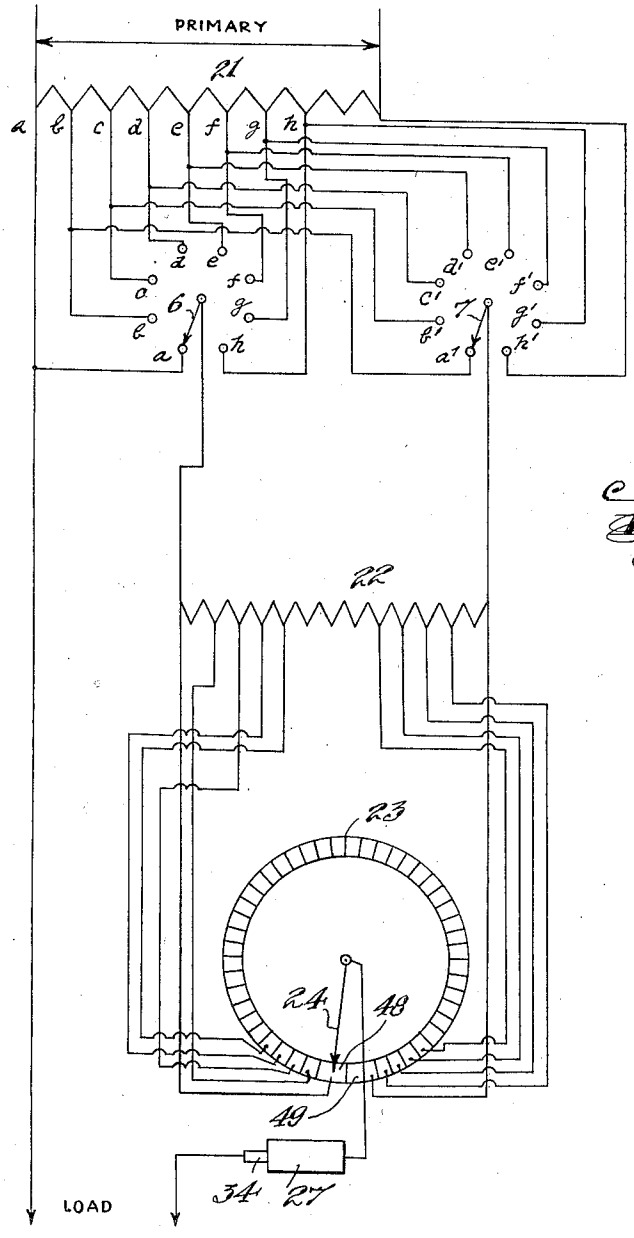

Fig. 6

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VOLTAGE REGULATOR

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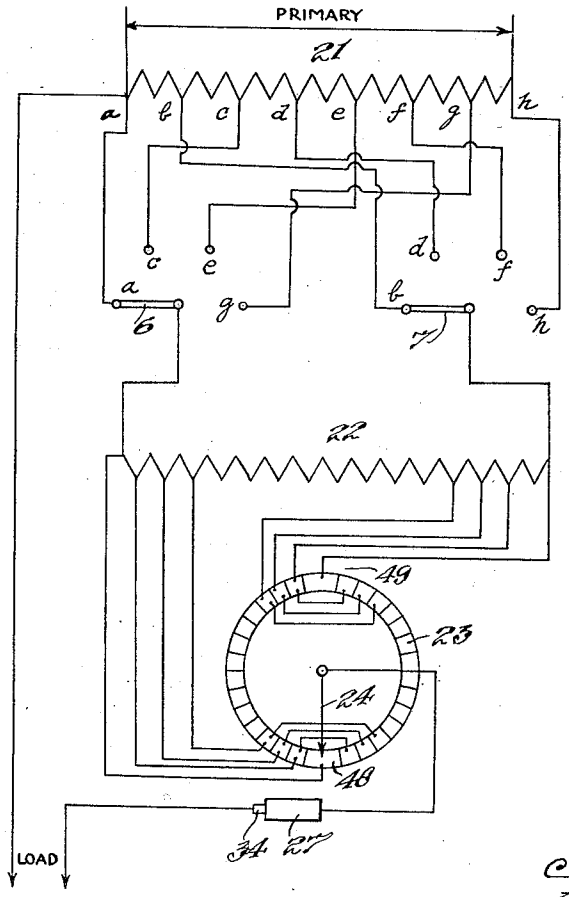
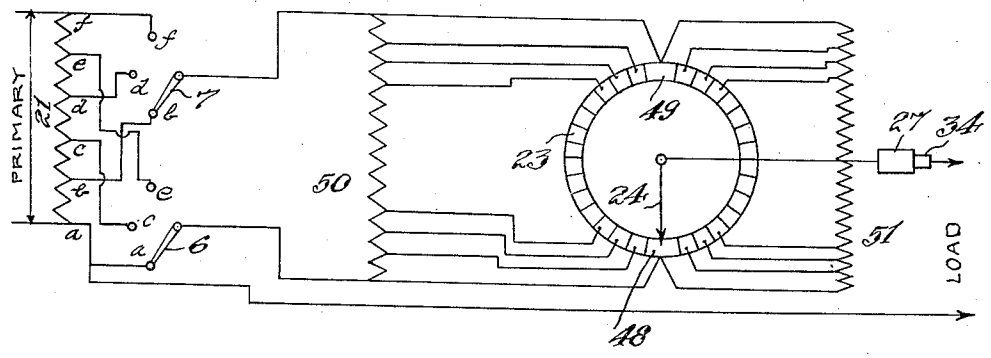


Fig. 7

Fig. 8



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UNITED STATES PATENT OFFICE

2,085,255

VOLTAGE REGULATOR

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Application December 26, 1935, Serial No. 56,216

20 Claims. (Cl. 171—119)

This invention relates to the construction of a voltage regulator particularly adapted for use in connection with the regulation of the voltage of an alternating current circuit.

Our invention utilizes a plurality of transformer windings having coarse and fine taps, the transformers being interconnected by rotary switches adapted to be alternately operated from contact to contact, the fine tap winding being connected to a collector of the commutator type having a brush mounted for rotation about the periphery of the collector. In general, such a voltage regulator is described in Hunter Patents 2,014,570, issued September 17, 1935; and 1,993,007, issued March 5, 1935, in which are shown certain mechanisms for reversing the brush rotating around the collector after the brush has reached the limit of its travel there-around; that is, substantially one full revolution, at the end of which time, the Geneva gear arrangement actuates one of the switches having contacts connected to the coarse taps of one of the transformer windings.

It is the principal object of our invention to simplify the construction and thereby reduce the cost of operation and maintenance of the regulator.

In particular, our invention is directed to entirely eliminating the mechanism used for reversing the direction of rotation of the collector brush at the end of each revolution thereof.

Our improvements will be readily understood by reference to the accompanying drawings, in which:

Figure 1 is an elevational view on a reduced scale, of one type of regulator to which our invention is applied.

Figure 2 is a view looking from right to left of Figure 1.

Figure 3 is a top view of Figure 1.

Figure 4 is a view on the line 4—4 of Figure 5.

Figure 5 is a part-sectional and part-elevational view through the regulator, without any of the connections being shown, these connections being omitted for the purpose of clarity, since they are more clearly shown in the diagrammatic forms of Figures 6, 7, and 8.

Figure 6 is a diagram of the circuit connections, showing one form in which our invention may be applied.

Figure 7 is a wiring diagram of another form which our invention may take.

Figure 8 is a wiring diagram of a further modified form.

In the various views, wherein like numbers refer to corresponding parts, 1 illustrates, generally, a casing supported by a framework 2 having end closure plates 3 and 4. Adjacent the top closure plate 4, is a plate 5, preferably of strong insulating material, which carries two sets of rotary switch contacts designated, alternately, *a* to *h* inclusive, corresponding to the diagram shown in Figure 7.

Cooperating with these contacts are two switch levers 6 and 7 which are carried on coupling members 8 and 9 of insulating material operatively connected to bearing pins 10 and 11, the pin 11 having a bearing in the top plate 4. One of the bearing pins 11, for one of the switches, carries a Geneva gear 12, while the corresponding pin for the other switch carries a Geneva gear 13, both of which are adapted to be operated by a gear 14 having a single tooth 15. The gear 14 is operatively connected to a main drive shaft 16 carrying a gear 17 adapted to mesh with the pinion 18 carried on an operating shaft 19 which, as shown, is adapted to be manually operated by the handwheel 20, although it is to be understood that the regulator may be operated automatically as shown and described in Hunter Patent 1,993,007.

Within the framework 2 of the regulator is carried a main transformer 21 having a series of coarse taps connected to the switch contacts of the rotary switches 6 and 7 as shown in the wiring diagrams. A collector transformer 22 is also carried by the framework 2 and has a series of fine taps connected to the various bars of the commutator type collector 23. Cooperating with the collector 23 is a pair of brushes 24 carried on a stud 25 attached to a flange 26 and preferably integral with a slip ring 27. While we have shown two brushes 24 in cooperation with the collector 23, we have referred in the claims, broadly, to a brush. The slip ring 27 is fastened to an insulator 28 in any satisfactory manner as by a bolt 29 engaging a stud or projection 30 within the interior portion of the ring 27. The lower end of the shaft 16 has a bearing within a gland 31 at one end of the collector 23.

The insulator 28 is fastened to the shaft 16 in any satisfactory manner as by a pin 32 and a clamping collar 33. Contacting with the slip ring 27, is a brush 34 carried on a stud 35 which is attached to a metal plate 36, which in turn is fastened by a bolt or stud 37 to an insulator 38 of strong material, which in turn is fastened to a frame member 39 by any satisfactory means as by one or more bolts or studs 40.

The shaft 16 is threaded intermediate its ends at 41, and on this threaded portion are adjust-

ably positioned, by set screws 42, a pair of nuts 43 and 44. Between the nuts 43 and 44, a stop member 45 is positioned, it being threaded to engage the threads 41 on the shaft 16. The outer end of the member 45 engages a guide and support member 46 which is slotted between the dotted lines 47 to receive the end of the arm 45, thereby preventing it from rotating about the shaft 41, but allowing the member 45 to travel up and down on the shaft as the shaft 16 is rotated. This travel of the stop member 45 is adjusted by the nuts 43 and 44, so as to allow the brush 24 to travel around the collector 23 continuously in the same direction as many times as there are steps of the rotary switches 6 and 7. By way of illustration and reference to Figures 4 and 7, the switch 6, while having four contacts, has three steps; and likewise, the switch 7 has three steps so that the brush 24 will rotate around the collector 23 three complete times before it is stopped by the member 45 engaging either the nut 43 or the nut 44. In other words, after the rotary switches have been moved throughout their complete range in one direction, the regulator is locked against further movement in that particular direction. Then the regulator can be operated in reverse direction to the full limit as provided by the corresponding stop devices described.

From the above, it is seen that the reversing mechanism for reversing the direction of rotation of the brush 24 about the collector 23, as required in Hunter Patent 1,993,007, is entirely eliminated, but in making this elimination, special provision must be made in the commutator to allow a time interval for the switches 6 and 7 to be operated so that they will be on contact, whereby the load circuit will never be opened. This arrangement is accomplished in Figure 6, by providing two special commutator bars 48 and 49 of sufficient width to accomplish the desired purpose, which will be readily understood by a brief description of the operation of the regulator as shown in Figure 6.

In this diagrammatic arrangement, the brush 24 is shown in contact with the special extra-width commutator bar 48, the switches 6 and 7 being on the contacts *a* and *a'*, it being understood that the contacts associated with the switches 6 and 7 are connected to coarse taps on the transformer 21. As the brush 24 rotates around the collector 23 in clockwise direction, the various fine taps from the transformer winding 22 are encountered to regulate the voltage in accordance with the well-known way as set forth in said Hunter patents, so further description does not appear to be necessary. When the brush 24 reaches the bar 49, the mechanism and gearing are arranged so that the switch lever 6 moves from *a* to *b*, the width of the bar 49 being sufficient to allow for this switching to take place, so that the load circuit will not be opened. After the brush 24 moves from 49 to 48 and is on 48, the switch 7 is moved from *a'* to *b'*. Because of the continuous rotation of the brush 24 around the commutator, the slip ring 27 must be used in order to carry the current through the brush 24 out to the load circuit.

We have shown in Figure 6, the switches 6 and 7 each having eight contacts, but there may be any number of contacts desired. For example, in Figure 7 only four contacts for each switch are illustrated. In the arrangement of Figure 7, the collector 23 is a little differently constructed than in Figure 6. In this arrangement the wide bars 48 and 49 are diametrically disposed so that the brush 24 covers all of the fine taps during one-half revolution, and then while it is on one of the wide bars, for example 49, one of the switches is operated and the brush 24 contacts with bars on the opposite sides of the commutator, which are cross-connected to the corresponding bars on the opposite side of the collector, one set of the bars being connected to the fine taps of the transformer 22.

A modification of Figure 7 is shown in Figure 8, wherein the winding 22 is split into two windings 50 and 51, which arrangement does not require cross-connecting of the commutator bars as in Figure 7. As heretofore explained, however, the adjustment of the stop member 45 on the shaft 16 controls the number of times the brush 24 travels around the collector, or in accordance with the number of steps or movement required by the switches 6 and 7.

From what has been said, it will be seen that our arrangement does away with the more or less complicated reversing mechanism required where the brush 24 has to be reversed in direction at the end of each revolution around the commutator.

While the various details of construction may be varied, we have shown a practical illustration of the application of our invention.

What we claim is:

1. In a voltage regulator including; at least a pair of separate transformer windings, one having coarse taps and the other fine taps, the coarse taps from one winding being interconnected to the other winding through a pair of independently operable switches with means for operating the switches alternately in steps so the circuit between the windings, including the load circuit, is never opened, a collector of the commutator type having bars connected to the fine taps of said other winding, a brush adapted to be continuously connected to a circuit whose voltage is to be regulated, said brush being mounted for rotation around said collector, characterized in that the electrical connections between said windings, switches and collector are such that the brush on the collector can be rotated continuously in the same direction around the collector throughout the range of movement of said switches.

2. A voltage regulator as set forth in claim 1, further characterized in that the collector is constructed so the brush engaging it traverses all the taps of the fine tap winding and while continuing its rotation around the collector, holds the circuit closed while at least one of said switches moves one step, the brush then continuing on in the same direction of rotation for another cycle of step movements.

3. A voltage regulator of the type herein described utilizing transformer windings, one having coarse taps and another having fine taps, interconnected by rotary switches with means for alternately operating the switches from contact to contact, and a collector of the commutator type having its bars connected to the transformer having the fine taps, a brush mounted for continuous rotation around the collector, the commutator connections being such that the brush may be rotated successively around the collector in the same direction throughout the entire range of movement of said switches in one direction.

4. A voltage regulator as set forth in claim 3,

further characterized in that the brush will move continuously and successively around the collector in the opposite direction when the regulator, including said switches, is operated in reverse direction from that set forth in claim 3.

5. A voltage regulator as set forth in claim 3, further characterized in that means are provided for stopping the regulator after the full number of cycle steps have been completed in a given direction of regulation.

6. A voltage regulator as set forth in claim 3, further characterized in that the collector has at least a pair of bars of an arcuate length and positioned at the end and beginning of the series of fine taps so the rotating brush will remain on at least one of them while one of said switches is moving one step.

7. A voltage regulator as set forth in claim 3, further characterized in that the collector has at least a pair of bars of an arcuate length and positioned at the end and beginning of the series of fine taps so the rotating brush will remain on at least one of them while one of said switches is moving one step, said pair of bars being adjacent each other whereby the rotating brush must make substantially a revolution around the collector before one of said switches moves a step.

8. A voltage regulator as set forth in claim 3, further characterized in that the collector has at least a pair of bars of an arcuate length and positioned at the end and beginning of the series of fine taps so the rotating brush will remain on at least one of them while one of said switches is moving one step, said pair of bars being spaced approximately 180° apart, whereby the brush has to rotate only approximately halfway around the collector to cover the range of fine taps before the next switch is operated one step, the corresponding commutator bar on opposite sides of said pair of bars being electrically cross-connected whereby the brush may continue its movement in the same direction for the next cycle step.

9. A voltage regulator as set forth in claim 3, further characterized in that the collector has at least a pair of bars of an arcuate length and positioned at the end and beginning of the series of fine taps so the rotating brush will remain on at least one of them while one of said switches is moving one step, said pair of bars being spaced approximately 180° apart, whereby the brush has to rotate only approximately halfway around the collector to cover the range of fine taps before the next switch is operated one step, a second fine tap transformer winding having the taps connected to complementary bars on the opposite side of said pair of bars from the bars to which the fine taps from the first winding are connected.

10. A voltage regulator including a casing, and frame work, said frame work comprising a pair of Geneva gears, a pair of rotary switches operated by said gears, a collector of the commutator type, a main transformer having coarse taps connected to the switch contacts, a collector transformer connected to said rotary switches and having fine taps therefrom, a drive shaft with means for operating it, a brush mounted for rotation around the collector by said shaft, said drive shaft being operatively connected to said Geneva gears, a slip ring carried by said shaft, an auxiliary brush contacting with the slip ring, the ring and auxiliary brush serving to carry the current from the collector brush to the load circuit, and special bars in the collector interconnected with the fine tap transformer, said special bars having an arcuate length so the rotary brush can continuously move successively around the collector as the switches are moved from step to step without opening the load circuit.

11. A voltage regulator as set forth in claim 10, further characterized in that adjustable means are carried on the drive shaft for stopping the action of the regulator at both ends of a cycle of movements of said switches.

12. A voltage regulator as set forth in claim 10, further characterized in that said slip ring has a part carrying a stud on which said collector brush is mounted.

13. A voltage regulator as set forth in claim 10, further characterized in that the special bars of the collector are located adjacently, one being connected to one end of the collector transformer winding and the other to the opposite end of said winding, the arcuate length of the bars being such as to allow the required switch movements to be made before the rotary brush leaves said special bars.

14. A voltage regulator as set forth in claim 10, further characterized in that the special bars of the collector are located 180° apart and connected one each to opposite ends of the collector transformer winding while complementary opposed bars are cross-connected, whereby the fine tap winding is traversed twice by one rotation of the collector brush, said switches being actuated in steps when the rotary brush is on said special bars.

15. A voltage regulator as set forth in claim 10, further characterized in that the special bars of the collector are located 180° apart and connected one each to opposite ends of the collector transformer winding while complementary opposed bars are connected to fine taps on another transformer winding which may be on the same transformer carrying the first-mentioned fine tap windings, whereby each fine tap winding is traversed by one rotation of the rotary brush, said switches being actuated in steps when the rotary brush is on said special bars.

16. A voltage regulator as set forth in claim 10, further characterized in that the special bars of the collector are located adjacently, one being connected to one end of the collector transformer winding and the other to the opposite end of said winding, the arcuate length of the bars being such as to allow the required switch movements to be made before the rotary brush leaves said special bars, the contacts of one switch being connected in order to the taps on the coarse tap winding beginning with the first tap adjacent the starting end which is connected to the first position contact on the other of said switches.

17. In a voltage regulator including; at least a pair of separate transformer windings, one having coarse taps and the other fine taps, the coarse taps from one winding being interconnected to the other winding through a pair of independently operable switches with means for operating the switches alternately in steps so the circuit between the windings, including the load circuit, is never opened, a collector of the commutator type having bars connected to the fine taps of said other winding, a brush adapted to be continuously connected to a circuit whose voltage is to be regulated, said brush being mounted for rotation around said collector; characterized in that means are provided whereby the brush may be rotated continuously in the same direction until the limit of movement of said switches in one

direction is reached, said means including a drive shaft carrying a slip ring, an auxiliary brush serving to connect the rotary brush to the load circuit, said means further including special bars in the collector connected to the terminals of the fine tap winding and having an arcuate length such that the switches may be operated from one step to another before the rotary brush leaves said special bars.

18. A voltage regulator as defined in claim 17, further characterized in that said shaft carries adjustable means to automatically stop the regulator when the last step cycle in either direction of operation is reached.

19. A voltage regulator including a drive shaft, at least two auto-transformers, one having coarse taps and another having fine taps, at least a pair of switches having contacts connected to the said coarse taps and having their moving elements connected to said fine taps, the movable parts of the switches being operated from the drive shaft, a collector of the commutator type having its bars connected to the fine taps, a brush mounted for successive rotation around the collector in one direction according to the action of the drive shaft, means for synchronizing the movement of the movable parts of said switches when said brush has traversed the fine tap winding in one direction, and means for stopping the regulator when the full cycle of movement of the switches and said brush has been completed in either direction of regulation.

20. A voltage regulator as set forth in claim 1, further characterized in that the collector is constructed so the brush engaging it traverses all the taps of the fine tap winding and while continuing its rotation around the collector, holds the circuit closed while at least one of said switches moves one step, the brush then continuing on in the same direction of rotation for another cycle of step movements, and adjustable means for automatically stopping the regulator when the last step cycle in either direction of operation is reached.

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