May 23, 1944. F. L. SNYDER 2,349,682

ELECTRICAL APPARATUS

Filed Oct. 10, 1942 5 Sheets-Sheet 1

Fig. 1.

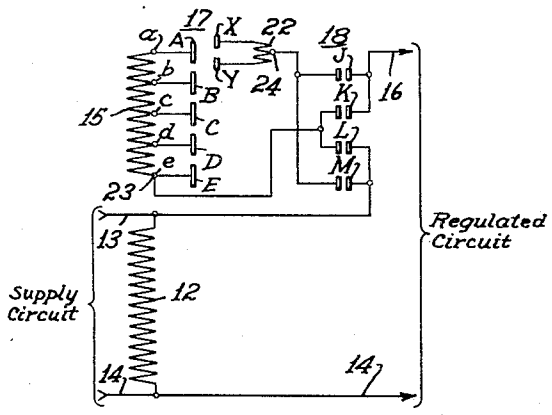


Fig. 2.

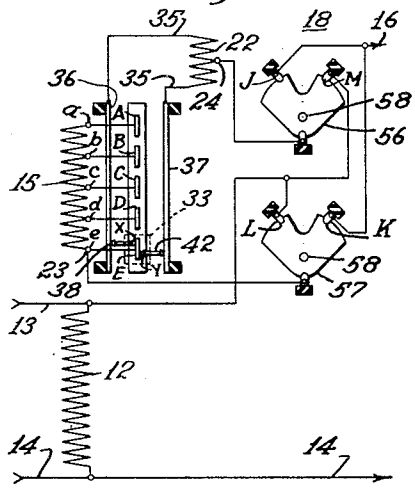
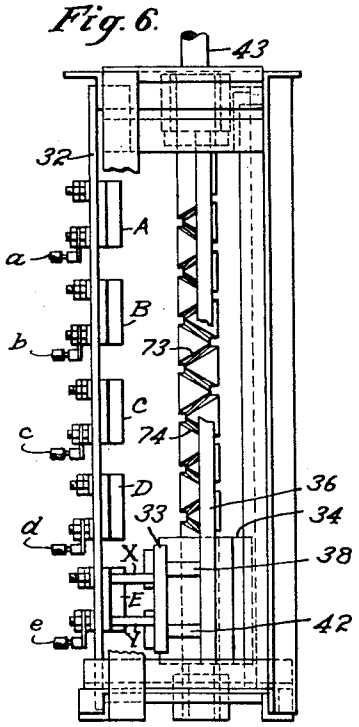


Fig. 3.

Sequence Chart

		Boost					Buck				
Position	1	2	3	4	5	6	7	8	9		
Switch	X-A	○									○
	Y-A	○	○							○	○
	X-B		○	○						○	○
	Y-B			○	○				○	○	
	X-C				○	○			○	○	
	Y-C					○	○	○	○		
	X-D					○	○	○	○		
	Y-D						○	○	○		
	X-E							○	○		
	Y-E								○		
	J	○	○	○	○	○	○	○	○	○	
	K							○	○	○	○
	L	○	○	○	○	○	○	○	○	○	
	M							○	○	○	○

Fig. 6.



WITNESSES:

Edward Michaels

Mrs. C. Groome

INVENTOR

Franklin L. Snyder.

BY

Franklin E. Hardy

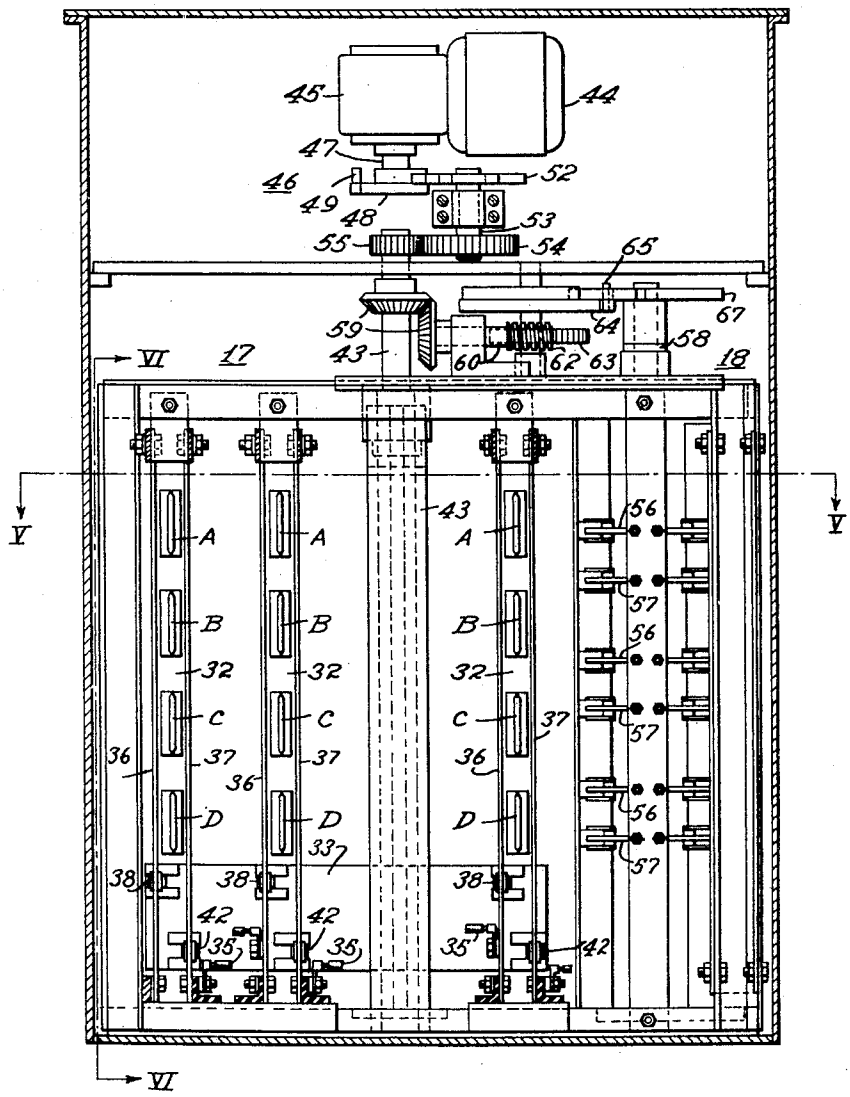
ATTORNEY

May 23, 1944. F. L. SNYDER 2,349,682

ELECTRICAL APPARATUS

Filed Oct. 10, 1942 5 Sheets-Sheet 2

Fig. 4.



WITNESSES:

Edward Michaels

Wm. C. Goodwin

INVENTOR

Franklin L. Snyder

BY

Franklin E. Hardy

ATTORNEY

May 23, 1944. F. L. SNYDER 2,349,682

ELECTRICAL APPARATUS

Filed Oct. 10, 1942 5 Sheets-Sheet 3

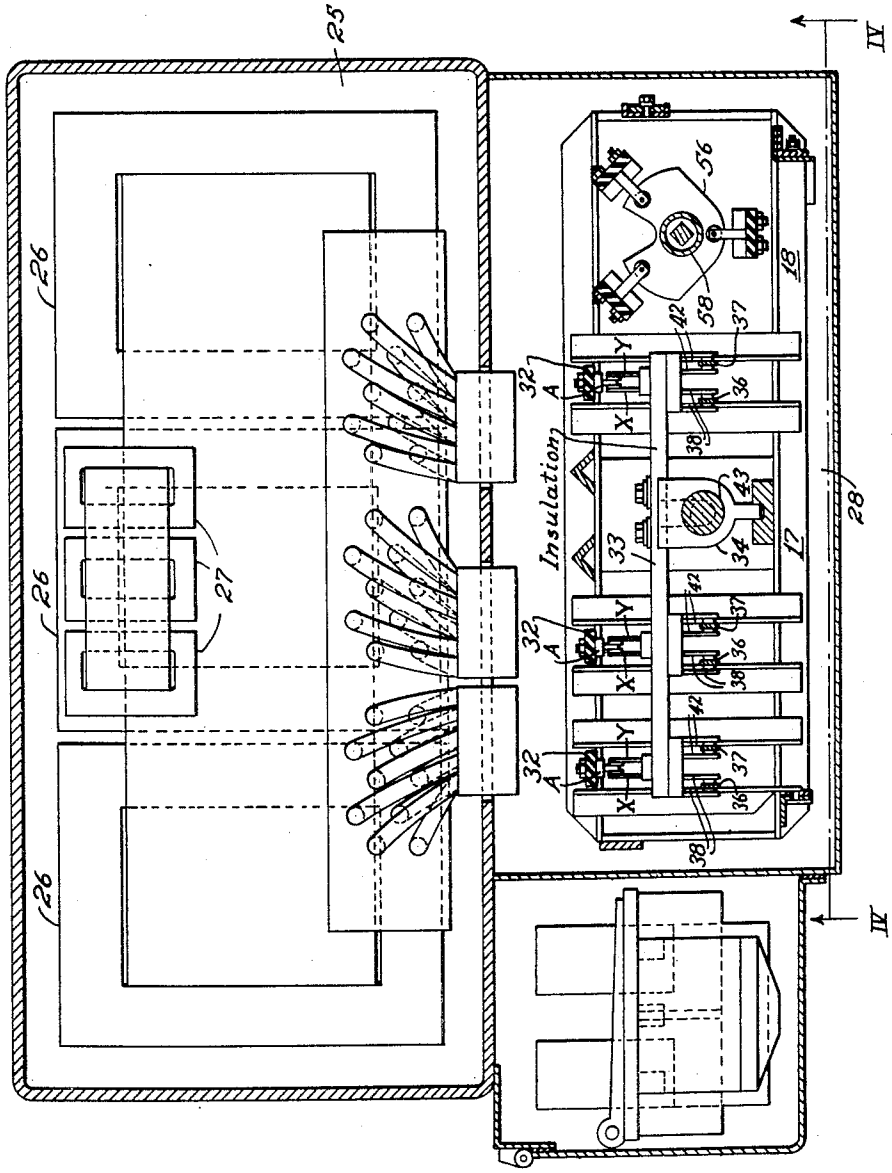


Fig. 5.

WITNESSES:

Edward Michaels

Mrs. E. Goosen

INVENTOR

Franklin L. Snyder.

BY

Franklin E. Hardy

ATTORNEY

May 23, 1944. F. L. SNYDER 2,349,682

ELECTRICAL APPARATUS

Filed Oct. 10, 1942 5 Sheets-Sheet 4

Fig. 7.

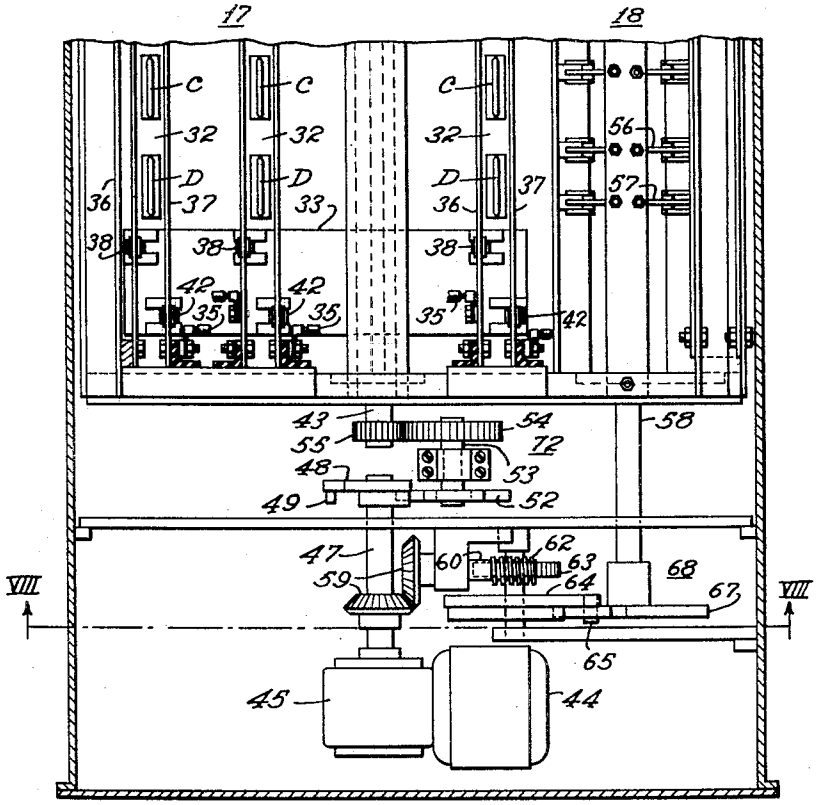
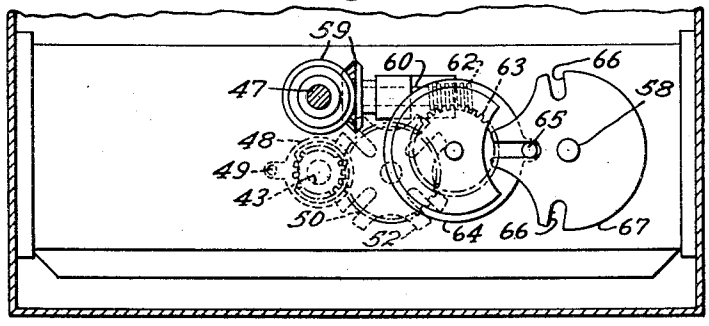


Fig. 8.



WITNESSES:
Edward Michaels
Wm. C. Gooseve

INVENTOR
Franklin L. Snyder.
BY Franklin E. Hardy
ATTORNEY

May 23, 1944. F. L. SNYDER 2,349,682

ELECTRICAL APPARATUS

Filed Oct. 10, 1942 5 Sheets-Sheet 5

Fig. 9.

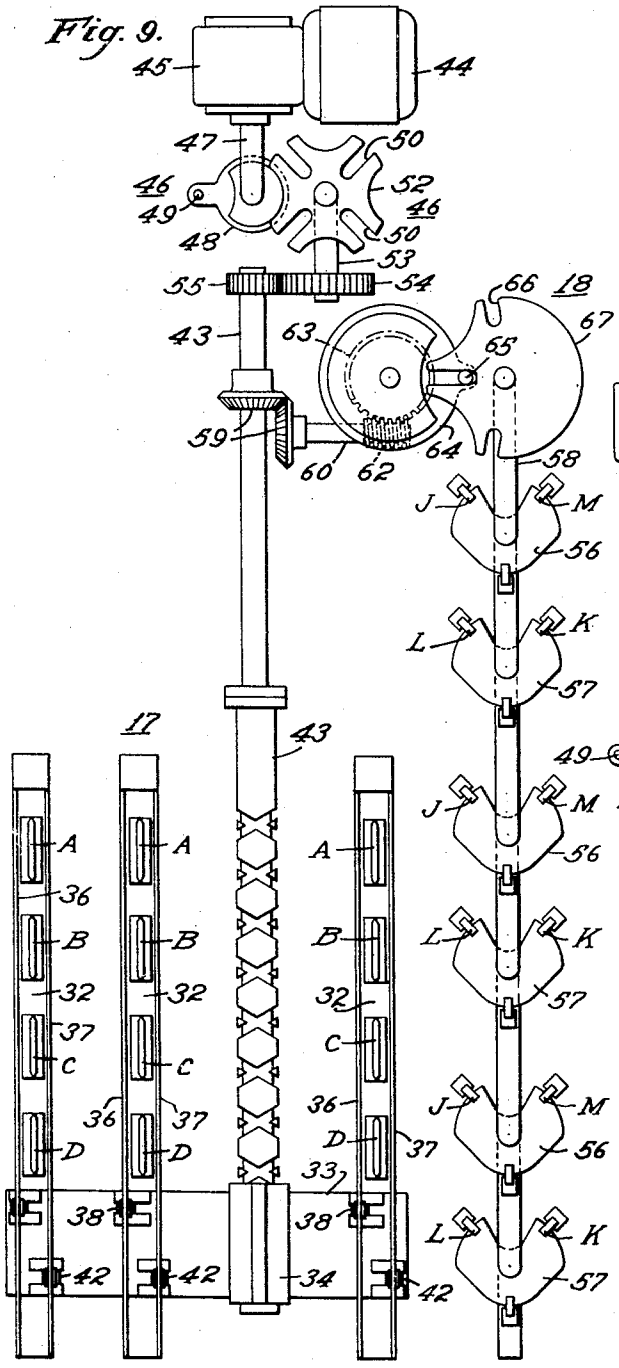
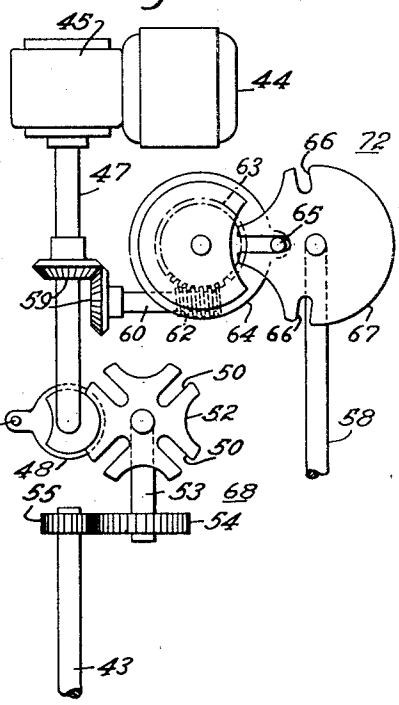


Fig. 10.



WITNESSES:

Edward Michaels

Mrs. C. Goodwin

INVENTOR

Franklin L. Snyder.

BY

Franklin E. Hardy

ATTORNEY

Patented May 23, 1944 2,349,682

UNITED STATES PATENT OFFICE

2,349,682

ELECTRICAL APPARATUS

Franklin L. Snyder, Sharon, Pa., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application October 10, 1942, Serial No. 461,574

8 Claims. (Cl. 171—119)

This invention relates to apparatus for adjusting the voltage of alternating-current electrical circuits, and has particular relation to equipment for effecting such adjustment in a plurality of steps without interrupting the load current of the circuit.

In maintaining the voltage supplied to load centers through distribution or feeder circuits, regulating apparatus is required to correct for variations in the voltage of the power source resulting in changes in the circuit impedance drop which result from load fluctuations on the supply circuit. My invention is directed to a step type voltage regulator which is particularly well suited for application to feeder circuits of relatively high-voltage low-current ratings which are prevalent in present day distribution systems.

An object of my invention is to provide an equipment involving multi-tap transformer windings for regulating the voltage of alternating-current circuits having improved mechanical means for actuating the circuit controlling switches of a tap changing mechanism to secure fast contact operation without mechanical shock.

A further object of the invention is the provision of means for effecting a quick switching operation in transferring the circuit conductor connection from one transformer tap connection to another and to thus reduce arcing at the contacts.

Other objects and advantages of the invention will be apparent from the following description of preferred embodiments thereof, reference being had to the accompanying drawings, in which:

Figure 1 is a diagrammatic view of the circuits and switching apparatus of a single phase tap changing regulator organized in accordance with the invention, and which will be duplicated in each phase of a polyphase regulator.

Fig. 2 is a diagrammatic view illustrating the manner in which the tap changer and reversing switch mechanisms are incorporated with the windings of the main regulating and tap changing transformers in each phase of the equipment,

Fig. 3 is a chart showing the sequence of operation of the several switches utilized by the tape changing equipment shown in Fig. 1,

Fig. 4 is a sectional view taken on the line IV—IV of Fig. 5, on a reduced scale illustrating the mechanical details of the tap changing and reversing switch assemblages for a three-phase equipment, each phase corresponding to the circuit shown in Figs. 1 and 2,

Fig. 5 is a horizontal sectional view taken on an enlarged scale along the line V—V of Fig. 4,

Fig. 6 is a vertical view taken along the line VI—VI of Fig. 4, showing the construction of the tap changing switches and their operating mechanism,

Fig. 7 is a vertical sectional view similar to Fig. 4, but showing a modified form of apparatus in which the motorized driving equipment is mounted below the tap changing switches,

Fig. 8 is a horizontal sectional view taken along the line VIII—VIII in Fig. 7,

Fig. 9 is a diagrammatic view of the mechanical connections between the driving motor and the switch operating mechanism of the apparatus corresponding to that shown in Figs. 4, 5 and 6, and

Fig. 10 is a diagrammatic view of the mechanical connections between the driving motor and the switches corresponding to the equipment shown in Figs. 7 and 8.

Referring to Fig. 1 of the drawings, the voltage adjusting equipment of my invention is diagrammatically illustrated as comprising for each phase of the circuit to be regulated a transformer having a main primary or exciting winding 12 connected to receive energization from the voltage of the supply circuit represented by conductors 13 and 14 and a series winding 15 inductively related to the winding 12 and adapted to connect the supply conductor 13 to one of the conductors 16 of the circuit 16—14 to be regulated through operation of tap changing switches 17 and reversing switches 18.

The assembly of tap changing switches 16 is associated with the winding 14 which is provided with a plurality of tap connections represented as *a*, *b*, *c*, *d* and *e*, and respectively connected to switch segments A, B, C, D and E with which segments a pair of movable contact members X and Y is adapted to cooperate. The movable contact members X and Y are connected to the opposite ends of a tap bridging auto-transformer winding 22. The series connection of the winding 15 with the regulated circuit includes one end 23 of the winding, the mid-point 24 of the tap bridging auto-transformer winding 22 and switches J, K, L and M included in the reversing switch equipment assembly 18. By properly operating the tap changing and reversing switches, the voltage of the regulated circuit may be varied with respect to that of the supply circuit in 9 separate steps with the five tap wind-

ings shown. The proper sequence is set forth in the sequence chart shown in Fig. 3.

The tap changing switches comprising the fixed segments A to E and the movable contact members X and Y perform all of the load switching operations, so that all arcing is confined to these switches. The reversing switches J, K, L and M reverse the series connection between the winding 15 of the regulating equipment and the winding 12 as the tap changing equipment passes through the neutral position in which the winding 15 neither bucks or boosts the voltage supplied to the regulated circuit with respect to that received from the supply circuit. Since the voltage across the switches J, K, L and M is substantially zero when they are operated, no appreciable arcing takes place at their contacts. By reversing the connection of the winding 15 with respect to that of the winding 12, the number of tap leads required for a given number of operating tap positions is only one more than half of the number of those positions, and a correspondingly reduced number of tap switches are required for effecting a given range of operation or number of voltage steps. The tap changing auto-transformer winding 22 is short-circuited on each operating position in which the two contact members X and Y are in engagement with the same conducting segment A to E, thereby eliminating the exciting current in this winding, except during the period of transition from one tap changing position to the next in which the two contact members X and Y are in engagement with adjacent segments A to E.

In the chart shown in Fig. 3, the presence of a circle indicates that the switch indicated in the column at the left is closed, and the absence of the circle indicates that the switch is open. Thus in the first position of the voltage adjusting mechanism which is indicated at the left-hand column of the chart of Fig. 3 under the numeral "1," the tap changing switches indicated by conducting members X—A and Y—A are closed and the reversing switches J and L are likewise closed and all of the remaining switches in the system are in their open positions.

For this first tap position, the full length of the winding 15 is connected between the conductor 13 of the supply circuit and conductor 16 of the regulating circuit in a direction such that the voltage induced in the winding 15 as a result of the flux developed by the series winding 15 aids or adds to that of the supply circuit voltage, thus increasing the voltage appearing between the regulated circuit conductors 14 and 16 above the voltage between the supply conductors 13 and 14. When the equipment occupies tap position No. 1, a maximum value of regulated voltage for a given supply circuit voltage results. In this position as in each of the other tap changing positions, the two ends of the winding 22 are each connected between the same tap segment A to E.

To reduce the voltage of the regulated circuit by one tap changer step, the switches are operated from position No. 1 to position No. 2 of the chart. During this operation the movable contact members X and Y are moved downwardly, the contact member Y first separating from engagement with the segment A and engaging segment B, as shown in the intermediate position in the chart between tap changing positions Nos. 1 and 2. Temporarily the voltage of the point 24 on the winding 22 will be a voltage intermediate that of the segments A and B. The contact member X upon further downward movement engages the conducting segment B bringing both ends of the winding 22 into engagement with the segment B through switch contact members X and Y, as shown in position No. 2 of the chart.

Continued movement of the equipment in the same direction causes a further reduction in the regulated voltage. By advancing the equipment to position No. 3 shown in the chart, the conductor 16 is connected to the winding tap *c* and in position No. 4 in the shart it is connected to the tap *d*. With each successive movement of the tap changing equipment, an additional portion of the winding 15 between adjacent tap segments is removed from the circuit between the winding 12 and the conductor 16 until, in position No. 5, the contact members X and Y are in engagement with the segment E, and the voltage between conductors 16—14 will correspond to that across the winding 12. In this position of the equipment, it will be noted that the reversing switches K and M are closed, together with the switches J and L which have been closed during operation of the equipment from position No. 1 to position No. 5.

Upon further operation of the equipment in a direction to reduce the voltage of the regulated circuit, the voltage of this circuit will be below that of the supply circuit voltage impressed across the winding 12. In movement of the equipment from position No. 5 to position No. 6, the switches J and L are opened so that the turns of the winding 15, connected between the conductors 13 and 16, will be connected in the opposite direction from that which existed during operation of the mechanism from position No. 1 to position No. 5. As a result of this reversal of connection in the winding turns, the voltage of the winding 15 that is introduced into the supply circuit opposes or bucks the supply circuit voltage so that when the equipment has advanced to position No. 6, the regulated voltage between conductors 16 and 14 is reduced one step below that of the supply circuit voltage between conductors 13 and 14. Further movement of the equipment to position No. 7 increases the amount of this reduction in voltage of the regulated circuit, as does each successive step of movement of the tap changing equipment. In position No. 9, the full voltage of the winding 15 is effective in reducing the regulated voltage with respect to that of the supply circuit voltage.

To progressively raise the regulated circuit voltage, the equipment is operated in the reverse direction from position No. 9 of the chart toward position No. 1 through a series of operations which are exactly the reverse of those just described.

I have illustrated in Figs. 4, 5 and 6, the structure of a three-phase regulating equipment for use on a three-phase circuit. Each of the three phases of the circuit is provided with a regulating transformer including shunt and series windings 12 and 15, a set of tap changing switches 17 and a set of reversing switches 18. The conductor 14 may represent the ground connection of the system and the three sets of transformer windings will be supplied by three conductors 13 of the three-phase supply circuit and will supply

power to three conductors 16 of the three-phase conductors regulated circuit.

Fig. 5 illustrates one preferred arrangement of the apparatus. The three regulating auto-transformers comprising the windings 12 and 15 are positioned side by side in the rear tank compartment 25 and indicated by the outlines 26. Also mounted in this compartment are the tap bridging auto transformers indicated by the numeral 22 in Figs. 1 and 2 and indicated in Fig. 5 by the outlines 27. A compartment 28 is provided to house the tap changing switches and reversing switch assemblies. This compartment is adapted to be filled with insulating oil.

The operating equipment is illustrated in Figs. 2, 4, 5, 6 and 9 as occupying position No. 5 on the chart of Fig. 3. The segments A to E of each of the tap changing switch assemblies 17, which segments are connected with the tap conductors *a* to *e*, respectively, of the winding 15 of each of the three regulating transformers, are in the form of protruding metal plates mounted upon a vertically positioned panel or strip 32 of insulating material while the associated movable fingers X and Y connected to the ends of each tap bridging auto-transformer winding 22 are carried by a panel or movable carriage 33 of insulating material which is supported by bracket member 34.

As perhaps best shown in Fig. 2, the opposite ends of the tap bridging auto-transformer winding 22 are connected through conductors 35 to parallel conducting strips 36 and 37 extending in vertical positions on one side of the movable carriage 33 and connected respectively through travelling contact members 38 and 42 with the contact members X and Y that engage the various tap changing conducting segments A to E, inclusive. It will be noted that the conducting segments A to E, inclusive, are of a length slightly greater than the spacing between the cooperating movable contact members X and Y and the spacing between the adjacently positioned segments is slightly less than the spacing between the members X and Y. As a result of this spacing when the equipment is in any one of its operative positions, both ends of the tap bridging winding 22 are connected to the same stationary conducting segment so that current flowing through the two halves of the winding to the middle point 24 tends to deenergize the winding.

Referring particularly to Figs. 4 and 9, the tap switch operating shaft 43 may be driven in any suitable manner as manually or by an electric motor 44 through a suitable reduction gearing 45 and a drive shaft 47. The motor may be controlled by means of a conventional primary and secondary relays governed in accordance with the voltage of the regulated circuit in a well-known manner and which are not shown in the drawings. For the purpose of effecting a quick movement of the panel 33 carrying the movable contact members X and Y from engagement with one contact segment A to E to the adjacent segment, a gear train including a Geneva gear connection indicated generally by the numeral 46, is provided between the driving shaft 47 and the driven shaft 43 which includes a Geneva pinion 48 having a pin 49 adapted to engage within a slot 50 of the Geneva gear 52. The gear 52 drives a shaft 53 upon which is mounted a spur gear 54 engaging a spur gear 55 mounted on the shaft 43. During the operation of the motor 44 for operating the tap changing equipment in either direction from the position 5 shown, the shaft 47 carrying the pin 49 will move at a constant rate of speed. The movable contact members X and Y will, however, not move until the pin 49 engages within the slot 50 of the Geneva gear 52 and through a relatively small movement of the shaft 47 causes the gear 52 to move from one position to the next, this being a quarter of a turn in the mechanism illustrated. As the pin 49 engages the gear 52, this gear starts to move slowly and accelerates rapidly to its maximum speed, and then decelerates rapidly, so that the carriage is moved quickly without mechanical shock. During this quarter of a turn of the member 52, the shaft 43 will be rotated a sufficient amount to move the carriage 33 upwardly from one tap changing position to the next, this movement taking place rapidly so that the arcing between the movable contact members X and Y and the segments engaged thereby will be very slight, thus reducing to a minimum any damage to the switch segments and conducting members which might be caused by excessive arcing.

The reversing switch assembly 18 which comprises two conducting disk members 56 and 57 for each of the three phases of the apparatus carried by a reversing switch shaft 58 may be operated from the shaft 43, as shown in Figs. 4 and 9, through a train of gears including spur gears 59, a shaft 60 carrying a worm 62 for engaging a worm gear 63 which, in turn, drives a Geneva pinion 64 carrying a pin 65 for engaging one of the three slots 66 in a Geneva gear 67 mounted on the shaft 58. In the illustrated position of the apparatus corresponding to position No. 5 on the chart in Fig. 3, the switch J, K, L and M are all closed. Upon movement of the shaft 43 in either direction from this position, the shaft 47 will be operated abruptly through the Geneva gear train so as to open switches J and L retaining switches K and M closed, or to open switches K and M, retaining switches J and L closed, depending upon in which direction from position No. 5 the equipment is operated.

Referring to the modified form of the equipment shown in Figs. 7, 8 and 10, the motor is placed at the bottom of the equipment and drives the driving shaft 47 through the reduction gear 45. In this form of the equipment the tap changing switch shaft 43 is driven through a Geneva gear and spur gear train 68 that is structurally similar to that shown in Fig. 9 between the shafts 47 and 43, and the shaft 58 is driven through a train of gears 72 including the worm gear drive and the Geneva gear connected between shafts 43 and 58 in Fig. 9. In the form shown in Figs. 7 and 8 however, this second gear train 72 is driven directly from the driving shaft 47 instead of from the tap changing switch shaft 43.

The tap switch operating shaft 43 is provided with two independent screw-like grooves best shown in Fig. 6, at 73 and 74, one of which, as the shaft is rotated in a given direction, serves to move the cooperating brackets 34 downwardly to their illustrated lower limit of travel, at which time control thereof is transferred to the second one of the grooves which serves upon continuation of the rotation in the same direction to move the bracket members 34 and the movable carriage 33 carrying the contact members X and Y upwardly along its length of travel.

Modifications may be made in the apparatus illustrated and described within the spirit of my invention, and I do not wish to be limited other-

wise than by the scope of the appended claims.

I claim as my invention:

1. Apparatus for changing tap connections between a circuit conductor and a selected one of a plurality of tap conductors connected to a winding for adjusting the portion of the winding that is included in an electric circuit comprising, in combination, tap changing means which include a plurality of stationary switch contact segments respectively connected with the winding tap conductors and mounted in spaced straight line relation, cooperating switch contact fingers, a movable member for supporting said fingers in engageable relation with the conducting segments, and a tap switch operating shaft adapted to parallel said line of contact segments and to threadedly engage said movable member in a manner that when rotated it shifts the contact fingers through their extreme position at one end of the line of the plurality of segments in which the winding portion in active circuit is zero, means, comprising switches, for reversing the winding in its connection with the circuit, a reversing switch actuating shaft, means comprising a Geneva gear connection between said two shafts, whereby a movement of the tap switch operating shaft through the position in which the active portion of the winding is zero effects a switch actuating movement of the reversing switch actuating shaft, and means for driving the tap switch operating shaft comprising a driving shaft and a second Geneva gear connection between the driving shaft and the tap switch operating shaft for effecting a quick movement of the switch contact fingers from engagement with one set of contact segments to engagement with another set of contact segments through a relatively small movement of rotation of the driving shaft.

2. Apparatus for changing the connection of a circuit conductor from one to another of the tap connecting points of a multi-tap transformer winding comprising, in combination, a plurality of stationary contact segments respectively connected with the winding tap conductors points and stationarily mounted in spaced straight line relation, a pair of contact fingers, a movable member for spacedly supporting said fingers in engageable relation with said segments, and a tap switch operating shaft positioned to parallel said line of contact segments and adapted to threadedly engage said movable member in a manner that when rotated in a given direction it effects a shifting of the contact fingers from an extreme position at one end of the line of contact segments to a corresponding position at the opposite end of the line and then back to the first-named position, and means for driving the tap switch operating shaft comprising a driving shaft and a second Geneva gear connected between the driving shaft and the tap switch operating shaft for effecting a quick movement of the switch contact fingers from engagement with one set of contact segments into engagement with another set of contact segments through a relatively small movement of rotation of the driving shaft.

3. Apparatus for changing the tap connections between a circuit conductor and a selected one of a plurality of tap conductors connected to a winding for adjusting the portion of the winding that is included in an electric circuit and for reversing the connection when said active winding portion is adjusted to zero comprising, in combination, tap changing means which include a plurality of stationary switch contact segments respectively connected with the winding tap conductors mounted in spaced straight line relation, cooperating switch contact fingers, a movable member for supporting said fingers in engageable relation with the conducting segments, and a tap switch operating shaft adapted to parallel said line of contact segments and to threadedly engage said movable member in a manner that when rotated it shifts the contact fingers through their extreme position at one end of the line of conducting segments in which the winding portion active circuit is zero, means, comprising switches, for reversing the winding in its connection with the circuit, a reversing switch operating shaft, and means for driving the reversing switch operating shaft comprising a Geneva gear connection between the tap switch operating shaft and the reversing switch operating shaft for effecting a quick movement of the reversing switch operating shaft upon a relatively small movement of the tap switch operating shaft through its said zero winding portion range, and means for driving the tap switch operating shaft comprising a driving shaft and a second Geneva gear connection between the driving shaft and the tap switch operating shaft for effecting a quick movement of the switch contact fingers from engagement from one set of contact segments to engagement with another set of contact segments through a relatively small movement of rotation of the driving shaft.

4. Apparatus for changing the tap connections between a circuit conductor and a selected one of a plurality of tap conductors connected to a winding for adjusting the portion of the winding that is included in an electric circuit and for reversing the connection when said active winding portion is adjusted to zero comprising, in combination, tap changing means including a plurality of stationary switch contact segments respectively connected with the winding tap conductors mounted in spaced straight line relation, cooperating switch contact fingers in engageable relation with the segments, and a tap switch operating shaft adapted to parallel said line of contact segments and to threadedly engage said movable member in a manner that when rotated it shifts the contact fingers through their extreme position at one end of the line of contact segments in which the winding portion in active circuit is zero, means, comprising switches, for reversing the connection of the winding in the circuit, means for driving the tap switch operating shaft comprising a driving shaft and a Geneva gear connection between the driving shaft and the tap switch operating shaft for effecting a quick movement of the contact fingers from engagement with one set of contact segments to engage with another set of contact segments through a relatively small movement of rotation of the driving shaft, a reversing switch operating shaft and means for driving the reversing switch operating shaft comprising a second Geneva gear connection between the driving shaft and the reversing switch operating shaft for effecting a quick movement of the reversing switch operating shaft upon a relatively small movement of the driving shaft through the range of movement of the driving shaft in which the tap switch operating shaft is actuated through its said zero winding portion range.

5. Apparatus for changing tap connections between a circuit conductor and a selected one of a plurality of tap conductors connected to a wind-

ing for adjusting the portion of the winding that is included in an electric circuit comprising, in combination, tap changing means which include a plurality of stationary switch contact segments respectively connected with the winding tap conductors, cooperating switch contact fingers, a movable member for supporting said fingers in engageable relation with the conducting segments, and a tap switch operating shaft adapted to operate said movable member in a manner that when actuated it shifts the contact fingers through their extreme position at one end of the line of the plurality of segments in which the winding portion in active circuit is zero, means for reversing the connection of the winding in the circuit comprising a reversing switch actuating shaft, and means comprising a Geneva gear connection between said two shafts, whereby a movement of the tap switch operating shaft through the position in which the active portion of the winding is zero effects a switch actuating movement of the reversing switch actuating shaft, and means for driving the tap switch operating shaft comprising a driving shaft and a second Geneva gear connection between the driving shaft and the tap switch operating shaft for effecting a quick movement of the switch contact fingers from engagement with one set of contact segments to engagement with another set of contact segments through a relatively small movement of rotation of the driving shaft.

6. Apparatus for changing the connection of a circuit conductor from one to another of the tap connecting points of a multi-tap transformer winding comprising, in combination, a plurality of stationary contact segments respectively connected with the winding tap points, a pair of contact fingers, a movable member for spacedly supporting said fingers in engageable relation with said segments, and a tap switch operating shaft positioned to operate said movable member in a manner that when rotated in a given direction it effects a shifting of the contact fingers from an extreme position at one end of the line of contact segments to a corresponding position at the opposite end of the line and then back to the first-named position, and means for driving the tap switch operating shaft comprising a driving shaft and a Geneva gear connected between the driving shaft and the tap switch operating shaft for effecting a quick movement of the switch contact fingers from engagement with one set of contact segments into engagement with another set of contact segments through a relatively small movement of rotation of the driving shaft.

7. Apparatus for changing the tap connections between a circuit conductor and a selected one of a plurality of tap conductors connected to a winding for adjusting the portion of the winding that is included in an electric circuit and for reversing the connection when said active winding portion is adjusted to zero comprising, in combination, tap changing means which include a plurality of stationary switch contact segments respectively connected with the winding tap conductors, cooperating switch contact fingers, a movable member for supporting said fingers in engageable relation with the conducting segments, and a tap switch operating shaft adapted to operate said movable member in a manner that when actuated in shifts the contact fingers through their extreme position at one end of the line of conducting segments in which the winding portion in active circuit is zero, means, comprising switches, for reversing the winding in its connection with the circuit, a reversing switch operating shaft, and means for driving the reversing switch operating shaft comprising a Geneva gear connection between the tap switch operating shaft and the reversing switch operating shaft for effecting a quick movement of the reversing switch operating shaft upon a relatively small movement of the tap switch operating shaft through its said zero winding portion range, and means for driving the tap switch operating shaft comprising a driving shaft and a second Geneva gear connection between the driving shaft and the tap switch operating shaft for effecting a quick movement of the switch contact fingers from engagement from one set of contact segments to engagement with another set of contact segments through a relatively small movement of rotation of the driving shaft.

8. Apparatus for changing the tap connections between a circuit conductor and a selected one of a plurality of tap conductors connected to a winding for adjusting the portion of the winding that is included in an electric circuit and for reversing the connection when said active winding portion is adjusted to zero comprising, in combination, tap changing means including a plurality of stationary switch contact segments respectively connected with the winding tap conductors cooperating switch contact fingers in engageable relation with the segments, and a tap switch operating shaft adapted to operate said movable member in a manner that when actuated it shifts the contact fingers through their extreme position at one end of the line of contact segments in which the winding portion in active circuit is zero, means for reversing the connection of the winding in the circuit, means for driving the tap switch operating shaft comprising a driving shaft and a Geneva gear connection between the driving shaft and the tap switch operating shaft for effecting a quick movement of the contact fingers from engagement with one set of contact segments to engagement with another set of contact segments through a relatively small movement of rotation of the driving shaft, a reversing switch operating shaft and means for driving the reversing switch operating shaft comprising a second Geneva gear connection between the driving shaft and the reversing switch operating shaft for effecting a quick movement of the reversing switch operating shaft upon a relatively small movement of the driving shaft through the range of movement of the driving shaft in which the tap switch operating shaft is actuated through its said zero winding portion range.

FRANKLIN L. SNYDER.