

July 17, 1962

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3,045,173

TRANSFORMER PROTECTIVE DEVICE

Filed May 1, 1959

3 Sheets-Sheet 1

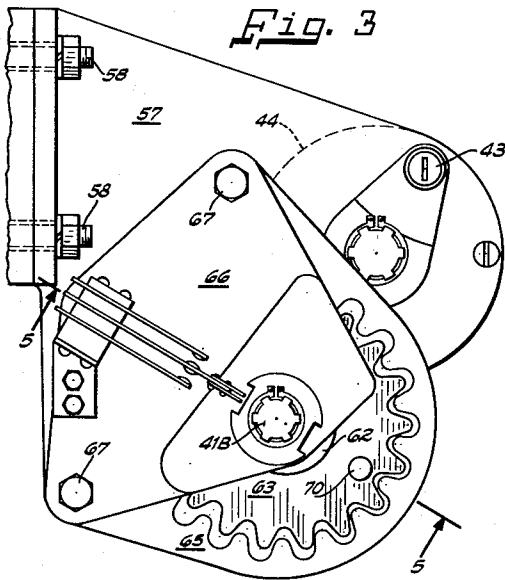
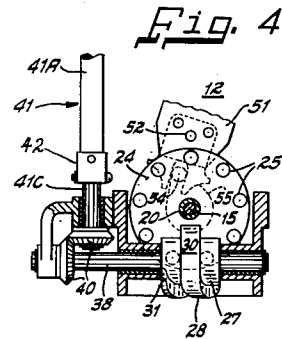
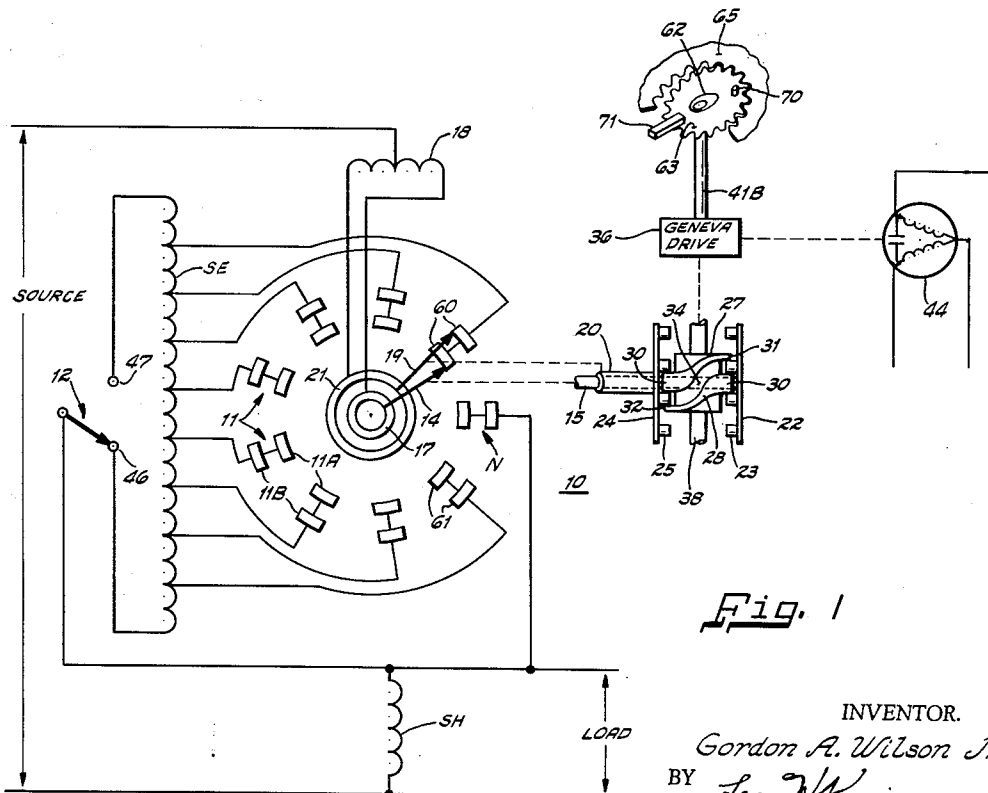


Fig. 1

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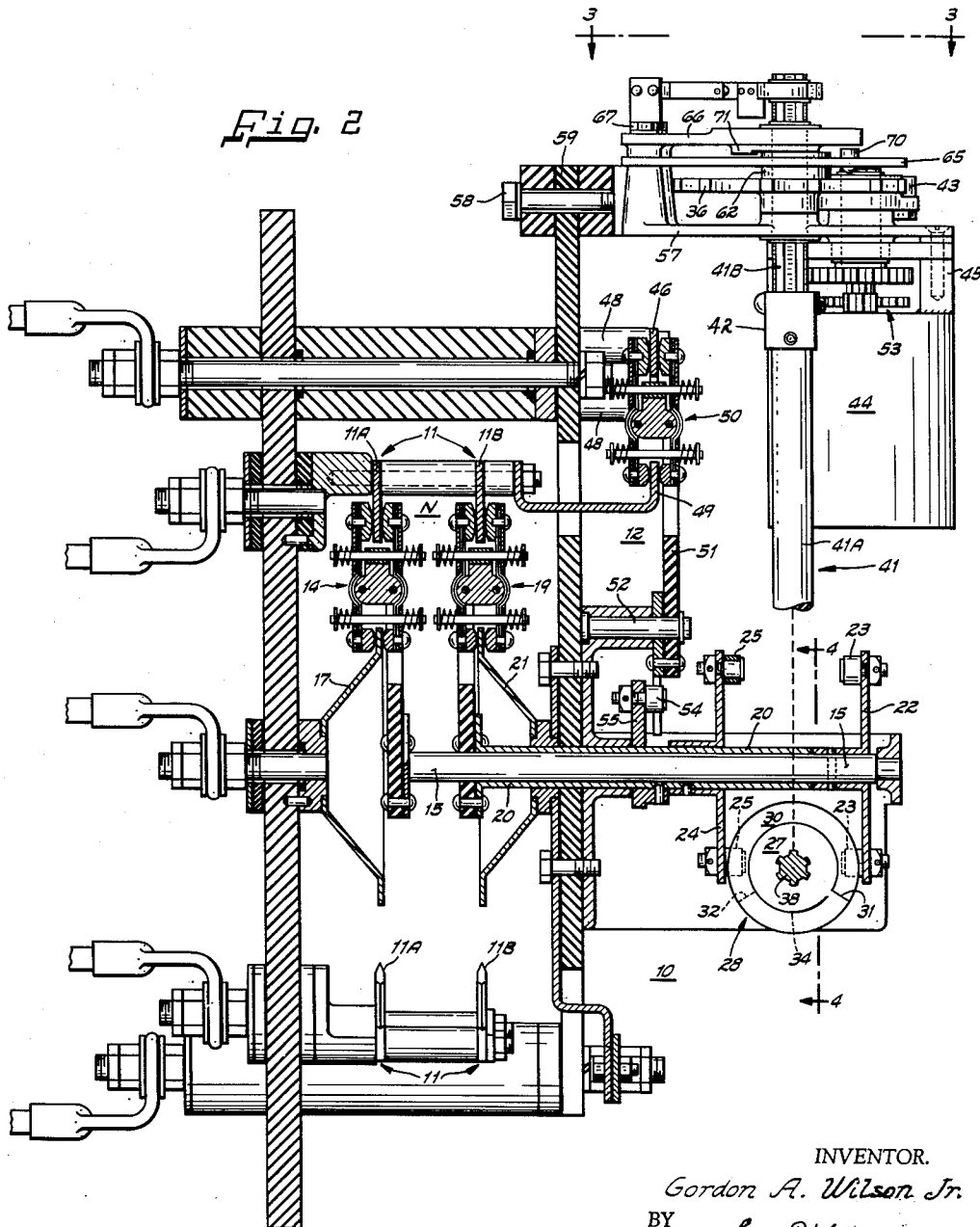
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3 Sheets-Sheet 2



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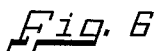
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TRANSFORMER PROTECTIVE DEVICE

3 Sheets-Sheet 3



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3,045,173

TRANSFORMER PROTECTIVE DEVICE

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10 Claims. (Cl. 323—43.5)

This invention relates to stationary induction apparatus and in particular to load tap changing mechanisms for stationary induction apparatus.

In any constant potential system involving two separately located and independently varying loads, series impedance introduces changes in the relative voltage level between the two points with changes in load which cannot be neutralized by the control of the generator field. Auxiliary voltage control devices such as load tap changing transformers are therefore required if the voltage at the several points of utilization are to be maintained at substantially constant value. In transformers designed for the purpose of maintaining a constant voltage on a power system, tap changers are conventionally utilized to change the ratio of transformation by increasing or decreasing the number of active turns in one winding with respect to another winding. Such a tap changer must be capable of effecting a change in the output voltage of the transformer without interrupting the input or output circuits of the transformer. In order to accomplish this change in turn ratio without interfering with the load, it is necessary to provide at least two moving contacts so that one of the moving contacts will at all times maintain an uninterrupted electrical circuit from the input to the output of the transformer. However, when the movable contacts are in engagement with adjacent stationary contacts, the current flow through the movable contacts would be excessive unless a bridging reactor, or preventive autotransformer, were connected thereto for limiting the resulting circulating current to a safe value during the interval that two adjacent taps are bridged.

If a tap changer is rotated beyond its minimum or maximum position, the preventive autotransformer would be connected across all of the tapped portion of the transformer winding, thus causing excessive current to flow through the preventive autotransformer.

It is an object of the invention to provide in a transformer tap changer having a preventive autotransformer for shunting the load current from one winding tap to the next, novel stop means to prevent the rotation of the tap changer beyond its maximum or minimum positions and thus prevent flow of excessive current through the preventive autotransformer. It is a further object to provide such novel stop mechanism having a single means effective to prevent actuation of the tap changer beyond its normal operating range in either the maximum or the minimum direction. A still further object of the invention is to provide such a transformer stop mechanism which is much more compact, simpler, and less expensive than conventional transformer stop mechanisms and which provides a material saving in the size and weight of pole-mounted voltage regulators in which it is utilized.

These and other objects and advantages of the invention will be more apparent from the following detailed description when taken in conjunction with the accompanying drawing wherein:

FIG. 1 is a schematic circuit diagram of a transformer tap changer embodying the invention;

FIG. 2 is a sectional view through a tap changer incorporating a preferred embodiment of the invention;

FIG. 3 is a top view of the stop means taken along lines 3—3 of FIG. 2;

FIG. 4 is a detail sectional view taken along lines 4—4 of FIG. 2;

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FIG. 5 is a sectional view taken on line 5—5 of FIG. 3 and omitting the drive motor; and

FIG. 6 is a sectional view taken on line 6—6 of FIG. 5.

The indexing means of the tap changer 10 embodying the invention is disclosed and claimed in my co-pending application entitled "Tap Changer", Serial No. 810,489 filed May 1, 1959, and having the same assignee as the present invention. Tap changer 10 will be described as embodied in an autotransformer type voltage regulator adapted to be mounted on a pole. Tap changer 10 includes a plurality of arcuately disposed stationary contacts 11 comprising a first set of nine coplanar stationary contact members 11A arranged in a circle and a second set of nine coplanar stationary contact members 11B also arranged in a circle and spaced axially from the first set of stationary contact members 11A and electrically connected thereto. Eight stationary contacts 11 are electrically connected as shown in the schematic diagram of FIG. 1 to individual taps in the tapped series winding SE of the autotransformer type voltage regulator. The ninth stationary contact N is the "neutral" contact which is connected to one end of the shunt winding SH and also connected by the reversing switch 12 to one end of the series winding SE. One movable contact 14 of the tap changer carried by a rotatable shaft 15 is adapted to sequentially engage stationary contact members 11A and to remain continually in electrical contact with a conducting ring 17 connected electrically to one end of the preventive autotransformer 18. A second rotatable contact 19 carried by a sleeve 20 rotatably surrounding shaft 15 is adapted to sequentially engage stationary contact members 11B and remain continually in electrical contact with a conducting ring 21 connected electrically to the other end of the preventive autotransformer 18.

The movable contacts 14 and 19 thus connect the tapped section of the series winding SE into the circuit. Shaft 15 and sleeve 20 are actuated independently so that rotatable contacts 14 and 19 are individually operable. Inasmuch as stationary contact members 11A and 11B are electrically commoned, the rotatable contacts 14 and 19 can be indexed to a "bridging" position wherein each of the rotatable contacts 14 and 19 is on one of two adjacent stationary contacts 11 and the voltage obtained is midway between the taps, or to a "symmetrical" position wherein both movable contacts 14 and 19 are on the same stationary contact. Tap changer 10 and associated series winding SE conventionally provide plus or minus ten percent voltage regulation, and inasmuch as eight stationary contacts 11 are electrically connected to eight taps of the series winding SE, a 1¼ percent variation in voltage occurs when both rotatable contacts 14 and 19 are indexed to a succeeding stationary contact 11. Movement of only one rotatable contact 14 or 19 to a succeeding stationary contact 11 results in a voltage midway between the taps, or ½ percent regulation, and full plus or minus 10 percent voltage regulation is accomplished in thirty-two ⅝ percent steps.

The shaft 15 is affixed to a first rotatable index plate 22 carrying a plurality of circumferentially spaced cam followers 23. The sleeve 20 is affixed to a second rotatable index plate 24 coaxial with and spaced from the first index plate 22 and carrying a plurality of circumferentially spaced cam followers 25. A positive-motion cylindrical cam 27 disposed between index plates 22 and 24 has a single circumferentially extending raised cam track 28 adapted to sequentially engage the cam followers 23 and to sequentially engage the cam followers 25 and to alternately engage and tangentially displace the cam followers 23 and 25. The cylindrical cam 27 is thus adapted to alternately rotate the index plates 22 and 24 and also to alternately index the rotatable contacts 14 and 19 from one stationary contact 11 to a succeeding

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stationary contact. The midportion 30 of raised cam track 28 extends approximately 260 degrees around the circumference of drum cam 27 and is in a plane substantially at right angles to the axis of cam 27. The ends 31 and 32 of cam track 28 overlap and diverge in a generally axial direction on opposite sides of said plane to define a double-edge approximately S-shaped cam track portion 34 adapted to positively constrain a cam follower 23 or 25 as it tangentially displaces it. Two cam followers on the same index plate, e.g., two cam followers 25 on index plate 24, are disposed on opposite sides of midportion 30 to lock movable contact 19 at rest (see FIG. 4) while the double-edge S-shaped cam track portion 34 is displacing a cam follower 23 of the index plate 22 to index rotatable contact 14 from one stationary contact 11 to a succeeding stationary contact 11.

The cam track portion 34 preferably transmits simple harmonic motion to a cam follower 23 or 25 and is adapted to be rotatably driven in three steps by a Geneva gear 36 (see FIGS. 5 and 6) to index a movable contact 14 or 19 between stationary contacts 11. Cylindrical cam 27 is secured, preferably by a splined connection, to a stub shaft 38 which is operatively connected by a set of bevel gears 40 to a drive shaft 41 on which Geneva gear 36 is affixed. Drive shaft 41 preferably comprises a central shaft member 41A connected at its upper end to a splined shaft member 41B carrying Geneva gear 36 and at its lower end to a splined shaft member 41C carrying a bevel gear 40. The three shaft members 41A, 41B, and 41C are interconnected by suitable means such as collars 42 pinned to the ends of the shaft members. Geneva gear 36 and drive shaft 41 are intermittently actuated by a Geneva pinion 43 which is rotatably driven by a prime mover 44, and in the preferred embodiment prime mover 44 is a reversible, single-phase capacitor type motor. As illustrated in the drawing, studs 45 affixed to motor 44 are secured by screws to a drive casting 57 which, in turn, is rigidly affixed by bolts 58 to panel board 59 of the tap changer. Motor 44 responds to a signal from the control circuit of the voltage regulator to drive Geneva pinion 43 through a suitable reduction gear train 53. Geneva pinion 43 engages Geneva gear 36 and imparts intermittent motion to main drive shaft 41 and positive-motion cam 27. In rotating 180 degrees, cylindrical cam 27 engages a cam follower 23 or 25 and drives an index plate 22 or 24 through 40 degrees of rotation. The 40 degree rotation of index plate 22 or 24 causes equal movement of rotatable contact 14 or 19 and this movement produces one tap change of 5% percent.

The direction of cylindrical cam rotation determines the cam follower 23 or 25 that will be engaged to effect a tap change. When positive-motion scroll cam 27 rotates in one direction for successive tap changes, it drives the index plates 22 and 24 alternately in the same direction. The direct indexing of movable contacts 14 and 19 accomplished by cylindrical cam 27 and index plates 22 and 24 inherently insures positive mechanical interlocking of rotatable contacts 14 and 19 and also positively controls contact speed to insure the most efficient arc interruption. Three steps of Geneva gear 36 produce 180 degree rotation of cylindrical cam 27 to positively index one of the rotatable contacts 14 or 19 to a succeeding stationary contact 11, and the Geneva drive 36—43 permits the electric motor 44 to start without load during each step of cam 27.

Reversing switch 12 changes the electrical connection tapped series winding SE from "lower" to "raise" and thus doubles the voltage range of tap changer 10. Reversing switch 12 is only actuated when both movable contacts 14 and 19 engage neutral contact N and thus the reversing switch 12 is out of the load circuit. Stationary contact members 46 and 47 of reversing switch 12 are each connected through support studs 48 to opposite ends of the tapped series winding SE within the transformer

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tank. The reversing switch 12 includes an elongated stationary contact 49 and a movable contact 50. Movable contact 50 is mounted on a switch arm 51 pivoted about a pin 52 and adapted to electrically bridge between elongated contact 49 and a reversing switch stationary contact 46 or 47. When both movable contacts 14 and 19 of the tap changer engage neutral contact N, a driving pin 54 carried by a reversing link 55 affixed to sleeve 20 actuates switch arm 51 to disengage movable contact 50 from one stationary contact 46 or 47 and actuate it into electrical engagement with the other stationary contact.

The drive means of tap changer 10 including motor 44, Geneva gear 36, and cylindrical cam 27 is adapted to rotate movable contacts 14 and 19 from an initial position in engagement with neutral contact N in a clockwise direction into sequential engagement with stationary contacts 11 to a "maximum" position at one limit of the tap changer operating range wherein both movable contacts 14 and 19 engage a stationary contact 60 and the voltage output of the autotransformer is a maximum. Similarly the drive means is adapted to rotate the movable contacts 14 and 19 from the initial position in a counterclockwise direction into sequential engagement with stationary contacts 11 to a second extreme, or "minimum," position wherein both movable contacts 14 and 19 engage stationary contact 61 and the voltage output of the autotransformer is a minimum. It will be apparent from FIG. 1 that if one movable contact 14 or 19 were rotated beyond "maximum" or "minimum" position and into engagement with neutral contact N, the preventive autotransformer 18 would be connected across all the tapped portion of the series winding SE, thus causing excessive current to flow through the preventive autotransformer 18.

The novel means of the invention for preventing rotation of movable contacts 14 and 19 beyond maximum and minimum positions includes a simple internal-gear epicyclic drive and stop means actuated by the driven member of the epicyclic drive to block the drive shaft 41 and motor 44 at the extreme limits of tap changer operating range. Shaft member 41B affixed to Geneva gear 36 has a splined connection with an eccentric 62 which thus rotates with the drive shaft. An oscillating spur gear 63 rotatably mounted on eccentric 62 has external teeth meshing with the internal teeth on an internally toothed gear 65. Internal gear 65 and a top plate 66 disposed above internal gear 65 are secured by bolts 67 to drive casting 57. External spur 63 rotatably mounted on eccentric 62 and internally toothed gear 65 meshing therewith together comprise a simple, inexpensive, and compact epicyclic, or planetary, gear reducer having high speed reduction. Eccentric 62 comprises the driving arm of the epicyclic train rotating about the axis of the fixed internal tooth gear, and eccentric 62 rotates relative to external spur 63 while oscillating it into and out of engagement with the teeth of internal gear 65 and angularly advancing external spur 63 at a low angular velocity relative to fixed gear 65. In the preferred embodiment internal gear is provided with 19 teeth and external spur with 18 teeth so that the gear ratio of the epicyclic, or planetary, gear drive is approximately 1/8.

A stop pin 70 is affixed to spur gear 63 radially away from the axis thereof, and a stop member 71 integral with top plate 66 is in the path of stop pin 70 and limits rotation of spur gear 63 to one turn or approximately 360 degrees. Stop pin 70 has an initial position diametrically opposite from stop member 71, and such initial position corresponds to the initial position of movable contacts 14 and 19 in engagement with neutral contact N. Rotation of movable contacts 14 and 19 in either clockwise or counterclockwise direction from initial position actuates external spur 63 and stop pin 70 carried thereby away from initial position through the reduction gearing provided by the epicyclic train. When both movable contacts 14 and 19 have rotated in one direction from initial

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position to maximum position in engagement with stationary contact 60, stop pin 70 has been rotated by the epicyclic gear train to a position wherein stop member 71 interferes with further rotation of stop pin 70 and external spur 63, thereby mechanically blocking further rotation of drive shaft 41 and movable contacts 14 and 19 and also preventing rotation of contacts 14 and 19 beyond maximum position into engagement with neutral contact N wherein the tapped section of series winding SE would be connected across preventive autotransformer 18 and cause excessive current to flow therethrough. Similarly, when movable contacts 14 and 19 have rotated in a counterclockwise direction to their minimum position in engagement with stationary contact 61, spur gear 63 and stop pin 70 have been rotated by the epicyclic gear drive in the opposite direction from initial position into interfering relation with stop member 71 which blocks further rotation of drive shaft 41 tending to rotate movable contacts 14 and 19 beyond their minimum position and thus positively prevents injury to the preventive autotransformer 18.

In the preferred embodiment of the invention, drive shaft 41 is actuated by motor 44 through 360 degrees to effect movement of both movable contacts 14 and 19 through 40 degrees between adjacent ones of the nine stationary contacts 11. The gear ratio of the planetary, or epicyclic, gear train comprising fixed internal gear 65, spur gear 63, and eccentric 62 rotatably carrying spur 63 is selected to so reduce motion of drive shaft 41 that stop member 71 interferes with stop pin 70 when movable contacts 14 and 19 are at the limits of the normal tap changer operating range. In other words, actuation of drive shaft 41 through somewhat less than nine revolutions results in approximately one half revolution angular advance of spur gear 63 to rotate stop pin 70 from its initial position into interfering relation with stop member 71, and the gear ratio of epicyclic train including internal gear 65 and spur gear 63 is selected to be approximately $\frac{1}{2}n$ where n is the number of stationary contacts sequentially engaged by movable contacts 14 and 19.

In the preferred embodiment illustrated in the drawing, internal gear 65 is provided with 19 teeth and spur gear 63 has 18 teeth, thus giving a gear ratio of 1/18 for the epicyclic gear train. The improved results of the invention can also be obtained with other gear ratios, with different tap changers, and with other stop means. The gear ratio GR for any alternative embodiment may be determined from the relationship.

$$GR = \frac{\text{Driven member rotation (W) from initial to interfering position}}{\text{No. of stationary contacts (n) } \times \text{ drive shaft rotation (y) for } 1-1\frac{1}{4}\% \text{ tap change.}}$$

$$= \frac{w}{ny}$$

In certain embodiments the drive shaft actuating the epicyclic gear train is rotated through an angle y of other than 360° to effect a $1\frac{1}{4}$ percent tap change. For example, in a tap changer wherein 180° rotation of the drive shaft would effect movement of both contacts 14 and 19 between adjacent ones of nine stationary contacts, the epicyclic gear drive would be selected to have a gear ratio of approximately

$$\frac{180^\circ}{9 \text{ times } 180^\circ}$$

equal $\frac{1}{9}$ in order to move stop pin 70 approximately 180° until it abuts against stop member 71.

Although in the preferred embodiment a single stop member 71 interferes with stop pin 70 after 180° rotation of external spur 63 in either direction from an initial position, it will be appreciated that stop means other than members 70 and 71 can be utilized to block further movement of the driven member 63 of the epi-

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cyclic train. Further, such blocking can be accomplished after an angular advance w of the driven member 63 other than 180° degrees from an initial position, for example, after ninety degree rotation of driven member 63 in either direction from an initial position, by employing two stops equivalent to member 71. In such alternative embodiment wherein the driven member 63 is rotated through an angle of w equals ninety degrees from initial to interfering positions, a gear ratio GR of

$$\frac{90^\circ}{n \text{ times } y}$$

would be selected, and assuming a drive shaft that is rotated $y=360^\circ$ degrees to actuate both movable contacts through a tap change and n equals nine stationary contacts, a gear ratio of $90^\circ/9 \text{ times } 360^\circ = \frac{1}{36}$ would be selected to block movement of the rotatable contacts beyond maximum and minimum positions.

Although the invention has been described as having the internal gear of the epicyclic drive fixed, it will be appreciated that in alternative embodiments the external spur can be fixed and the internal gear made the driven gear.

The novel stop means of the invention is extremely simple, inexpensive, and compact in comparison to conventional tap changer stop mechanisms; its utilization in pole mounted step voltage regulators permits material reduction in the size and weight of such apparatus wherein every cubic inch of space and ounce of weight is at a premium; and it positively blocks actuation beyond the maximum and minimum limits of tap changer operating range and does not require manual resetting. While only a single embodiment of the invention has been illustrated and described, many variations and modifications thereof will be apparent to those skilled in the art, and consequently it is intended in the appended claims to cover all such variations and modifications which fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The combination with a transformer tap changer having a preventive autotransformer and a pair of movable contacts each of which is electrically connected to one end of said preventive autotransformer and adapted to rotate from an initial position in one direction into sequential engagement with a plurality of stationary contacts connected to taps on a transformer winding and arranged in a circle to a maximum position at one limit of the operating range of said tap changer and also to rotate from said initial position in the opposite direction into sequential engagement with said stationary contacts to a minimum position at the other limit of the operating range of said tap changer; of means including a reversible prime mover for alternately actuating said movable contacts, means including a simple internal-gear epicyclic gear train driven by said prime mover for preventing rotation of said movable contacts beyond said maximum and minimum positions and thus prevent damage to said autotransformer, said epicyclic gear train having an internally toothed gear and a spur gear disposed within and meshing with said internal gear, one of said gears being fixed and the other carrying a stop member disposed radially away from the axis thereof, said means also including a fixed stop in the path of said stop member.

2. The combination with a transformer tap changer having a preventive autotransformer and a pair of movable contacts each of which is electrically connected to one end of said preventive autotransformer and adapted to rotate from an initial position in one direction into sequential engagement with a plurality of stationary contacts connected to taps on a transformer winding and arranged in a circle to a maximum position at one limit of the operating range of said tap changer and also to rotate from said initial position in the opposite direction into

sequential engagement with said stationary contacts to a minimum position at the other limit of the operating range of said tap changer; of a reversible prime mover, a shaft rotatably driven by said prime mover, means driven from said shaft for alternately actuating said movable contacts, means for preventing rotation of said movable contacts beyond said maximum and minimum positions and thus prevent flow of excessive current through said preventive autotransformer including an eccentric carried by said shaft for rotation therewith, an oscillating member rotatably mounted on said eccentric and oscillated thereby and having external teeth thereon, a fixed gear mounted concentrically with said shaft and having internal teeth thereon in meshing relation with the teeth on said oscillating member, a stop member on said oscillating member, and a fixed stop in the path of said stop member.

3. The combination with a tap changer having a movable contact adapted to rotate from an initial position in one direction into sequential engagement with a plurality of stationary contacts arranged in a circle to a position at one limit of the operating range of said tap changer and also to rotate from said initial position in the opposite direction into sequential engagement with said stationary contacts to a position at the other limit of the operating range of said tap changer; of a reversible prime mover for rotatably driving said movable contact, said prime mover being rotated through a predetermined angle to actuate said movable contact from said initial position to one of said limit positions, an epicyclic gear train driven by said prime mover, the driven member of said epicyclic gear train having an initial position corresponding to the initial position of said movable contact, stop means for blocking movement of said driven member after a predetermined angular rotation thereof in either direction from said initial position, the gear ratio of said epicyclic train being such that said predetermined angular rotation of said prime mover results in actuation of said driven member through approximately said predetermined angle.

4. In combination with a tap changer having a movable contact adapted to move from an initial position into sequential engagement with a plurality of stationary contacts to a position at a limit of the operating range of said tap changer; a prime mover, a shaft rotatably driven by said prime mover, means for interconnecting said shaft and said movable contact, said shaft being rotated through a predetermined angle to actuate said movable contact from said initial position to said limit position, an epicyclic gear train, means for interconnecting said shaft and the driving member of said epicyclic train, the driven member of said train having an initial position corresponding to the initial position of said movable contact, means for stopping said driven member after rotation thereof through a predetermined angle from said initial position, the gear ratio of said epicyclic gear train being such that said predetermined angular rotation of said shaft results in actuation of said driven member through said predetermined angle.

5. The combination with a tap changer having a movable contact adapted to rotate from an initial position in one direction into sequential engagement with n stationary contacts arranged in a circle to a maximum position at one limit of the operating range of said tap changer and also to rotate from said initial position in the opposite direction into sequential engagement with said stationary contacts to a minimum position at the other limit of the operating range of said tap changer; of a reversible prime mover, a shaft, a Geneva pinion rotatably driven by said prime mover, a Geneva gear on said shaft adapted to be intermittently driven by said pinion, intermittent motion transmitting means driven from said shaft for actuating said movable contact step by step into engagement with said stationary contacts, stop means for preventing rotation of said movable contact beyond said

maximum and minimum positions including an eccentric carried by said shaft for rotation therewith, an oscillating member rotatably mounted on said eccentric and oscillated thereby and having $2n$ external teeth thereon, a gear fixedly mounted concentrically with said shaft and having $(2n+1)$ internal teeth thereon in meshing engagement with the teeth on said oscillating member, said oscillating member having an initial position corresponding to the initial position of said movable contact, and means for stopping said oscillating member after rotation thereof through approximately one half revolution in either direction from said initial position.

6. In combination with a transformer tap changer having a preventive autotransformer and a pair of movable contacts each of which is electrically connected to one end of said preventive autotransformer and adapted to move from an initial position in one direction into sequential engagement with a plurality of stationary contacts connected to taps on a transformer winding and arranged in a circle to a maximum position at one limit of the operating range of said tap changer and also to move from said initial position in the opposite direction into sequential engagement with said stationary contacts to a minimum position at the other limit of the operating range of said tap changer; a reversible prime mover, a Geneva pinion rotatably driven by said prime mover, a shaft, a Geneva gear on said shaft adapted to be intermittently driven by said pinion, intermittent motion transmitting means driven from said shaft for alternately actuating said movable contacts step by step into engagement with said stationary contacts, and means for preventing rotation of said movable contacts beyond said maximum and minimum positions including an eccentric carried by said shaft for rotation therewith, an oscillating member rotatably mounted on said eccentric and oscillated thereby, a gear fixedly mounted concentrically with said shaft and having internal teeth thereon in meshing engagement with the teeth on said oscillating member, a stop on said oscillating member, and a fixed member in the path of said stop.

7. The combination with a tap changer having a movable contact adapted to be actuated from an initial position in one direction into sequential engagement with n stationary contacts arranged in a circle to a maximum position at one limit of the operating range of said tap changer and to also rotate from said initial position in the opposite direction into sequential engagement with said stationary contacts to a minimum position at the other limit of the operating range of said tap changer; of a reversible prime mover for actuating said movable contact, stop means including a simple epicyclic gear train having a gear ratio of $\frac{1}{2}n$ actuated by said prime mover for preventing movement of said movable contact beyond said maximum and minimum positions, said gear train including an internally toothed gear and a spur gear disposed within and meshing with said internally toothed gear, one of said gears being fixed and the other carrying a stop member spaced radially from the axis thereof, said stop means also including a fixed stop in the path of said stop member.

8. In combination with a tap changer having a movable contact adapted to be actuated in clockwise and counterclockwise directions from an initial position into sequential engagement with n stationary contacts to maximum and minimum positions at the limits of the operating range of said tap changer; a reversible prime mover, a shaft rotatably driven by said prime mover, means for interconnecting said shaft and said movable contact, said shaft being rotatably driven by said prime mover through 360 degrees each time said movable contact is actuated from one stationary contact to a succeeding stationary contact, means for preventing rotation of said movable contact beyond said maximum and minimum positions including an epicyclic gear train having a gear ratio of $\frac{1}{2}n$ actuated from said shaft, said gear train including an in-

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ternally toothed gear and a spur gear disposed within and meshing with said internally toothed gear, one of said gears being fixed and the other gear having an initial position corresponding to the initial position of said movable contact, and stop means for preventing movement of said other gear after approximately 180 degree rotation thereof in either direction from said initial position.

9. In combination with a tap changer having a movable contact adapted to rotate from an initial position in one direction into sequential engagement with n stationary contacts arranged in a circle to a maximum position at one limit of the operating range of said tap changer and also to rotate from said initial position in the opposite direction into sequential engagement with said stationary contacts to a minimum position at the other limit of the operating range of said tap changer; of a prime mover, a shaft rotatably driven by said prime mover, means interconnecting said shaft and said movable contact, said shaft being rotated through an angle of y degrees for each actuation of said movable contact from one stationary contact to a succeeding stationary contact, a simple internal-gear epicyclic gear train having a gear ratio of GR driven by said shaft and including an internally toothed gear and a spur gear disposed within and meshing with said internally toothed gear, one of said gears being fixed and the other gear having an initial position corresponding to the initial position of said movable contact, and means for stopping said other gear after rotation thereof through $(n \text{ times } y)$ (GR) degrees in either direction from said initial position.

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10. The combination with a tap changer having a movable contact adapted to rotate from an initial position in one direction into sequential engagement with a plurality of stationary contacts arranged in a circle to a maximum position at one limit of the operating range of said tap changer and also to rotate from said initial position in the opposite direction into sequential engagement with said stationary contacts to a minimum position at the other limit of the operating range of said tap changer; of a prime mover for actuating said movable contact, a simple internal-gear epicyclic train driven by said prime mover and including an internally toothed gear and an external spur gear disposed within and meshing with said internally toothed gear, one of said gears being fixed and the other being driven, said driven gear being rotated by said epicyclic train through a predetermined angle when said movable contact is rotated by said prime mover between said maximum and minimum positions, said driven gear having an initial position corresponding to the initial position of said movable contact, and stop means for blocking movement of said driven gear after rotation thereof through half said predetermined angle in either direction from said initial position.

References Cited in the file of this patent

UNITED STATES PATENTS

2,151,534	Scofield	Mar. 21, 1939
2,677,113	Godfrey	Apr. 27, 1954