

Dec. 19, 1967

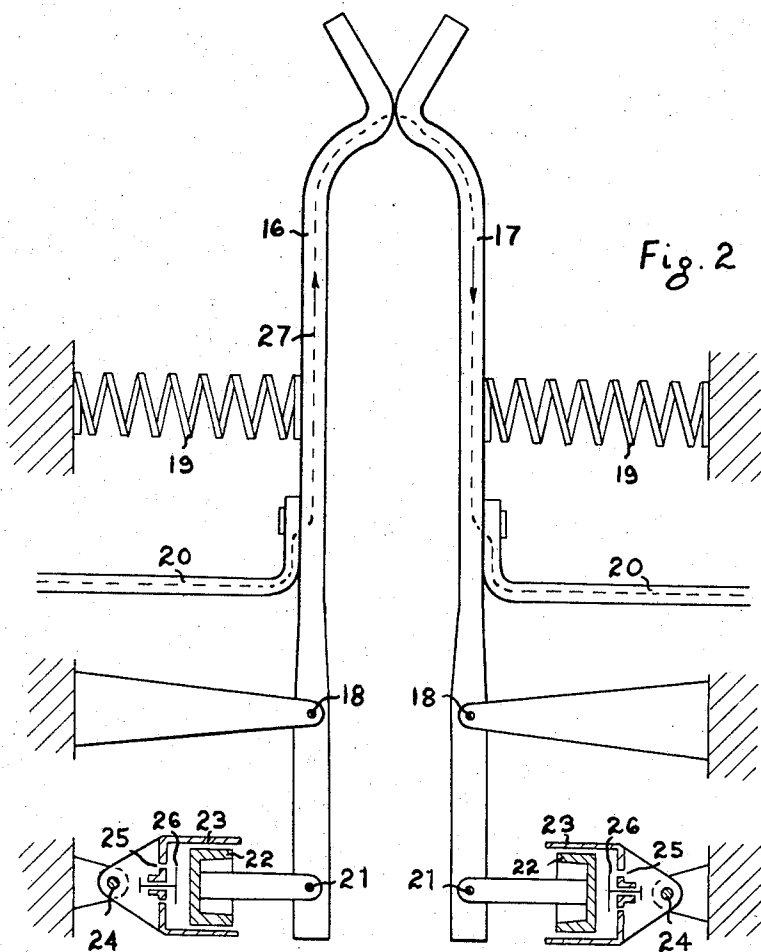
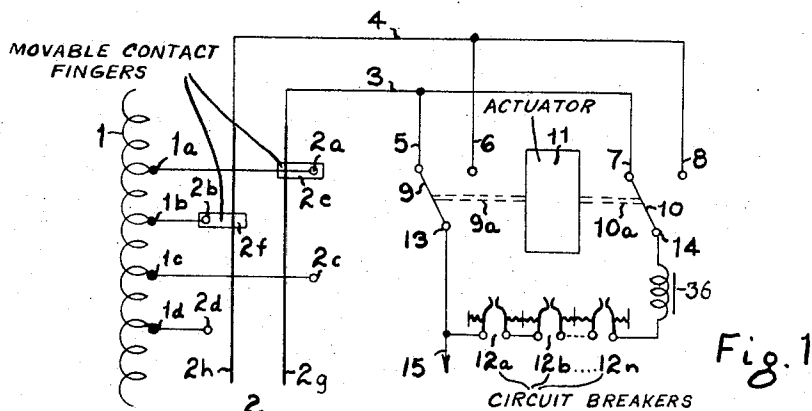
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3,359,485

TAP CHANGING DEVICE FOR TRANSFORMER WINDINGS WITHOUT
INTERRUPTING THE LOAD CURRENT

Filed Sept. 8, 1964

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

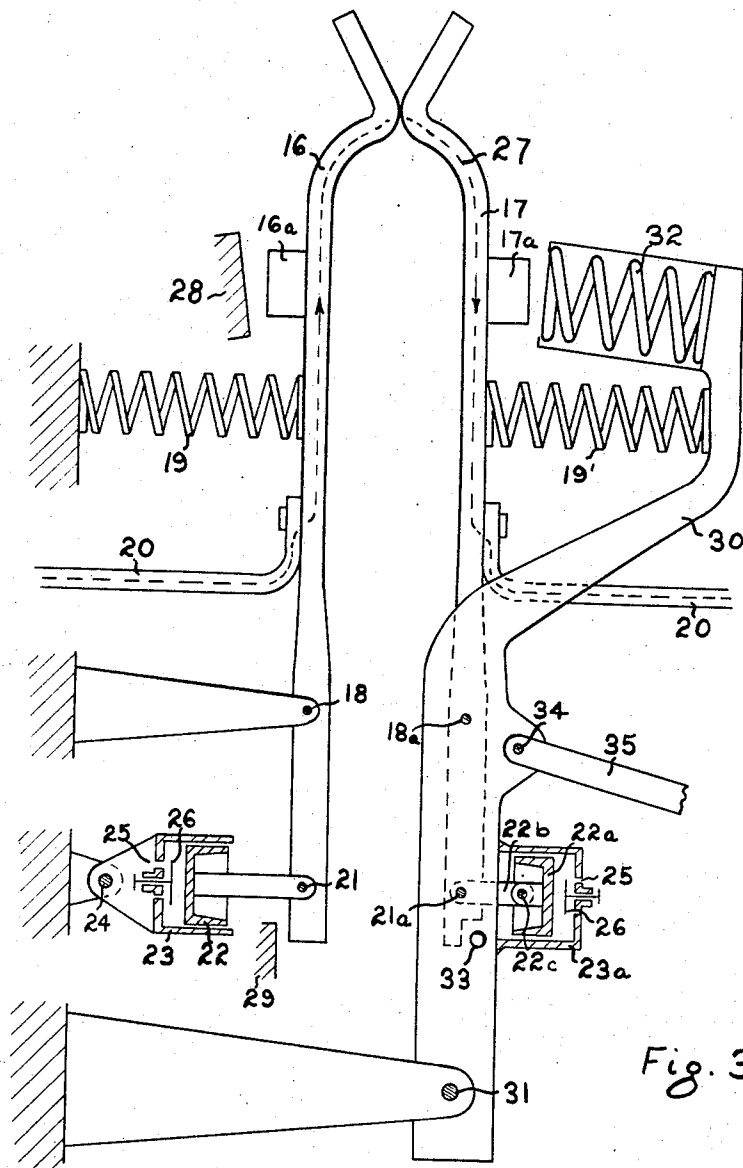


Fig. 3

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1

2

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TAP CHANGING DEVICE FOR TRANSFORMER WINDINGS WITHOUT INTERRUPTING THE LOAD CURRENT

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Filed Sept. 8, 1964, Ser. No. 394,811

Claims priority, application Switzerland, Sept. 27, 1963, 11,939/63

6 Claims. (Cl. 323-43.5)

ABSTRACT OF THE DISCLOSURE

A tap changing device for a transformer winding without interrupting the load current comprises two sets of tap points each of which is associated with a tap changing switch for selecting different taps. Diverter switches are associated with each tap changing switch and connected in series with these diverter switches are a plurality of series connected circuit breakers. The contacts of these circuit breakers are biased to a closed position and remain closed for normal load currents taken off the transformer winding. However, when a temporary short circuit condition through a section of the transformer winding between taps arises as a result of a tap changing operation, the circuit breakers open automatically due to the electrodynamic effect. After interrupting the short circuit current, the circuit breakers re-close due to the biasing action provided—but with a time delay—to enable completion of the diverter switch operation.

The present invention relates to a tap changer for controllable transformers comprising mechanically operable switch means for switching the load from tap to tap. During the change-over from one tap to another the portion of the transformer winding between the taps is momentarily short-circuited. This is necessary to prevent the load circuit from being momentarily broken. In order to prevent a short circuit current from flowing during the brief interval of change-over, conventional on-load tap changers are provided with supplementary contacts and diverter resistors. Although the short circuit current is thus replaced by a reduced circulating current the on-load switch means are nevertheless called upon to rupture heavy currents. The design of the contact fingers of the tap changer as well as of the diverter resistors therefore involves expensive forms of construction. A tap changer which lacks diverting resistors has already been proposed in which means are provided whereby the arcing voltage at the tapping switches exceeds the voltage induced in the inductive circuit between the two taps. To this end the time between rupturing and remaking the connections at the taps must be very short in order to prevent the short circuit current between the taps from exceeding a fraction of its maximum value. This necessity requires mechanically complicated and expensive forms of construction of the means for actuating the contact fingers.

The object of the present invention is to provide a simple and cheap arrangement which avoids the known disadvantages of known forms of construction. The improved tap changing arrangement comprises mechanically operable switching contacts for stepping the load current from one tap to another on the transformer winding. For rupturing the short circuit current which arises during a change-over, the invention proposes to provide circuit breakers which during the tap change are temporarily electrically included in the short circuit between the taps in series with mechanically operable contacts, the circuit breakers being shortly thereafter opened at high speed by the electrodynamic effect of the step short circuit current

and then automatically reclosed by spring means which normally bias the contacts of the circuit breakers to their closed position. Thus, the circuit breakers relieve the mechanically actuated tap changing contacts and also limit the step short circuit current so that there is no need to utilize current limiting resistors in the tap changing arrangement. The idea which underlies the invention will be described in greater detail by reference to the accompanying drawings in which

FIG. 1 is a somewhat schematic representation of an embodiment of the proposed tap changing equipment, whereas

FIG. 2 is an embodiment shown on a larger scale of an automatically rupturing circuit breaker used in the arrangement of FIG. 1.

FIG. 3 illustrates the structural combination of an automatically rupturing circuit breaker and of mechanical actuating gear and locking means.

In FIG. 1 part of the tapped winding of a transformer is shown at 1. It is provided with several taps 1a to 1d connected to the contact elements 2a to 2d of a tap changing switching means 2. 2e and 2f are the movable contact fingers of the tap changer 2 for connecting the contact elements 2a to 2d to bars 2g, 2h in such manner that 2e permits either contact element 2a or 2c to be connected to bar 2g and contact element 2b or 2d to be connected to bar 2h by 2f. The two bars 2g and 2h are connected by lead off conductors 3 and 4 to contacts 5 and 7 and to 6 and 8 respectively. These contacts cooperate with diverter switch means in the form of mechanically operable contact arms 9 and 10, contact arm 9 being shiftable between stationary contacts 5 and 6, and contact arm 10 being shiftable between stationary contacts 7 and 8. The actuator 11 for the contact arms 9 and 10 is coupled to the arms by links 9a and 10a. 12a, 12b . . . 12n are electrically series-connected circuit breakers which automatically open under load, and which are connected between the ends 13 and 14 of the two contact arms 9 and 10. The voltage tapped by the tap changer appears at output lead 15.

The described arrangement functions as follows: In the illustrated position, the output 15 of the tap changer is connected to tap point 1a of the transformer winding 1, the major portion of the load current flowing through contact arm 9. Assuming now that it is desired to change over to tap 1b, then contact arm 9 is first switched over from contact 5 to contact 6, the load current being momentarily diverted through the parallel path formed by 7, 10, 14, 12a to 12n. As soon as arm 9 makes contact with contact 6 a rapidly rising short circuit current builds up in the circuit formed by 1a, 2a, 2e, 2g, 3, 7, 10, 14, 12a to 12n, 13, 9, 6, 4, 2h, 2f, 2b, 1b and the winding between 1a and 1b. As soon as this current reaches a prescribed value above the rated value of the load current, the circuit breakers 12a to 12n are automatically opened by the electrodynamic effect of the short circuit current they carry. Arcs are struck and the sum of the arcing voltages rises beyond the value of the potential difference between the two taps 1a and 1b so that the short circuit current falls to zero. At the same time as contact arm 9 closes on contact 6 contact arm 10 moves away from contact 7. The voltage of the arc between 7 and 10 augments that between the circuit breaker contacts 12a to 12n and therefore supports its effect. When all the arcs are extinguished the gap between 7 and 10 isolates the potentials between the two taps 1a and 1b, permitting the circuit-breakers 12a to 12n to be reclosed by restoring springs (19, FIG. 2) without a fresh short circuit current surge being initiated. The tap change is completed as soon as arm 10 has closed on contact 8 and the major part of the load current again flows through contact arm 9. A tap change in the reverse direction, for instance from tap 1b to tap 1a

3

proceeds in analogous manner, 9 first relinquishing 6 and closing on 5. In this arrangement contact arm 10 as well as the circuit breakers 12a to 12n may be advantageously designed for a lower rated current than contact arm 9 and the tap changer 2 because contrary to the latter they are required to conduct current only for a short time whilst the load is being transferred. Particularly, with respect to the circuit breakers 12a to 12n this provides the advantageous possibility of light weight construction with small moving masses and correspondingly high rupturing speeds.

FIG. 2 exemplifies a circuit breaker which is automatically opened by the short circuit current. 16 and 17 are two contact members each pivotally mounted at 18 and held in contacting position by springs 19. 20 are flexible connections which feed the contact members 16 and 17 with current. The bottom end of each contact member 16 and 17 is linked by an articulation 21 to a piston 22 slidably guided in a cylinder 23 which is pivotally mounted at 24. The floor of the cylinder is provided with openings 25 controlled by a non-return valve 26. The springs 19 are designed to keep the contact members 16 and 17 in contacting position so long as they carry the normal current. However, when the short circuit current initiated by a tap change rises beyond the rated value of the load current the contact members 16 and 17 are thrust apart by the electrodynamic repulsion due to the current. The path of the current is indicated by the discontinuous line 27. As soon as the arc struck between the separating contact members 16 and 17 is extinguished, the springs 19 restore the contact members to closing position. In order to prevent this from happening too soon, i.e., before contact arm 10 (in FIG. 1) is separated from contact 7 by a gap of sufficient width, the closing movement of contact members 16 and 17 is delayed. This delay is produced in that the returning piston 22 in cylinder 23 compresses the air in the cylinder, the non-return valve 26 having closed and only slowly permitting the occluded air to escape through the existing small clearance between valve and seat. When the contact members 16 and 17 open, this delaying action does not arise because the air can freely enter the expanding space behind piston 22 through the openings 25. Thus each cylinder 23 and its piston 22 functions as a one way dashpot.

Assuming that a tap change is effected at the precise instant in which a system short circuit occurs, it is then desirable to prevent contact arm 9 which opens first from striking an arc. To this end the circuit breakers 12a and 12n should be associated with locking means which prevent these members from opening automatically until shortly before the contact arm 9 engages contact 6.

FIGURE 3 illustrates an embodiment in which the same reference numbers are used as in FIG. 2 to indicate the same parts as in FIG. 2. Contact member 16 is constructed in the same way as in FIG. 2, but it is provided with a supplementary abutment 16a which cooperates with an external stop 28. Moreover, another abutment 29 cooperates with the bottom end of the contact member. However, contact member 17 is pivotally mounted at 18a on a lever 30 which is itself pivotally mounted at 31. A spring 19' is interposed between parts 17 and 30, and a further spring 32 is attached to the upper end of lever 30 for cooperation with an abutment 17a. Spring 32 serves as a locking means to delay opening of the contacts 16, 17 of the circuit breakers until shortly before contact arm 9 engages contact 6. At 21a, at the bottom end of contact member 17, a piston 22a is linked to the contact member by a rod 22b and a pin 22c. The piston is slidably guided in a cylinder 23a which is firmly affixed to lever 30. Furthermore, lever 30 is attached at 34 to an actuating rod 35, and lever 30 also carries a pin 33 engageable with the lower portion of contact member 17.

This arrangement functions as follows: In a position of rest the actuating rod 35 which is connected to the tap changing actuator (in a manner not specially shown in the drawing) urges lever 30 into its left hand end position in

4

which the precompressed spring 32 bears against abutment 17a and abutment 16a bears against the external stop face 28. The contact members 16 and 17 are held in closed position by the cooperation of the two springs 19' and 32. Spring 32 is so designed that contact members 16 and 17 cannot open when urged by a system short circuit current. The illustrated position is one in which lever 30 has already been sufficiently deflected in the clockwise direction for spring 32 to be clear of abutment 17a. This position will apply roughly at the instant contact arm 9 (FIG. 1) makes contact with contact 6 and a short circuit current through the relative winding section has been initiated. The rising electrodynamic effect will now cause the two contact members 16 and 17 automatically to separate in the manner already described by reference to FIG. 2 since separation now requires only the resistance of springs 19 and 19' to be overcome.

Occasionally, it may be desirable to combine the mechanically operated contact arm 10 (FIG. 1) which together with contacts 7 and 8 form a two-way switch, with an automatic circuit breaker such as 12a and electrically to connect several such combinations in series. The automatic circuit breaker illustrated in FIG. 3 is particularly suitable for such a purpose since, as will be readily appreciated, the contact members 16 and 17 can also be mechanically opened by continuing the clockwise deflection of lever 30 provided contact member 17 is entrainable by pin 33. The arrangement is therefore also capable of performing the functions of parts 10 and 7 in the diverter switch means 10, 7, 8 in FIG. 1. By combining this arrangement with another unit such as that shown in FIG. 3, excepting that actuation is correspondingly in closing direction, a two-way switching device can be provided in a manner known to the art. Sometime it may be advisable to include a current limiting inductance 36 in the short circuit, for instance between point 14 and circuit breaker 12n in FIG. 1. The rise of the short circuit current can thus be limited or adapted to the rupturing speed of the circuit breakers 12a to 12n.

I claim:

1. In a tap changer device for a controllable transformer having a winding provided with first and second sets of tap points, first and second tap changing switching means for connecting selected tapping points of said first and second sets respectively to first and second lead off conductors, a pair of diverter switches, each said diverter switch including a first contact member movable into selective engagement with a second or third contact member, circuit means connecting said second contact members of said diverter switches with said first lead off conductor, circuit means connecting said third contact members of said diverter switches with said second lead off conductor, an output lead connected to a first contact member of one of said diverter switches, a plurality of circuit breakers connected in series between said first contact members of said diverter switches, means biasing the contacts of said circuit breakers to a closed position, said circuit breaker contacts remaining closed when traversed by normal load currents taken off said tapped transformer winding but opening automatically by electrodynamic effect of the current carried thereby when said current rises above the normal load level as a result of a short circuit established through a portion of said transformer winding between taps thereon when said diverter switches are actuated, and time delay means opposing the action of said biasing means of said circuit breakers in re-closing the contacts thereof.

2. A tap changer device as defined in claim 1 wherein said means biasing the contacts of each circuit breaker to a closed position is constituted by a spring.

3. A tap changer device as defined in claim 1 wherein said time delay means opposing the action of said biasing means for the circuit breaker contacts is constituted by a one way dashpot.

5

4. A tap changer as defined in claim 1 wherein said means biasing the contacts of each circuit breaker to a closed position is constituted by a spring working against a pivotally mounted contact member of the circuit breaker, and wherein said time delay means opposing the action of said biasing means for the circuit breaker is constituted by a one way dashpot connected to said pivotally mounted contact member.

5. A tap changer device as defined in claim 1 and wherein means are provided for locking the contacts of said circuit breakers against opening, said locking means being coupled with said diverter switches and being released just prior to the creation of said short circuit.

6. A tap changer device as defined in claim 1 and which further includes a current limiting inductance inserted in the connections through which said short circuit current passes.

6

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