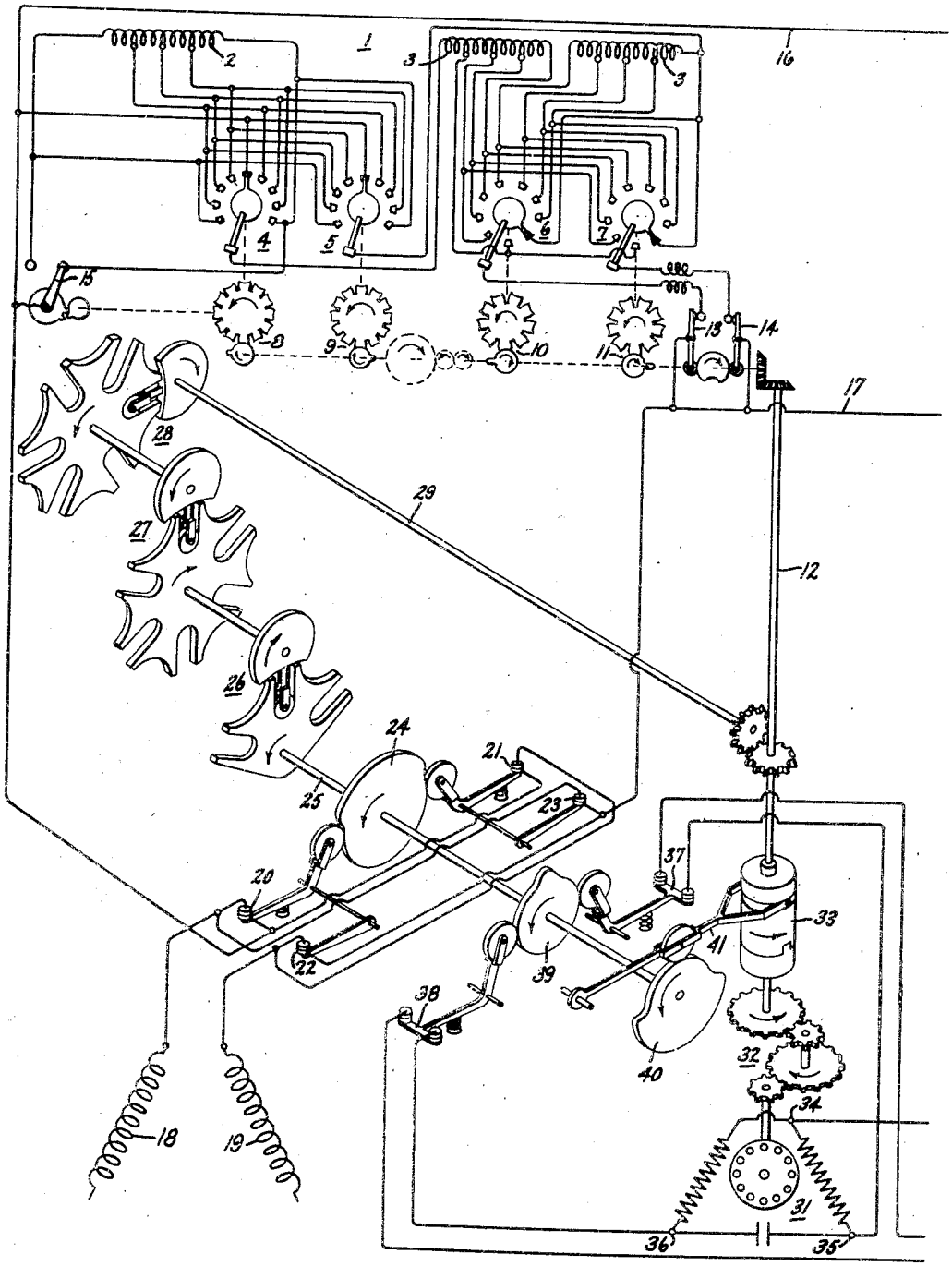
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ELECTROMECHANICAL TAP CHANGING MECHANISM

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ELECTROMECHANICAL TAP CHANGING MECHANISM

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1 Claim. (Cl. 323—43.5)

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This invention relates to electromechanical mechanism and more particularly to improvements in mechanisms of this type which are used in transformer tap-changing-under-load systems.

In certain transformer tap-changing-under-load systems, especially those for very large transformers, there is a relatively large number of tap-changer positions in the entire range of the system. For example, in one such system which has been built there are seventy-three separate and distinct tap-changer positions in the range of the system. Of these seventy-three positions the thirty-seventh is a neutral position of the system so that it has thirty-six positions on one side of the neutral position and thirty-six other positions on the other side of the neutral position. In the operation of such systems it is usually necessary to make a number of control or switching operations between particular steps or positions of the system. Ordinarily the system is motor driven and typically there is a main drive shaft which makes one complete revolution for each tap change or change of the system from one position to the next. It is therefore difficult to provide means for giving proper timing and operation of the auxiliary control and switching elements in a tap-changing system having a very large number of steps because if a simple gear reduction is used the operation of the auxiliary control and switching means will be too slow.

In accordance with this invention a novel and simple mechanism is provided whereby the auxiliary control and switching elements of the system are driven from the main tap changer drive shaft through cascaded Geneva gears. In this manner rapid and positive actuation of the auxiliary control and switching elements may be obtained at both ends and at the middle of the tap range while no operation or motion of the auxiliary control and switching means will take place in the other parts of the range of the tap-changing system.

An object of the invention is to provide a new and improved electromechanical system.

Another object of the invention is to provide a new and improved control mechanism for transformer tap-changing-under-load systems.

A further object of the invention is to provide a new and improved mechanical drive mechanism for certain auxiliary control and switching elements of load-ratio-control systems.

The invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

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Referring now to the single figure of the accompanying drawing, there is illustrated diagrammatically therein an embodiment of the invention as applied to one phase of a three-phase system. This phase is indicated generally at 1 and comprises a tapped main winding 2 and a pair of tapped vernier windings 3. Co-operating with the taps of the main winding 2 are a pair of ratio adjusters 4 and 5 and co-operting with the taps of the vernier windings 3 are a pair of ratio adjusters 6 and 7. These adjusters are driven by any suitable means, such as by Geneva gears 8, 9, 10 and 11 respectively, from a main drive shaft 12. The ratio adjusters are of the non-arcing duty type and the arcing duty of the system is performed by a pair of arcing contactors 13 and 14 which are cam driven from the shaft 12. A reversing switch 15 is provided for reversing the connections of the phase 1 between a pair of line terminals 16 and 17. The phase 1 and the line terminals 16 and 17 are connected to two other phase windings 18 and 19 through a set of transfer switches 20, 21, 22 and 23. These transfer switches are for the purpose of transposing connections of the line conductors 16 and 17 relative to the phase windings 18 and 19. The tapped phase 1 and the phase windings 18 and 19 constitute part of a hexagonally connected transformer winding, the remainder of which has not been shown.

The transfer switches 20, 21, 22 and 23 are actuated by a cam 24 on a cam shaft 25. This cam shaft 25 is driven by a set of cascaded Geneva gears 26, 27 and 28, the latter being actuated by a spur shaft 29 driven by bevel gears 30 from the main drive shaft 12.

The main drive shaft 12 is driven by a reversible motor 31 through a set of speed reducing gears 32 and a clutch 33. The motor has a common terminal 34 and separate forward and reverse direction of rotation controlling terminals 35 and 36, it being understood that the connection of a suitable source of current supply between terminals 34 and 35 will cause forward rotation of the motor and, similarly, application of this current supply between terminals 34 and 36 will cause reverse rotation of the motor. In order to protect the system from overrunning its range it is provided with limit switches 37 and 38 which are connected respectively in series with the terminals 35 and 36 of the motor. These limit switches 37 and 38 are normally closed and they are opened at the respective ends of the range of the tap-changing mechanism by means of a cam 39 on the cam shaft 25.

As back-up protection for the system in case of a failure of the limit switches another cam 40 on the cam shaft 25 is provided for actuating a lever 41 which is attached to the clutch 33 so that slight rotation of the cam shaft beyond its positions for opening the limit switches will cause the clutch 33 to be released so that it will be impossible for the motor 31 to drive the shaft 12 and its driven parts any further.

The operation of the illustrated embodiment of the invention is as follows: The parts have been shown in the positions they occupy when the tap-changing system is in its neutral position, that is to say, in position No. 37 of its 73-position range. Thus, all of the contacts of the transfer switches are closed so that line conductors 16 and 17 are connected together and the phase windings 18 and 19 are connected together. The reversing switch 15 is closed but as the tap changers 4 and 5 are in their mid positions no part of winding 2 is connected between lines 16 and 17. This corresponds to a delta connection of the main three-phase mesh (normally hexagon) winding of the system. Assume now that the motor 31 is energized so as to cause clockwise rotation of the shaft 12 when viewed from bottom to top in the drawing and similar rotation of the spur shaft 29 when viewed from right to left. It will be seen that all of the cascaded Geneva gears 26, 27 and 28 are in engagement so there is practically a 1:1 direct drive connection between the shaft 29 and the cam shaft 25 with the result that the cam shaft 25 will rotate counter clockwise, as viewed from right to left in the drawing, at approximately the same speed as the shafts 12 and 29. After a few degrees of rotation the cam 24 will open the transfer switches 20 and 22 so that line conductor 16 will now be connected exclusively to phase winding 19 through switch 21 only and line conductor 17 will be connected to phase winding 18 exclusively through switch 23 only. After about ninety degrees of rotation of the spur shaft 29 the switches 20 and 22 will not have reached their full open positions, the driver for the Geneva gear 28 will be out of engagement therewith, the driver for the Geneva gear 27 will be practically out of engagement therewith and the driver for the Geneva gear 26 will have caused about thirty degrees of rotation of the cam shaft 25. It will be observed that the Geneva gears 27 and 28 each have six notches so that there is a 36:1 ratio between the shaft 29 and the driver for Geneva gear 26.

Continued rotation of the shaft 12 causes the vernier tap changers 6 and 7 to move step by step counterclockwise along their paths of motion. Before they have made half a complete revolution the ratio adjuster 4 is actuated one step. After vernier ratio adjusters 6 and 7 have made a half revolution and before they have made a full revolution main ratio adjuster 5 is actuated one step. Then the vernier ratio adjusters start their next complete revolution and this alternate vernier and main ratio adjuster action continues until the shaft 12 has made thirty-six complete revolutions when the ratio adjusters 4 and 5 will be at one end of their range of operation. In the meantime the Geneva gears 27 and 28 have been operating the driver for the Geneva gear 26 so that the latter is now ready to cause a second movement of the cam shaft 25 in the counterclockwise direction and such second or additional movement will cause the cam 39 to open the limit switch 38 and

stop the motor 31. If for any reason the limit switch 37 does not open, then a slight further rotation of the cam shaft 25 will cause the cam 40 to release the clutch 33.

The operation of the system in the opposite direction from the neutral position is essentially the same as has been explained above except that transfer switches 21 and 23 will then be opened at once and at the end of the range of operation the limit switch 37 will be opened. Also the reversing switch 15 is actuated the first time the main ratio adjuster 4 operates.

The details of the vernier load-ratio-control circuit for phase I are no part of this invention as that system constitutes the subject matter of patent 2,200,979 granted the present assignee on May 14, 1940, on an application of Louis F. Blume. Likewise, the combination of a reversible voltage load-ratio-control system and transfer switches for voltage phase shifting purposes in connection with hexagonal three-phase windings is the subject matter of application Serial No. 566,562, filed December 4, 1944 now Patent No. 2,421,299, May 27, 1947 in the name of Wallace M. Johnson and assigned to the present assignee. However, in the Blume vernier load-ratio-control circuit when used with a reversing switch, that switch is driven by the operating mechanism for one of the main ratio adjusters so that it operates relatively slowly in comparison with the speed of operation of the vernier ratio adjusters. Consequently, the Blume system is not readily adaptable for use in the Johnson circuit and it is the novel mechanism driven by the spur shaft 29 and the combination of this mechanism with the load-ratio-control mechanism for phase I and the hexagonal three-phase winding which makes the present system operate properly. Thus, it is essential that the transfer switches which are driven by the cam 24 operate very quickly as soon as the mechanism departs in either direction from its neutral position because such switches must effect the proper change in connections, that is to say, the proper transposition of the line conductors 16 and 17 relative to the phase windings 18 and 19 before the first step has been made by either of the vernier ratio adjusters 6 or 7. For that reason it is not possible in practice to operate the transfer switches from one of the main ratio adjusters 4 and 5. The reason it is possible to operate the reversing switch 15 from one of the main ratio adjusters is that during the first half of the vernier action in either direction from the neutral position of the system the voltage of the vernier winding is applied between the line conductors 16 and 17 without going through the reversing switch so that all that is necessary is that the reversing switch be operated by the time the proper main ratio adjuster is ready to be operated, and as the latter operates slowly, the reversing switch can be operated slowly.

At each end of the range of operation of the ratio adjuster system it is also necessary that the limit switches be operated relatively quickly but, of course, they must not be operated at any other time except at each end of the range of operation. It is therefore necessary to provide the additional mechanism shown for accomplishing this purpose as the limit switches cannot be driven from any of the mechanism ordinarily included in the load-ratio-control means for phase I.

Another feature of the invention is that as the spur shaft 29 continues to rotate, the transfer

switches will be opened in increments because the second revolution of the shaft 29 will advance the gear 27 slightly and this through gear 28 will advance the cam shaft 25 slightly. This incremental opening of the transfer switches corresponds with the step by step increase in voltage between the line conductors 16 and 17 which is produced by the connection of more and more of the tapped windings 2 and 3 between these line conductors due to the step by step action of the load-ratio-control system. It will thus be seen that the degree of opening of the transfer switches is roughly proportional to the voltage between their contacts.

While there has been shown and described a particular embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications can be made therein without departing from the invention and, therefore, it is aimed in the appended claims to cover all such changes and modifications as 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:

A switching system for a multi-tapped transformer winding having a pair of line terminals comprising, in combination, a driving motor, selectively energizable circuits for respectively energizing said motor for forward and reverse rotation, separate normally closed limit switches in each of said circuits, a speed reducing gear train connected to be driven by said motor, a normally engaged dog clutch driven by said gear train, a main multi-position tap changing dial switch having a mid position and two end positions, a single pole double throw switch connected for reversing the polarity of said winding with respect to its terminals, means connected to said main dial switch for driving said reversing switch relatively slowly from one closed position to another when said dial switch goes through its mid position, a vernier multi-position tap changing dial switch, means including a Geneva gear for driving said vernier switch from said clutch through a plurality of complete revolutions in each direction, means including reduction gearing and a second Geneva gear for driving said main dial switch from one position to the next

for each complete revolution of said vernier dial switch, a cam shaft having a neutral position, means including three cascaded additional Geneva gears for rotating said cam shaft from said clutch with relatively rapid but short angular motion from said neutral position in opposite directions respectively whenever said main dial switch goes through its mid position in a corresponding direction and for further rotating said cam shaft with relatively rapid but short angular motion in opposite directions respectively whenever said main dial switch moves beyond its end positions, a pair of line conductors for connection to the terminals of said winding, transfer switching means for reversing the connections of said line conductors to the winding terminals, a cam on said cam shaft for operating said transfer switching means whenever said cam shaft is moved through its neutral position, an additional cam on said cam shaft for opening the appropriate one of said limit switches whenever said main dial switch is moved beyond an end position, and a third cam on said cam shaft for mechanically releasing said clutch if said cam shaft rotates any further in either direction than is required to open said limit switches.

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