Jan. 1, 1935. B. JANSEN 1,985,927

STEP SWITCH ARRANGEMENT FOR TAPPING TRANSFORMERS

Filed April 20, 1932 4 Sheets-Sheet 1

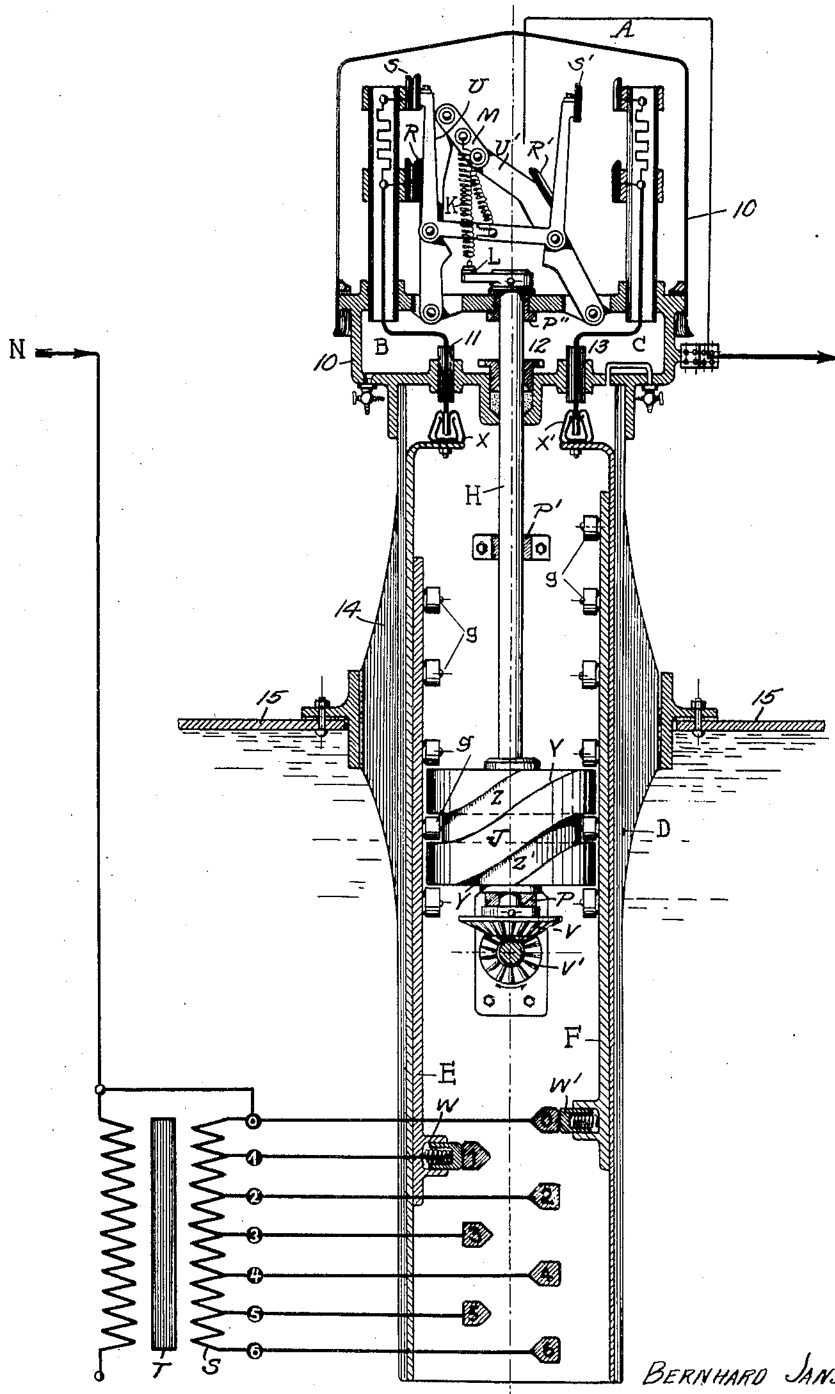

Fig. 1

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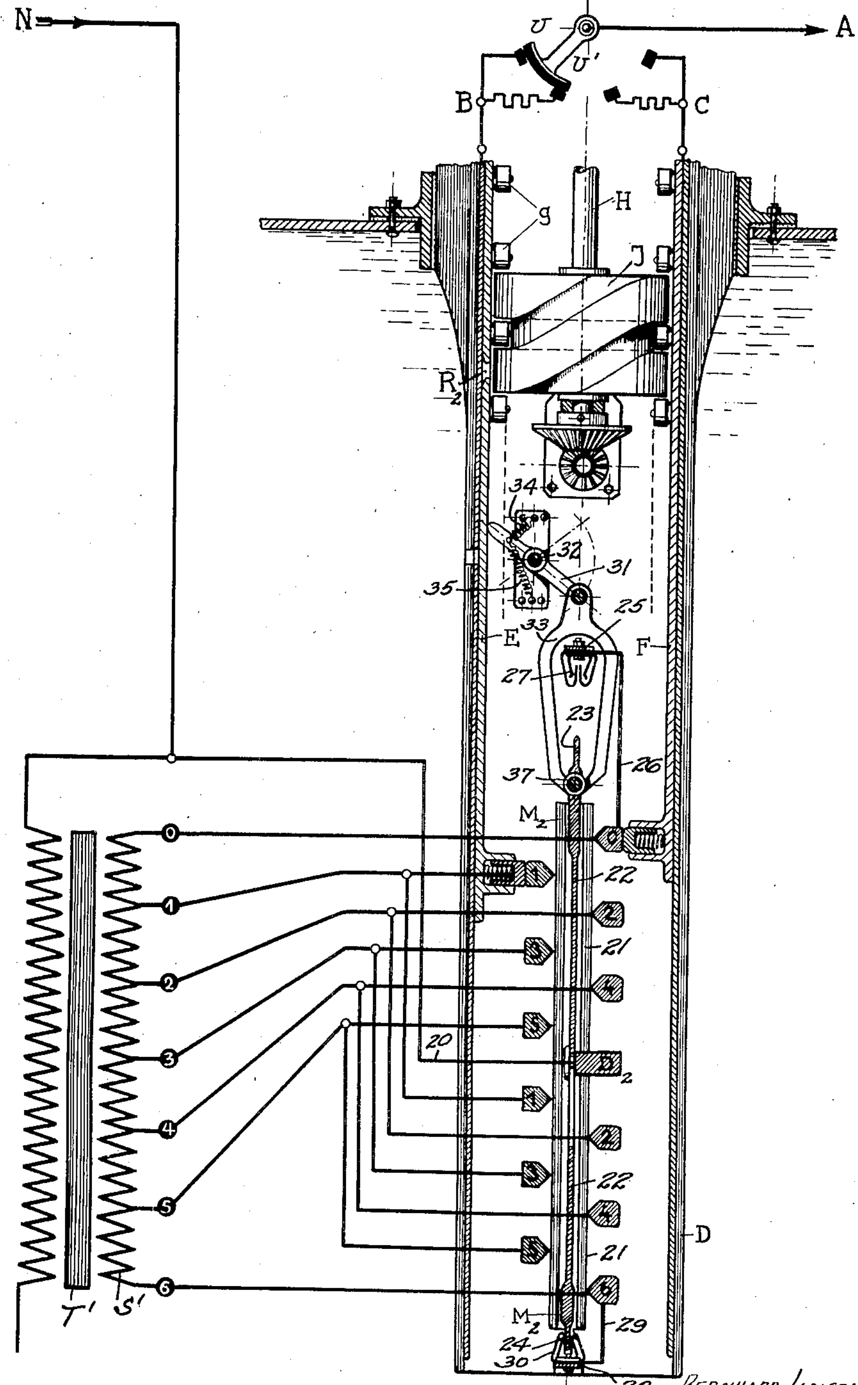

Fig. 2

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STEP SWITCH ARRANGEMENT FOR TAPPING TRANSFORMERS

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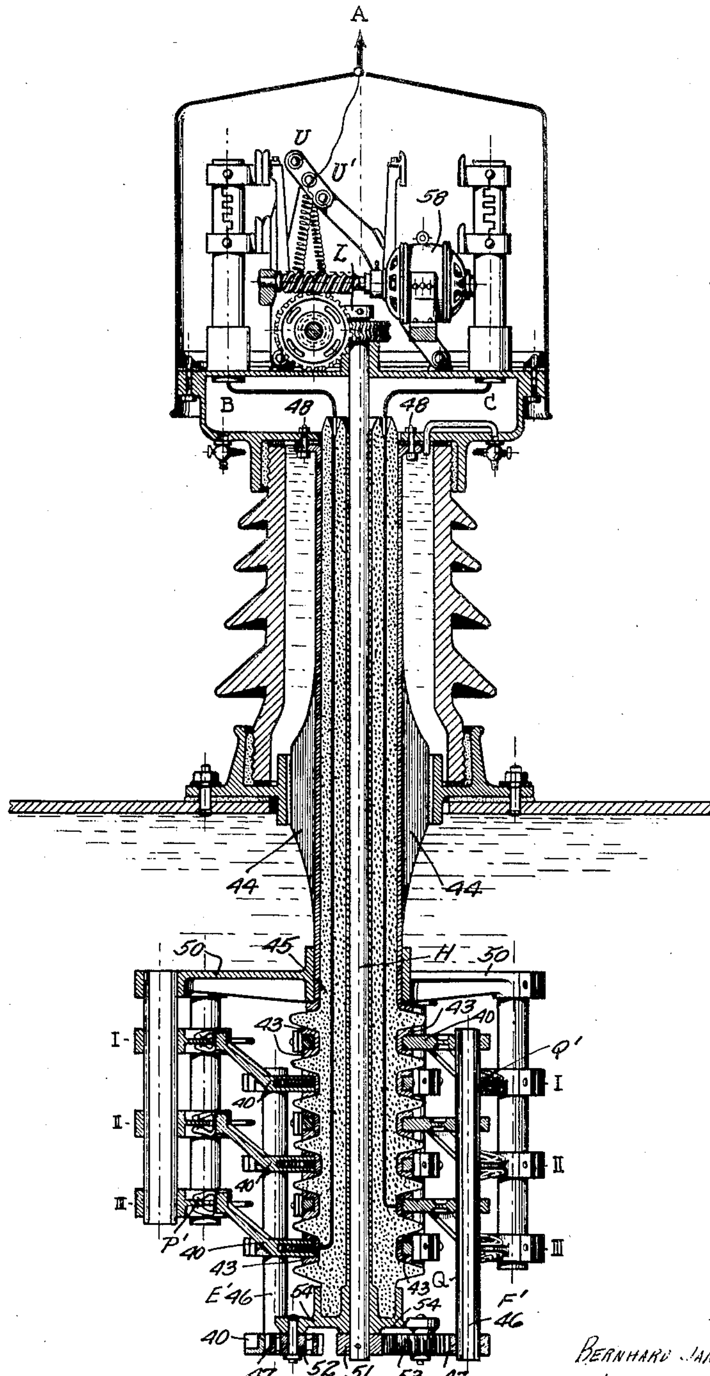

Fig. 3

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STEP SWITCH ARRANGEMENT FOR TAPPING TRANSFORMERS

Filed April 20, 1932

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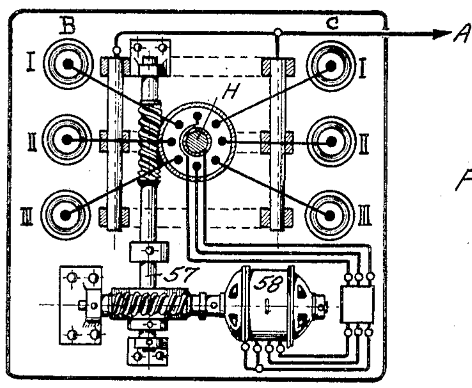

Fig. 4.

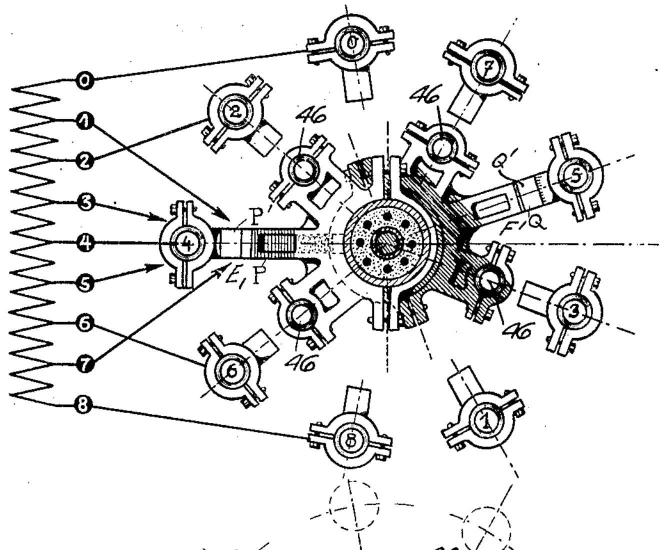

Fig. 5.

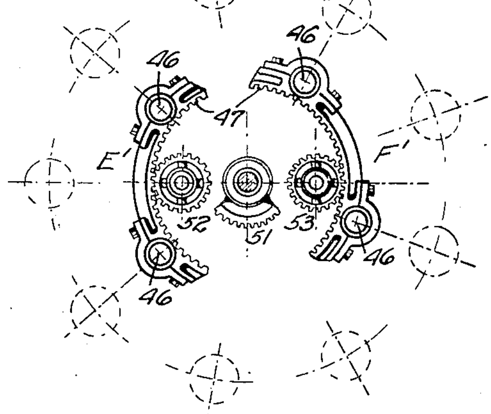

Fig. 6.

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UNITED STATES PATENT OFFICE

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STEP-SWITCH ARRANGEMENT FOR TAPPING TRANSFORMERS

Bernhard Jansen, Regensburg, Germany

Application April 20, 1932, Serial No. 606,392
In Germany October 2, 1931

5 Claims. (Cl. 171—119)

This invention relates to regulators for transformers and particularly to apparatus for changing the taps of transformers and comprising a load transfer switch.

For changing the taps of a transformer to accommodate for load changes without interrupting service, switches are used which by the temporary insertion of an ohmic or inductive resistance change the working current over from one tap to the next without effecting a direct metallic short-circuit between the first tap and the next tap. In transformers having a large output the current is led to the switch-elements of the load-transfer switch from the transformer tappings over a step intercommunication switch. In step switch arrangements of the type known heretofore, every switching-on or switching-off movement of the main or resistance contacts at the load-transfer switch required a special position of the step intercommunication switch. Thus, in the course of a single change of the working current from one transformer tap to the next, a whole series of switching movements had to be effected alternately at the contacts of the load-transfer switch, and others in harmony with said series of contacts of the step intercommunication switch. With step-switch arrangements of that kind a relatively complicated mechanism is necessary to provide for the proper sequence of the individual switching actions in the load-transfer switch and in the step intercommunication switch. This results in the switching action taking a relatively long time and entailing the possibility of disturbances, for instance a stop at any phase of movement, before the whole switching-over is finished. This constitutes a decided disadvantage, especially when using ohmic resistances which can only be loaded for a short time.

The tap chamber of the present invention is singularly free of the above noted defects even when operating on transformers having large outputs. Essentially, the new tap changer comprises, first, a two-pole quick-break-load transfer-switch (e. g. such as that described in my copending application Serial No. 508,447, filed January 13, 1931) having two poles either one of which is connected in the external circuit when the transformer is operating, and secondly, a step intercommunication switch constructed with a pair of movable parts. Each of said movable parts is firmly connected to a pole of said transfer switch, one of said parts when the transformer is operating being in contact with the transformer tap included in the circuit at that time.

In the present device a different tap is cut in by moving the part of the intercommunication switch which at the time is not included in the circuit, into contact with the tap to be cut in, while the other part of said switch remains stationary. When contact has been established, the means effecting movement of said part of the intercommunication switch causes a movement of the transfer switch, whereby the tap to be cut in is included in the external circuit, while the movable switch part, formerly in said circuit, is cut out. The above action is made possible by an arrangement of the transformer taps which requires a disposition of adjacent taps in two groups or rows, the taps of one group cooperating with one movable part of the intercommunication switch and the taps in the other group cooperating with the other movable switch part. A convenient method of realizing the above arrangement is to dispose the off number taps in one group and the even number taps in the other group.

This construction has the advantage that while the change proper, which alone entails some risk in the transformer operation, is effected by the quick-break load transfer switch in a short time and without any interruption taking place, the selection of the next tap can be effected by the step intercommunication switch without any danger to the transformer. This is possible, because the taps next adjacent to the taps switched-on at the time, are located in that half of the step intercommunication switch, which have just been switched-off by the quick-break load transfer switch and which, therefore, cannot carry current under any circumstances.

A device of the above described type is illustrated in the drawings, in which

Fig. 1 is a partially sectional and partially diagrammatic view showing one embodiment of a step intercommunication switch;

Fig. 2 is a similar view showing a modified form of a step intercommunication switch;

Fig. 3 is a vertical cross section of a tap changer applied to a three phase circuit; and

Figs. 4, 5, and 6 are horizontal cross sections of the device of Fig. 3.

On the drawings

Fig. 1 shows the tap changer of the present invention connected to transformer T comprising a secondary S. Current is supplied from line N. The tap changer consists of a selector switch movable in a straight line and comprising a pair of sliding plate contacts E and F located in the insulating tube D. Each of plates E and F is electrically connected with one of the poles B and C of the double pole load-transfer switch U, U′ by means of connections X and X′. Either one of said poles B, C can be connected to the external circuit A by means of switch U, U′.

The tube D houses the taps 0, 1, 2, 3, 4, 5 and 6. Said taps are arranged in two separate groups so that the even taps are in one group and the odd taps in another. Said groups of taps are so situated in the tube D that the odd taps lie adjacent the path of plate E and the even number taps, lie adjacent the path of the plate F. Plate E carries a contact piece W adapted to make electrical connection with any one of the odd numbered taps. Plate F carries a corresponding contact piece W'' adapted to establish electrical contact with the even numbered taps.

The sliding plates E and F are moved by means of cylinder J carried by shaft H. Cylinder J is provided with spiral groove Y receiving rollers G mounted on slide plates E and F. The rollers G are spaced apart a distance equal to the spacing of the various taps. Shaft H is journaled in bearings at P, P' and P''. The lower end of shaft H is provided with a bevel gear V which meshes with gear V', supplying the power for rotating the shaft H and the cylinder J.

Attention is directed to the special construction of groove Y in the cylinder J. Groove Y extends at a high pitch from the upper part of the cylinder to a point adjacent the median line of the cylinder while embracing one half of its circumference; thence the groove continues in the same plane across the other half of the circumference of the cylinder, then again sloping downwardly towards the lower end of the cylinder. Two sets of cam surfaces Z and Z' are thus obtained on one half of the cylinder while the other half carries only one straight groove. By virtue of this construction, rotation of the cylinder for one half revolution (i. e. 180°) causes either of the plates E or F, depending upon the position of the cylinder, to move a distance equal to the distance between adjacent taps of a series, the other plate remaining stationary. In other words, on rotation of the cylinder, sliding plate E, for instance is moved when its rollers G ride over the sloping portion of cam surface Z, Z', while slide plate F remains stationary because its rollers merely idle in the straight portion of said groove. The motion of the plate will of course be up or down depending upon the direction of rotation of cylinder J.

Rotation of the cylinder J not only effects movement of the plates E and F but also movement of the switch U, U'. This switch is described in my aforementioned copending application. It is composed of two separate switches U and U', equipped with main contacts R and R' and pre-contacts S and S'. Said switches U and U' are connected together by means of a link M.

The upper end of shaft H carries a crank L which is connected at its outer end with one end of a spring K. The other end of the spring is connected to link M at a point adjacent the center portion thereof.

In normal operating position, such as shown in Fig. 1, the switch U is in contact with pole B, the switch U' being in a position in which it forms an obtuse angle lever with the link M. This effects secure locking of switch U in position. The lock is released upon rotation of the crank L by the crank striking against switch U'. Rotation of the crank also tenses spring K, so that as soon as the lock is released, the spring K instantaneously shifts switch U, U', bringing switch U' into contact with pole C.

The operation of the device of Fig 1 is as follows: As illustrated, the tap 1 is connected in the external circuit through contact piece W, plate E, connector X, pole B, main contact R, switch U and then through a connection not shown to line A. When it is desired to cut tap 2 into the circuit, shaft H is rotated to the right for 180°, whereby the 2nd and 3rd rollers from the bottom of plate F will ride downwardly on the sloping cam surfaces Z and Z', thus causing plate F to descend so that its contact W' connects with tap 2. Plate E of course does not move since its active roller idles in the straight portion of said groove Y.

When shaft H is rotated to the right the crank L tenses spring K. After the shaft has reached a position in which plate F contacts with tap 2, crank L strikes switch U' breaking the angle lever lock formed by said switch and link M, whereupon spring K effects movement of switch U' against pole C. Tap 2 is joined in the external circuit through contact piece W'', plate F, connector X', pole C, main contact R' of switch U' and line A. The selection of the tap to be cut in by the intercommunication switch E, F, W, W' thus effects automatic operation of the load transfer switch U, U' so as to cut in the tap selected. It should be noted that current does not flow through the new tap cut in until after the load transfer switch U, U' has made new contact.

When the quick-break load-transfer switch is actuated while in operation, sparks will originate at the contacts, which in the course of time will cause the oil to deteriorate. So as to safeguard the oil of the transformer against such deterioration the quick-break load-transfer switch is housed in a special oil-tank 10 through which the leading-in wires to the poles B and C as well as the shaft H are led through oil-tight bushings 11, 12 and 13. If the quick-break load-transfer switch U, U' is intended to work in an air space instead of in oil, the above mentioned oil-tight bushings may be dispensed with, provided the oil-level does not rise up to the spark contacts under the influence of the pressures. No sparks whatever originate at the intercommunication switch E, F, W, W', the latter being dead at the moment of load transfer, so that it can be arranged inside the transformer pit. The installation of the two halves of the step intercommunication switch in a cylindrical or rectangular insulating tube as represented in Fig. 1 permits the constructions of transformers adapted for a large output while having small horizontal cross-sections, less bottom space being thus required in the transformer pit. The relatively great length of the tube intercommunication switch E, F, W, W' is no disadvantage, because the transformer is sufficiently high to easily accommodate the switch.

If the insulating tube D containing the step intercommunication switch E, F, W, W' be strengthened at the point 14, where it passes through the lid of the transformer by means of insulating layers, so that it can stand the disruptive strain of the full working voltage against the transformer case 15, the insulating tube may be constructed as a bushing, as shown in Fig. 1.

Fig. 1 illustrates the case of a simple step-intercommunication switch for changing 7 transformer taps, tap 0 to tap 6. Fig. 2, on the other hand, represents a step-intercommunication switch which can be employed to cut in additional taps so as to either increase or decrease the working voltage. For this purpose all the taps, with the exception of the end taps 0 and 6, occur twice in the two series of taps cooperating with plates E and F. In the place of the omitted end taps 0 and 6, a contact D_2 is provided which is connected directly with the lead-in wire N by means of a wire 20, contact D_2 being inserted in the series of even numbered taps co-acting with plate F. Contact D_2 may be connected either with the end tap 0 or with the end tap 6 by means of a two-point control switch M_2.

In the embodiment shown in Fig. 2 this two-point control switch M_2 is installed in an insulating tube 21, thus being insulated against the tap contacts. The two-point control switch M_2 comprises an elongated vertically movable conducting element 22 adapted to cooperate with stationary contact points 23 and 24. In the raised position of the element 22 its contact point 23 establishes electrical communication with the stationary contact piece 25, which is connected to tap 0 by means of wire 26. Springs 27 are provided on contact 25 for firmly gripping the cooperating contact 23.

Contact point 24 on the other end of switch element 22 is adapted to electrically communicate with a contact piece 28 in the lowered position of the element 22. Said contact 28 which is electrically connected to the tap 6 by means of line 29 is further connected to the secondary S' at point 6. Springs 30 are provided on the contact 28 for retaining the point 24 in electrical conducting relationship with the contact 28.

Switch element 22 is moved by means of a lever 31, pivotally mounted upon the tube D at 32. The inner end of said lever 31 is pivotally connected to the upper end of a yoke element 33, forming an integral part of the conducting element 22. The free end of the lever 31, is adapted to slide upon the inner surface of the plate E as this plate moves up and down in the manner explained in connection with the device of Fig. 1. The free end of the lever 31 is adapted to engage in slot R_2 in the plate E when the latter slides up or down, thereby raising or lowering the connected end of the lever 31 and with it the conducting element 22.

Premature movement of the switch element 22 by virtue of the friction set up between the lever and the plate E is prevented by means of springs 34 and 35, one of which is connected to the lever and the tube D at a point above the lever, and the other is connected to the lever and the tube D at a point below the lever. The stress set up by the friction between the lever and the plate E is thus taken by the springs 34 and 35 without being communicated to the yoke 33.

Operation of the device shown in Figure 2 which, it must be remembered, contains the elements described in Fig. 1, in addition to those described above, is as follows: In the position shown, the switch M_2 is in lowered position, the point 24 of the element 22 being firmly held against the contact 28. At this moment, electrical connection is established between tap D_2, element 22, lower contact M_2, contact 28, wire 29, contact piece 6 and secondary S' at point 6. At this time, cylinder J has moved plate E downwardly to cut tap 1 into the external circuit A. Current flows now from line N through the transformer T', S' to tap 1, thence to pole B and through switch U, U' to A.

The working current entering at lead-in N, apart from flowing into the exciting winding of the transformer T' also flows over the two-point control switch element 22, lower contact M_2, contact 28, wire 29 to end contact 6; thence it flows to winding S' (at point 6) and through the same up to tap contact 1 and further over the switched-on load transfer switch U, U' to the lead-off wire A. The 5 voltage steps lying between the taps 6 and 1 of winding S' are thus added in this case to the voltage of the tap already cut in so as to increase the voltage. By changing-over the step switch arrangement to successively cut in taps 2, 3, 4 and 5, the voltage added becomes smaller by one step in every instance, until in the position D_2 of the step intercommunication switch the lead-in wire N is connected directly with the lead-off wire A over the pole C of the load transfer switch. In such case the stepwinding 0—6 is not touched at all by the flow of current in which event the primary and secondary voltages are the same.

When the sliding contact F is moved from tap 1 to tap 5, the slot R_2 in the plate E receives the end of lever 31 thereby moving the two-point control switch element 22 upwards, thus effecting the connection D_2—0 instead of connection D_2—6. In that case, the current flows from line N to tap D_2, thence to tap 0 and into the secondary, being taken off at tap 5 which is cut in. In this position of the switch the current acts in opposition to or "bucks" that set up by the included voltage of the secondary between taps 5 and 6. Thus, instead of an increase in voltage a reduction in voltage at the lead-off A takes place in relation to the leading-in N.

Another form of the step intercommunication switch, that is the so-called rotary intercommunication switch, is illustrated in Figs. 3 to 6, inclusive. This device includes in combination the quick-break load-transfer switch shown in Figs. 1 and 2. This kind of intercommunication switch is especially suitable for three-phase circuits, wherein the taps of the three phases are arranged in three groups I, II, III at different elevations, the taps of each group being positioned one above the other.

In this case the two movable halves E_1 and F_1 of the intercommunication switch are made semicircular and are composed of a plurality of rings or plates 40 supported by the lower end 45 of an insulated bushing 44. As may be seen from Fig. 5, the even taps 0, 2, 4, 6 and 8 are installed adjacent to and cooperate with the left half E_1 of the intercommunication switch. The connections of the odd taps are not. They coact with the right half F_1 of said switch. The plates or rings 40 of the halves E_1 and F_1 are held together by vertical pieces 46. Said plates or rings 40 carry brushes P_1 and O_1 which are adapted to make sliding contact with the taps as shown in Figs. 3 and 5. The lowermost plate of each of the halves E_1 and F_1 projects below the bushing 44 and is provided at its inner side with gear teeth 47 for the purposes described hereinafter.

The lower end 45 of the bushing 44 is corrugated as shown in Fig. 3, to provide for the reception of grooved contacts 43 which are connected by means of conductors 48 with the poles B and C of the load transfer switch U, U'. Said contacts 43 act as sockets for the rings or plates 40 of the movable switch parts E_1 and F_1. The lower end 45 of the bushing 44 also acts as a base for a bracket 50 which supports the series of taps I, II and III.

The movement of the halves E_1 and F_1 of the intercommunication switch is effected in this case by the shaft H, journalled in the bushing 44, which shaft carries at its lower end an interrupted tooth gear 51. The gear 51 is adapted to mesh at intervals with gears 52 and 53 fastened to opposite sides of a face plate 54 secured to the lower end of the bushing 44. Said gears 52 and 53 in turn mesh with the gear teeth 47 on the inner faces of the lower plates of the switch parts E_1 and F_1. It will be clear that in this arrangement rotation of the shaft H will, at different periods, effect rotation of the plates E_1 and F_1 of the intercommunication switch about the same central axis.

Rotation of the shaft H is effected by the conventional gear train, designated collectively by numeral 57, said gear train being located adjacent the upper end of the shaft H. Power is applied to gear train 57 by means of a motor 58.

The upper end of shaft H is also provided with a crank L for operating the load transfer switch U, U' in the manner described in connection with the device of Figs. 1 and 2. It is of course to be understood that the load transfer switch U, U' in this case will be provided with three poles B and three opposed poles C as well as with three pairs of switch parts similar in all respects to the pair disclosed in Figs. 1 and 2. The operation for this three-phase arrangement is the same as for the single-phase arrangement described above. The only difference is that the bodies of the three quick-break load-transfer switches cannot be connected with three different lead-off wires A, but must be joined with one common lead-off wire A, that is with the neutral point of the transformer. The three quick-break load throw-over switches are, therefore, metallically connected with each other. Consequently, the whole step switch arrangement can be driven by the single three-phase motor 58 connected with the potential of the neutral point. In the present construction the current is led to the three-phase motor through the bushing 44, as may be seen from Fig. 4, the guidance of the driving shaft being used simultaneously as a conductor. In the interior of the transformer case a small insulating transformer may be disposed, which may be fed by the middle taps 3 and 4 of the phases I—III.

What I claim is:

1. Apparatus for changing the taps of a transformer comprising a load transfer switch having two poles, a step intercommunication switch having two movable switch parts, each part being connected to a pole of said transfer switch, means for connecting said poles in an external circuit, the taps of said transformer being arranged in two opposed groups with the normally adjacent taps in separate groups, each group lying adjacent the path of movement of a switch part so that the taps of a group may be selectively contacted by a switch part, means permanently connected with said switch parts for alternately moving said switch parts a predetermined distance to select a tap in either series to be cut in, and means responsive to the movement of said switch parts for automatically shifting the load transfer switch to cut in said tap after a movable part contacts the tap to be cut in.

2. Apparatus for changing the taps of a transformer comprising a load transfer switch having two poles, a step inter-communication switch having two opposed movable switch parts, means for connecting each of said movable switch parts with a pole of said transfer switch, means for connecting said poles in an external circuit, the taps of said transformer being arranged in two opposed groups with the odd number taps in one group and the even number taps in another group, each group being located adjacent the path of movement of a movable switch part, means on each movable switch part for making contact with a tap in a group adjacent said part, means for alternately effecting a predetermined movement of said switch parts to select a tap in either group to be cut in said external circuit, a single operating means for said last mentioned means, and means responsive to movements of said switch parts for automatically shifting said transfer switch after a movable switch part has contacted the tap to be cut in, to cut said tap into said circuit.

3. Apparatus for changing the taps of a transformer comprising a load transfer switch having two poles and a pair of swingable switch members adapted to cooperate therewith, a step intercommunication switch having a pair of sliding switch parts, each part being connected with a pole of said transfer switch, means for connecting said poles in an external circuit, said taps being disposed in two groups with the even number taps in one group and the odd number taps in another group, each group being located adjacent the path of movement of a sliding switch part, means on each sliding switch part for making selective contact with a tap in that group adjacent a sliding switch part, a tap of one group being cut in the circuit by a sliding switch part, a pole of the two pole transfer switch and a switch member of said transfer switch co-acting with that pole, means for effecting sliding movement of the other switch part into contact with a tap in the other group, desired to be cut in, a common control for sliding said pair of switch parts, and means responsive to movements of said switch parts and comprising a spring-pressed lever for automatically shifting the transfer switch to bring the other switch member thereof into contact with the other pole after said sliding switch part has contacted the tap to be cut in, to cut said tap into said external circuit.

4. A device as defined in claim 2, wherein alternate movement of the switch parts is effected by a cylinder carried on a rotatable shaft, said cylinder having a groove therein running downwardly across one face of the cylinder to the mid point of said face, thence straight across the other face of said cylinder, thence downwardly from the mid point of said first mentioned face to the bottom of said face, rollers carried by the sliding switch parts adapted to be received in said groove, the rollers in one switch part at one time being received in the downwardly inclined groove in one face of the cylinder while a roller of the other switch part is received in the straight groove in the other part of said cylinder, whereby rotation of said cylinder causes a movement of one switch part, the other remaining stationary.

5. Apparatus for changing the taps of a transformer comprising a two pole load transfer switch, a step intercommunication switch having a pair of movable plates, each connected to a pole of said transfer switch, the taps of said transformer being disposed in two groups with the taps of one group adjacent one of said plates and the taps of the other group adjacent the other plate, means common to said pair of plates for selectively moving one of said plates into contact with a tap to be cut in and means responsive to movements of said switch parts for automatically shifting said load transfer switch after said plate has contacted the tap to be cut in, to cut in said tap.

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