Feb. 11, 1941. B. JANSEN 2,231,627

STEP SWITCH DEVICE FOR REGULATING TRANSFORMERS

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Fig. 1.

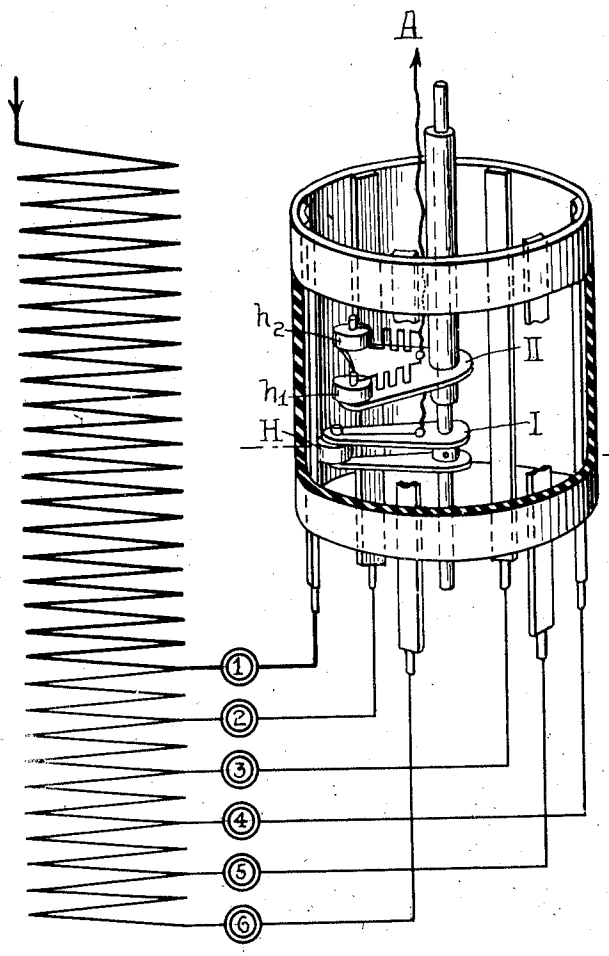
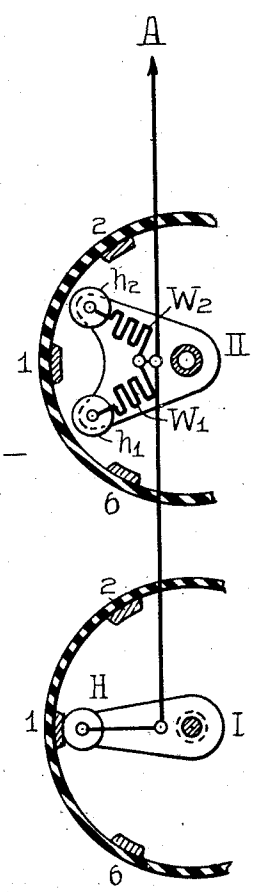


Fig. 1a.



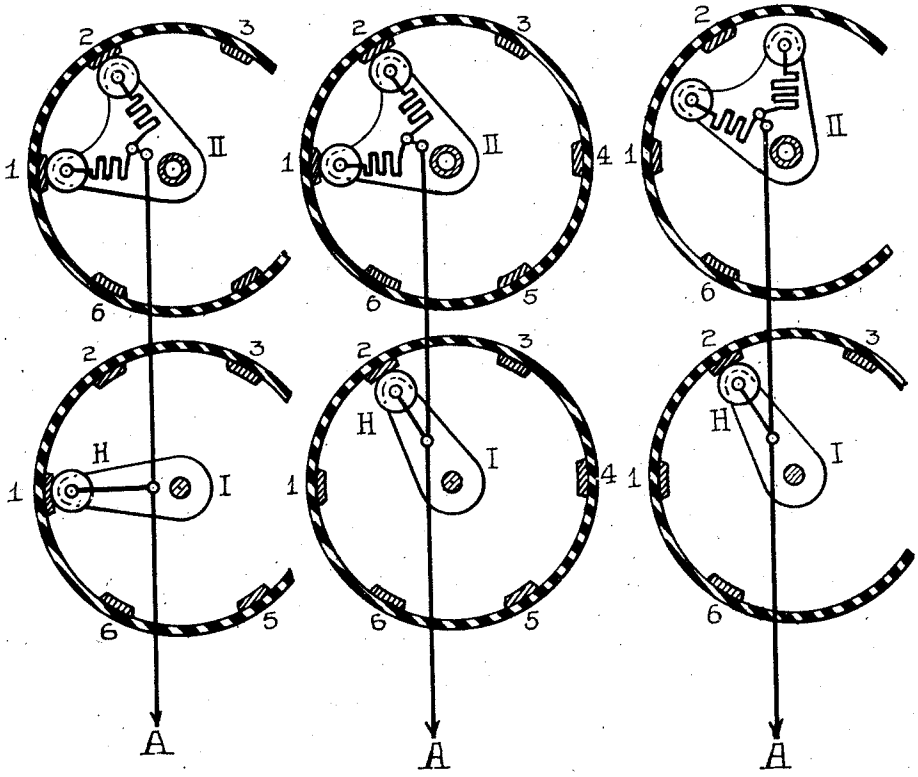
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Fig. 1b. Fig. 1c. Fig. 1d.

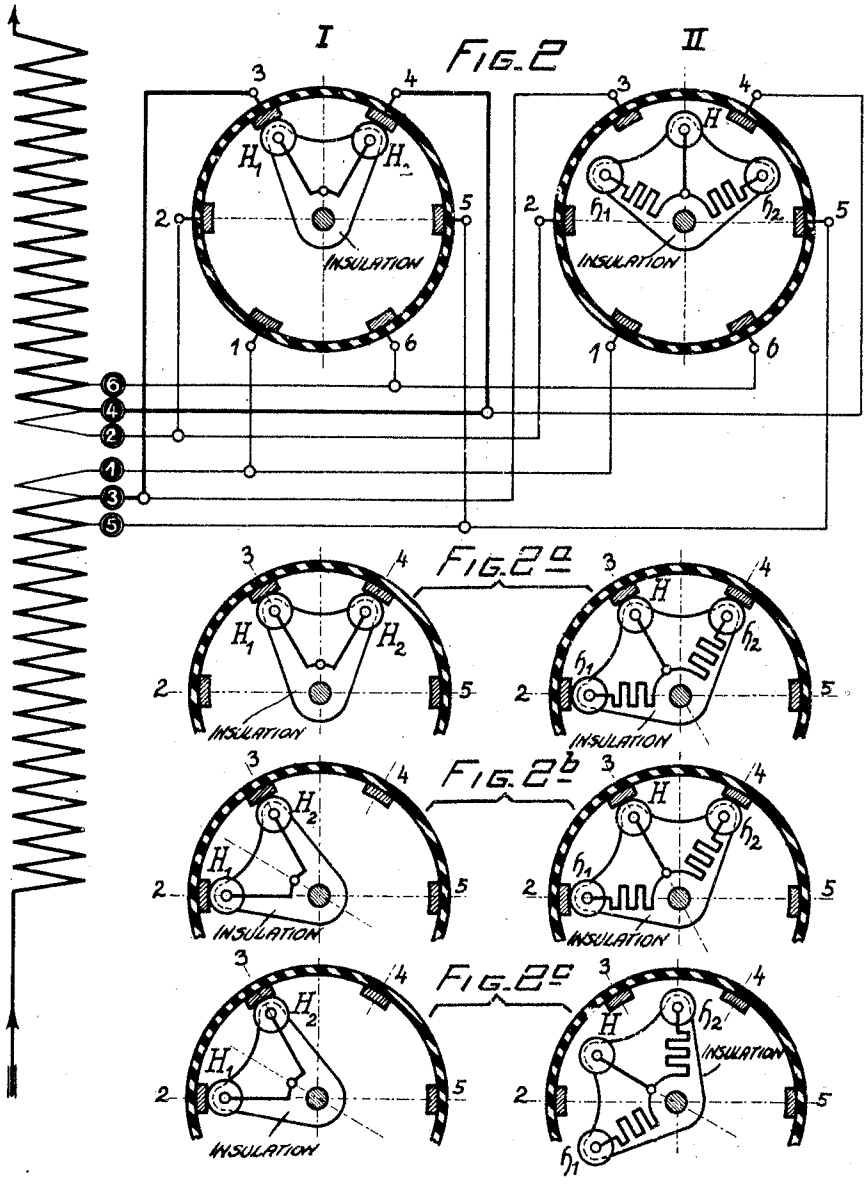


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STEP SWITCH DEVICE FOR REGULATING TRANSFORMERS

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STEP SWITCH DEVICE FOR REGULATING TRANSFORMERS

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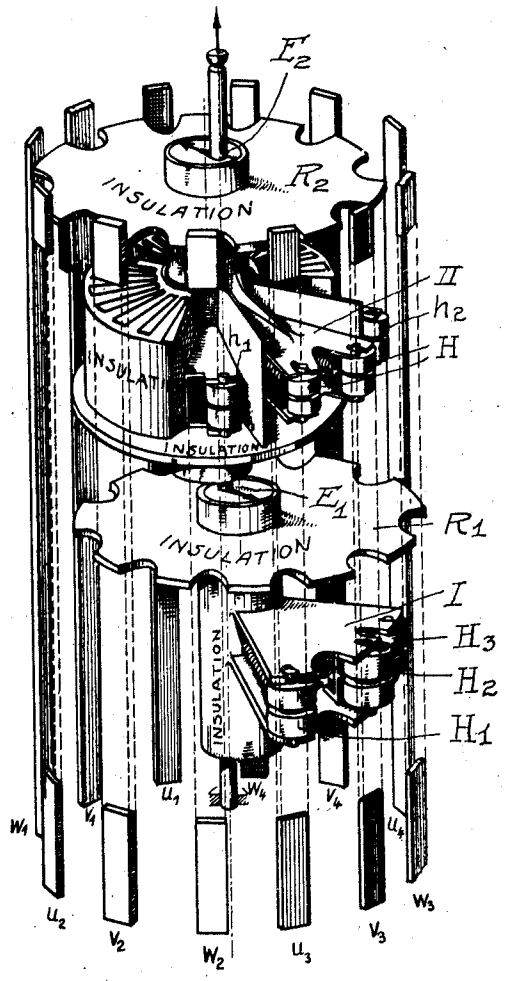


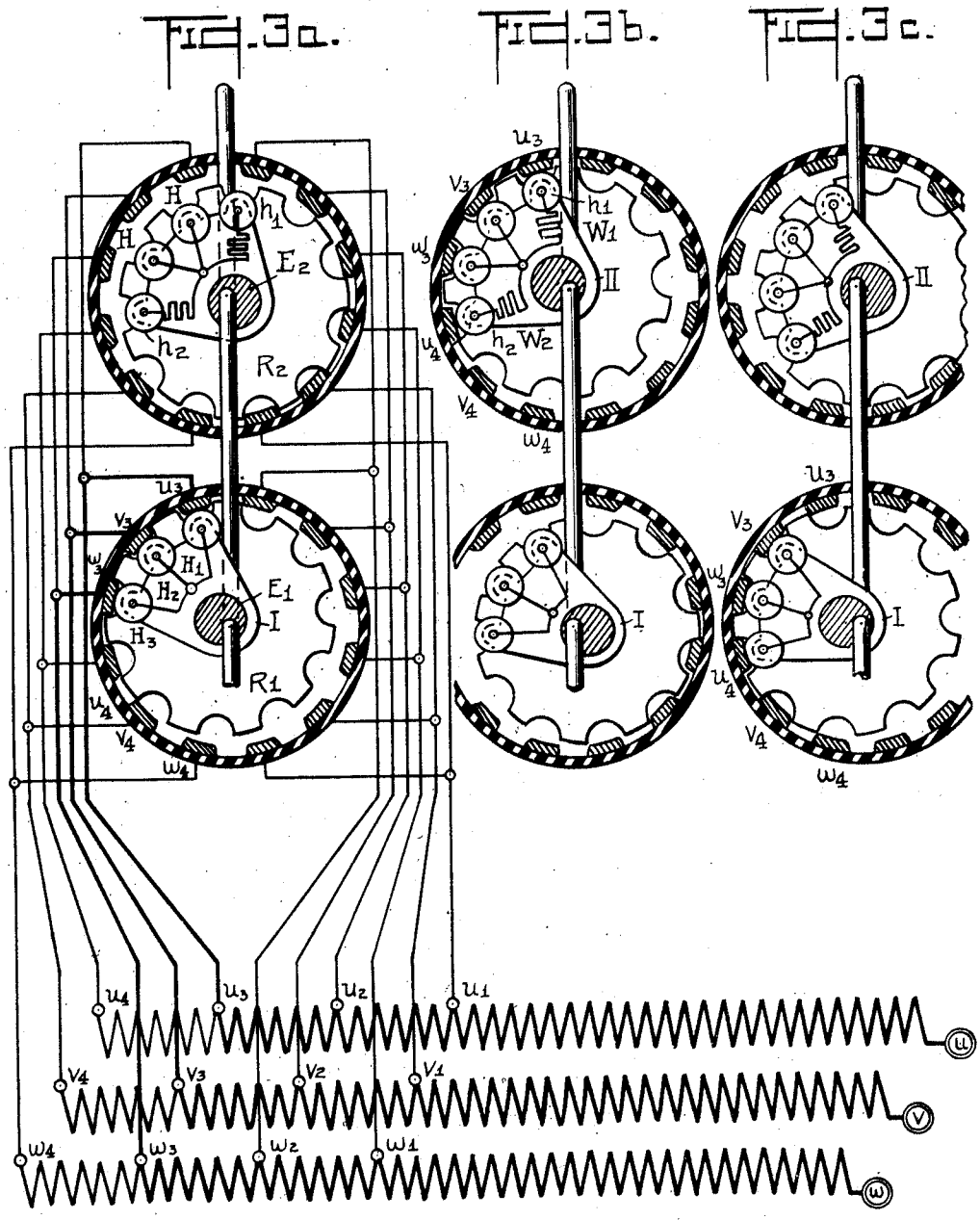
Fig. 3

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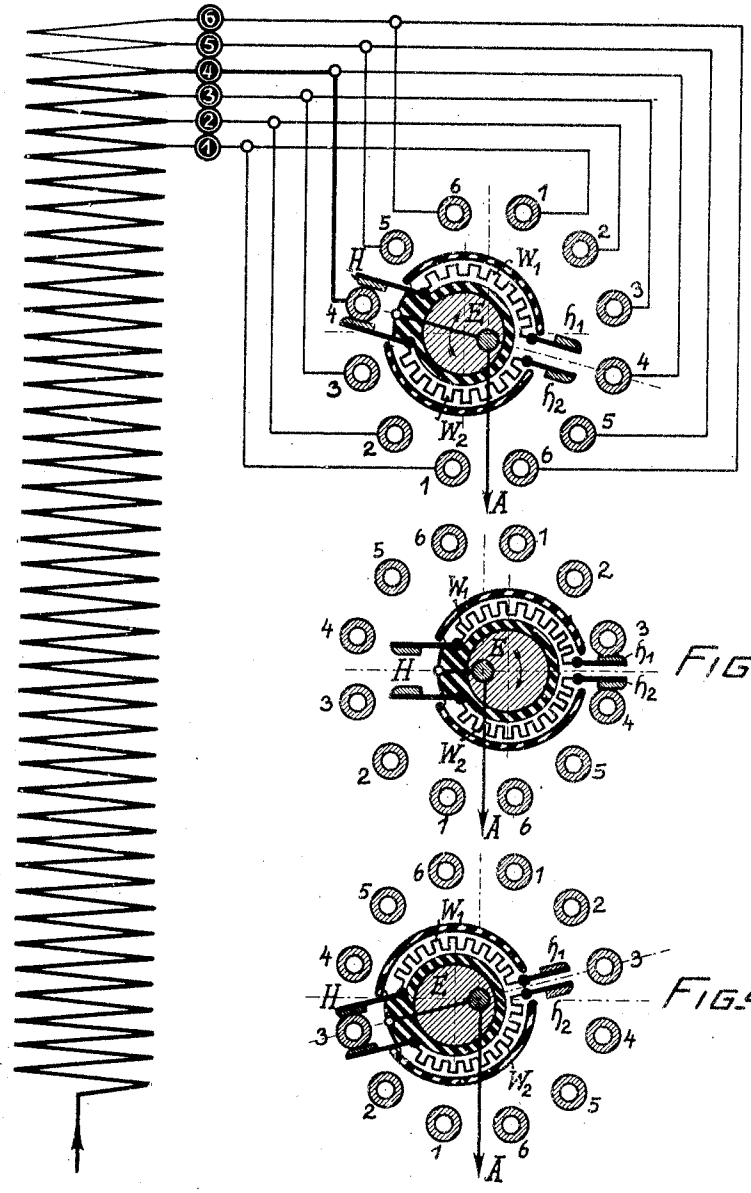


FIG. 4

FIG. 4a

FIG. 4b

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FIG. 5

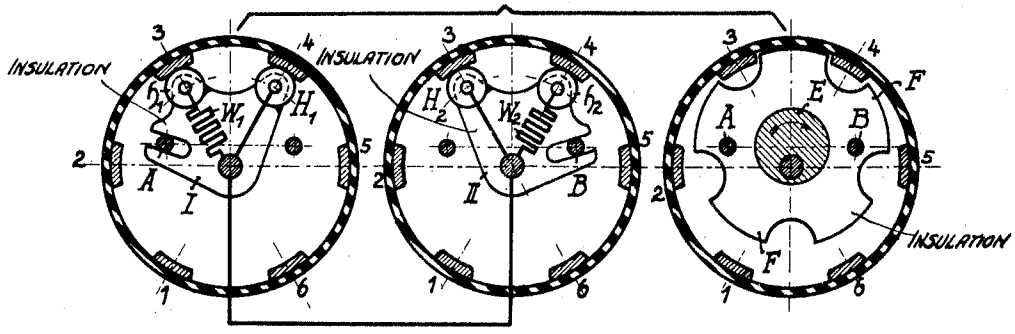


FIG. 5a

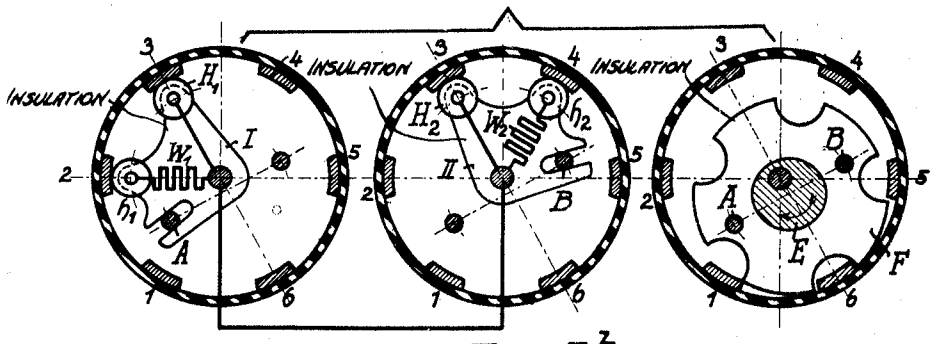
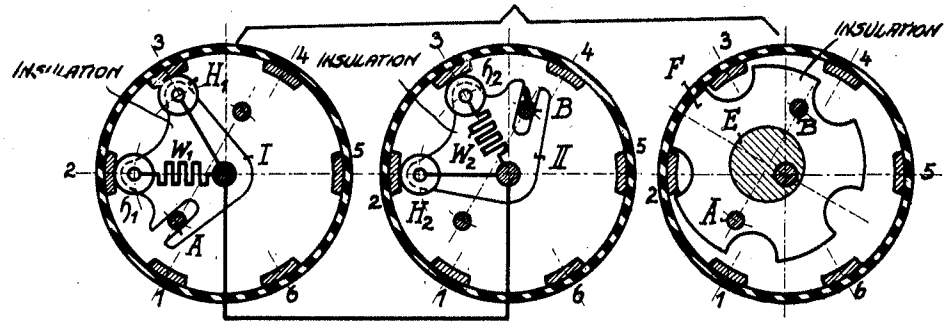


FIG. 5b



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Fig. 6.

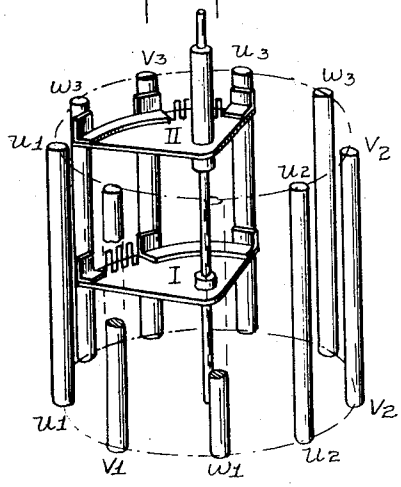
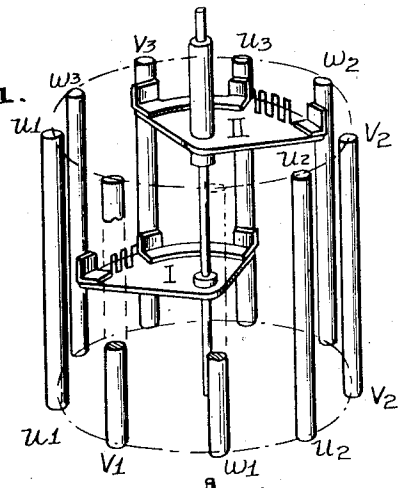


Fig. 6a.



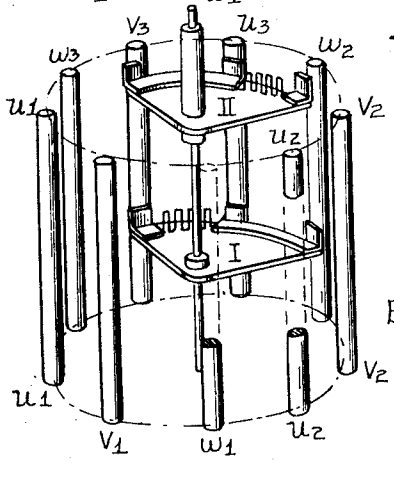


Fig. 6b.

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UNITED STATES PATENT OFFICE

2,231,627

STEP SWITCH DEVICE FOR REGULATING TRANSFORMERS

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Application April 16, 1935, Serial No. 16,656
In Germany April 20, 1934

6 Claims. (Cl. 200—9)

The majority of the on load tap changing gear devices for tapped transformers known so far, use for the purpose of changeover without interruption of the main current from one tap to the other, resistances connected to auxiliary contacts. For this purpose, and in order to attain a suitable changeover process during which neither an interruption of the main current nor a bridging of two taps may take place, the main contacts as well as the auxiliary contacts and the resistances, must operate jointly in a definite sequence. In using ohmic resistances which, owing to their small heat capacity must not be subjected for any length of time to the main and circulating current, it is also very desirable that the changeover take place in as short a period as possible, consecutively and in correct sequences of the individual switching means.

The correct sequence of the single switching apparatus can be brought about either by a suitable gear, which actuates the individual elements consecutively in the prescribed sequence or by placing on a carrier the individual contact elements in the sequence of operation corresponding to the spacings and which is then moved without interruption from step to step. To the first type correspond the changeover switches, mainly for larger outputs, with separate tap selector and load switch. To the second type correspond all those changeover switches in which the main and auxiliary contacts are moved from step to step upon a joint contact carrier along which the transformers taps are arranged in a straight or circular row. During this operation the load switches then carry out the required single switching operations corresponding to the spacing of the respective contacts. This latter arrangement is comparatively simple and correspondingly cheap to manufacture, but requires too much space, making it much more difficult to connect them to the tap transformers, especially in the case of a transformer of small output which leads to an uneconomical enlargement of the transformer receptacles. The reason for this is found in the fact that all the switching operations following each other must take place during the motion of the entire tap gear from one tap to the other. The spacing from one tap contact to the other in the stationary contact row can, therefore, not be as small as would be possible if consideration were given only to the differences of voltage, but the spacing must be so dimensioned as to correspond to the sum of the switching distances and the contact widths of all main and auxiliary contacts movable from step to step.

In accordance with my invention, this defect can be avoided by subdividing into two contact groups all main and auxiliary contacts necessary for the permanent operation and for the changeover, which are alternately actuated in the required rhythm from tap to tap. It follows that each main and auxiliary contact need move only so much and only at the moment as is necessary in regard to the sequence of switching operations. Each contact, therefore, remains stationary when inactive and another contact operates. The relation of the switch distance to the spacing of the tap contacts is thereby reduced to one half, and at the same time the length of the contact row or the diameter of the contact circle, as the case may be, can be considerably reduced.

A further possibility for reducing the spacing of the tap contacts is offered by various constructive arrangements of the invention relating to the manner of actuating the main and auxiliary contacts with the assistance of one or more eccentrics. By these eccentrics, the main and auxiliary contacts are not displaced in the plane of the contact surface from one tap contact to the next, but are lifted in the direction of the contact pressure from the tap contact, brought in a curved path to the next tap contact, and replaced in the direction of the contact pressure. Whereas, therefore, in the first instance the movable contact reduces the existing space of the tap contacts by its full width in each intermediate position, this does not happen in the second instance, and thus the contact spacing can be kept correspondingly smaller.

The invention is illustratively exemplified in the accompanying drawings, in which:

Fig. 1 is a perspective view of one embodiment of a switch with two contact groups according to the invention, showing the transformer and the tap connections diagrammatically;

Figs. 1*a*, 1*b*, 1*c* and 1*d*, each comprising two horizontal sections through the switch of Fig. 1 taken on planes adjacent the contact groups, serve to illustrate four different positions, respectively, of the said switch;

Figs. 2, 2*a*, 2*b* and 2*c* are sectional views, each taken on two horizontal planes adjacent the two contact groups of a second switch embodiment, Figs. 2, 2*a*, 2*b* and 2*c* showing said contact groups in four different positions, respectively;

Fig. 3 is a perspective view similar to that of

Fig. 1 and showing a third switch embodiment with driving mechanism;

Figs. 3*a*, 3*b* and 3*c* are sectional views of the embodiment according to Fig. 3, each taken on two horizontal planes adjacent the two contact groups, respectively. Figs. 3*a*, 3*b* and 3*c* show the two contact groups in three different positions, respectively.

Figs. 4, 4*a* and 4*b* show each a horizontal section through a fourth embodiment of a switch and driving means, the three figures illustrating the movable parts of the switch in three different positions, respectively.

Figs. 5, 5*a* and 5*b* each showing three horizontal sections taken on planes adjacent the two contact groups and an eccentric follower disc, respectively, illustrate a fifth switch embodiment with driving gear in three different positions, respectively, and

Figs. 6, 6*a* and 6*b* show perspectively three different positions, respectively, of a sixth switch embodiment.

In Figure 1 the changeover switch device is shown schematically for six taps, 1—6 arranged at the end of a transformer winding. The device consists of two separately movable contact groups I and II. In the position 1 illustrated in Figs. 1 and 1*a*, the conductor A is connected with tap 1 by the main contact H of the lower group I. The auxiliary contacts *h*—1 and *h*—2 in the upper group II, which are also connected through resistances W—1 and W—2 with lead A, are located during permanent operation at the designated intermediate position between the operating contact 1 and the adjoining contacts 2 and 6, respectively.

Should the changeover now take place from tap 1 to tap 2, then initially only the upper contact group II with the auxiliary contacts *h*—1 and *h*—2 is moved to the right, until it reaches the second position, shown in Fig. 1*b*, in which an auxiliary connection from 1 to 2 is established through the resistances. While this auxiliary connection is maintained the main contact H can be moved in the lower group I from 1 to 2 (see Fig. 1*c*) without an interruption of the operating current. After this changeover has taken place, the new permanent operating position can be effected by moving the auxiliary contacts of the upper group II further to the right to the position shown in Fig. 1*d*. The alternating successive rotation of the changeover operations of the two contact groups in this case avoids all useless movements of the contacts, so long as they must not themselves operate.

By a comparatively simple modification of the main and auxiliary contacts, the afore-described contact groups can also be used for the changeover of the taps of a step transformer located in the middle of the winding and in the neutral point respectively. Figures 2, 2*a*, 2*b* and 2*c* show a switch arrangement for connection in the middle of the winding. The phase-winding shown on the left of Fig. 2 consists of two halves, which are equipped with symmetrical taps, facing each other at the ends. The changeover switch, which again consists of two contact groups I and II, is used for connecting in series two taps of the two winding halves, and for successively changing the two taps between which the series connection is established, so that voltage changes are effected. The taps of the two winding halves are for this reason arranged alternately in the fixed contact row. In position 1 illustrated in Fig. 2, tap contacts 3 and 4 are connected with each other through the two main contacts H—1 and H—2 of the left group. The current flows, therefore, only through the winding parts which are shown with heavy lines in the drawings. If the voltage is to be increased by one step, this can be accomplished by turning to the left the aforementioned contact group I until it connects in series the tap contacts 2 and 3. The winding group located between taps 2 and 4 is, therefore, additionally connected to the current circuit. Electrotechnically, it is merely a question of a change of the connection of the tap contact 3 of the lower winding half with the tap contacts 2 and 4 of the upper winding half. The actual changeover, therefore, takes place between the contacts 2 and 4 in the same winding half.

In order that this change may take place without interruption of operation, the auxiliary contacts *h*—1 and *h*—2 of the right contact group effect in position 2 shown in Fig. 2*a* the resistance connection between tap 3 in operation and taps 2 and 4 which are to be changed. While this auxiliary connection is maintained, the main contacts H—1 and H—2 can change from the connection 3—4 to the connection 3—2, which is shown accomplished in position 3 (see Fig. 2*b*). The auxiliary connection of the right contact group can now be discontinued and the auxiliary contacts H as well as *h*—1 and *h*—2 can be brought into the position 4 (see Fig. 2*c*), which they maintain during permanent operation.

For the changeover of the taps arranged at the neutral point of a three-phase transformer, the hitherto described changeover switch devices can in principle be used, especially in the form shown in Figure 1. In such a case it is, however, necessary to provide a special changeover switch device for each phase. If for the sake of economy it is desired to connect with each other the changeover switches of the three phases, which show no difference in voltage at the movable contacts, as these are connected with a neutral conductor, then it is merely necessary to triple the number of the contacts in each of the two contact groups I and II of Figure 1. With this arrangement it is obvious that then the taps of all three phases are changed over simultaneously. We obtain, therefore, a so-called symmetrical phase contact.

If it is desired to obtain a non-symmetrical phase connection, the switch is constructed, as shown in Figs. 3, 3*a*, 3*b*, and 3*c*, by arranging the taps of the three-phase windings alternately and in succession in one row, and in actuating the changeover switch only one changeover in each phase winding is made. In the position 1, illustrated in Figs. 3 and 3*a*, the taps u_3, v_3, w_3 are connected by the three main contacts H_1, H_2, H_3, with each other forming the neutral point. The operating current, therefore, flows only through those parts of the windings shown in thick lines in Fig. 3*a*. The neutral lead is made use of only in case of a short to ground. By a movement to the left of the aforementioned three main contacts to position 3 (see Fig. 3*c*) only one change of the taps *u*3 and *u*4 of the first phase winding can be made, whereas the contacts *v*3 and *w*3 of the two other phase windings continue to operate.

The two auxiliary contacts H, together with h_1, and h_2 included in the upper contact group II serve to carry out this changeover from position 1 to position 3 without any interruption. The two auxiliary contacts H are first connected so that the taps v_3 and w_3 remain in operation

as shown in position 2 (see Fig. 3b), whereas the auxiliary contacts h_1 and h_2 through their resistances w_1 and w_2 connect with each other the two taps u_3 and u_4, which are to be changed. While the upper contact group II effectuates this auxiliary connection, the lower contact group I is now in a position to change over to the desired position 3 whereupon the auxiliary contact group II can again resume its intermediate position for permanent operation (see Fig. 3c).

Figure 3 also illustrates a modified form of driving mechanism by means of which the alternate switching operations are effected. The lower and upper contact groups are moved by eccentrics E_1, E_2 respectively, which are displaced at an angle of 180°.

In the illustrated embodiment the two eccentrics move two hypocycloidal toothed wheels of insulating material R_1 and R_2 with eleven teeth along the twelve teeth formed by the twelve tap-contacts fixed in a circle. During each complete turn of the two eccentrics the two wheels R_1 and R_2 carrying the two contact groups I and II make a progression of one tooth (12—11=1) from one contact to the next one. As the two eccentrics are displaced at an angle of 180° the movement of the lower and upper contact group changes by this displacement from one tap to another corresponding to positions 1—3. At first the upper auxiliary contact group II moves from position 1 (Figs. 3 and 3a) to position 2 (Fig. 3b) and, while this remains almost stationary, the lower main contact group I changes from position 1 (Figs. 3 and 3a) to position 3 (Fig. 3c), whereupon the upper auxiliary contact group II again moves further from position 2 (Fig. 3b) to position 3 (Fig. 3c)

In the embodiment according to Figs. 3, 3a, 3b and 3c, it is obvious that owing to the hypocycloidal movement, the main and auxiliary contact groups no longer make a sliding motion from one tap to the other, but that rather each single contact lifts itself in the direction of the contact pressure from its tap contact and moves further in a curve to the next tap contact. By this an advantage is attained in that the main and auxiliary contacts in their movements and in the permanent positions never decrease the required contact spacing between the adjoining tap contacts. With this form of movement of the two contact groups with asisstance of the eccentrics, the spacing of the tap contacts from one another can be determined solely by the required arc of movement. The length of the contact row and hence the diameter of the contact circle, is thus diminished to a minimum. The same type of drive may be used for all connections shown in the Figures 1 to 3 and 5 to 6.

A special kind of hypocycloidal drive, where instead of two eccentrics only one such eccentric is employed, is shown in Figs. 4, 4a and 4b. Instead of the eccentrics being spaced by 180° the two contact groups themselves have been spaced by 180°. This can only be done in special instances where one-half of the contact circle is sufficient for placing the tap contacts. Such special instances occur, for example, when it is desired to undertake a reversal and when therefore the same contacts must again be placed in the second contact half, or when so few taps are available at the winding that the taps are placed upon one half of the contact circle and upon the other half of the contact circle are placed the auxiliary contacts belonging thereto and connected with the taps of the resistances.

The changeover operation from position 1 (Fig. 4) to position 3 (Fig. 4b) is as follows: In position 1 (Fig. 4) the tap 4 is in operation and connected directly with main lead A by the left main contact group H. A turn to the right of the eccentric E brings the two auxiliary contacts h_1 and h_2 of the right auxiliary contact group, which are connected with the main lead A through resistances w_1 and w_2, in connection with the taps 4 and 3 respectively, when the main contact H is about to leave the tap 4. In position 2, shown in Fig. 4a, the auxiliary contacts h_1 and h_2 maintain the resistance contact between the two taps 4 and 3 to be changed and the main lead A, whereas the main contact H is just in the middle of its movement from 4 to 3. When the main contact H has reached the tap 3 due to further turning of the eccentric E, then the auxiliary contacts can discontinue the resistance connection between the contacts to be changed and take their intermediate position shown in position 3, as shown in Fig. 4b.

Another method of drive, for which one eccentric is sufficient to actuate the two contact groups alternately, and which is similar to the driving arrangement illustrated in Fig. 2 is shown in more detail in Figs. 5, 5a, 5b. On the right side the eccentric E, which moves the five tooth disc F within the six section tap contact circle 1—6, is shown in three characteristic positions, respectively. Positions 1 and 3 (Figs. 5 and 5b, respectively) are the permanent operating positions where the left and the right contact groups I and II connect in series the taps 3 and 4 and 3 and 2 respectively. The alternate movement of the two contact groups, notwithstanding the use of only one single eccentric E ensues by virtue of the provision on the eccentric follower disc F of two drive-bolts A and B, displaced against each other by 180°. The drive bolt A engages in a slot of the left contact group I, whereas the drive bolt B engages in a slot of the right contact group II so that the two contact groups are turned each time in conformity to the movement of the two drive bolts A and B around the center of the contact circle. As, owing to their displacement of 180°, the two drive bolts move alternately, as is evident by comparing positions 1 to 3 (Figs. 5, 5a, 5b), the required alternate movements of the left and right contact groups take place. From position 1 (Fig. 5) to position 2 (Fig. 5a) the right contact group II has remained almost stationary and only the left contact group I has moved further by a notch. From position 2 (Fig. 5a) to position 3 (Fig. 5b) the left contact group I has remained almost stationary and the right contact group II has followed it into the same position. This type of drive can also be used for all contacts shown on the Figures 1–3 and 5–6.

Figs. 5, 5a and 5b show, in addition to the modified driving means, another mode of distribution of main and auxiliary contacts on the two alternately moved contact groups I and II. The transformer taps and their connections with the fixed contacts 1—6 are the same as in Fig. 2. The step switch device thus serves for the connection of the taps of two winding halfs with each other. However, the one contact group does not contain all main contacts and the other all auxiliary contacts, as is the case with the step switch device, shown in Figure 2, but both contact groups contain—each in juxtaposition—one main contact each with corresponding auxiliary contact and switch-over resistor. Contrary to the step switch equipment, as shown in Fig. 2, all

main and auxiliary contacts are connected with the taps in use, i. e., in the permanent position. The current lead from one tap to the other (3—4 position I) therefore takes place from one contact group to the other (from H_1+h_1 to H_2+h_2). The change over from the existing connection 3—4 (Fig. 5) to the desired connection 3—2 (Fig. 5b) at first takes place by moving the left contact group I by one spacing to position 2 (Fig. 5a). The direct connection with tap 4 is thus at first discontinued and there remains only the resistance connection in the right contact group II by means of the auxiliary contact h_2. In addition there is effectuated by the left contact group I, the resistance connection through the auxiliary contact h_1 with the tap 2. In this position 2 there is therefore now connected the tap 3 through resistances $w2$ and $w1$ with the two adjoining taps 4 and 2. The further movement of the right contact group II to position 3 (Fig. 5b) now removes the resistance connection of the former tap 4 and makes direct contact, with assistance of the main contact H_2, of the tap 3 with tap 2.

The same idea of switching over can be applied to the unsymmetrical phase alternating changeover of the taps at the zero point of a three phase transformer as has already been described in connection with Figs. 3, 3a and 3b. Only the distribution of the main and auxiliary contacts is changed in the two contact groups I and II of the step switch device, as is evident from Figs. 6, 6a and 6b. From these spatial illustrations, which are clear without any further explanations, it can be easily seen, that the changeover takes place exactly as described for the step switch device, Figs. 5, 5a, 5b. Owing to the fact that, to the two winding parts (sections) which are to be connected with each other, also a third has been added, the number of main contacts has been increased by one each in each contact group. The auxiliary contacts and changeover resistances have, however, remained unchanged.

What I claim is:

1. A step switch device for successively tapping in a plurality of circuits, comprising a plurality of conducting means adapted to be connected with different circuits, respectively, each of said conducting means having two fixed contact places, the contact places of said conducting means being arranged in two sets, each set including one contact of each conducting means, a plurality of movable contacts arranged in two groups, supporting means and movable means associated with said supporting means and carrying said groups, said movable carrying means being adapted to move each of said movable groups stepwise and in alternate succession with respect to the other group into and out of contact position along one of said sets of fixed contact places, one of said movable groups including a main contact adapted to establish direct connection with a selected circuit, the second group comprising a plurality of contacts connected in parallel and spaced apart a distance corresponding to that provided between the fixed contacts and ohmic resistances in series with the end contacts of said second group.

2. A step switch device for changing over from one circuit to another, comprising a plurality of conducting means adapted to be connected with different circuits, respectively, each of said conducting means having two fixed contact places, the contact places of said conducting means being arranged in two sets, each set including one contact of each conducting means, a plurality of movable contacts arranged in two groups, supporting means and movable means associated with said supporting means and carrying said groups, said movable carrying means being adapted to move each of said movable groups, stepwise and in alternate succession with respect to the other group into and out of contact position along one of said sets of fixed contact places, one of said movable groups including a main contact adapted to establish direct connection with a selected circuit, the second group comprising a pair of auxiliary contacts connected in parallel and spaced apart a distance corresponding to that provided between the fixed contacts and two ohmic resistances in series with said auxiliary contacts, respectively.

3. A step switch device for changing over from a series connection between two circuits to a series connection between one of said circuits and a third circuit, comprising a plurality of conducting means adapted to be connected with different circuits, respectively, each of said conducting means having two fixed contact places, the contact places of said conducting means being arranged in two sets, each set including one contact of each conducting means, a plurality of movable contacts arranged in two groups, supporting means and movable means, associated with said supporting means and carrying said groups, said movable carrying means being adapted to move each of said movable groups stepwise and in alternate succession with respect to the other group into and out of contact position along one of said sets of fixed contact places, one of said movable groups including a pair of interconnected main contacts, the second group comprising two auxiliary contacts and a main contact disposed therebetween, said auxiliary contacts and the main contact being connected in parallel, two ohmic resistances disposed in series with the auxiliary contacts, the individual contacts in each of said movable groups being spaced apart a distance corresponding to that provided between the fixed contacts.

4. A step switch device for changing over from a parallel connection between three circuits to a parallel connection between two of said circuits and a fourth circuit, comprising a plurality of conducting means adapted to be connected with different circuits, respectively, each of said conducting means having two fixed contact places, the contact places of said conducting means being arranged in two sets, each set including one contact of each conducting means, a plurality of movable contacts arranged in two groups, supporting means and movable means, associated with said supporting means and carrying said groups, said movable carrying means being adapted to move each of said movable groups stepwise and in alternate succession with respect to the other group into and out of contact position along one of said sets of fixed contact places, one of said movable groups including three main contacts, the second group comprising two auxiliary contacts and two main contacts disposed therebetween, said main contacts and auxiliary contacts being connected in parallel, two ohmic resistances disposed in series with the auxiliary contacts, the individual contacts in each of said groups being connected in parallel and spaced apart a distance corresponding to that provided between the fixed contacts.

5. A step switch device for successively tapping in a plurality of circuits, comprising a series of

fixed contact bars spaced apart and disposed parallel with respect to one another and along the periphery of a circle, the individual bars being adapted to be connected with different circuits, respectively, a rotatable shaft centrally disposed with respect to said bars, a plurality of movable contacts arranged in two groups, two disk-shaped carriers for said movable groups disposed in different planes and rotatably mounted on said shaft, said carriers consisting of insulating material and provided with peripheral projections adapted to move into and out of the recesses between said spaced contact bars, and two eccentrics mounted on said shaft and cooperating with the said carriers to produce stepwise and alternate movement of said carriers and associated contact group into and out of contact position, said two eccentrics being off-set 180° with respect to each other.

6. A step switch device for successively tapping in a plurality of circuits comprising a series of fixed contact bars spaced apart and disposed parallel with respect to one another and along the periphery of a circle, the individual bars being adapted to be connected with different circuits, respectively, a rotatable shaft centrally disposed with respect to said bars, a plurality of movable contacts arranged in two groups, two carriers for said movable groups disposed in different planes and rotatably mounted on said shaft, an eccentric fixed to said shaft, a disk-shaped follower for said eccentric, said follower consisting of insulating material and being provided with peripheral projections adapted to move into and out of the recesses between said spaced contact bars, and two driving devices cooperating with said carriers to produce stepwise and alternate movement of said carriers and associated contact groups into and out of contact position, said driving devices being carried by said follower and offset 180° with respect to each other.

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