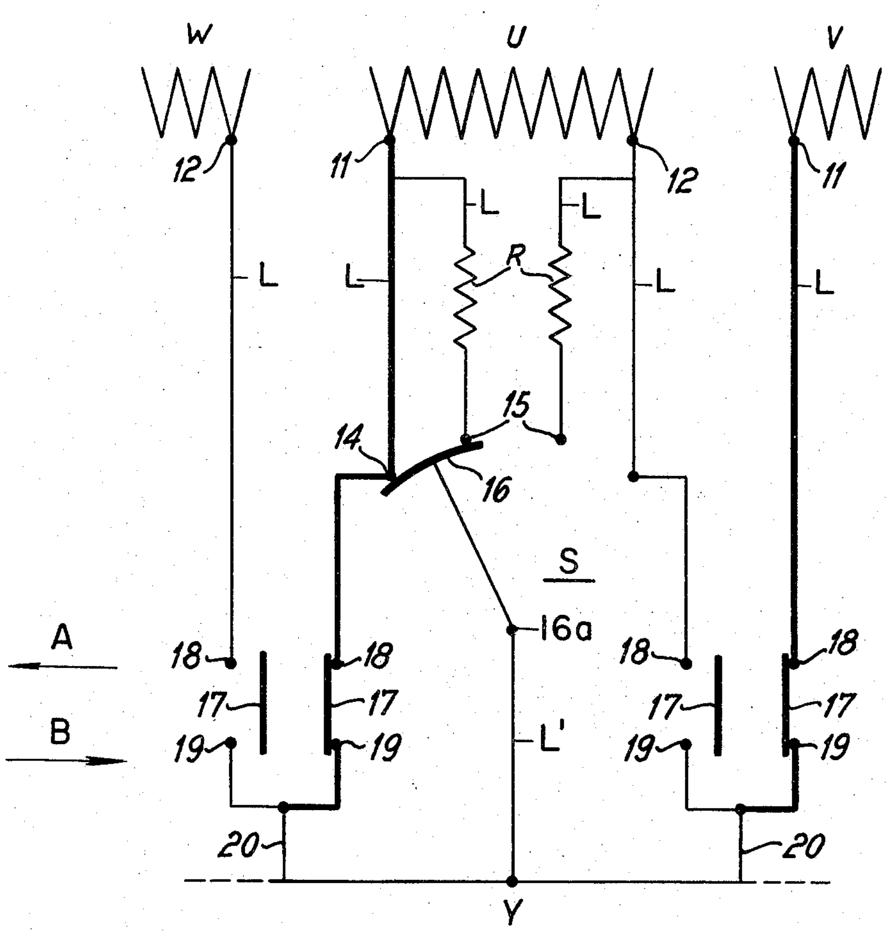
TRANSFER SWITCH FOR TAP-CHANGING REGULATING TRANSFORMERS HAVING CURRENT-CARRYING CONTACTS AND OPERATING MEANS THEREFOR ACHIEVING HIGH INITIAL SPEEDS OF CONTACT SEPARATION

Filed Oct. 19, 1965 3 Sheets-Sheet 1

FIG. 1



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Dec. 10, 1968 A. BLEIBTREU ET AL 3,415,957

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FIG. 2

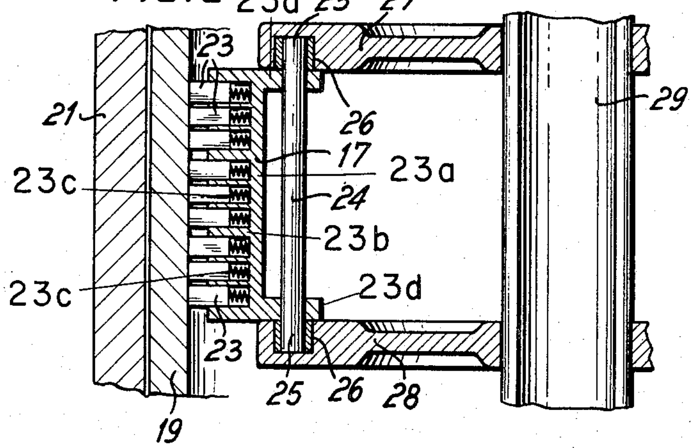

FIG. 3

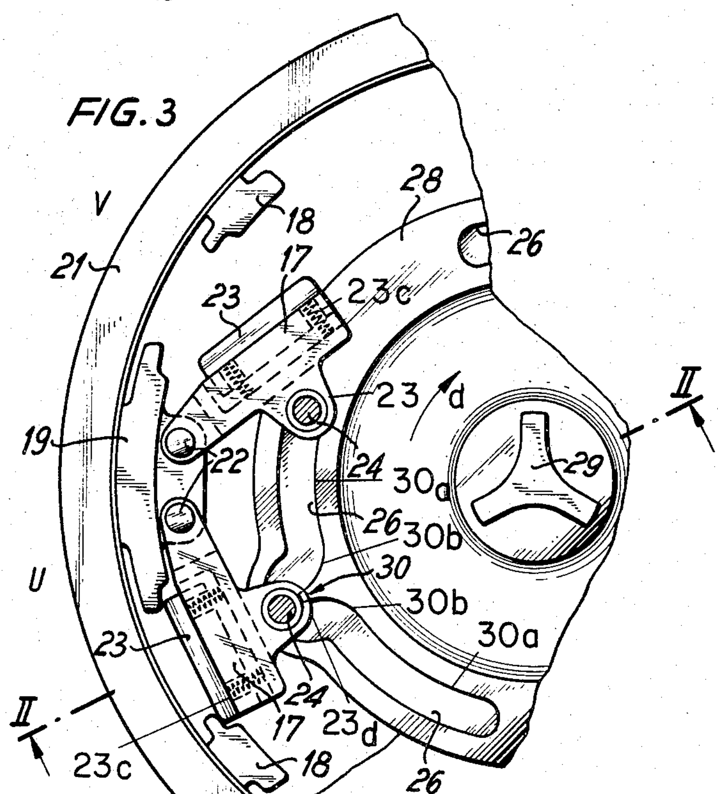

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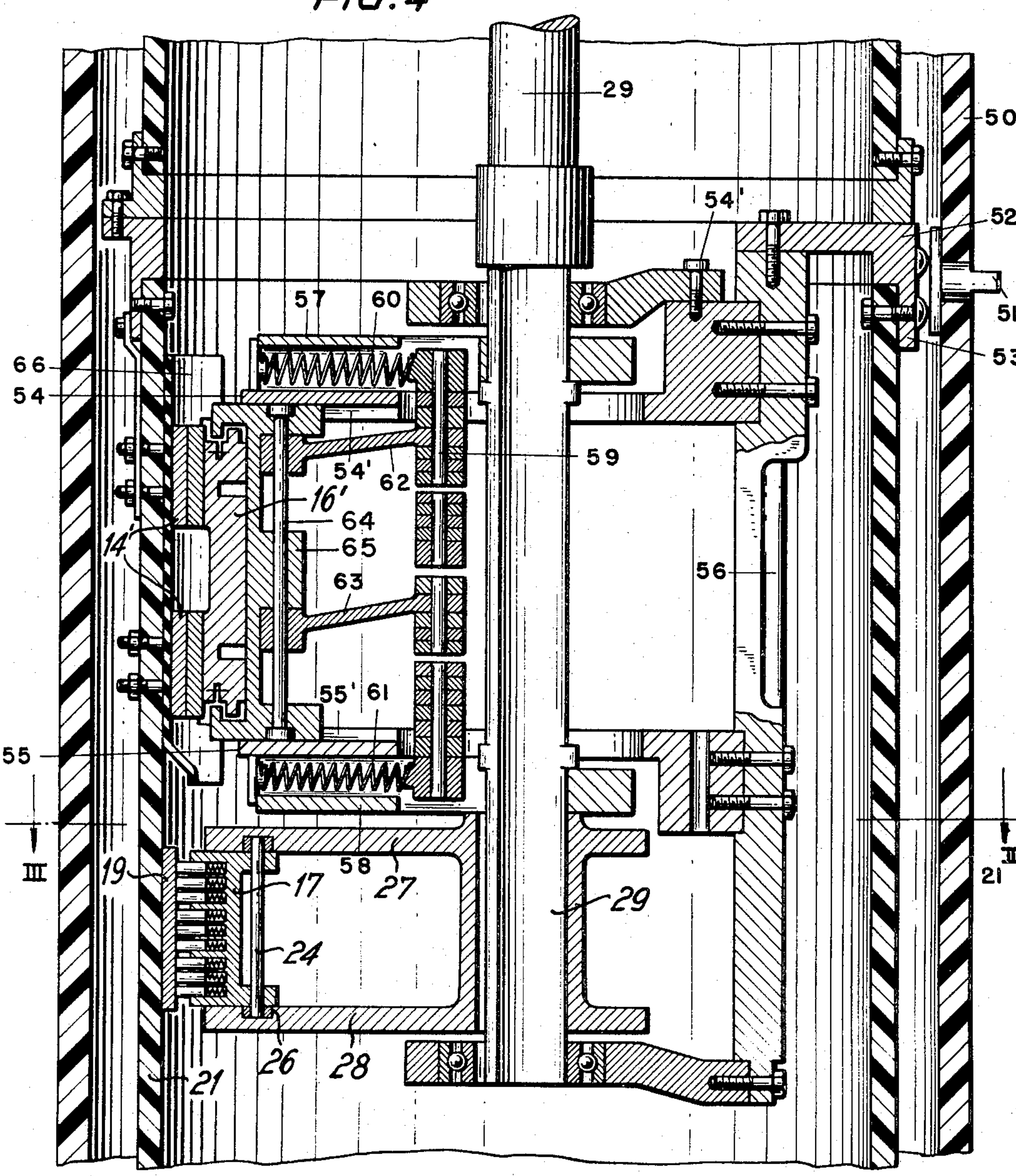
FIG. 4



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14 Claims. (Cl. 200—8)

This invention relates to transfer switches for tap-changing regulating transformers, and more particularly to tap-changing regulating transformers of the so-called Jansen type.

It is a general object of this invention to provide improved transfer switches for tapped regulating transformers, and more particularly improved transfer switches for tap-changing regulating transformers of the so-called Jansen type.

In Jansen type tap-changing regulating transformers the changes of the transfer switches from one limit position to the other limit position thereof are effected very rapidly, and auxiliary contacts insert ohmic switch-over resistors into the circuit in position of the transfer switches intermediate the limit positions thereof. Since these auxiliary contacts are generally required to break currents, these auxiliary contacts must be designed to perform this duty, i.e. to perform as arcing contacts. The contacts which are closed in the two limit positions of transfer switches may also be required to break currents and should, therefore, also be designed to perform this duty, i.e. to perform as arcing contacts. Since cooperating separable contacts can be designed to either perform as arcing contacts, or to perform as current-carrying contacts, i.e. perform a continuous current-carrying duty, and since contacts cannot be designed to perform both duties, it is desirable to provide transfer switches with current-carrying contacts in addition to arcing contacts. To be more specific, each part of cooperating separable arcing contacts which is closed in one of the limit positions of the transfer switch is associated with a pair of current-carrying contacts. In the closed position of the arcing contacts the latter are shunted by the current-carrying contacts. The current-carrying contacts must engage subsequent to the engagement of the arcing contacts which they are intended to shunt, and must separate prior to the separation of the arcing contacts which they have been shunting.

It is another object of this invention to provide transfer switches for tap-changing regulating transformers having improved current-carrying contacts and improved means for operating the same.

United States Patent 3,174,097, issued Mar. 3, 1965, to Alexander Bleibtreu for Transfer Switch for Tap Changers for Regulating Transformers discloses a transfer switch including current-carrying contacts in addition to arcing contacts.

It is another object of this invention to provide an improved version of the transfer switches disclosed in the above patent.

It is possible to operate current-carrying contacts by means of toggle-lever mechanisms under the control of

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the same operating shaft which operates the arcing contacts of the transfer switch. If toggle-lever mechanisms are used to operate the current-carrying contacts of a transfer switch, the initial acceleration and the initial velocity of the contacts is necessarily relatively small. As a result, the degree of separation of the current-carrying contacts after a predetermined increment of time is relatively small. This establishes a tendency of restrike, or re-ignition, between the separated contacts. In order to counter this tendency it is necessary to assign a relatively large portion of the angle of rotation of the common operating shaft of the arcing contacts and of the current-carrying contacts to separating the latter. This, in turn, reduces the portion of the total angle of rotation of the aforementioned shaft available for operating the arcing contacts.

It is, therefore, another object of this invention to provide transfer switches for tap-changing regulating transformers which transfer switches include current-carrying contacts and are not subject to the aforementioned drawbacks and limitations.

Still another object of the invention is to provide transfer switches for tap-changing regulating transformers including current-carrying contacts under the control of operating means which impart to the current-carrying contacts high initial speeds of separation.

The present invention is applicable to single-phase transfer switches as well as to polyphase transfer switches and is particularly desirable in connection with three-phase transfer switches.

The above referred to objects and additional objects and advantages of the invention will be fully apparent from the ensuing description of a particular embodiment of the invention when considered in conjunction with the appended drawings.

Referring now to the drawings:

FIG. 1 is a diagrammatic representation of a transfer switch embodying the present invention and shows also the electrical connections thereof with a tap-changing three-phase regulating transformer;

FIG. 2 is a section along II—II of FIG. 3 and shows a current-carrying contact embodying this invention and the operating means therefor;

FIG. 3 is a section along III—III of FIG. 4 and shows in top-plan view on a larger scale than FIG. 4 current-carrying contacts and their operating means embodying this invention; and

FIG. 4 is a vertical section along a transfer switch embodying this invention.

In FIG. 1 reference characters U, V, W have been applied to indicate portions of three-phase windings of a tap-changing three-phase regulating transformer and reference character S has been applied to generally indicate a portion of a transfer switch associated with the winding U of the transformer. The portions of the transfer switch associated with windings V and W are identical to that of portion S associated with winding U and, therefore, need not to be shown. Leads L interconnect windings U, V, W with the transfer switch S. Normally a selector switch is included in such leads to select between different pairs of taps of windings U, V, W. Such a selector switch has been omitted in FIG. 1, assuming that the duty of the transfer switch is limited to change from taps **11** to taps **12** of windings U, V, W, and vice versa, from taps **12** to taps **11**. The transformer under consideration is a

Y connected transformer and the letter Y has been applied to indicate the neutral point thereof. Reference numerals **14** and **15** have been applied to indicate the fixed arcing contacts connected to taps **11** and **12** of winding U. The fixed main arcing contact **14** on the left of FIG. 1 is directly connected by lead L to tap **11** of winding U and the fixed main arcing contact **14** on the right of FIG. 1 is directly connected by lead L to tap **12** of winding U. The fixed auxiliary arcing contact **15** on the left of FIG. 1 is connected by a lead L by the intermediary of an ohmic resistor R to tap **11** of winding U, and the fixed auxiliary contact **15** on the right of FIG. 1 is connected by a lead L and by the intermediary of an ohmic resistor R to tap **12** of winding U. Normally a separate movable arcing contact is provided to engage each of fixed arcing contacts **14, 15** and to separate from each of the fixed arcing contacts **14, 15** in a predetermined sequence. To simplify FIG. 1 a single movable arcing contact **16** has been shown performing the same switching operations in the same sequence as the four separate movable arcing contacts normally provided in a transfer switch of the kind under consideration. Movable arcing contact **16** is supported by an arm fulcrumed at **16***a*. Fulcrum **16***a* is conductively connected by lead L′ to the neutral point Y of the three-phase system. The taps **11** and **12** of windings U, V, W are conductively connected by leads L to fixed current-carrying contacts **18**, and the neutral point Y of the three-phase system is conductively connected by leads **20** to fixed current-carrying contacts **19**. A current-carrying contact bridge **17** is operatively related to each pair of fixed current-carrying contacts **18, 19**. Contact bridges **17** may be moved selectively in the direction of arrow A, or of arrow B, indicated in FIG. 1. In the position of parts shown in FIG. 1 the current-carrying contacts **18, 17, 19** connected to tap **11** of winding U are in engagement, or the closed position thereof, and the current-carrying contacts **18, 17, 19** connected to tap **12** of winding U are out of engagement, or the open position thereof. The contact resistance between current-carrying contacts **18, 17, 19** is less than the contact resistance between the arcing contacts **14, 16**. Since the former shunt the latter, the latter do not need to carry current, or they carry but a relatively small fraction of the current flowing from tap **11** of winding U to the neutral point Y of the system.

If it is desired to connect tap **12** to the neutral point Y instead of tap **11**, the following operations are sequentially performed.

Current-carrying contact bridge **17** connecting tap **11** of winding U to the neutral point Y is moved from the right limit position thereof shown in FIG. 1 in the direction of arrow A to the left limit position thereof. This is achieved by operating means not shown in FIG. 1. As a result of the operation of bridge **17** the current path shunting the arcing contacts **14, 16** to the left of FIG. 1 is interrupted and these contacts are then caused to carry the entire current flowing from tap **11** of winding U to the neutral point Y of the system. Thereupon movable arcing contact **16** is pivoted in clockwise direction as seen in FIG. 1 about fulcrum **16***a*. This causes the following sequential switching operations:

(a) Separation of movable arcing contact **16** from the left main arcing contact **14** interrupts the direct current path from left tap **11** of winding U to the neutral point Y. The aforementioned tap **11** remains still connected to the neutral point Y by the intermediary of the left ohmic resistor R.

(b) Continued movement of movable arcing contact **16** results in simultaneous engagement of both fixed arcing contact **15** by movable arcing contact **16**. At this point both taps **11, 12** of winding U are conductively connected to the neutral point Y of the system by the intermediary of both ohmic resistors R then operating as a voltage divider.

(c) Continued movement of arcing contact **16** results in separation of the latter from the left arcing contacts **15** as a result of which neutral point Y is no longer connected to tap **11** of winding U. Tap **12** of winding U is then connected to the neutral point Y of the system by the intermediary of the right ohmic resistor R.

(d) Continued movement of movable arcing contact **16** results in engagement by the latter of the right fixed arcing contact **14**, thus establishing a direct current path from tap **12** of winding U to the neutral point Y of the system. This current path is still a current path involving a relatively high contact resistance between the fixed arcing contact **14** connected to tap **12** of winding U and the movable arcing contact **16**.

(e) The switching sequence is completed by moving the particular current-carrying contact bridge **17** to the left which shunts the current path from tap **12** of winding U to point Y including fixed arcing contact **14** and movable arcing contact **16**.

As shown in FIGS. 2 and 3 the fixed main current-carrying contacts **18** and **19** of FIG. 1 have been replaced in the embodiment of the invention according to FIGS. 2–4 by a pair of contacts **18** and **19** which are supported by the cylindrical contact support **21** of insulating material in the center of which operating shaft **29** is located. FIGS. 2 and 3 further show that the contact bridges **17** of FIG. 1 have been replaced by a pair of pivotable contact bridges or contacts **17**, each pivotable about a fulcrum **22**. Each fulcrum **22** is in the form of a pin or shaft extending parallel to shaft **29** and supported by a bracket integral with contact **19** or, in other words, a bracket supported by contact support **21**. It is apparent from FIGS. 1 and 3 that in the structure of FIG. 3 fixed current-carrying contacts **19** intended to be connected to the neutral point Y of the three-phase system are associated with windings pertaining to different phases. The movable current-carrying contacts or current-carrying contact bridges **17** of FIG. 2 pertain likewise to different phases. The upper fixed current-carrying contact **18** of FIG. 3 may be connected to tap **12** of winding W of FIG. 1 and the lower fixed current-carrying contact **18** of FIG. 3 may be connected to tap **11** of winding U of FIG. 1. If the structure shown in part in FIG. 3 were completed, as required for a three-phase transfer switch for a three-phase tap-changing regulating transformer, it would include three fixed current-carrying contacts **19** angularly displaced 120 deg., each pivotally supporting a pair of movable current-carrying contacts or current-carrying contact bridges **17**, i.e. a total of six movable current-carrying contacts or current-carrying contact bridges **17**, and it would also include a total of six fixed current-carrying contacts **18** of which each may be engaged by, and separated from, one of the movable current-carrying contacts or contact bridges **17**. Each movable current-carrying contact or current-carrying contact bridge **17** includes a housing **23***a* open at one side thereof, i.e. at the side thereof opposite the cooperating fixed current-carrying contact **18**. A stack of contact laminations **23** is arranged in each such housing and projects out of the housing at the aforementioned open side thereof. Ribs **23***b* extending from the bottom of housing **23***a* toward its open side subdivide each stack of contact laminations **23** in a plurality of sub-stacks and form guiding means for contact laminations **23**. Reference character **23***c* has been applied to indicate spring means, such as a plurality of helical springs, interposed between the bottom of housing **23***a* and contact laminations **23**, biasing the latter in the direction of the open side of each housing **23***a*. As shown in FIG. 3 contact laminations **23** define recesses for receiving one of the ends of the lamination-biasing springs **23***c*. Each movable current-carrying contact, or current-carrying bridge **17** is further provided with abutment means (not shown) for maintaining laminations **23** inside of their housings **23***a*, i.e. precluding the former to be pushed entirely out of the latter under the action of biasing springs 23*c*. Each housing 23*a* is further provided at the side thereof opposite to its open side with a pair of brackets 23*d* supporting a pin or shaft 24 extending parallel to shaft 29. The ends of each pin or shaft 24 extend axially outwardly beyond brackets 23*d* and are adapted to form cam-followers 25. Cam-followers 25 are engaged and operated by cams. Shaft 29 operates a pair of parallel, spaced cam plates 27, 28 of which each defines a substantially V-shaped groove or slot 26 the sides of which form the aforementioned cams. Each of grooves 26 defines an abutment portion 30 which is a relatively short cylindrical surface coaxial with shaft 29 and having a relatively large radius, and outer cylindrical surfaces 30*a* coaxial with shaft 29 and having a relatively small radius. Each of grooves 26 further defines a smoothly curved pin-moving portion 30*b* intermediate abutment portion 30 and outer cylindrical or circular portions 30*a*. It will be apparent that the lateral side of each groove or slot 26 forms a sharp or abrupt turn between abutment portion 30 and pin-moving portions 30*b*. On the other hand, pin-moving portions 30*b* blend smoothly into outer cylindrical or circular portions 30*a*. The length of outer portions 30*a* is selected in such a fashion that when cam-follower 25 of one of the current-carrying contacts, or current-carrying bridges 17 is engaged by abutment portion 30, the cam-follower 25 of the adjacent current-carrying contact or current-carrying bridge 17 engages the end of an outer portion 30*a* of the cam defined by groove 26. The current-carrying contact or current-carrying bridge 17 whose cam-follower is engaged by the abutment portion 30 of cam plates 27, 28 is positively blocked, or locked, in the closed position thereof wherein its contact limitations 23 conductively interconnect a fixed current-carrying contact 19 and a fixed current-carrying contact 18, as clearly shown in the lower left of FIG. 3. When cam-plates 27, 28 are in that particular position, the cam-followers 25 pertaining to the adjacent movable current-carrying contact, or current-carrying contact bridge 17 are located at the ends of grooves 26 remote from abutment portion 30, i.e. at the ends of outer cam portions 30*a*.

Assuming the upper fixed current-carrying contact 18 of FIG. 3 to be connected to tap 12 of winding W of FIG. 1 and the lower fixed current-carrying contact 18 of FIG. 3 to be connected to tap 11 of winding U of FIG. 1 and the intermediate fixed contact 19 of FIG. 3 to be connected to the neutral point Y of FIG. 1. Clockwise rotation of shaft 29 and of cam plates 27, 28 then results in an instantaneous separation of the lower movable current-carrying contact, or current-carrying contact bridge 17 from lower fixed current-carrying contact 18 and from intermediate fixed current-carrying contact 19, thus forming two series breaks in the circuit shunting the arcing contact 14, 16 to the left of FIG. 1. Continued motion of shaft 29 and cam plates 27, 28 has no immediate effect on the two movable current-carrying contacts or current-carrying bridges 17 of FIG. 3. In other words, the current-carrying upper contact bridge 17 and the lower current-carrying contact bridge 17 remain in their respective open positions as long as the cam-followers 25 are in engagement with, or move along, the outer cylindrical surfaces 30*a* defined by slot 26. Toward the end of the clockwise pivotal motion of shaft 29 and cam-plates 27, 28 the cam-followers 25 pertaining to the upper current-carrying contact bridge 17 are engaged by the pin-moving portions 30*b* defined by slots 26 of plates 27, 28 and consequently the upper current-carrying contact bridge 17 is rapidly moved to the closed position thereof, in which position it interconnects conductively the intermediate fixed current-carrying contact 19 and the upper fixed current-carrying contact 18 and in which position it is maintained by the action of abutment 30. The time interval between separation of the lower current-carrying contact bridge 17 from its cooperating fixed contacts 18, 19 to engagement of the upper current-carrying contact bridge 17 with its cooperating fixed contacts 18, 19 is available for performing the switching operations required of the main arcing contacts and of the auxiliary arcing contacts of the particular transfer switch.

The separation of the laminations 23 pertaining to each current-carrying contact bridge 17 from its cooperating fixed current-carrying contacts 18, 19 is initiated under the action of biasing springs 23*c*. As shaft 29 and cam-plates 27, 28 begin the clockwise motion thereof, withdrawing abutment surfaces 30 from cam-followers 25, springs 23*c* expand and push housings 23*a*, brackets 23*d*, pins 24 and cam-followers 25 in radially inward direction. This initial relative movement of laminations 23 and housings 23*a* is followed by a joint pivotal movement thereof about a fulcrum 22.

Shaft 29 may be operated by a spring motor. In such an instance it is necessary to provide a shock absorber to absorb the energy still inherent in the spring motor at the end of each operating cycle of shaft 29. Such shock absorbers may be formed by springs which are wound up by the residual energy inherent in the spring motor at the end of each operating cycle, i.e. such shock absorbers are stressed or loaded by the excess energy inherent in the spring motor at the end of an operating cycle thereof. The springs 23*c* biasing contact laminations 23 operate as shock absorbers, absorbing excess energy of a spring motor (not shown) which may be provided for operating shaft 29. Thus spring means 23 are dual function devices, one of their functions consisting in establishing resilient contact pressure between contacts 17, 18, 19 and the other of their functions consisting in operating as shock absorbers.

The structure of FIGS. 2 and 3 might be modified in such a way that each movable current-carrying contact 17 is adapted to engage a single current-carrying fixed contact 18, but not to engage simultaneously another fixed current-carrying contact 19. The movable current-carrying contacts 17 might be connected by means of flexible braids to parts 19, which would not any longer be current-carrying contacts but merely terminal elements. Such a change would turn current-carrying contact bridges 17 into simple movable current-carrying contacts. The structure as shown in FIGS. 2 and 3 is, however, generally more desirable than the aforementioned modification thereof.

The transfer switch shown in FIG. 4 comprises a cylindrical tank 50 accommodating in the upper portion thereof the coaxial cylindrical transfer switch housing or contact support 21, while the lower portion of tank 50 houses the switching resistors R shown in FIG. 1. Tank 50 contains a body of oil (not shown) and is preferably made of an appropriate casting resin. Terminal 51 is integral with tank 50. Terminal 51 is intended to connect the transfer switch to the neutral point of the transformer shown in FIG. 1. The aforementioned terminal 51 may be arranged in pairs in view of the high current-carrying duty imposed upon this part. If tank 50 is made of a casting resin terminals 51 are formed by inserts in the casting.

Flange element 52 is arranged in the upper portion of transfer switch housing or contact support 21. Element 52 is provided with contacts 53 cooperatively engaging with terminals 51. A structure substantially in the shape of a squirrel-cage is suspended on flange element 53 by means of screws 54′. The above mentioned structure substantially in the shape of a squirrel-cage comprises the upper guide plate 54, the lower guide plate 55 and the conductive vertical bars 56 extending parallel to the common axis of tank 50 and housing or contact support 21. The upper end plate 57 and the lower end plate 58 are fixedly mounted upon operating shaft 29 which is arranged in coaxial relation to tank 50 and housing 21. Rod 59 is spaced from shaft 29 and extends parallel to shaft 29. The upper end and the lower end of rod 59 is loosely guided by the upper end plate **57** and the lower end plate **58**, respectively. The upper end of rod **59** is mechanically connected to the upper end plate **57** by means of a helical tension spring **60**. In like fashion the lower end of rod **59** is mechanically connected to the lower end plate **58** by means of a helical tension spring **61**. Reference numeral **62** has been applied to indicate a plurality of upper arcing contact operating arms and reference numeral **63** has been applied to indicate a plurality of lower arcing contact operating arms. Each arcing contact operating arm **62, 63** has a radially inner bearing and a radially outer bearing. Rod **59** extends through the radially inner bearings of arcing contact operating arms **62, 63**. The radially outer ends of each pair of arcing contact operating arms **62, 63** support a vertical shaft **64** which, in turn, supports pivotally a contact carrier **65**. Each contact carrier **65** is provided with bearing means for supporting one of a plurality of vertical shafts **64**. Contact carriers **65** support arcing contact bridges **16'** which—since supported by contact carriers **65**—are adapted to be pivoted about vertical shafts **64**. The aforementioned upper and lower guide plates **54, 55** are provided with radially extending slots or grooves **54'** and **55'**, respectively, engaged by and guiding the upper and the lower ends of contact carriers **65**. Because of this function of plates **54** and **55** the same have been referred to as guide plates. The contact carriers **65** are provided with upper grooves and with lower grooves intended for insertion of arcing contact bridges **16'** into the same. These grooves are sufficiently large to provide a predetermined amount of clearance between contact carriers **65** and contact bridges **16'**. Arcing contact bridges **16'** are electrically insulated from contact carriers **65** and resiliently supported by contact carriers **65** as shown in considerable detail in the aforementioned U.S. Patent 3,174,097. The upper end of each arcing contact bridge **16'** and the lower end of each arcing contact bridge **16'** is adapted to cooperate with a pair of fixed arcing contacts **14'**. Contacts **14'** are supported by the wall of the switch housing or contact support **21** and include terminal elements which are arranged on the radially outer surface of the switch housing **21**. Pairs of fixed contacts **14'** are arranged in vertically extending channel members **66** insulating contiguous pairs of contacts **14'** from each other. Because of the provision of channel-shaped insulating barriers **66** the angular spacing of pairs of contacts **14'** may be small, and yet flashovers between pairs of contacts **31, 30** which are at different potentials are effectively precluded by the presence of channel-shaped barriers **66**.

The circuitry of FIG. 1 calls for the provision of four contact carriers **65** and four arcing contact bridges and four pairs of fixed arcing contacts per phase. In other applications the number of contact carriers, contact bridges and of pairs of fixed contacts per phase may be larger than four. The fixed contacts of each phase and the contact bridges of each phase are arranged in form of a sector of a circle. The fixed contacts at the ends of each such sector are main arcing contacts and the fixed contacts of each such sector arranged between main contacts are auxiliary arcing contacts to be connected to the switching resistors R of FIG. 1 arranged in the lower portion of switch housing **21**.

When a tap-changing operation has been completed, the main tap-changing arcing contacts which are designed to perform switching operations should preferably be shunted by main current-carrying contacts which are specially designed to perform this particular duty, as distinguished from current switching duty. As shown in FIGS. 3 and 4 shaft **29** supports cam-plates **27, 28** for controlling the operation of pivotable current-carrying contact bridges **17** including contact laminations **23**. Contact bridges **17** are adapted to interconnect conductively current-carrying contacts **18, 19**, thereby shunting the main arcing contacts **14, 16** of FIG. 1 or the main arcing contacts **14', 16'** of FIG. 4.

The mechanism shown in FIG. 4 for operating arcing contact bridges **65** and arcing contacts **16'** achieves the same operating sequence as the structure of FIG. 1, and since it is well known in the art how to achieve such a sequence, and since this invention has no bearing on how to achieve the required sequence of operation of the movable arcing contacts, further details regarding this aspect of the structure of FIG. 4 are deemed unnecessary.

Although we have shown and described a specific structure, it is to be clearly understood that the same was merely for the purpose of illustration, and that changes and modifications may readily be made by those skilled in the art without departing from the spirit and scope of the invention.

We claim as our invention:

1. A transfer switch for tap-changing regulating transformers comprising in combination:

(a) a plurality of cooperating pairs of arcing contacts including two pairs of cooperating main arcing contacts and additional pairs of cooperating auxiliary arcing contacts;

(b) operating means including an operating shaft for said plurality of pairs of arcing contacts for selectively operating said plurality of pairs of arcing contacts in a predetermined sequence and the reverse of said sequence;

(c) two pairs of current-carrying contacts each having an open position and a closed position for selectively shunting one of said two pairs of main arcing contacts, each pair of said two pairs of current-carrying contacts including a fixed current-carrying contact and a movable current-carrying contact pivotable about a pivot parallel to said operating shaft relative to said fixed current-carrying contact and having a cam-follower for operation thereof; and

(d) a pair of cams operated by said operating shaft each operatively engaging said cam-follower of a movable current-carrying contact, and each including a contact-guiding portion and an abutment portion for selectively maintaining said movable current-carrying contact of one of said two pairs of current-carrying contacts in said closed position thereof.

2. A transfer switch for tap-changing regulating transformers as specified in claim **1** wherein each movable current-carrying contact includes a housing open at one side thereof, a stack of contact laminations arranged inside said housing and projecting out of said housing at said open side thereof, and spring means interposed between said housing and said contact laminations biasing said contact laminations in the direction of said open side of said housing.

3. A transfer switch for tap-changing regulating transformers comprising in combination:

(a) a plurality of cooperating pairs of arcing contacts including two pairs of cooperating main arcing contacts and additional pairs of cooperating auxiliary arcing contacts;

(b) operating means including an operating shaft for said plurality of pairs of arcing contacts for selectively operating said plurality of pairs of arcing contacts in a predetermined sequence and the reverse of said sequence;

(c) two pairs of current-carrying contacts each having an open position and a closed position for selectively shunting one of said two pairs of main arcing contacts, each pair of said two pairs of current-carrying contacts including a fixed current-carrying contact and a movable current-carrying contact pivotable about a pivot parallel to said operating shaft relative to said fixed current-carrying contact;

(d) an operating pin extending parallel to said operating shaft supported by and having ends projecting axially outwardly from said movable current-carrying contact of each of said two pairs of current-carrying contacts;

(e) an upper pair of cams operated by said operating shaft each operatively engaging the upper end of said operating pin of said movable current-carrying contact of one of said two pairs of current-carrying contacts, each of said upper pair of cams including a smoothly curved pin-moving portion and an abutment portion making a sharp turn relative to the end of said pin-moving portion immediately adjacent thereto; and

(f) a lower pair of cams operated by said operating shaft each operatively engaging the lower end of said operating pin of said movable current-carrying contact of one of said two pairs of current-carrying contacts, each of said lower pair of cams including a smoothly curved pin-moving portion and an abutment portion making a sharp turn relative to the end of said pin-moving portion immediately adjacent thereto.

4. A transfer switch for tap-changing regulating transformers comprising in combination:

(a) a plurality of cooperating pairs of arcing contacts including two pairs of cooperating main arcing contacts and additional pairs of cooperating auxiliary arcing contacts;

(b) operating means including an operating shaft for said plurality of pairs of arcing contacts for selectively operating said plurality of pairs of arcing contacts in a predetermined sequence and the reverse of said sequence;

(c) two pairs of current-carrying contacts each having an open position and a closed position for selectively shunting one of said two pairs of main arcing contacts, each pair of said two pairs of current-carrying contacts including a fixed current-carrying contact and a movable current-carrying contact pivotable about a pivot parallel to said operating shaft relative to said fixed current-carrying contact;

(d) an operating pin extending parallel to said operating shaft supported by and having ends projecting axially outwardly from said movable current-carrying contact of each of said two pairs of current-carrying contacts;

(e) an upper plate arranged at right angles to and operated by said operating shaft and defining a substantially V-shaped groove engaging the upper end of said operating pin of said movable current-carrying contact of each of said two pairs of current-carrying contacts, said groove including two smoothly curved pin-moving portions and said groove further forming an abutment projection intermediate said two pin-moving portions thereof for selectively maintaining said movable current-carrying contact of one of said two pairs of current-carrying contacts in the closed position thereof; and

(f) a lower plate arranged in spaced relation from said upper plate at right angles to and operated by said operating shaft and defining a substantially V-shaped groove operatively engaging the lower end of said operating pin of said movable current-carrying contact of each of said two pairs of current-carrying contacts, said groove including two smoothly curved pin-moving portions and said groove further forming an abutment projection intermediate said pin-moving portion thereof for selectively maintaining said movable current-carrying contact of one of said two pairs of current-carrying contacts in the closed position thereof.

5. A transfer switch for tap-changing regulating transformers comprising in combination:

(a) a plurality of cooperating pairs of arcing contacts including two pairs of cooperating main arcing contacts and additional pairs of cooperating auxiliary arcing contacts;

(b) operating means including an operating shaft for said plurality of pairs of arcing contacts for selectively operating said plurality of pairs of arcing contacts in a predetermined sequence and the reverse of said sequence;

(c) two pairs of current-carrying contacts each having an open position and a closed position for selectively shunting one of said two pairs of main arcing contacts, each pair of said two pairs of current-carrying contacts including a fixed current-carrying contact and a movable current-carrying contact pivotable about a pivot parallel to said operating shaft relative to said fixed current-carrying contact and having a cam-follower for operation thereof;

(d) a plate arranged at right angles to and operated by said shaft and defining a groove operatively engaging said cam-follower of said movable current-carrying contact of each of said two pairs of current-carrying contacts, said groove including two symmetrical portions having immediately adjacent ends formed by a cylindrical surface coaxial to said shaft and having a relatively large radius, said groove further including remote ends each formed by a cylindrical surface coaxial to said shaft and having a relatively small radius, and said groove further including cam-follower operating portions intermediate said immediately adjacent ends and said remote ends thereof.

6. A transfer switch for tap-changing regulating transformers as specified in claim **5** wherein said cam-follower of said movable current-carrying contact of each of said two pairs of current-carrying contacts is formed by a pin parallel to said shaft having an end projecting into said groove defined by said plate.

7. A transfer switch for tap-changing polyphase regulating transformers comprising in combination:

(a) a contact support defining a substantially cylindrical surface;

(b) an operating shaft coextensive with the axis of said surface;

(c) groups of arcing contacts, each of said groups for one phase of a polyphase circuit, each of said groups including two pairs of cooperating main arcing contacts and pairs of cooperating auxiliary arcing contacts, each of said groups being arranged in an arcuate pattern around said operating shaft;

(d) means operated by said shaft for selectively operating the arcing contacts of each of said groups in a predetermined sequence and the reverse of said sequence;

(d) current-carrying contact means for shunting selectively one of said two pairs of main arcing contacts of each of said groups of arcing contacts, said current-carrying contact means including pairs of fixed angularly displaced current-carrying contacts supported by said contact support and pairs of cooperating movable current-carrying contacts having pivots extending parallel to said shaft and each being arranged in a space bounded by one pair of said pairs of fixed current-carrying contacts;

(e) a cam-follower on each movable current-carrying contact of each of said pairs of movable current-carrying contacts; and

(f) a cam structure operated by said operating shaft and including a plurality of cam surfaces equal in number to the number of said groups of arcing contacts, each of said plurality of cam surfaces including two symmetrical smoothly curved portions each for operating a cam-follower, and each of said plurality of cam surfaces including an abutment portion intermediate said two symmetrical portions thereof for precluding movement of a cam-follower in engagement with said intermediate abutment portion.

8. A transfer switch for tap-changing polyphase regulating transformers as specified in claim **7** wherein said cam-follower on each movable current-carrying contact of each of said pair of movable current-carrying contacts is substantially in the shape of a cylindrical pin, and wherein each of said plurality of cam surfaces is in the shape of a substantially V-shaped groove defined by a plate arranged at right angles to said operating shaft.

9. A transfer switch for tap-changing regulating transformers as specified in claim **7** wherein said pivots of each of said pairs of movable current-carrying contacts are supported by a bracket supported by said contact support.

10. A transfer switch for tap-changing regulating transformers comprising in combination:

(a) a substantially cylindrical contact support of insulating material;

(b) an operating shaft coextensive with the axis of said contact support;

(c) a plurality of cooperating pairs of arcing contacts including pairs of cooperating main arcing contacts and additional pairs of cooperating auxiliary arcing contacts, each of said plurality of cooperating pairs of arcing contacts including at least one fixed contact supported by said contact support and a relatively movable contact;

(d) means for selectively operating one of each of said plurality of cooperating pairs of arcing contacts in a predetermined sequence and the reverse of said sequence;

(e) cam-plate means mounted on said shaft at a level lower than said plurality of cooperating pairs of arcing contacts, said cam-plate means defining a plurality of angularly displaced substantially V-shaped grooves;

(f) a plurality of cam-followers inside said plurality of grooves operable by said cam-plate means; and

(g) relatively movable current-carrying contact means having open positions and closed positions for selectively shunting pairs of cooperating main arcing contacts supported by said contact support and operated by said plurality of cam-followers.

11. A current-carrying contact arrangement for transfer switches for tap-changing regulating transformers comprising in combination:

(a) a cylindrical contact support of insulating material;

(b) a plurality of angularly displaced fixed current-carrying contacts arranged on the radially inner surface of said support and supported by said support, said plurality of fixed current-carrying contacts including a number of fulcrum-forming contacts and a number of non-fulcrum-forming contacts, the number of fulcrum-forming contacts being half the number of non-fulcrum-forming contacts and each fulcrum-forming contact being arranged in a space bounded by a pair of non-fulcrum-forming contacts;

(c) a plurality of pairs of current-carrying contact bridges each pivotally suported by one of said fulcrum-forming contacts and arranged to bridge said one of said fulcrum-forming contacts and one of said non-fulcrum-forming contacts;

(d) a plurality of cam-followers each on one current-carrying contact bridge of said plurality of pairs of current-carrying contact bridges;

(e) an operating shaft coextensive with the axis of said cylindrical contact support; and

(f) a plurality of radially symmetrical cam means jointly movable with said shaft, each of said plurality of cam means being operatively related to one pair of said plurality of cam-followers and including cam-follower-operating portions and an abutment portion formed by an abrupt change of the direction of said cam-follower-operating portions.

12. A current-carrying contact arrangement for transfer switches for tap-changing regulating transformers comprising in combination:

(a) a cylindrical contact support of insulating material;

(b) a plurality of angularly displaced fixed current-carrying contacts arranged on the radially inner surface of said support and supported by said support, said plurality of fixed current-carrying contacts including a number of fulcrum-forming contacts and a number of non-fulcrum-forming contacts, the number of fulcrum-forming contacts being half the number of non-fulcrum-forming contacts and each fulcrum-forming contact being arranged in a space bounded by a pair of non-fulcrum-forming contacts;

(c) a plurality of pairs of current-carrying contact bridges each pivotally supported by one of said fulcrum-forming contacts and arranged to bridge said one of said fulcrum-forming contacts and one of said non-fulcrum-forming contacts;

(d) a plurality of pairs of cam-followers, each cam-follower of each of said plurality of pairs of cam-followers being supported by a current-carrying contact bridge of said plurality of pairs of contact bridges;

(e) an operating shaft coextensive with the axis of said cylindrical contact support; and

(f) a pair of parallel spaced plates mounted on said shaft for joint movement with said shaft, said pair of plates defining a plurality of grooves each in engagement with one pair of said plurality of pairs of cam-followers, and each of said plurality of grooves including cam-follower operating portions and a cam-follower blocking portion.

13. A current-carrying contact arrangement for transfer switches of tap-changing regulating transformers comprising in combination:

(a) a substantially cylindrical contact support of insulating material;

(b) a pivotable operating shaft coextensive with the axis of said contact support;

(c) a pair of angularly displaced fixed contacts arranged on the inside of said contact support and supported by said contact support;

(d) a contact bridge pivotable about a pin extending parallel to said shaft and supported by one of said pair of fixed contacts for conductively interconnecting said pair of fixed contacts;

(e) a cam-follower on said contact bridge; and

(f) a cam-plate mounted on said shaft for joint movement with said shaft, said cam plate having a groove engaged by said cam-follower, said groove defining an abutment for maintaining said contact bridge in the contact interconnecting position thereof, said groove further defining a contact-bridge-operating-portion and said groove further including a circular portion coaxial with said shaft allowing said cam-follower to freely move therein without transmitting any force component upon said cam-follower.

14. A current-carrying contact arrangement for transfer switches for tap-changing regulating transformers comprising in combination:

(a) a substantially cylindrical contact support of insulating material;

(b) a pivotable operating shaft coextensive with the axis of said support;

(c) a pair of angularly displaced fixed contacts arranged at the inside of said contact support and supported by said contact support;

(d) an additional fixed contact arranged between said pair of fixed contacts on the inside of said contact support and supported by said contact support;

(e) a pair of contact bridges pivotable about pins extending parallel to said operating shaft and supported by said additional fixed contact for conductively interconnecting said additional fixed contact and one of said pair of fixed contacts;

(f) a pair of cam-followers one on each of said pair of contact bridges; and

(g) a cam-plate mounted on said shaft for joint movement with said shaft, said cam-plate defining a groove having two radially symmetrical portions and being engaged by said pair of cam-followers.

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