United States Patent [19]

Breuer

[11] **3,813,503**

[45] **May 28, 1974**

[54] **TRANSFER SWITCH FOR TAP-CHANGING REGULATING TRANSFORMERS**

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[22] Filed: **Jan. 15, 1973**

[21] Appl. No.: **323,560**

[30] **Foreign Application Priority Data**

Feb. 3, 1972 Germany 2204983

[52] **U.S. Cl.** ..... **200/11 TC,** 323/43.5 R

[51] **Int. Cl.** **G05f 1/14**

[58] **Field of Search** ..... 336/150; 200/11 TC; 323/43.5 R; 307/113

[56] **References Cited**

UNITED STATES PATENTS

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Assistant Examiner—William J. Smith
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[57] **ABSTRACT**

A so-called Jansen type transfer switch for regulating transformers is provided with an additional resistor and additional switching means rendered operative and inoperative, respectively, at predetermined points of time during a tap-changing operation for improving the L/R ratio during the particular tap-changing operation, and thus rendering less onerous the switching duty which the auxiliary contacts or arcing contacts of the transfer switch have to perform.

6 Claims, 6 Drawing Figures

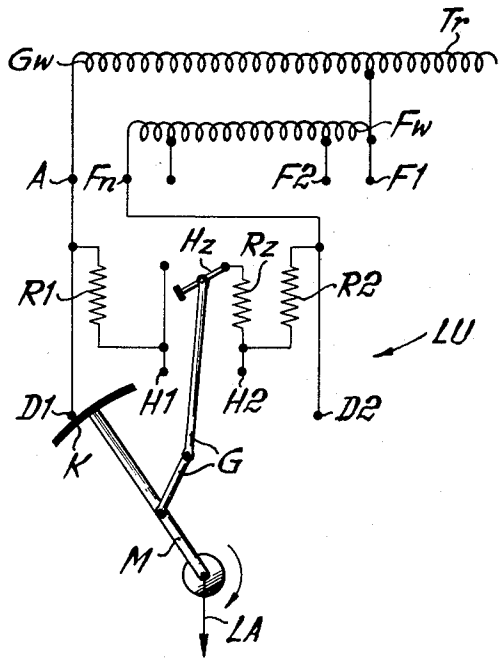


FIG.1

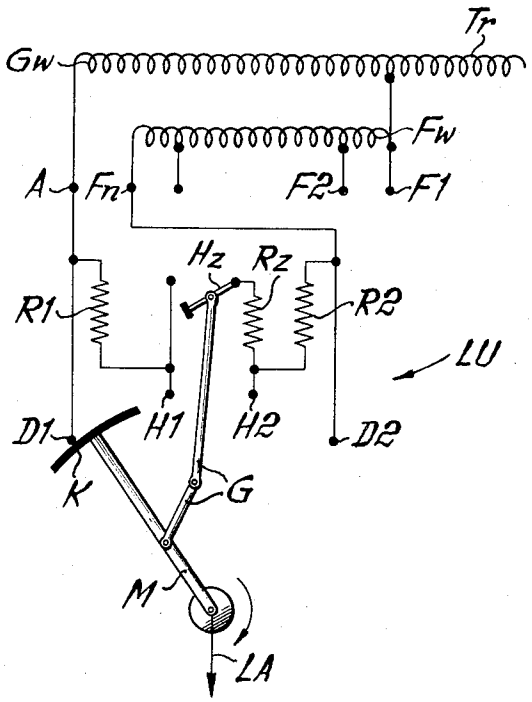


FIG. 2

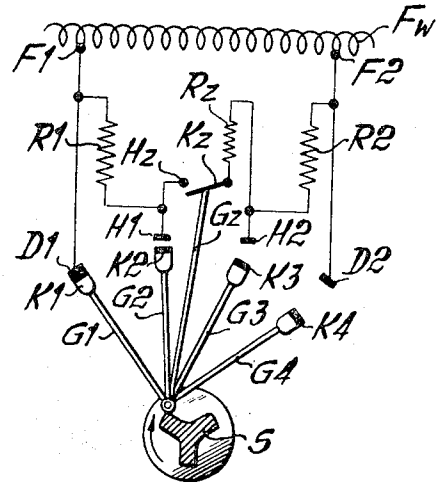


FIG. 3

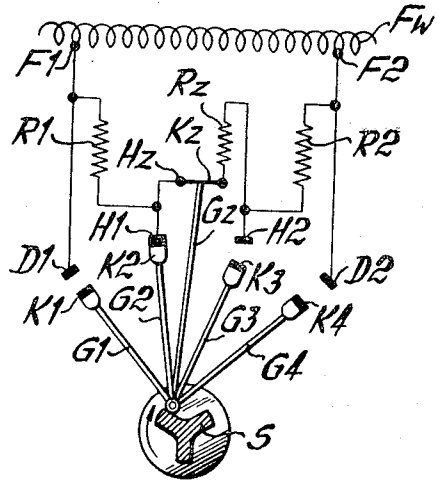


FIG. 4

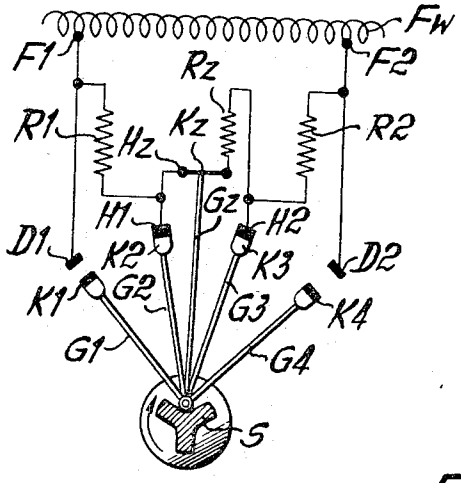


FIG. 5

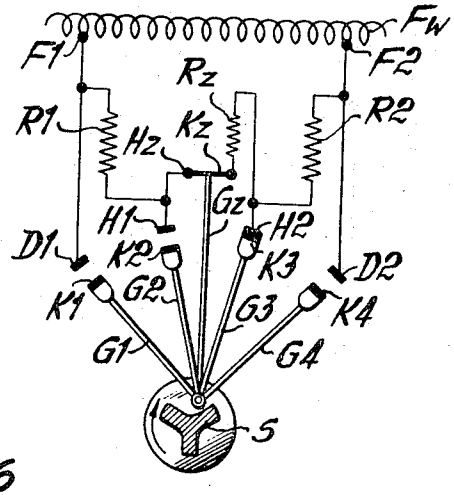
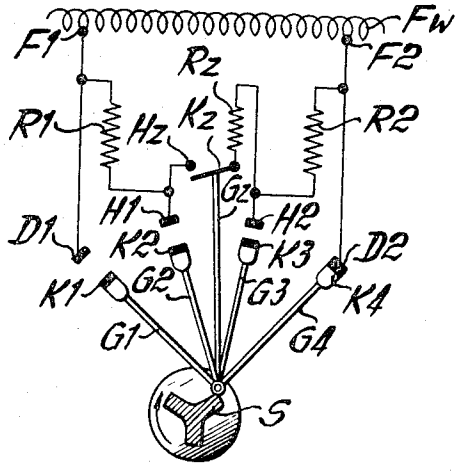


FIG. 6



TRANSFER SWITCH FOR TAP-CHANGING REGULATING TRANSFORMERS

BACKGROUND OF THE INVENTION

This invention relates to regulating transformers of the so-called Jansen type.

Such transformers include three basic parts:

1. Tapped transformer windings.
2. Selector switches.
3. Transfer switches.

Selector switches make it possible to select any desired tap and the transfer switches make it possible to insert the desired tap into the circuit of a load. Selector switches do not perform any switching operations between contacts that carry current. This task is performed by the transfer switches.

This invention relates more particularly to the transfer switch of a load-tap-changer and hence only this portion of a load-tap-changer will be considered below more in detail. For a description of a complete Jansen type load-tap-changer reference may be had, for instance, to U.S. Pat. No. 3,396,245 to A. Bleibtreu; 8/6/68 for ARRANGEMENT FOR AVOIDING EDDY CURRENT LOSSES IN TRANSFER SWITCH AND SELECTOR SWITCH UNITS WITH INTERPOSED GEAR DRIVE.

Transfer switches have two limit positions and a plurality of intermediate positions. In one of the limit positions a load is directly connected to a given tap, or first tap. In the other of the limit positions the load is directly connected to another given tap, or second tap. The term directly means in this context that no significant resistance or inductance is interposed between the respective tap and the load. The term direct is not intended to exclude the contacts of a selector switch. The intermediate positions of a transfer switch of known design perform the intermediate switching steps of (1) inserting but a first resistor into the path of the load current from the first tap to a load-current-carrying outgoing line; (2) interconnecting said first tap and a second tap by said first resistor and by a second resistor and connecting said line to a point situated between said first resistor and said second resistor; and (3) disconnecting said first resistor from said line and inserting but said second resistor into the current path from said second tap to said line.

Prior art transfer switches of the character referred-to above have generally been based on the assumption that the currents which must be switched by auxiliary contacts or arcing contacts of the transfer switch in the intermediate positions thereof are substantially in phase with the voltage. This assumption is correct as long as the inductance of the windings which are shunted by the transfer switch during a tap-changing operation is small or negligible when compared to the ohmic resistance of the constituent parts of the transfer switch. There are, however, instances where the inductance of shunted windings by far exceeds the aforementioned ohmic resistance, and in such cases the phase angle between the driving voltage and the current to be switched may be considerable. One such instance are industrial distribution transformers the windings of which have taps arranged in such a way that the voltages between consecutive taps vary widely. As a general rule the switching capacity of transfer switches is sufficiently large to make it possible to cope wth any

phase angle situation that may occur. There are, however, situations involving industrial load-tap-changers where the presence of a significant phase angle between the current to be switched and the driving circuit voltage results in difficulties.

Another instance where the inductance and the resulting phase angle have a tendency to be excessive is that of regulating transformers having separate tapped windings, one for coarse regulation and another for fine regulation of the output voltage. In that particular instance a situation may occur wherein the transfer switch, i.e. some of the auxiliary contacts thereof, are shunted across both aforementioned regulating windings. By virtue of this condition very large inductance may be inserted into the circuit to be switched by the transfer switch, resulting in large phase angles and critical, or dangerous, switching conditions.

It is the primary object of this invention to provide means on transfer switches of the aforementioned kind for keeping the L/R ratio during switching operations within safe limits, however high the inductance of the transformer winding, or windings, may be.

SUMMARY OF THE INVENTION

Transfer switches embodying the present invention have a plurality of relatively movable main contact means including a pair of fixed main contacts each adapted to be directly conductively connected to one of a pair of transformer winding taps. Such transfer switches further include switch-over resistor means, or at least one pair of switch-over resistors each having a transformer side end and a load side end. Transfer switches embodying this invention further have a plurality of relatively movable auxiliary contact means including fixed auxiliary contacts arranged between said pair of fixed main contacts and each adapted to be conductively connected by the intermediary of said switch-over resistor means to one of said pair of transformer winding taps. Contact operating means effect selective engagement and disengagement, respectively, of said main contact means and of said auxiliary contact means in a predetermined sequence. Transfer switches embodying this invention further include an additional resistor and an additional switch arranged in series with said additional resistor for selectively interconnecting by said additional resistor the load side ends of said switch-over resistor means. The additional switch is operated by means under the control of said contact operating means and the additional switch operating means are adapted to effect closing of said additional switch at a first point of time prior to separation of one of said plurality of relatively movable auxiliary contact means, and to effect opening of said additional switch at a second point of time following said first point of time and preceding the time of engagement of one of said plurality of relatively movable main contact means that had previously been separated.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic representation of a transfer switch embodying the present invention including tapped transformer windings but omitting selector switch means;

FIGS. 2 to 6, inclusive, are diagrammatic representations of another transfer switch embodying the present invention in various positions thereof, including a

tapped transformer winding, but excluding selector switch means.

DESCRIPTION OF PREFERRED EMBODIMENTS

In FIG. 1 reference character Lu has been applied to generally designate a transfer switch of the Jansen type, and reference character Tr has been applied to generally designate a regulating transformer. Transformer Tr is an auto-transformer and includes a first winding or coarse regulating winding Gw and a second winding or fine regulating winding Fw. Reference characters A,Fn,F2 and F1 have been applied to indicate several taps of transformer Tr. Windings Gw and Fw have a common tap F1. Transfer switch Lu includes the fixed main contacts D1,D2, the fixed auxiliary or arcing contacts H1,H2 and the movable contact K affixed to the radially outer end of an arm M pivotable in clockwise direction from the initial position shown in FIG. 1. The outgoing line LA carries load currents from transformer Tr to any other equipment energized by the former. Reference characters R1,R2 are applied to indicate a pair of conventional switch-over or tap-changing resistors. One end of switch-over resistor R1 is conductively connected to tap A which, in turn, is conductively connected to fixed main contact D1. The other end of switch-over resistor R1 is conductively connected to fixed auxiliary contact H1. One end of switch-over resistor R2 is conductively connected to tap Fn which, in turn, is conductively connected to fixed main contact D2. The other end of switch-over resistor R2 is conductively connected to fixed auxiliary or arcing contact H2. The structure of FIG. 1 includes a third or additional resistor R2 of which one end is conductively connected to fixed auxiliary contact H2. The other end of resistor Rz is conductively connected to a pivotable contact arm of an auxiliary switch Hz. The pivotable contact arm of switch Hz cooperates with a fixed contact which is conductively connected to fixed auxiliary contacts H1. The contact arm of switch H2 is operated by crank arm M supporting contact K by the intermediary of linkage G.

In the position of the parts shown in FIG. 1 the outgoing load line LA is conductively connected by means of engaging contacts K and D1 to the tap A of transformer Tr.

Assuming that it is intended to change from tap A to tap Fn. To this end crank arm M is moved clockwise tending to disengage contact K from contact D1 and to cause engagement of contact K with contact H1. Due to the size of contact K the latter engages contact H1 before it disengages from contact D1. Therefore resistor R1 is connected into the load circuit at the point of time when contact K parts from contact D1. As crank arm M further moves in clockwise direction, the contacts of switching device Hz are closed by the action of linkage G at a point of time prior to that at which contact K parts from contact H1. As a result, taps A and Fn are now interconnected by resistors R1,R2 and Rz in series and contacts H1, H2 are shunted by resistor Rz. The ohmic value of resistance Rz is much larger than the ohmic value of either switch-over resistors R1 and R2. It is the high resistance of resistor Rz which results in that the current and voltage are substantially in phase as long as resistor Rz is shunted across fixed auxiliary contacts. This includes also the instant when contact K parts from contact H1, and then virtually simultaneously engages contact H2. This establishes a current path from the load line LA by way of contacts K and H2 and resistor R2 to tap Fn. Linkage G opens switch Hz after the point of time of engagement of contact H2 by contact K and before engagement of contact D2 by contact K. Following a short period during which contact K engages both contacts H2 and D2 contact K comes to rest and then engages only contact D2. This terminates the tap-changing operation from tap Gw to tap Fn.

A change from one tap of winding Fw to another, e.g., from tap F1 to tap F2, does not involve any particular problem. The difficulty in changing from tap A to tap Fn results mainly from the relatively high inductance of winding Gw.

The structure of FIG. 1 differs from conventional transfer switches for tap-changers for regulating transformers such as, for instance, the transfer switch shown in FIG. 1 of U.S. Pat. No. 3,396,254 to A. Bleibtreu, 8/6/1968 for ARRANGEMENT FOR AVOIDING EDDY CURRENT LOSSES IN TRANSFER SWITCH AND SELECTOR SWITCH UNITS WITH INTERPOSED GEAR DRIVE by the addition of resistor Rz, switch Hz and linkage G.

Referring now to FIGS. 2 to 6, inclusive, these figures show a transformer winding Fw' having two taps F2' and F1'. Tap F2' is directly connected to fixed main contact D1' of a transfer switch Lu' and fixed auxiliary contact H1' is connected to tap F2' by the intermediary of switch-over resistor R1'. In a similar fashion tap F1' is directly connected to fixed main contact K4' and by the intermediary of switch-over resistor R2' to fixed auxiliary contact H2'. Fixed auxiliary contacts H1', H2' are adapted to be conductively interconnected by auxiliary switch Hz',Kz' and resistor Rz. This switch includes fixed contact Hz' and pivotable contact arm Kz'. Fixed contacts D1',H1',H2' and D2' are adapted to cooperate with movable contacts K1',K2',K3' and K4', i.e. the latter are adapted to selectively engage the former and to be disengaged from the former. This is achieved by a Y-shaped shaft S' pivotable in clockwise direction and in counterclockwise direction and thereby operating linkages G1', G2', G3', G4' of which each operates one of the contacts K1',K2',K3',K4'. Shaft S' further actuates the radially inner end of a linkage Gz' whose radially outer end is pivotally connected to the pivotable contact arm Kz' of auxiliary switch Hz', Kz'.

It will be apparent that the contact operating mechanism G1',G2', G3',G4',Gz' has been shown only diagrammatically in FIGS. 2–6. Contact operating mechanisms of the kind diagrammatically shown in FIGS. 2–6 are well known in the art and described in considerable detail in the patents which are identified below:

U.S. Pat. No. 3,238,320 to A. Bleibtreu; 3/1/66 for TRANSFER SWITCH FOR TAP CHANGERS FOR REGULATING TRANSFORMERS ETC.;

U.S. Pat. No. 3,258,546 to A. Bleibtreu; 6/28/66 for TRANSFER SWITCH WITH MOVABLE CONTACT TOGGLE MECHANISM ETC;

U.S. Pat. No. 3,458,670 to G. Wittenzellner; 7/29/69 for TAP CHANGER CONTACT BRIDGE WITH SPRING-BIASED LOST MOTION PIN CONNECTION; and

U.S. Pat. No. 3,671,687 to A. Bleibtreu; 6/20/72 for TRANSFER SWITCH FOR TAP-CHANGING REGULATING TRANSFORMERS INCLUDING LOST

MOTION INTER-CONNECTION DRIVING MECHANISM.

Reference may be had to any or all of the patents referred-to above for a detailed disclosure of contact operating mechanisms of the kind diagrammatically shown in FIGS. 2–6 and briefly described above.

As shown in FIG. 2 movable contact K1′ engages initially fixed contact D1′ and all other pairs of contacts K2′,H1′; K3′, H2′; K3′, H2′; K4′,D2′ and Kz′,Hz′ are initially out of engagement. Then tap F2′ is directly connected by engaging contacts D1′,K1′ to an outgoing line (not shown in FIGS. 2–6) in the same way as shown in FIG. 1.

When shaft S′ moves or is pivoted in clockwise direction, linkage G2′ first causes engagement of fixed contact H1′ by movable contact K2′. At a time shortly following engagement of contacts K2′,H1′ linkage G1′ causes contact K1′ to part from contact D1′. Shortly thereafter linkage Gz′ moves contact arm Kz′ in clockwise direction into engagement with fixed contact Hz′. This position of parts is shown in FIG. 3.

Further clockwise pivotal motion of shaft S′ results in engagement of contact H2′ by contact K3′ as the latter is moved radially outwardly by linkage G3′. The position of parts referred-to above is shown in FIG. 4.

As the clockwise pivotal motion of shaft S′ continues, this results in separation of movable auxiliary contact K2′ from fixed auxiliary contact H1′ by the action of linkage G2′. This is shown in FIG. 5. At the time contact K2′ separates or is retracted from contact H1′, contacts Kz′,Hz′ are still in engagement as is also apparent from FIG. 5.

As shaft S′ further pivots in clockwise direction contact arm Kz′ is pivoted by linkage Gz′ in counterclockwise direction, thus parting from fixed contact Hz′. Contact K3′ parts by the action of linkage G3′ from contact H2′ shortly after the point of time at which contacts Kz′,Hz′ have parted. This ultimate position of the transfer switch is shown in FIG. 6. Now the load current is taken from tap F1, and tap F2 is inactive.

The operation or function of resistors R1′,Rz′ and R2′ is the same as described above in connection with FIG. 1 in regard to resistors R1,Rz and R2.

It will be apparent that the structure of FIG. 1 differs mainly from the structure of FIGS. 2 to 6, inclusive, on account of the fact that in the first mentioned structure contact K performs the function of movable main contacts and movable auxiliary contacts or arcing contacts. To be more specific, contact K of FIG. 1 performs the function of contacts K1′,K2′,K3′ and K4′ of FIGS. 2–6.

The periods of time when additional resistor Rz′ is shunted across tap F2′,F1′ and across the fixed auxiliary contacts H1′,H2′ are very short as the speed of pivotal motion of shaft S′ is very high.

The ohmic value of resistor Rz,Rz′ is much higher than that of resistors R1,R2 and R1′, R2′, respectively. While the ohmic value of resistor Rz,Rz′ depends upon both the inductance of the tapped transformer winding means and the ohmic value of resistors R1,R2 and R1′,R2′, respectively, as a general rule Rz R1; Rz Rz; Rz′ R1′; Rz′ R2′, and the ohmic value of the additional resistor Rz,Rz′ should generally exceed by a power of 10 the ohmic value of each pair of switch-over resistors or tap-changing resistors R1,R2 and R1′,R2′, respectively.

The presence of additional resistor Rz makes it possible to maximize arc-quenching conditions in the transfer switch, i.e. the conditions of quenching arcs between contacts H1,H2 and H1′,H2′, respectively, and the movable contact means K and K2′,K3′, respectively, parting from said fixed contacts.

A crucial feature of this invention resides in interconnecting contacts H1,H2 and H1′,H2′, respectively, by resistor Rz and Rz′, respectively, before the load-current-path including resistor R1 and R1′, respectively, is interrupted. Another crucial feature of this invention resides in reopening the connection between contacts H1, H2; H1′,H2′ formed by resistor Rz,Rz′ before a direct path for the load current from the second tap Fn,F1′ to the load is established by engagement of contacts K,D2 and K4′,D2′, respectively.

It will be apparent from FIG. 1 that the tap-changing operation shown in that figure can be reversed when contact K moves in counterclockwise direction away from fixed main contact D2, ultimately engaging fixed main contact D1. It will also be apparent from FIGS. 2 to 6, inclusive, that the tap-changing operation shown in these figures can be reversed when shaft S′ is pivoted in counterclockwise direction resulting initially in separation of movable contact K3′ from fixed contact H2′ and ultimate engagement of fixed main contact D1′ by movable main contact K1′.

I claim as my invention:

1. A transfer switch for tap-changing regulating transformers including

a. a plurality of relatively movable main contact means including a pair of fixed main contacts each adapted to be directly conductively connected to one of a pair of transformer winding taps;

b. switch-over resistor means comprising at least one pair of resistors having transformer side ends and load side ends;

c. a plurality of relatively movable auxiliary contact means including fixed auxiliary contacts arranged between said pair of fixed main contacts and each adapted to be conductively connected by the intermediary of said switch-over resistor means to one of said pair of transformer winding taps;

d. contact operating means for effecting selective engagement and disengagement of said main contact means and of said auxiliary contact means in a predetermined sequence;

e. means for forming a current path between said load side ends of said pair of switch-over resistors, said current path forming means comprising an additional resistor having an ohmic value exceeding by a power of ten the ohmic value of each of said pair of switch-over resistors and an additional switch having open and closed positions arranged in series with said additional resistor; and

f. means for operating said additional switch under the control of said contact-operating means, said additional switch-operating means being adapted to effect closing of said additional switch at a first point of time prior to separation of one of said relatively movable auxiliary contact means and to effect opening of said additional switch at a second point of time following said first point of time and preceding the time of engagement of one of said relatively movable main contact means that previously has been separated.

2. A transfer switch as specified in claim 1 wherein

a. said plurality of relatively movable main contact means includes one pair of movable main contacts each cooperating with one of a pair of fixed main contacts;

b. said plurality of relatively movable auxiliary contact means includes one pair of movable auxiliary contacts each cooperating with one of a pair of fixed auxiliary contacts;

c. each of said pair of movable main contacts and each of said pair of movable auxiliary contacts is operated by a linkage and said additional switch is operated by an additional linkage; and wherein

d. a common pivotable shaft operates the linkage of each said pair of movable main contacts, the linkage of each of said pair of movable auxiliary contacts and said additional linkage of said additional switch.

3. A transfer switch arrangement including

a. tapped transformer winding means having a first tap and having a second tap;

b. a pair of tap-changing resistors including a first resistor conductively connected to said first tap and a second resistor conductively connected to said second tap;

c. a load current-carrying line;

d. switching means for disconnecting said line from said first tap and connecting said line directly to said second tap, said switching means being adapted to sequentially performing the intermediate steps of inserting but said first resistor into the current path from said first tap to said line, interconnecting said first tap and said second tap by said first resistor and said second resistor and connecting said line to a point situated between said first resistor and said second resistor, and disconnecting said first resistor from said line and inserting but said second resistor into the current path from said second tap to said line;

e. a third resistor having a considerably higher ohmic value than said first resistor and than said second resistor;

f. additional switching means having a closed position connecting said third resistor in series with said first resistor and said second resistor across said first tap and said second tap and having an open position disconnecting said first resistor from said second resistor;

g. common drive means for said switching means and said additional switching means; and

h. means under the control of said common drive means for closing said additional switching means prior to disconnection of said first resistor from said line and for opening said additional switching means prior to establishment of a direct connection between said second tap and said line.

4. A transfer switch arrangement as specified in claim 3 wherein said tapped transformer winding means include a coarse regulation winding and a fine regulation winding connected to a tap of said coarse regulation winding.

5. A transfer switch arrangement including

a. tapped transformer winding means having a first tap and having a second tap;

b. relatively movable main contact means including a first fixed main contact conductively connected to said first tap and a second fixed main contact conductively connected to said second tap;

c. a pair of tap-changing resistors including a first resistor having a first end directly connected to said first tap and a second end remote from said first tap and a second resistor having a first end directly connected to said second tap and a second end remote from said second tap;

d. relatively movable auxiliary contact means including a first fixed auxiliary contact and a second fixed auxiliary contact both arranged in the space bounded by said first fixed main contact and said second fixed main contact, said first fixed auxiliary contact being conductively connected to said first tap by the intermediary of said first resistor and said second fixed auxiliary contact being conductively connected to said second tap by the intermediary of said second resistor;

e. means for selectively connecting said second end of said first resistor and said second end of said second resistor and for disconnecting said second end of said first resistor from said second end of said second resistor, said connecting and disconnecting means including an additional switch having an open position and a closed position and an additional resistor having a resistance exceeding by a power of ten the resistance of said first resistor and the resistance of said second resistor arranged in series relation to said additional switch;

f. drive means for operating said relatively movable main contact means and for operating said relatively movable auxiliary contact means in a predetermined sequence, said sequence including the step of parting from said first fixed auxiliary contact of a relatively movable auxiliary contact means followed by the step of engagement of said second fixed main contact by a relatively movable main contact means; and

g. means under the control of said drive means for automatically closing said additional switch prior to said step of parting and for automatically closing said additional switch prior to said step for engagement.

6. A transfer switch arrangement as specified in claim 5 wherein said tapped transformer winding means include a coarse regulation winding and a fine regulation winding connected to a tap of said coarse regulation winding, and wherein said first tap is on said coarse regulation winding and said second tap is on said fine regulation winding.

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