United States Patent

Van Riemsdijk

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[45] Feb. 15, 1972

[54] **COMPOSITE POLYPHASE ON-LOAD TAP-CHANGERS FOR REGULATING POLYPHASE TRANSFORMERS AND POLYPHASE TRANSFORMERS PROVIDED WITH SUCH TAP-CHANGERS**

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[30] **Foreign Application Priority Data**

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

[51] **Int. Cl.** **H02p 13/06,** H01f 29/04

[58] **Field of Search**..........................200/10, 11; 323/43.5 R

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[57] **ABSTRACT**

Composite polyphase on-load tap-changer comprising the series connection of at least a rotary polyphase diverter switch adapted to rotate stepwise on and on in both directions and a plurality of monophase tap selectors, said diverter switch having at least one circular series of fixed contacts of which the number is an integer multiple of the number of phases and sets of rotating contacts and rotating transition resistances which are connected to a star point and said tap selectors having each two series of fixed contacts and two alternately moving bridging contacts for connecting each the fixed contacts of a relative series with the same individual fixed contact of the diverter switch.

1 Claims, 8 Drawing Figures

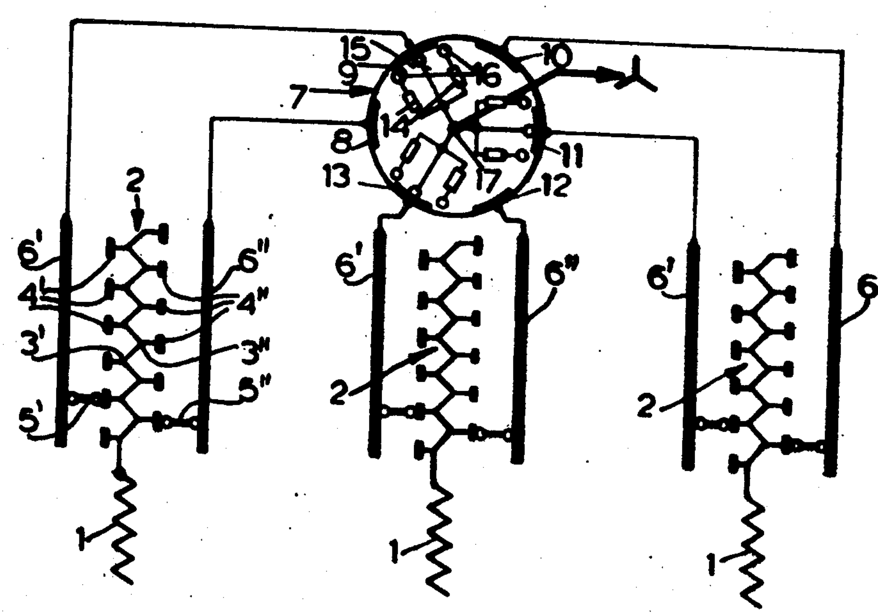

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FIG.1

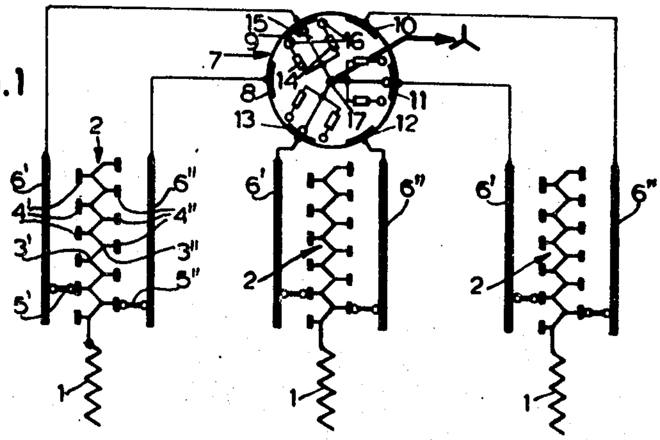


FIG.2

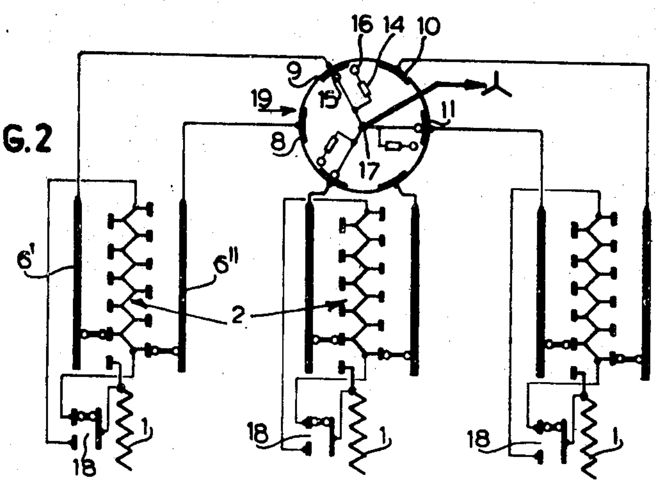
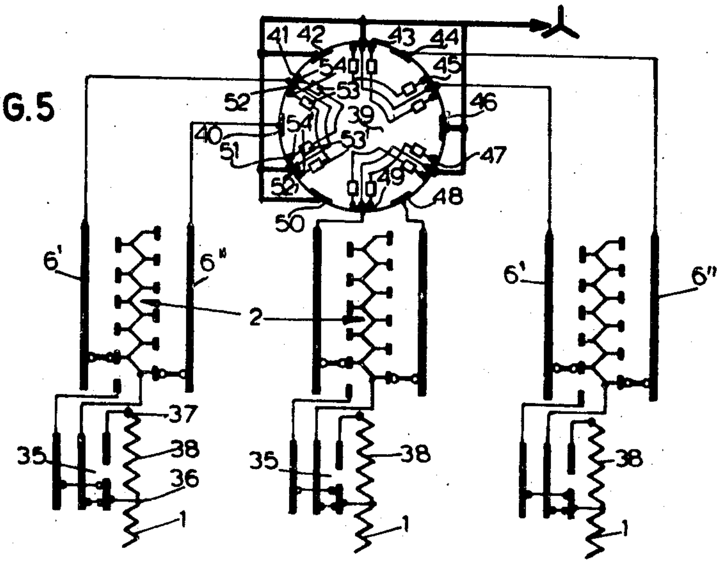


FIG.5



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GERARDUS A. VAN [illegible]

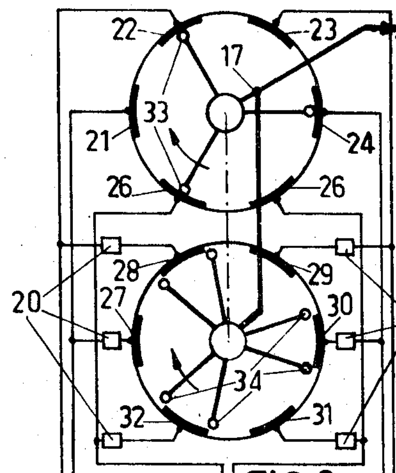

FIG.3

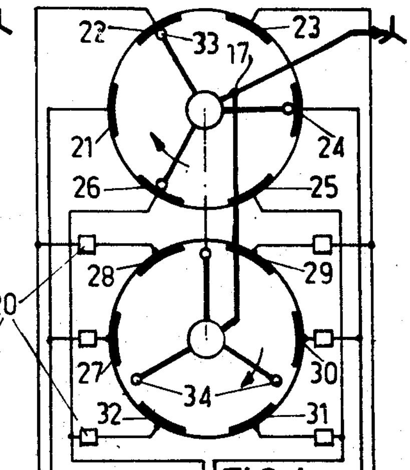

FIG.4

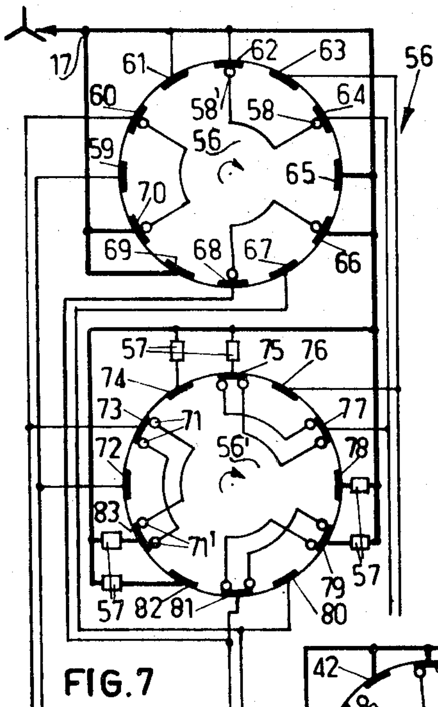

FIG.7

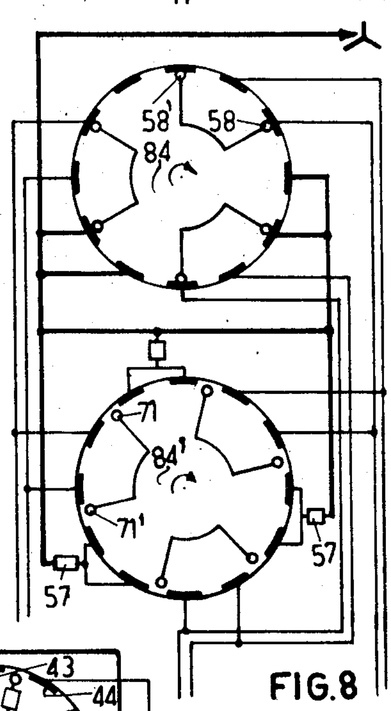

FIG.8

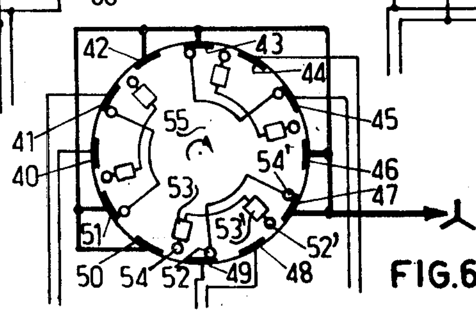

FIG.6

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COMPOSITE POLYPHASE ON-LOAD TAP-CHANGERS FOR REGULATING POLYPHASE TRANSFORMERS AND POLYPHASE TRANSFORMERS PROVIDED WITH SUCH TAP-CHANGERS

The invention relates to a composite polyphase on-load tap-changer for a regulating transformer, said tap-changer consisting of at least two switches connected in series, of which one switch is a polyphase diverter switch comprising at least one circular series of angularly equidistanced fixed contacts, of which the number is an integer multiple of the number of phases, at least one group of mechanically rigidly interconnected equal sets of relatively fixed movable contacts, the number of said sets of movable contacts being equal to the number of phases, said sets of movable contacts cooperating with said fixed contacts and being mounted for rotation about the axis of said circular series of fixed contacts and said sets being equiangularly spaced by angles which are equal to an even multiple of the angle between the fixed contacts and each consisting of one main contact and at least one auxiliary contact, and transition resistances cooperating with said auxiliary contacts, said main and auxiliary contact being relatively mounted and said auxiliary contacts cooperating with the transition resistances, in such a manner, that during each changeover operation a bridge of resistance is formed between the fixed contacts between which the changeover operation takes place, and the other switch is a currentlessly switching polyphase tap selector comprising for each phase two series of pairs forming fixed contacts and two alternately movable bridging contacts, of which each one cooperates with an individual one of said series of fixed contacts for the interconnection of the fixed contacts of each individual pair of the relative series, one contact of each one of said pairs of fixed contacts being connected with a fixed contact of the diverter switch and the other contact thereof being intended for connection to a tapping of a regulating winding of the transformer, said diverter switch being connected between said tap selector and a star point.

The invention has for its object to provide a composite on-load tap-changer intended to be connected between the regulating winding of the transformer and a star point, in which this disadvantage is avoided, that means in which, irrespective of the number of tappings of the winding for the fine voltage regulation, the number of fixed contacts of the diverter switch need not be greater than an even multiple of the number of phases. This means that in a diverter switch for three phases and single interruption the number of fixed contacts of said diverter switch need not be greater than six and in a diverter switch for double interruption and three phases this number need not be greater than twelve. According to the invention this is achieved in that for each phase all fixed contacts belonging to the same series of the tap selector and connected to the diverter switch are connected both with each other and with one single individual fixed contact of the or each circular series of fixed contacts of the diverter switch. In this tap-changer the tap selector does not operate as phase changeover switch for the fixed contacts of the diverter switch any more. In the present case the changeover of the phases is superfluous, as during a transition between two transformer tappings not only the connection between said tappings of each individual phase but also the connection between one tapping of a phase and the other tapping of another phase always takes place over at least one transition resistance which is inserted between a tapping and the star point, so that never more than the step voltage can occur across said resistance and it does not matter, with the tapping of which phase said transition resistance is temporarily connected. The on-load tap-changer according to the invention has also the advantage that all fixed contacts belonging to a series of the tap selector and connected with the diverter switch may form one continuous contact path. This makes not only the construction of the tap selector simpler but it also means a considerable decrease of the wear and tear of the relative cooperating contacts.

The diverter switch of the tap-changer according to the invention can be constructed in many ways which will appear from the next description of the embodiments of an on-load tap-changer according to the invention which are diagrammatically shown in the drawing.

In the drawing:

FIG. 1 is a diagrammatical view of a first embodiment of the part, essential to understand the invention, of a composite on-load tap-changer for linear voltage regulation provided with a diverter switch for single interruption,

FIG. 2 is a diagrammatical view of an on-load tap-changer for so-called plus-and-minus regulation provided with a differently constructed diverter switch for single interruption,

FIG. 3 is a diagrammatical view of a variant of the diverter switch shown in FIG. 1,

FIG. 4 is a diagrammatical view of a variant of the diverter switch shown in FIG. 2,

FIG. 5 is a diagrammatical view of a composite on-load tap-changer for coarse and fine regulation provided with a diverter switch for double interruption,

FIG. 6 is a diagrammatical view of a differently constructed diverter switch for double interruption,

FIG. 7 is a diagrammatical view of a variant of the diverter switch shown in FIG. 5 and

FIG. 8 is a diagrammatical view of a variant of the diverter switch shown in FIG. 6.

In FIG. 1 base windings of a threephase transformer are designated by 1. Connected with each one of these windings is a regulating winding 2 provided with tapping 3′, 3″ for the fine voltage steps of the regulating transformer. Cooperating with the regulating windings 2 is a threephase tap selector which comprises for each regulating winding 2 fixed contacts 4′, 4″ connected with the tappings 3′, 3″ and arranged in two series, two alternately movable bridging contacts 5′, 5″ and two fixed contact paths 6′, 6″. The bridging contacts 5′, 5″ are adapted to connect each time a fixed contact 4′, 4″ with a fixed contact path 6′, 6″.

A threephase diverter switch is designated by 7 and consists of six equiangularly spaced fixed contacts 8, 9, 10, 11, 12, 13 arranged in circular series, three equiangularly spaced sets of movable contacts mounted for rotation about the axis of said circular series and six transition resistances 14.

Each set of movable contacts is composed of a main contact 15 and two auxiliary contacts 16. The main contacts 15 of the three sets are directly connected with a star point 17 and the auxiliary contacts 16 are each connected to said star point 17 through a transition resistance 14. If, for instance, the sets of mechanically rigidly interconnected movable contacts 15, 16 are rotated counterclockwise, the pair of contacts 9, 8, the pair of contacts 11, 10 and the pair of contacts 13, 12 are each first bridged by two resistances 14 connected in series, so that in each phase the voltage step occuring between the bridging contacts 5′, 5″ is shunted by said resistances. On further rotation the main contacts 15 are placed on the fixed contacts 8, 10 and 12. In the then obtained new position of the diverter switch the lowest fixed contact 4″ of each phase is connected with the star point, so that the voltage supplied by the transformer is equal to the voltage of the base winding 1 increased by the voltage of one step of the regulating winding 2. If a further decrease of the voltage is required the bridging contact 5′ of each phase must be first shifted to the lowest fixed contact 4′ of the tap selector. Thereupon the diverter switch must be again rotated one step counterclockwise. In that case the pair of fixed contacts 8, 13, the pair of fixed contacts 10, 9 and the pair of fixed contacts 12, 11 are each temporarily bridged by two transition resistances 14 connected in series and the contact path 6′ of each phase is connected with the contact paths 6″ of the two other phases.

In the described on-load tap-changer each set of movable contacts of the diverter switch is provided with two auxiliary contacts mounted on either side of the main contact and two transition resistances which are moved along with said contacts. Consequently, the diverter switch is symmetrically constructured. Furthermore, the tap selector is only suitable for so-called linear voltage regulation, so that the regulating range is not greater than that of the regulating winding.

The composite threephase on-load tap-changer shown in FIG. 2 is provided with a tap selector for so-called plus-and-minus regulation and with an asymmetric diverter switch. To that end the tap selector illustrated in FIG. 1 is amplified with a changeover selector **18**, by means of which the regulating winding **2** can be alternately connected with the base winding **1** in the same direction and in the opposite direction as the base winding **1**, so that the regulating range is doubled. Furthermore in this tap-changer the diverter switch **19** is asymmetrically constructed, that means each set of movable contacts has only one auxiliary contact **16** and one transition resistance **14**. The asymmetric diverter switch can be advantageously used in transformers which pass the energy in one direction only. In that case it is possible to obtain, when the auxiliary contacts **16** are placed on the right side of the main contacts **15**, that during each changeover operation the circulating current opposes the main current, so that when the contacts leave a fixed contact they need to break a smaller power and can be made lighter. Another advantage is that the construction is simpler.

The threephase diverter switch shown in FIG. 3 cooperates with stationary transition resistances **20**. To that end said diverter switch is provided with two coaxial circular series of six fixed contacts **21, 22, 23, 24, 25, 26** and **27, 28, 29, 30, 31, 32**, of which the fixed contacts **21–26** cooperate with the movable main contacts **33** and the fixed contacts **27–32** cooperate with the auxiliary contacts **34** which are symmetrically positioned in regard to the main contacts **33**. The six symmetrically positioned transition resistances **20** are connected between the fixed contact paths **6'** and **6''** of the three phases of the tap selector (see FIGS. **1** and **2**). All movable contacts **33, 34** of this diverter switch are mechanically rigidly interconnected and directly connected with the star point **17**. To the operation of this diverter switch in the tap-changer the same is applicable as to the operation of the diverter switch in the tap-changer shown in FIG. **1**.

FIG. **4** shows the asymmetric variant of the diverter switch illustrated in FIG. **3**. This diverter switch which operates as the diverter switch shown in FIG. **2** comprises only three auxiliary contacts **34** which cooperate with the circular series of fixed contacts **27–32**.

In FIG. **5** a composite threephase on-load tap-changer is shown, of which the tap selector is amplified with a double changeover selector **35**, by means of which the regulating winding **2** for the fine voltage steps can be connected either with the end **36** of the base winding **1** or with the free end **37** of a winding **38** for the coarse voltage regulation which is permanently connected in series with the base winding. Cooperating with the contact paths **6', 6''** of the tap selector is a diverter switch **39** with double interruption which is provided with a circular series of twelve fixed contacts **40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51**, with which three double sets of movable contacts cooperate. Each double set of movable contacts consists of two main contacts **52, 52'** directly connected in series and two pairs of auxiliary contacts **54, 54'** positioned on either side of said main contacts and connected in series through transition resistances **53, 53'** which are moved together with the contacts. The resistances **53, 53'** connected in series may be replaced by one single resistance. The six fixed contacts **40, 41, 44, 45, 48, 49** are connected with the contact paths **6', 6''** of the three phases of the tap selector and the fixed contacts **42, 43, 46, 47, 50, 51** are connected to the star point **17**. This diverter switch is symmetric and operates with transition resistances moved along with the contacts.

The asymmetric variant of the diverter switch with double interruption shown in FIG. **5** is illustrated in FIG. **6**. In this diverter switch **55** each double set of movable contacts is provided with only one single pair of auxiliary contacts **54, 54'** connected in series through the transition resistances **53, 53'**.

In the diverter switch **56, 56'** with double interruption shown in FIG. **7** the transition resistances **57** are stationary and the three sets of movable main contacts **58, 58'** which are directly connected in series cooperate with 12 fixed contacts **59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70** arranged in a first circular series, whereas the sets of double pairs of auxiliary contacts **71, 71'** which are also directly connected in series cooperate with a second circular series of fixed contacts **72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83**. All movable contacts **58, 58', 71, 71'** are mechanically rigidly interconnected. The fixed contacts **59, 60, 63, 64, 67, 68**, of the first circular series and the fixed contacts **72, 73, 76, 77, 80, 81** of the second circular series are connected with the contact paths **6', 6''** of the tap selector (see FIGS. **1, 2** or **5**), whereas the fixed contacts **61, 62, 65, 66, 69, 70** of the first circular series are directly connected to the star point **17** and the fixed contacts **74, 75, 78, 79, 82, 83** of the second circular series are connected to said star point through the transition resistances **57**. This diverter switch **56, 56'** is symmetrically constructed.

The asymmetric variant of the diverter switch **56, 56'** with double interruption shown in FIG. **7** is illustrated in FIG. **8**. Therein the diverter switch **84, 84'** comprises also two coaxial circular series of fixed contacts **59–70** and **72–83**, the first one of which cooperates with the main contacts **58, 58'** and the second one cooperates with only one pair of auxiliary contacts **71, 71'** in each phase. Furthermore there are only three transition resistances **57**.

It is observed, that all diverter switches are adapted to cooperate with a tap selector for linear regulation (FIG. **1**), a tap selector for plus-and-minus regulation (FIG. **2**) or a tap selector for fine-and-coarse regulation (FIG. **5**).

What I claim is:

1. Composite polyphase on-load tap-changer for a regulating transformer, said tap-changer consisting of at least two switches connected in series, of which one switch is a polyphase diverter switch comprising at least one circular series of angularly equidistanced fixed contacts, of which the number is an integer multiple of the number of phases, at least one group of mechanically rigidly interconnected equal sets of relatively fixed movable contacts, the number of said sets of movable contacts being equal to the number of phases, said sets of movable contacts cooperating with said fixed contacts and being mounted for rotation about the axis of said circular series of fixed contacts and said sets being equiangularly spaced by angles which are equal to an even multiple of the angle between the fixed contacts and each consisting of one main contact and at least one auxiliary contact, and transition resistances cooperating with said auxiliary contacts, said main and auxiliary contact being relatively mounted and said auxiliary contacts cooperating with the transition resistances, in such a manner, that during each changeover operation a bridge of resistance is formed between the fixed contacts between which the changeover operation takes place, and the other switch is a currentlessly switching polyphase tap selector comprising for each phase two series of pairs forming fixed contacts and two alternately movable bridging contacts, of which each one cooperates with an individual one of said series of fixed contacts for the interconnection of the fixed contacts of each individual pair of the relative series, one contact of each one of said pairs of fixed contacts being connected with a fixed contact of the diverter switch and the other contact thereof being intended for connection to a tapping of a regulating winding of the transformer, said diverter switch being connected between said tap selector and a star point, characterized in that for each phase all fixed contacts belonging to the same series of the tap selector and connected to the diverter switch are connected both with each other and with one single individual fixed contact of each circular series of fixed contacts of the diverter switch.

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