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VOLTAGE REGULATED POLYPHASE AUTO TRANSFORMER

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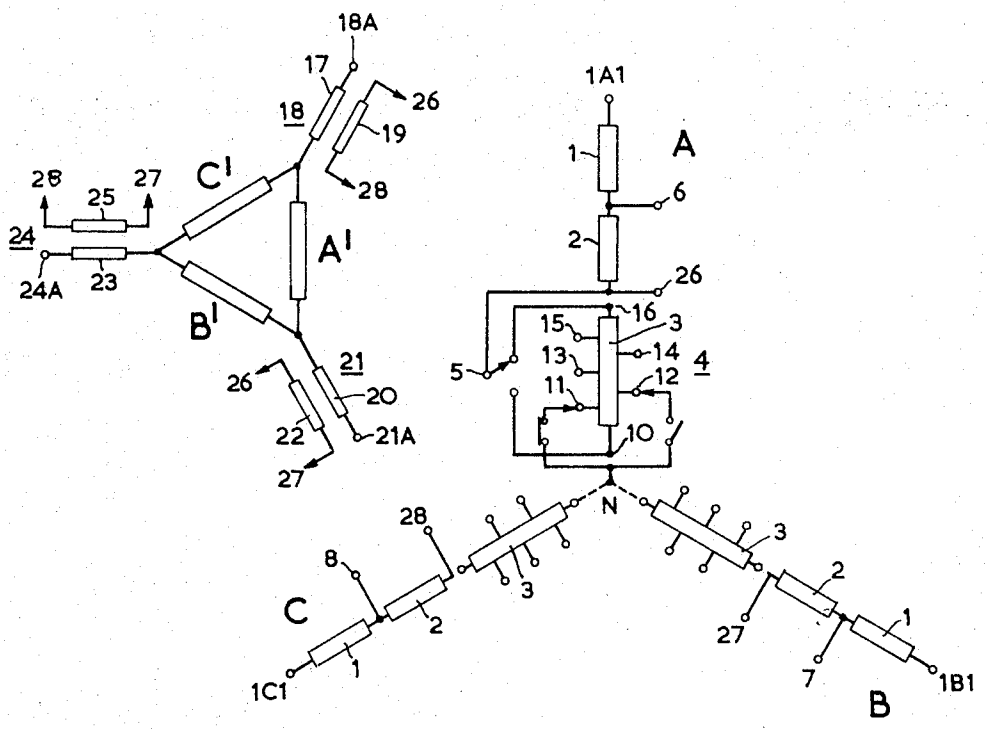

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VOLTAGE REGULATED POLYPHASE AUTO TRANSFORMER

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This invention relates to voltage regulated polyphase auto transformers.

More particularly the invention relates to a three phase auto-transformer which has its main windings on each phase comprised of three portions in series terminating in a single neutral point and interconnecting a higher voltage input or output with a lower voltage output or input, and consisting of a higher voltage portion between the higher voltage terminal and the lower voltage terminal, a common portion between the lower voltage terminal and an endtap near the neutral end and a tapping winding also forming part of the common portion and which has a number of additional tapping points for connection to a tapchanger and reversing switch for the purpose of voltage regulation, the transformer also having a delta connected fourth winding section in the main core limbs for supplying an additional load and referred to as the "tertiary winding" as it is associated with a third circuit in addition to the higher and lower voltage circuits mentioned above.

This type of transformer may be in the form of a single unit or it may comprise three single phase transformers arranged as a three phase transformer bank.

The above described type of transformer which is hereinafter referred to as a voltage regulated auto-transformer of the kind described can be used with a substantially constant higher voltage applied to the higher voltage terminals of the main windings so that the voltage of the lower voltage output can be varied according to the tapping point selected, or, it can be used with a substantially constant lower voltage applied to the lower voltage terminals and with a higher voltage load connected to the higher voltage terminals of the main windings so that the voltage of the higher voltage output can be varied as above.

Whichever way the transformer is used, its output voltage, whether it be the lower voltage or higher voltage, can be regulated or kept constant by connecting the neutral point, via the tapchanger, to a selected tap of the tapping winding adjacent to the neutral point in the common portion of the main windings. This voltage regulation is carried out in a known manner and at a relatively low voltage. For a desired ratio of high voltage to low voltage there always exists a corresponding tapping point which will keep the main output voltage constant when the input voltage varies, but the difference between these two voltages will be by hypothesis variable and this variable voltage will be applied across the constant number of turns of the high voltage portion of the main winding thus producing a varying volts per turn for all windings on the common core. Therefore, the voltage across the constant number of turns of the tertiary winding cannot be kept constant unless the number of turns of this winding is also varied in the opposite sense by means of a second tapchanger and this is very often not convenient because of the large magnitude of the current in the tertiary winding due to its relatively low voltage.

In order to keep constant or to regulate in the desired manner the output voltage of the delta connected tertiary winding it is possible to inject into its output a variable voltage derived from the end-tap of the common portion

of the main winding which is varied according to the operation of a tapchanger connected to the additional tapping points. However, this would have the effect not only of varying the output voltage of the delta connected winding but also the phase thereof.

According to the invention therefore there is provided, in a three phase transformer of the kind described, means for injecting externally onto the output of each phase of the delta connected winding voltages which are derived from across two phases of the main winding and the magnitude and sense of which are dependent upon the setting of the tap selecting and reversing switches respectively of the tapchangers, the arrangement being such that when the output of the main winding is regulated to decrease its voltage output the voltages injected externally onto the output of the delta connected winding are 180° out of phase with the voltages across the delta winding proper, and when the main winding is regulated to increase its voltage output the voltages injected externally onto the output of the delta connected winding are in phase with the voltage across the delta winding proper, whereby the magnitude of the voltage output of the delta winding is regulated without any change in the phase thereof.

The output voltage of the delta winding may be regulated to maintain this voltage constant.

Alternatively the output voltage of the delta winding may be regulated to provide for over or under compensation thereof whereby the output voltage of this winding will rise or fall according to a predetermined law in response to operation of the tapchangers in the main winding.

One form of polyphase auto transformer of the kind described, in accordance with the invention, will now be described, by way of example, with reference to the accompanying drawing.

The single figure of the drawing is a block schematic circuit diagram of the windings, of a three phase auto transformer with the delta connected winding juxtaposed in relation thereto in a manner which indicates the physical and electrical relationship between the two windings. The magnetic core of the transformer is not shown.

In the drawing the three phases of the main transformer winding are indicated A, B, C with a neutral point N and the phase A is shown with its tapchanger arrangement **4** which includes tap selecting switches **11** and **12** and a changeover or reversing switch **5**. The other two phase arrangements are identical but are not shown in their entirety in the drawing. It is therefore only necessary to describe the A phase arrangement in which the winding comprises the portions **1**, **2** and **3** of which the latter two constitute the common part of the winding.

The winding portion **3** has tapping points **10** to **16** and any one of these tapping points may be selected by one of the switches **11** or **12** and connected to the neutral point N and either of the end taps **10** or **16** may be connected to the end **26** of the winding portion **2** through the changeover or reversing switch **5** in a known arrangement in which all or part of the winding portion **3** may be included in phase A either to increase the phase A voltage, or to reduce this voltage. With the changeover switch **5** in the position shown all or part of the winding portion **3** may be included in phase A in a sense to add winding portions into this phase.

In the other position of the switch **5** all or part of the winding **3** will be connected in phase A in a reverse sense so as to include in this phase a reverse voltage.

The tapchanger is also effective for connecting the neutral point N to the end **26** of winding portion **2** so that no part of winding portion **3** is connected in circuit.

The phases B and C are provided with identical tapchanger arrangements (not shown) so that if a constant

higher voltage supply is connected to the terminals 1A, 1B, 1C a lower voltage load may be connected to the terminals 6, 7 and 8 of the three phases and the lower voltage supplied to the load either regulated or maintained constant by operation of the tapchangers.

The arrangement described may also be used to supply a variable higher voltage load connected to the terminals 1A, 1B, 1C with a constant lower voltage supply connected to the terminals 6, 7, and 8.

The transformer is also provided with a delta connected tertiary winding having the phases A1, B1, C1 wound on the same limbs as the windings of A, B, and C respectively, as is indicated by the parallel arrangement of these parts in the drawings. Connected to the three corners of the delta winding are respective secondary windings of a double wound three phase auxiliary transformer having phases 18, 21, and 24; this transformer has primary windings 19, 22, and 25 respectively and secondary windings 17, 20 and 23 respectively. The necessary windings of this transformer are connected to the three ends of the delta winding and have terminals 18A, 21A and 24A from which the output of the delta winding is taken.

The primary windings 19, 22, and 25 of the double wound three phase transformer are each connected across two phases of the main transformer winding as indicated by the reference numerals and the juxtaposition of these primary windings relative to the main windings.

For example, the primary winding 19 is connected across terminals 26 and 28 of phases A and C respectively. Each primary winding of the double wound three phase auxiliary series transformer thus receives a voltage from across two phases of the main winding and these voltages are determined by the setting of two phases of tapchanger arrangements of the main phases A, B, and C. By suitable proportioning the primary and secondary turns ratio of the double wound three phase auxiliary series transformer, voltages are injected onto the output of the delta winding, so that these voltages are added to or subtracted from, the voltage output of the delta winding so as to maintain the output voltage across the terminals 18A, 21A and 24A substantially constant regardless of the setting of the tapchangers in the main windings A, B and C. These added or subtracted injected voltages are moreover in phase with the output voltage of the delta winding when the output of this winding is required to be increased, and 180° out of phase therewith when the voltage is required to be decreased so that the voltage output at the terminals 18A, 21A and 24A is kept substantially constant without any phase change.

Consider for example phase 18 of the double wound three phase transformer the primary winding 19 of which is connected across phase A and C terminals 26 and 28. The primary winding can receive from the phases A and C a maximum additive in-phase compensating voltage when the whole of the winding portion 3 of phases A and B are in circuit with the changeover switches 5 connected to add the winding portion 3 into the phases A and B. This additional voltage will thus automatically vary down to its minimum value when the neutral point is connected via the tapchanger to the tap point 15 of the winding portion 3.

At the stage at which the neutral point N of the main winding is connected to the terminals 26 and 28 of phases A and C respectively the primary windings of the double wound three phase transformer are completed, or short circuited so that no compensating voltage is injected into the output of the delta winding.

When the changeover switches 5 of phases A and B are reversed then similarly adjustments can be made except that the voltages injected in the output of the delta winding are 180° out of phase, so providing voltage reduction.

If desired the turns ratio of the double wound three phase transformer can be arranged such that the injected voltages provide either over or under compensation so that the voltage output at the terminals 18A, 21A and 24A varies according to a predetermined law to rise or fall with adjustment of the tapchanger switches in the main windings.

What I claim as my invention and desire to secure by Letters Patent is:

1. In a three phase electrical auto-transformer, three main windings and an auxiliary three phase delta connected winding, each main winding comprising first, second and third winding portions with the second and third portions connected in series, each first winding portion having tapping points thereon, a first terminal connection connected to the outermost end of each third winding portion, a second terminal connection connected between the junction of each second and third winding portion, a third terminal connection connected to the innermost end of each second winding portion, tapchanging means associated with the tapping points of each first winding portion and each third terminal connection and serving to connect the three main windings to a common star point and to raise or lower the output voltage from those terminal connections serving as output terminals of the transformer, additional transformer means having first, second and third primary windings and associated first, second and third secondary windings, one end of each such secondary winding being connected to a respective junction point of the windings of said delta winding, the primary windings of the additional transformer means being connected across respective pairs of said third terminal connections so that the secondary windings of the additional transformer means inject onto the output of the delta connected winding voltages which are of a magnitude and sense dependent upon the settings of the tapchanging means and which are 180° out of phase with the voltages delivered by the delta winding proper when the tapchanging means are operated in a sense to lower the output voltage at those terminal connections serving as output terminals of the transformer, and which are in phase with the voltages delivered by the delta winding proper when the tapchanging means are operated in a sense to raise the said output voltages.

2. A three phase transformer according to claim 1 in which the additional transformer means injects voltages onto the output of the delta winding which serve to maintain substantially constant the algebraic sum of the delta winding voltages and the injected voltages despite changes in the connections effected by the tapchanging means.

3. A three phase transformer according to claim 1 in which the additional transformer means injects voltages onto the output of the delta winding which serve to cause a fall in the algebraic sum of the delta winding voltage and the injected voltages in response to operation of the tapchanging means.

4. A three phase transformer according to claim 1 in which the additional transformer means injects voltages onto the output of the delta winding which cause a rise in the algebraic sum of the delta winding voltage and the injected voltages in response to operation of the tap changing means.

5. A three phase transformer according to claim 1 in which the tap changing means are operable to connect the third terminal connections together to form the star point of the three main windings and at the same time to remove each first winding portion from the transformer winding circuit and complete the primary windings of the additional transformer means.

No references cited.

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