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LOW WEIGHT/RATING RATIO, CONTINUOUSLY VARIABLE LOW IMPEDANCE TRANSFORMER ASSEMBLY

Filed March 31, 1966

4 Sheets-Sheet 1

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ABSTRACT OF THE DISCLOSURE

A transformer assembly such as disclosed in Gibson et al. Patent No. 3,268,842, providing continuous adjustment of a transformer having built-in good regulation characteristics, but including means for substantially reducing the copper and iron content by utilizing smaller size wire in the voltage winding and spanning a narrow voltage range of said winding by a bridging winding slidably connected through brushes to said voltage winding and providing through a load lead wire, heavier current than flows in said voltage winding.

My invention relates to transformers and more particularly to a continuously variable low impedance transformer assembly.

This invention is an improvement on the subject matter of pending application of Gibson et al., for Continuously Variable Voltage Low Impedance Transformer Assembly, Ser. No. 401,532, filed Oct. 5, 1964, now Patent No. 3,268,842 of Aug. 23, 1966.

Since any electrical apparatus operates most effectively at its rated voltage, it is important that the rated voltage be supplied to such apparatus, and be maintained as near constant as is possible from no load to full load. Where such loads are supplied to transformers, this means that the transformer must have good regulation.

One of the factors which adversely affects voltage regulation in a transformer is magnetic leakage. If there were no magnetic leakage, the ratio between the primary and secondary terminal voltages would differ from the turns ratio only by the relatively small resistance drop in the windings.

However, magnetic leakage contributes an additional component to the voltage drop through the transformer, in the form of a leakage reactance drop, and increases the departure of the voltage ratio from the ideal. Since this component of voltage drop is inductive, it not only increases with load, but also with frequency, and introduces a number of problems concerning regulation.

Leakage reactance is solely a function of the physical design of the transformer. It can be shown that the percent reactance drop varies directly with the number of turns, the thickness of the coils, the spaces between the windings, the average main length of turn, and inversely with the length of coils.

Some reduction can be made in the leakage reactance drop of a transformer by inter-leaving sections of the secondary winding with sections of the primary winding so as to increase the close coupling between the two windings. This is a practical approach to such problem, but unfortunately, does not lend itself to transformers from which a continuously variable secondary voltage is desired.

The invention of the aforementioned application overcomes these problems by disclosing a transformer of low impedance, which is capable of providing a continuously variable voltage output. The present invention is primarily directed to a transformer assembly of this type, though basically it may have other applications.

Among the objects of the present invention are:

1. To provide a novel and improved transformer assembly;
2. To provide a novel and improved transformer assembly requiring less core material and copper than one of conventional design of comparable rating;
3. To provide a novel and improved continuously variable voltage low impedance transformer assembly;
4. To provide a novel and improved continuously variable voltage, low impedance transformer assembly of the character disclosed in the aforementioned pending application, but requiring considerably less core material and copper, by an amount for example, of the order of half of that required for the other.

Additional objects of my invention will be brought out in the following description of a preferred embodiment of the same, taken in conjunction with the accompanying drawings wherein:

FIGURE 1 is a three-dimensional view of a transformer assembly embodying the present invention.

FIGURE 2 is a three-dimensional view of the transformer assembly of FIGURE 1, broken apart, to illustrate certain details involved in its construction.

FIGURE 3 is a circuit diagram representative of the invention.

FIGURE 4 is a circuit diagram of the transformer assembly embodying FIGURE 1.

Referring to the drawings for details of my invention in its preferred form, I have depicted the same as applied to the continuously variable voltage, low impedance transformer assembly of the aforementioned application, Serial No. 401,532, although it will be appreciated that the invention is applicable to equipment other than that illustrated in the drawings, to effect a similar reduction in core material and copper.

The apparatus illustrated, involves a fixed three phase transformer 1 which is designed in accordance with general practice to have good regulation, and accordingly, the primary and secondary windings of each phase may be sectionalized and interleaved, and/or other precautions may be taken to minimize magnetic leakage to assure such good regulation.

Electric connections, preferably in the form of taps 3 are taken off the secondary winding of each phase at electrically spaced voltage points, which are preferably equally spaced electrically.

Adjacently disposed on a common base assembly 7, is an output winding assembly 9 involving three similar separate windings 11, each separate winding 11 being associated with a different one of the secondary windings of the three phase transformer 1. Such separate windings are mounted on a three-legged core 15 of iron laminations, the laminations being held together by clamping bolts 19 through angle strips 21 along the upper and lower ends of the core, which angle strips function also to provide lateral mounting flanges, which may be utilized for the mounting of the winding assembly 9 to the base 7, or for assembling of components in association therewith.

Each leg of the core 15 is of rectangular cross section and supports one of the windings 11.

Electrical connections from the electrically spaced taps 3 of each of the secondary windings of the transformer 1, are made to corresponding physically spaced points on one of the windings 11, for which purpose, each of the windings 11 is provided with appropriate taps 25. Since the transformer 1 has been designed to give good regulation form load to full load, the voltage derived therefrom and applied to the windings 11, will thus be stabilized from one contact 25 to another.

The corresponding side of each winding of the output winding assembly, opposite that side to which the contacts 25 are provided, has insulation removed along
a path 29 extending substantially the full length of the winding to expose or bare the adjacent turns in such winding. Each gang brush assembly is made up of a number of layers, the exposed path will be in the outer layer.

For adjusting an adequate electrical connection to such windings, I provide one or more gang brush assemblies 35 installed for simultaneous longitudinal adjustment along the exposed path of the windings. Each gang brush assembly involves a plate 37 of insulation spanning the three windings and threadedly mounted on a pair of vertical screws 39 rotatably supported adjacent the windings, with their ends journaled in suitable end plates 41, 43. One adjacent the lower ends of the windings and the other adjacent the upper ends of the windings, with both screws simultaneously rotatable, preferably by a motor drive 44, in the manner of the aforementioned Gibson et al. application.

Associated with each winding 11 and mounted upon the upper edge of the plate is a multiple brush holder 47, and mounted on the lower edge of the same plate, is a similar multiple brush holder 49. Each multiple brush holder 47 or 49, is adapted to carry a set of brushes extending toward the proximate winding for electrical engagement with the exposed path on such winding, under pressure of a plurality of housed backing springs, one for each brush.

When a pair of gang brush holders is involved, as illustrated in FIGURE 2, a similar plate 45 of insulation may be employed as a spacer, and the brush holders can be bolted thereto to support the same.

The present invention calls for at least one gang brush assembly 35 to provide one pair of spaced brush holders 47, 49 for each winding, as described above, such minimum being the requirement for welding power units designed to operate in the lower welding current range of the order of 40 to 200 amperes, though for heavier duty equipment, more than one such gang brush assembly will be employed, the specific embodiment illustrated in the drawings, being depicted as utilizing a pair of such gang brush assemblies, designed, for example to handle a load range of the order of 200 to 600 amperes.

The upper and lower brush holders 47, 49 of each gang brush assembly, are bridged by a winding 55, through connections 57, 59, the winding having a center tap connection 63 leading therefrom. Winding 55 is preferably of the iron core type to enable use of a relatively small winding. When only the one gang brush assembly is involved, such center tap connection will constitute a terminal or load connection for three phase operation.

In equipment employing a pair of gang brush assemblies as depicted in the drawings, similar bridging windings 67 will connect the corresponding brush holders 47, 49 of the second gang brush assembly through connections 69, 71. Adjacent windings 55 and 67 will in turn be bridged by a third winding 75 connecting to the center taps thereof. This third winding will in turn have a center tap connection 77 leading therefrom as a load connection.

Each separate winding will be designed to a voltage per turn of the order of one volt, preferably less, which enables the utilization of brushes of the carbon type, and the electrical spacings between upper and lower brushes of each gang brush assembly should preferably equal the electrical spacing between the input tap connections to each of the separate windings. Thus the electrical spacing at the input taps of each separate winding is of the order of 20 volts, then the electrical spacing between the upper and lower brushes of a gang brush assembly should be of the same order.

Also, the electrical spacing between the lower brush holder of one brush gang assembly and the upper brush holder of the gang assembly below it, should preferably be of the same order.

When thus connected, the electrical circuit diagrams will appear as depicted in FIGURES 3 and 4, where FIGURE 3 represents the circuit for a transformer assembly of low power output requiring but a single gang brush assembly, whereas the circuit of FIGURE 4 depicts a similar transformer assembly designed to handle substantially greater power outputs requiring a pair of gang brush assemblies.

In either of such circuits, any one of the bridging windings 55, 67 connected directly to the separate windings 11, will carry the current flowing in the winding to which it is connected, and in the circuit of FIGURE 4, each of the output bridging windings 75 will carry twice the current flowing in the bridging windings 55, 67 to which it is connected.

Accordingly, in designing such equipment, the output bridging windings, namely those to which the load is connected, will be designed with a wire capacity conforming to the rated current range of the equipment. As regards the circuit of FIGURE 4, this means that the bridging windings 55 and 67 which are connected directly to the separate windings 11, will only have to carry half the current of the output windings 75 and therefore in designing these windings, the wire size need only be such as to have a capacity to carry such lower values of current.

Finally, inasmuch as each separate winding 11 will be called upon to carry but half the current to be carried by the directly connected bridging windings 55 and 67, each separate winding will be designed to employ wire of still smaller diameter, such as to carry but half the current for which the windings 55 and 67 are designed, but one quarter the current for which the windings 75 are built. The use of such smaller diameter wire permits of a smaller core, therefor enabling the separate windings 11 to be constructed, from a practical view point, to a size approaching half of that formerly required, thereby effecting a substantial savings of approximately half in copper and iron, as well as considerably reducing the weight and size of the windings.

Similar logic applies to the circuit of FIGURE 3 which is applicable to a transformer assembly for lower power requirements, in that each bridging coil 55, 67 will carry twice the current flowing in the separate winding to which it is connected, and with such bridging coils designed to carry load current requirements, the wire size for the current required in the separate windings 11 will be substantially half that in the bridging windings, and the core may be correspondingly reduced in size.

Looked at from another view point, a transformer assembly designed for operation in the lower current ranges, and having the circuit depicted in FIGURE 3, may have its power capacity increased by the addition of another gang brush assembly and the connection to the bridging windings 55, 67, of terminal bridging windings 75 having the desired load current carrying capacity, or in other words, converting the circuit from that of FIGURE 3 to that of FIGURE 4 without effecting any change in the separate windings 11 per se. One may therefore standardize on the design of the separate windings 11 and meet any load current requirements merely through the addition of brush gang assemblies and bridging windings along the lines described.

In this connection, the circuit of FIGURE 4 does not represent the limit to which the system may be expanded, for electrically speaking, there would be no limit to which the current carrying capacity of the equipment may be designed. The only limit would be that of physical space requirements, and when this has been reached, two or more transformer assemblies may be connected in parallel.

The invention, while illustrated and described for three phase operation, may be employed for single phase applications. When so applied, but one separate winding 11 will be employed. Load connections may be taken off between an end of the winding and the center tap of the bridging winding, or the separate winding may be split between two legs of a closed core, and serially connected.
by a connection between corresponding bridging windings. The load connections will then come from corresponding ends of the sections of the split winding.

From the foregoing description of my invention in its preferred form, it will be apparent that the same is subject to alteration and modification without departing from the underlying principles involved, and I accordingly do not desire to be limited in my protection to the specific details illustrated and described, except as may be necessitated by the appended claims.

I claim:

1. A low weight/rating ratio, continuously variable low impedance transformer assembly involving substantially less copper and iron than would be required in a comparably rated transformer assembly of the Gibson et al. Patent 3,268,842, comprising in combination a transformer having means to provide low-leakage reactance from no load to full load, to provide good voltage regulation, a separate winding, electrical connections from electrically spaced voltage points on the secondary winding of said transformer to corresponding physically spaced points along said separate winding, said separate winding being formed of wire having a rated current carrying capacity substantially less than the current rating of said transformer assembly, whereby the wire in said separate winding would be of a cross-sectional area substantially less than that required in said comparably rated transformer assembly of the Gibson et al. Patent 3,268,842, and resulting in a substantially smaller winding than required in said patented transformer assembly, and means for withdrawing current from said separate winding at spaced voltage points simultaneously and at values within the current carrying capacity of said winding, and delivering same at an increased value of current.

2. A low weight/rating ratio, continuously variable low impedance transformer assembly, in accordance with claim 1, characterized by said separate winding being formed of wire having a rated current carrying capacity substantially half the current rating of said continuously variable transformer assembly, whereby the wire in said separate winding would be of a cross-sectional area substantially half that required in said comparably rated transformer assembly of Gibson et al. Patent 3,268,842, and enabling a winding of approximately half the size of that required in said patented transformer assembly.

3. A low weight/rating ratio, continuously variable, low impedance transformer assembly in accordance with claim 1, characterized by said means for withdrawing current simultaneously from spaced voltage points, including electrically conductive bridge means electrically engaging spaced points along said separate winding and a connection from a point on said bridge means, said connection having a current carrying capacity approximately twice that of said separate winding.

4. A low weight/rating ratio, continuously variable, low impedance transformer assembly in accordance with claim 2, characterized by said transformer being of the three phase type having three phase windings, a separate winding for each phase of said transformer, and electrically conductive bridge means for each of said separate windings, each of said bridge means having a load connection whose current carrying capacity is at least twice the current carrying capacity of its associated separate winding.

5. A low weight/rating ratio, continuously variable, low impedance transformer assembly in accordance with claim 4, characterized by each of said electrically conductive bridge means comprising a winding having a load lead from the mid-point thereof, of approximately twice the current carrying capacity of its associated separate winding.

6. A low weight/rating ratio, continuously variable, low impedance transformer assembly in accordance with claim 1, characterized by said separate winding having substantially less core material than would be required in said comparably rated transformer assembly of the Gibson et al. Patent 3,268,842.

7. A low weight/rating ratio, continuously variable, low impedance transformer assembly in accordance with claim 2, characterized by said separate winding having substantially half the core material that would be required in said comparably rated transformer assembly of the Gibson et al. Patent 3,268,842.

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U.S. Cl. X.R.

323—43.5, 47; 336—146, 149