July 10, 1951 R. DESSARZIN 2,560,385

AUTOTRANSFORMER

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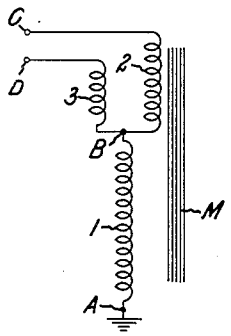


Fig. 1.

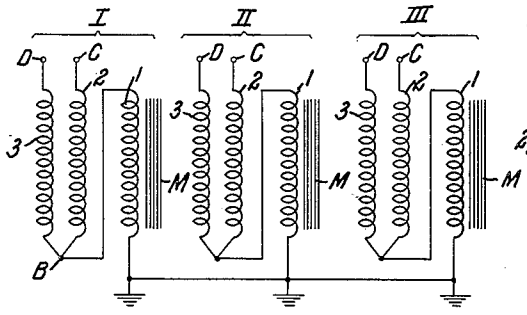


Fig. 2.

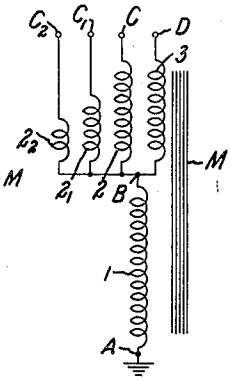


Fig. 3.

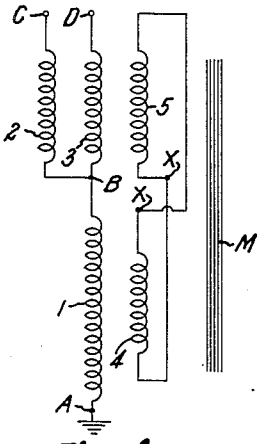


Fig. 4.

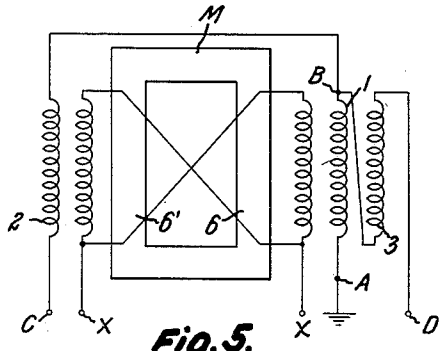


Fig. 5.

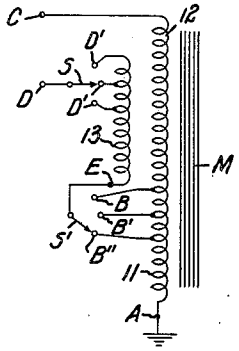


Fig. 6.

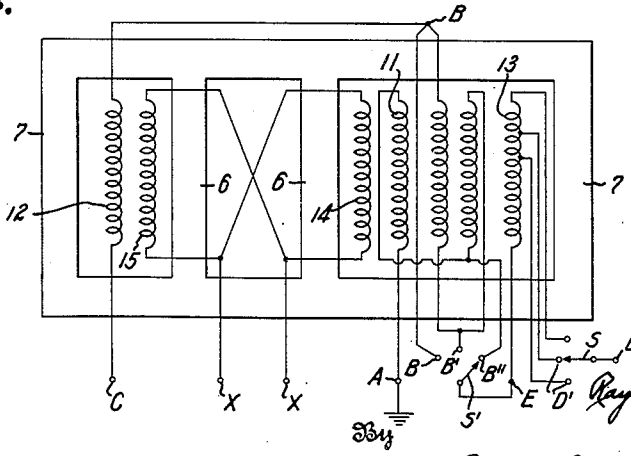


Fig. 7.

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UNITED STATES PATENT OFFICE

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AUTOTRANSFORMER

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10 Claims. (Cl. 323—45)

1

This invention relates to autotransformers, and particularly to autotransformers having reactances of a high order at transformation ratios of approximately unity.

It is well known that autotransformers are of more economical construction than the conventional transformers with separate primary and secondary windings, and that an autotransformer may be constructed with a reactance comparable to that of the equivalent conventional transformer when the transformation ratio is of the order of 0.5. As the ratio of transformation is increased to unity, the reactance of an autotransformer decreases progressively in comparison with the reactance of the conventional transformer and, when the ratio becomes equal to unity, the reactance of the autotransformer practically disappears.

The low value of the autotransformer reactance at transformation ratios approximating unity results in currents of high intensity in the case of short-circuits, and these heavy currents may result in damage to the autotransformer itself in view of the exaggerated electrodynamic stresses, and/or may result in damage to circuits and equipment energized through the autotransformer.

Objects of the invention are to provide autotransformers of economical construction and having reactances comparable to those of equivalent transformers of conventional separate-windings construction at various transformation ratios up to the order of unity. Objects are to provide autotransformers which include, in addition to the usual autotransformer windings, at least one additional winding inductively coupled to the usual windings, the several windings being spaced from each other according to the number of turns of each in such manner as to develop the desired reactance.

These and other objects and the advantages of the invention will be apparent from the following specification when taken with the accompanying drawings in which:

Fig. 1 is a schematic diagram of a single phase autotransformer embodying the invention;

Fig. 2 is a schematic diagram of a three phase autotransformer;

Fig. 3 is a schematic diagram of an autotransformer for supplying different voltages to a load circuit;

Fig. 4 is a schematic diagram of an autotransformer with windings as shown in Fig. 1 and, in addition, compensating windings;

Fig. 5 is a showing of the winding arrangement

2

of a compensated autotransformer such as shown schematically in Fig. 4;

Fig. 6 is a schematic diagram of an autotransformer provided with taps for adjustment of the voltage supplied to the load circuit; and

Fig. 7 is a vertical section through an autotransformer such as shown schematically in Fig. 6.

The basic assembly of an autotransformer according to the invention as illustrated in Fig. 1, includes serially connected windings 1, 2 on a magnetic core M, the winding 1 having a grounded terminal A and a terminal B in common with the winding 2. The winding 2 has an outer terminal C, and the windings 1, 2 with the three terminals A, B and C will be recognized as constituting an autotransformer of the previously known type. According to this invention, a third winding 3 is provided on the core M, one end of the winding 3 being connected to the junction B of windings 1, 2 and its outer end D serving as a terminal of the autotransformer. The autotransformer may be of the step-up or the step-down type according to the relative number of turns of windings 2, and 3, and to the connection of the supply and load circuits to the terminals C and D, it being understood that the supply and load circuits are both connected to the grounded terminal A of the winding 1. The primary circuit of the autotransformer includes the winding 1 and one of the windings 2 and 3, and the secondary circuit includes the winding 1 and the other of the windings 2 and 3. Both windings of each circuit are in series-additive relation, i.e. if the supply circuit is connected across the terminals A and C, the magnetic flux developed by winding 1 adds to the magnetic flux developed by winding 2; and the current induced in winding 3 is in such direction that the voltage across winding 3 adds to the voltage established across winding 1 by the supply circuit. The ratio of transformation is therefore

$$\frac{N_1+N_3}{N_1+N_2} \text{ or } \frac{N_1+N_2}{N_1+N_3}$$

according to the circuit connections, the terms N_1, N_2 and N_3 being the number of turns of windings 1, 2 and 3 respectively.

As illustrated in Fig. 2, a three phase autotransformer may comprise a separate autotransformer unit for each of the phases I, II and III; the windings 1, 2 and 3 of the units being of identical construction and the cores M being individual to each unit or, if desired, being separate columns of a common magnetic field sys-

tem. The low potential terminals A of the individual autotransformers are connected to form the neutral point of a star system and, as illustrated, the neutral point may be grounded.

It frequently is desirable to adjust the transformation ratio of an autotransformer to obtain different load circuit voltages from a source of fixed voltage, or to maintain a substantially fixed load circuit voltage in the case of a voltage source of varying voltage. The adjustment may be provided by taps along one or more of the windings, as will be discussed later, or by providing a plurality of windings having different numbers of turns. As shown in Fig. 3, additional windings 2_1 and 2_2 are connected to the junction point B, such additional windings having outer terminals C_1 and C_2 respectively which may be employed as a circuit terminal in place of the terminal C of winding 2. Winding 2_1 has a lesser number of turns than winding 2, and a greater number than winding 2_2.

The windings 1, 2 and 3 may be in radial alinement, as shown schematically in Fig. 2, or winding 2 may be axially displaced from winding 1, as shown schematically in Figs. 1 and 3, the winding 3 being in radial alinement with the winding 2. The latter arrangement has certain advantages so far as concerns an increase in reactance but it gives rise to losses in view of the loose coupling of the primary and secondary windings. These losses may be compensated in known manner by so-called compensating windings 4, 5, see Fig. 4, in closed series circuit and coupled to the axially spaced windings 1 and 2, 3 respectively. The windings 4, 5 are connected in opposition in the closed series circuit, but they are effectively in parallel so far as concerns feeding an external circuit connected to their junction points X, X.

A constructional embodiment of the invention, as shown in Fig. 5, includes a magnetic system M with two columns 6, 6', the windings 1 and 3 being on column 6 and the winding 2 being on the other column 6'. The compensating winding 4 is on column 6 with windings 1, 3; and the other winding 5 of the compensating system is on the column 6'. If the power source is connected to the terminals A and C of windings 1 and 2, the transformation ratio is

$$\frac{N_1+N_3}{N_1+N_2}$$

The number of turns of the windings 1, 2 and 3 may be of the same order, even if the transformation ratio is approximately unity. An external circuit may be energized by the voltage developed across the compensating windings 4, 5 by connecting the same across terminals X, X from the compensating circuit.

As above indicated, it is of course possible to provide one or more of the windings with taps for adjusting the voltage supplied to the load circuit. As shown in Figs. 6 and 7, the winding 11 is provided with taps B' and B'' between the winding terminals A, B, the winding 12 is not tapped between its terminals B and C, and the auxiliary winding 13 is provided with taps D' to which the terminal D may be connected by a switch S. Assuming that the supply circuit is connected between the terminals A and C, the load circuit L may be connected between terminal A and the terminal D of the tapped winding 13, the other terminal E of winding 13 being connected to one of the terminals B, B' and B'' of winding 11 by a switch S'. The magnetic

system M preferably includes, in addition to the columns 6 upon which the windings are located, one or more unwound columns 7 which provide an adequate flux path for the primary and leakage fluxes. Compensating windings 14, 15 are arranged on the columns 6, 6 but, for simplicity, are not shown in Fig. 6.

In the several embodiments of the invention, the windings 1, 2 or 11, 12 function in the same manner as the corresponding windings of a conventional autotransformer, and the windings 3 or 13 are inductively coupled to cooperate with the principal windings in the same manner as a separate winding of a conventional transformer. A desired reactance value may be had by providing appropriate spacings between windings and by a selection of the number of turns of the several windings. The autotransformers may be connected to and operated in parallel with conventional transformers having separate primary and secondary windings.

In the case of the autotransformer of Figs. 6 and 7, and assuming that the source circuit is connected across terminals A and C, the primary current flows through the section CB of winding 12 at all adjustments of the tap connections, and the current through the section AB'' of winding 11 is always equal to the difference between the primary and secondary currents since the section AB'' is always included in both the primary and the secondary circuits of the autotransformer. The currents through sections BB' and B'B'' of the winding 1 vary in accordance with the adjustment of switch S' to include one or both of these sections of winding 1 in the secondary circuit through the load L.

This invention is not limited to the particular constructions herein shown and described as various modifications which may occur to those familiar with the art fall within the spirit and scope of the invention as set forth in the following claims.

I claim:

1. An autotransformer for coupling a source circuit to a load circuit, said autotransformer comprising a magnetic core, a pair of windings on said magnetic core conductively connected in series-additive relation and spaced apart to develop a reactance of a high order in the event of a short circuit, the outer terminals of said windings constituting terminals across which the source circuit may be connected, and a third winding on said core and having one end conductively connected to the junction of said serially connected windings, the outer terminal of said third winding and an outer terminal of one of said pair of windings constituting terminals across which the load circuit may be connected; said third winding being in series-additive relation as regards voltage to that winding of said pair which is in series with the third winding.

2. An autotransformer comprising a magnetic core means, a pair of windings on said magnetic core means and connected in series-additive relation between a pair of terminals, said windings being spaced apart to develop a reactance of a high order in the event of a short circuit, and a third winding on said magnetic core means conductively connected to the junction of said pair of windings and in series-additive relation to one winding of said pair; said third winding having an outer terminal serving, with the terminal of that winding with which it is in series-additive relation, for connection to an external circuit.

3. An autotransformer as recited in claim 2,

wherein said third winding is in radial alinement with a part of one of said pair of windings.

4. An autotransformer as recited in claim 2, wherein said windings are in radial alinement.

5. An autotransformer as recited in claim 2, wherein the windings of said pair are axially displaced along said magnetic core means, and said third winding is in radial alinement with the winding of said pair to which it is connected in series-additive relation.

6. An autotransformer as recited in claim 5, in combination with a compensating system including auxiliary windings coupled to the respective axially displaced windings and serially connected in opposition.

7. An autotransformer as recited in claim 6, in combination with leads extending from the junctions of said serially connected auxiliary windings, said leads having terminals across which an external circuit may be connected.

8. An autotransformer as recited in claim 2, wherein said magnetic core means comprises a pair of columns and yokes cooperating therewith to form a substantially closed path of high permeability, the respective windings of said pair being on different columns; in combination with an additional column connecting said yokes.

9. An autotransformer as recited in claim 2,

wherein the winding of said pair which is in series-additive relation to the third winding is provided with a plurality of taps, in combination with switch means adjustable to connect said third winding to the desired one of said taps.

10. An autotransformer as recited in claim 2, wherein said third winding is provided with a plurality of taps, in combination with switch means for connecting said outer terminal of said third winding to the desired one of said taps.

RAYMOND DESSARZIN.

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