

March 9, 1926.

1,576,280

S. HORELICK

TRANSFORMER

Original Filed Feb. 11, 1922 2 Sheets-Sheet 1

Fig. 1.

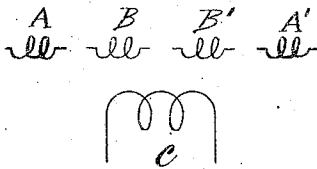


Fig. 2.

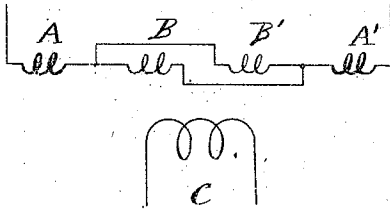


Fig. 3.

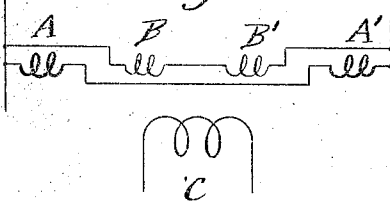


Fig. 4.

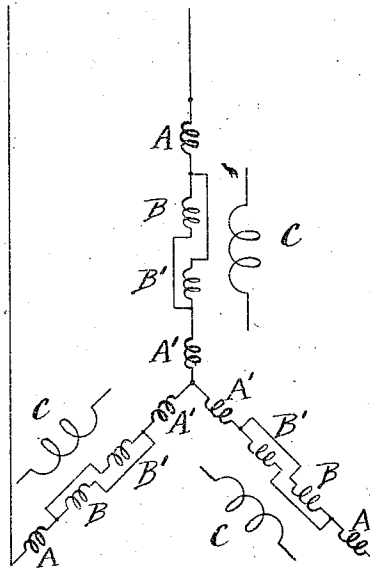
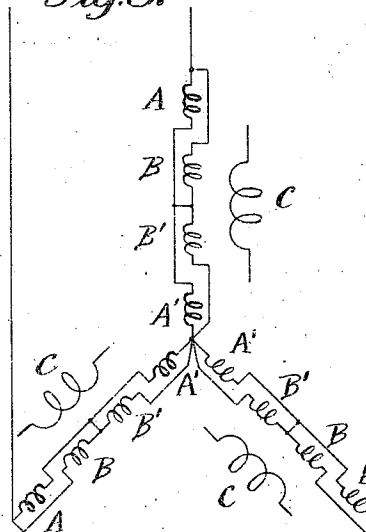


Fig. 5.



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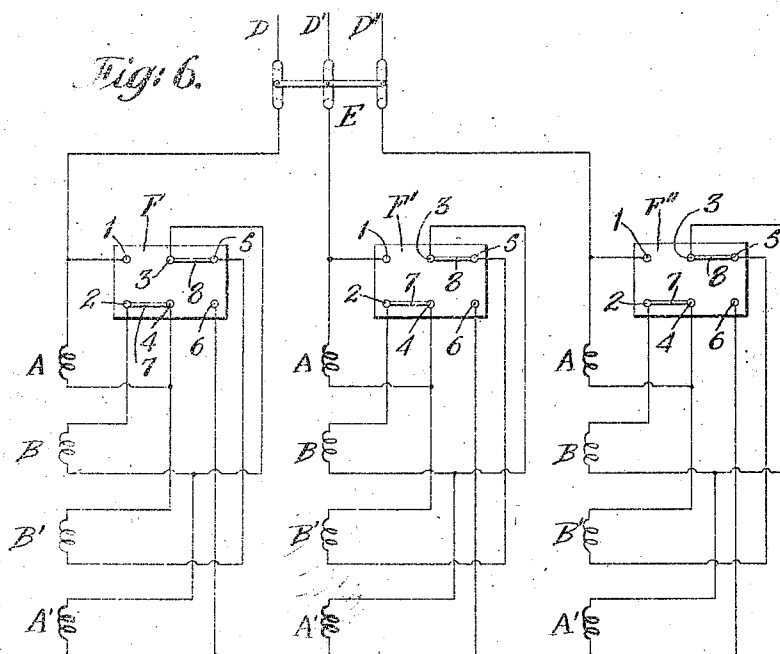
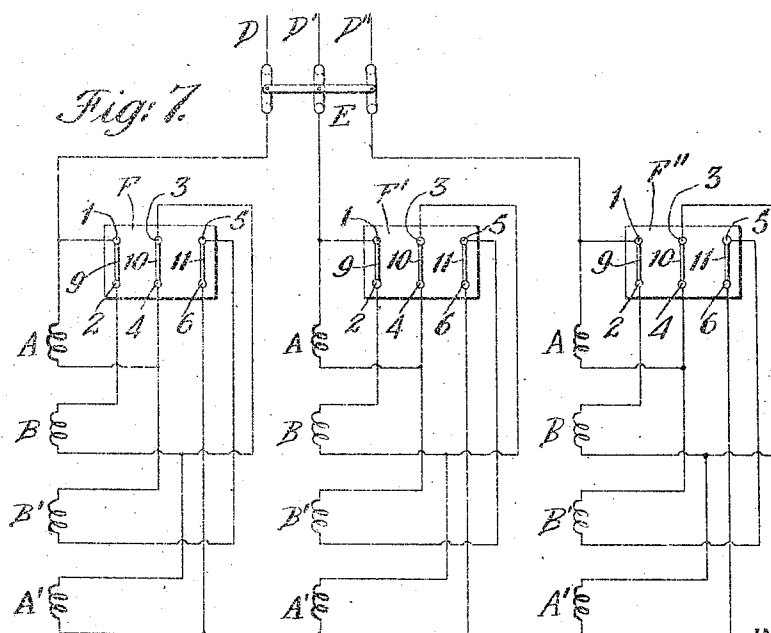
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UNITED STATES PATENT OFFICE.

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TRANSFORMER.

Application filed February 11, 1922, Serial No. 535,954. Renewed August 4, 1925.

To all whom it may concern:

Be it known that I, SAMUEL HORELICK, a citizen of the United States, residing at Pittsburgh, in the county of Allegheny and State of Pennsylvania, have invented certain new and useful Improvements in Transformers, of which the following is a specification.

My invention relates to electric transformers, particularly adapted for use with different applied voltages.

It is a common occurrence in practice to provide a transformer which will be readily adapted for use not only on the circuit for which it may be intended at the time, but also for possible use on a circuit of different voltage, or for use on the same circuit with an increased or lowered voltage. For example, a plant may have in use one circuit in which transformation from 22,000 volts to a lower voltage is being carried out and then have in use another circuit in which transformation from 33,000 volts to a lower voltage is being carried out, or it may be intended to increase the applied voltage in a 22,000 volt system to a 33,000 volt system. In either case in purchasing a transformer, it is desirable to have one which can readily be used on either the higher or lower voltage, while deriving the same voltage from the secondary winding of the transformer in each case. In this instance it has been common to provide a primary winding with a sufficient number of turns adapted to receive 33,000 volts for securing the desired secondary voltage; and to provide a $\frac{2}{3}$ tap on the primary winding so that when used on the 22,000 volt circuit, connection will be made to one terminal of the winding and to the $\frac{2}{3}$ tap, thus giving the same secondary voltage as before. In such a case, however, the ampere capacity of $\frac{2}{3}$ of the primary winding must be 50% greater than the remaining third of the winding to provide for use on the 22,000 volt circuit. But when the transformer is used on the 33,000 volt circuit, this excess ampere capacity in two-thirds of the winding is unnecessary and not economically used; and when the transformer is used on the 22,000 volt cir-

cuit, one-third of the winding is out of circuit and is not used at all.

It is thus evident that the provision of a transformer of this character requires a larger space and more expense in the windings, as well as increase in the size of the core, than would be the case if the transformer were adapted for use on only one of the two above mentioned voltages; yet the convenience and the saving in expense over the purchase of two transformers has been sufficiently great to warrant the practice above described.

The main object of my invention is to provide a transformer which will answer the above requirements of being adapted for use with a plurality of primary voltages and which will have a high efficiency in operation when used with either of the voltages for which it is intended. Another object is to reduce the size of the transformer compared with the size previously required. Another object is to provide a transformer which will be more economical in cost of construction compared with transformers of this type previously used. Another object is to provide means for conveniently connecting the windings so that the transformer will be adapted for use with the particular voltage desired at any time, and to also provide convenient means for changing the connections so as to be adapted for use with another voltage. Other objects and advantages of my invention will be understood from the following description and accompanying drawings which disclose a preferred embodiment of my invention.

Figs. 1, 2 and 3 are diagrams of single phase transformer windings adapted for use with different voltages; Figs. 4 and 5 are diagrams of transformer windings for a three phase circuit showing the connections for use with different voltages; and Figs. 6 and 7 are diagrams of transformer windings for a three phase circuit showing the provision of means for making the connections as required for the particular voltage on the circuit on which the transformer is to be used.

In the application of my invention here

particularly described, it is assumed that the lower voltage for which the transformer is to be adapted is two-thirds of the higher voltage, as in the case of the 22,000 and 33,000 volt circuit; but my invention is likewise applicable to other ratios of voltages, as will be understood by those skilled in the art. My invention is here described as applied to the primary windings of a transformer, but may likewise be applied to the secondary windings and may likewise be applied to special cases such as to auto-transformers.

In the particular case here considered, most advantageous results are obtained by subdividing the primary winding into four main divisions or sections. Two of these sections will be similar to each other and adapted in this instance to each receive one-third of the applied voltage, or 11,000 volts in this particular case as assumed.

In Fig. 1 of the drawings these two sections are indicated as sections A, A'. The remaining portion of the primary winding will constitute two other main divisions or sections B, B'. Each of these sections will be adapted to receive 11,000 volts, but the ampere capacity of each may be made one-half of that of the sections A, A'. The secondary winding is indicated generally at C.

When it is desired to use the transformer on the high voltage circuit, the four sections of the primary winding will be connected as shown in Fig. 2, the sections A, A', of larger ampere capacity being connected in series with each other and in series with the sections B B' of the smaller ampere capacity, but with the latter windings connected in parallel with each other. With this connection of the parts or sections, and with say a primary voltage of 33,000 volts applied to the windings, it will be seen that each section of the primary is utilized to its full volt and ampere capacity. Thus there will be 11,000 volts on each section A, A', each of which sections is adapted to carry the full amperage required; and each section B B' will be subjected to 11,000 volts and each section adapted to carry only one-half of the total amperage by reason of these sections being connected in parallel with each other.

When it is desired to use the transformer on the lower primary voltage of 22,000 volts, the primary sections will be connected as shown in Fig. 3. In this case, each section A A' of larger current capacity is connected in series with each other across the primary circuit and each section B B' of the smaller current capacity is connected in series with each other across the primary circuit and a cross connection may, if desired, be made at the connections between the sections. The windings may be considered as having one

of the larger current capacity sections, such as A, connected in parallel with a lower current capacity section B and these windings both connected in series with the other two sections which latter are connected in parallel with each other. In this case such section is subjected to 11,000 volts, but the increased current capacity which is necessary with the lower primary voltage is taken care of by the windings supplementing each other by reason of their parallel connection. The total ampere capacity of the windings should now be approximately 50% greater than when the higher primary voltage was used and it will be evident that this increased current capacity is provided for because the sections A, A' will carry the same current as before, but as the sections B B' have one-half the current capacity of the sections A, A', the total current capacity of the windings will evidently be 50% more than in the case when the connection for the higher voltage was used. The impedance, reactance and resistance of the sections should of course be so related to each other as to cause the total current to be divided in the desired proportion between the sections when connected in parallel.

It will also be apparent that when the lower voltage is used, all sections of the windings are utilized at full voltage and ampere capacity, which condition was also present when the sections were connected for use with the higher voltage.

With the above sub-division of the primary windings in sections of the voltage and current capacity referred to, it is clear that under each condition there is no section or part of the winding which is not used and it is also true that under each condition there is no excess capacity of the windings which is not used economically and to advantage; and by reason of the above relationship and construction of the windings, it is obvious that the total size of the coils or winding and the space occupied by them is much less than in prior practice where a necessary excess current capacity of two-thirds of the winding was required and a third portion which on the lower voltage was not used at all. The smaller total size of the windings obtained by use of my invention also permits a correspondingly reduced size of the transformer core. The use of the smaller core correspondingly reduces the core losses both at no load and full load and thus results in a higher transformer efficiency; and increased efficiency may also be obtained due to reduction of copper losses, while at the same time permitting the use of a smaller transformer as regards winding and core than heretofore required. My invention thus attains the double advantage of securing higher efficiency and a reduction in the size and cost of manufacture compared with

transformers previously used of the same volt amperes capacity and adapted to be used on circuits of different voltages.

Although I have referred in the above example to definite proportions as regards relative voltages and relative current capacities, it will be understood that these references are to be taken as having a general approximation and that in practice variations may be made therefrom to suit the particular case and such departure as is necessary in practice from theoretical requirements. It will also be understood that my invention is advantageously adapted to various types of transformers and different forms of construction and also to polyphase transformers as well as single phase and to single phase transformers connected in polyphase circuits. It will also be understood that the sections or divisions of the windings required by my invention may be arranged with reference to each other in various relationship and need not be necessarily relatively located as indicated in the drawings.

Figs. 4 and 5 show my invention as applied to a polyphase circuit in which the primaries are star-connected. Fig. 4 illustrates the connections between the coils required for use on the circuit of higher voltage, and Fig. 5 shows the connections of the coils as required for use on the circuit of lower voltage, which in this particular case is assumed to be two-thirds of the higher voltage.

Figs. 6 and 7 indicate one method of providing leads and connecting means for the coil sections in a three phase transformer. In this case, the coil sections are assumed to be arranged axially displaced on the core legs and have leads extending from the sections to terminal boards or blocks located in the upper part of the enclosing tank. The secondary windings are not shown as they would be located relatively to the primary windings and have leads extending upwardly through the cover of the enclosing tank in the customary manner. The primary three phase supply circuit is indicated at D, D', D'', and a service switch is located at E, from which the three primary wires extend through the cover of the tank and connected as indicated. Three terminal blocks or supports are shown at F, F', F'', on which are located terminals 1, 2, 3, 4, 5, 6. Leads from the coil connections are connected to these terminals and to each other as shown. When the transformer is to be used with a circuit of the higher primary voltage, connecting links 7, 8 will be utilized, the link 7 connecting terminals 2-4 and the link 8 connecting terminals 3-5. It will be apparent by tracing the connections in Fig. 6 that the sections of lower current capacity will be connected in parallel with each other and in

series with each of the coil sections of larger current capacity, giving the connections shown in Fig. 4.

When it is desired to use the same transformer upon a circuit of two-thirds the primary voltage, it is merely necessary to change the link connections on the terminal blocks so as to have the condition shown in Fig. 7. In this case link 9 connects terminals 1 and 2, link 10 connects terminals 3 and 4 and link 11 connects terminals 5 and 6. With these connections the coils of larger capacity are connected in series with each other and in parallel with the coil sections of smaller current capacity giving the condition shown in Fig. 5. Instead of using connecting links, it may sometimes be desirable to provide change over switches or any other suitable means for changing the connections, but inasmuch as the changes are likely to be made very infrequently, the link connections or other form of suitable lead connections may be preferable, especially as they are less likely to be disturbed by an unauthorized person than when change over switches are provided.

Although I have described particular embodiments of my invention and a particular relationship of primary voltages, it will be understood that my invention is advantageously usable with other voltage ratios, and with various subdivisions and relationships of coil windings and in many different forms of construction; and when used on polyphase circuits, the winding may be connected in delta, star or otherwise as desired.

I claim:—

1. A transformer for different voltages comprising windings subdivided into sections, said sections being adapted to be connected in different parallel and series relationship to each other and certain of said sections having different current capacity from other of said sections and adapted to receive the same voltage as each other.
2. A transformer for different voltages comprising windings subdivided into sections, said sections being adapted to be connected in different parallel and series relationship to each other and certain of said sections having a different resistance from other of said sections and having the same number of turns.
3. A transformer for different primary voltages in the ratio of two to three comprising a primary winding divided into four sections each having the same number of turns and two of said sections having a larger current capacity than the other two sections, and means whereby the two sections of larger current capacity may be connected in series with each other and in series with the other two sections in parallel and may also be connected with two of the sections in series with each other and in parallel with each other.

allel with the other two sections connected in series with each other.

4. A transformer for different voltages in the ratio of two to three comprising a winding divided in four sections each having the same number of turns and two of said sections having a larger current capacity than the other two sections, and means whereby the two sections of larger current capacity may be connected in series with each other 10 and in series with the other two sections in parallel and may also be connected with two of the sections in series with each other and in parallel with the other two sections connected in series with each other.

SAMUEL HORELICK.