

S. HORELICK.
POLYPHASE TRANSFORMER.
APPLICATION FILED MAY 28, 1921.

1,425,091.

Patented Aug. 8, 1922.

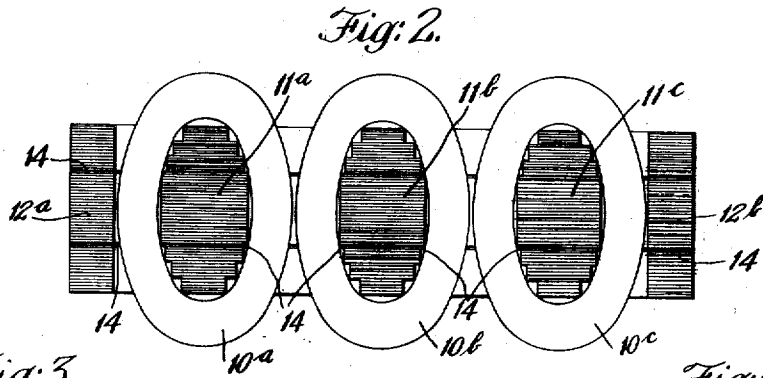
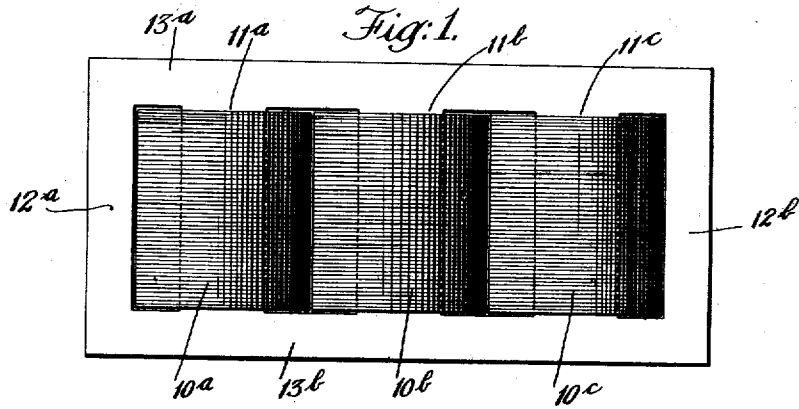


Fig. 3.

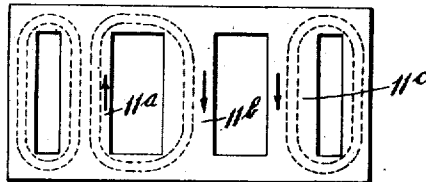


Fig. 5.

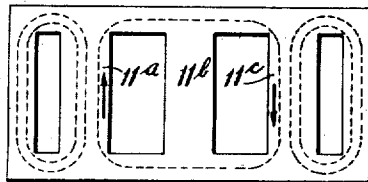
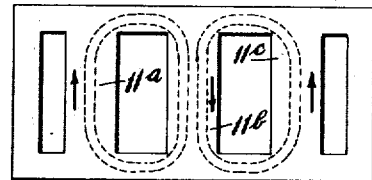


Fig. 4.

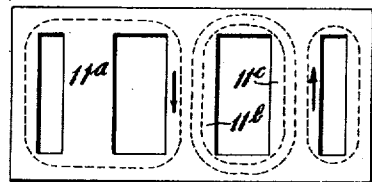


Fig. 6.

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POLYPHASE TRANSFORMER.

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Specification of Letters Patent.

Patented Aug. 8, 1922.

Application filed May 28, 1921. Serial No. 473,335.

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 Polyphase Transformers; of which the following is a specification.

This invention relates to polyphase transformers and particularly to the form of the core and its relationship to the polyphase windings.

The polyphase transformer is generally preferable to the use of a plurality of single phase transformers by reason of the economy in cost of material and the cost of manufacture. In some forms of polyphase transformers, particularly those of the simplest types, the parts are not symmetrical throughout in their relationship; and in operation the unsymmetrical distribution of magnetic flux causes an unbalanced or irregular action which not only lessens the efficiency, but also unbalances and distorts the resulting electromotive forces and currents induced in the secondary windings and results in wide variations in operating exciting current, with attendant greater variations in instantaneous exciting current and in the various magnetic circuits and phases.

One object of my invention is to produce a polyphase transformer of a simple construction and capable of being economically manufactured and in which the parts are so related as to give quite a symmetrical relationship and operation throughout the cycle of operation. I accomplish this by providing a construction which will give quite a symmetrical relationship of the paths for the magnetic flux so that in operation any irregular condition or relationship of the interactions is substantially avoided. Also by my improved construction all of the windings are capable of being symmetrically, similarly and uniformly supported and also similarly and equally ventilated in all parts. The construction as a whole is also economical in the amount of material required in the polyphase core and coils.

Another object of my invention is to produce a polyphase transformer which will have high efficiency and low and symmetrically distributed exciting current, both nor-

mal operating and instantaneous, on all magnetic circuits or phases, and this results from the relationship of the parts and their form of construction.

My invention will be understood by reference to the accompanying drawings illustrating one embodiment thereof, the particular embodiment illustrating a three-phase transformer.

Fig. 1 is a front elevation of the polyphase transformer illustrating the polyphase core and coils; Fig. 2 is a plan view thereof with the core shown in a central section; Fig. 3 is a diagram showing the outlines of the core and indicating generally the paths of the magnetic flux at a particular instant, and Figs. 4, 5 and 6 are similar diagrams indicating the general paths of the magnetic flux at different instants.

Figs. 1 and 2 show three windings 10^a , 10^b and 10^c each comprising the primary and secondary coils of one of the three phases, their connections being such as may be desired in any particular instance. The windings have laminated central cores 11^a , 11^b and 11^c respectively. At each end of the transformer is a leg 12^a and 12^b at the outside of the end windings and in the plane of the laminæ of the portions 11^a , 11^b and 11^c within the windings. The portions above referred to are joined to and complete their magnetic circuit through an upper portion 13^a and a lower portion 13^b which are made up of laminæ and extend lengthwise in the plane of the laminæ of the other portions, as shown in Fig. 1. It will of course be understood that the core may be built up of laminæ of such length and shape as to suit the particular preference of the designer as regards economy in cutting the sheet material and in the assembly of the parts to form the complete core as above described. Ventilating spaces 14 may be provided in the core.

The primary and secondary coils are of general elliptical or oval form, as shown in Fig. 2; and the central core of each of the coils and likewise the end legs and the upper and lower connecting portions are deep in the direction perpendicular to the plane of the laminæ compared with the width of the core between the interior side surfaces of a coil; and the central core of each of the coils has a general outline conforming to the

interior surface of the coils by tapering the ends. The core within each of the coils is therefore in close proximity to the coils throughout and preferably has a general elliptical form conforming in outline generally thereto, with notches as shown forming ventilating spaces. Also there is only a small part of the coils not enclosed by the iron, resulting in giving quite a complete low reluctance path for the flux around nearly all portions of the coils.

The continuous and gradually curved shape of the coils and the avoidance of abrupt bends, gives a very uniform distribution of the magnetic flux created by the coils and permits the effective and efficient use thereof. The portions of the core within the coils, being similarly shaped and in close proximity to the interior surface of the coils, results in their carrying the flux effectively and efficiently, because they preserve the uniform flux distribution as set up by the coils and fully utilize the space within the coils. The construction results in a harmonious interaction between the coils and the core, and irregular interactions which tend to reduce efficiency are overcome.

Figs. 3 to 6 indicate in a general way the paths of the magnetic lines of force at certain instants. In Fig. 3 the flux in portion 11^a is assumed to have the maximum value, at which time the flux in portions 11^b and 11^c will theoretically have one-half the value and pass downwardly through these portions and upwardly through portion 11^a. The flux will take the paths as indicated approximately in Fig. 3 in direction and amount. In Fig. 4 the flux through the portion 11^b is assumed to be zero and the flux through the portion 11^a will have the same direction as before, but less in amount. The flux through portion 11^c will have the same direction as before, but in greater amount. The paths of the flux and their amounts are indicated in a general way in Fig. 4.

In Fig. 5 the flux through the portion 11^b is assumed to have maximum value, at which time the flux through portions 11^a and 11^c will have half the maximum value and be in the opposite direction giving the paths of the flux and their amounts as indicated in Fig. 5. In Fig. 6 the flux through portion 11^a is assumed to be zero, at which time the flux through portion 11^b will be less than the maximum and the flux through portion 11^c will have the same value, but in the opposite direction, the general condition being indicated in Fig. 6.

Of course additional instants of operation could be considered but the above are sufficient to show the advantage of my invention in this respect. That is, it will be seen that the length of the paths taken by the magnetic flux is at all instants generally the same and in cases where the length of the

path is sometimes longer, the amount of flux passing through the longer path is of comparatively small amount. Consequently the reluctance opposing the small amount of flux taking the longer path causes no appreciable unbalancing. Thus with my invention a greatly improved condition is obtained due to the close approach to symmetrically related conditions at all times. Consequently the flux harmonizes quite well with the induced magneto electromotive forces and distortion of the wave forms is reduced to a minimum.

It will be noted that the magnetic flux of each phase has two paths in parallel at every instant of the cycle, thus reducing core loss and normal and instantaneous exciting current, and also at the same time attaining these advantages with a minimum amount of core material.

Also by use of my invention it will be seen that the upper and lower portions of the core and the end portions of the core carry only about one-half of the magnetic flux of the portions of the core within the coils which permits the size of the outside portions to be made considerably narrower than would be necessary in case they were required to carry the same amount of flux as the portions within the coils. The cross section of each end portion is such as to permit free and uninterrupted flow of approximately one-half of the magnetism from the core of an adjacent coil. In practice, this is attained with best economy by making the cross sectional area of each end portion approximately one-half of the cross sectional area of the portion of the core within a coil, as shown in Fig. 2 of the drawings. It is also evident that all of the coils are similarly situated with relation to the core which permits them all to be similarly supported and similarly and equally ventilated, thus giving a uniform and symmetrical construction throughout.

Since the portions of the core outside the coils are required to carry only one-half of the magnetic flux within the coils and since the core is deep in a direction perpendicular to the plane of the laminæ, the portions of the core outside the coils may be made comparatively narrow. These narrow portions also improve the efficiency and operating characteristics of the transformer in that the path of the flux is shortened closely around the coils and in passing through the narrow portions occupies quite completely and uniformly the whole of the cross sections of the portions through which the flux is passing at any instant.

The advantages resulting from my invention in improved operating characteristics and efficiency also permit the portions of the core within the coils to be made smaller than in prior constructions, which permits the size

of the coils to be made correspondingly smaller with resulting economy in cost of copper, while still obtaining greatly improved results in efficiency and operation.

5 Although I have described my invention with reference to a three-phase transformer, it is evident that it may be applied to polyphase transformers of a different number of phases and the connections of the coils may
10 of course be such as to suit the particular requirements without departing from the scope of my invention.

I claim:—

1. A polyphase transformer comprising,
15 coils side by side in the same plane, and a laminated transformer core having all of its laminæ in planes parallel to each other and having a lengthwise portion extending
20 along each end of the coils respectively, and having intermediate portions connecting said lengthwise portions and extending through the coils, and also having end portions located at the outside of the end coils respectively and connecting the said lengthwise portions, the magnetism created in the
25 said intermediate portions of the core all passing in said parallel laminæ, and the cross section of each of said end portions being approximately half that of one of said intermediate portions, the said intermediate
30 and end portions having greater depth of said parallel laminæ in a direction perpendicular to the plane of the coils than width, and the interior dimension of said
35 coils in a direction perpendicular to the plane of the coils being greater than the dimension in a direction parallel to their plane.

2. A polyphase transformer comprising
40 coils side by side in the same plane, the interior surfaces of said coils having gradually and continuously curved end portions, and a laminated transformer core having a lengthwise portion extending along
45 each end of the coils respectively, intermediate portions connecting said lengthwise portions and extending through the coils, and end portions located at the outside of the end coils respectively and connecting the said lengthwise portions, the
50 said core comprising laminæ all of which are parallel to the plane of the coils, the said intermediate portions having greater depth of said parallel laminæ in a direction perpendicular to the plane of the coils than width, the interior dimension of said
55 coils in a direction perpendicular to the plane of the coils being greater than the dimension in a direction parallel to their plane, the width of said lengthwise portions and of said end portions of the core being narrow compared with the width of said intermediate portions and the cross section of each of said end portions being approximately half that of one of said inter-

mediate portions, and the magnetism created in said intermediate portions of the core all passing in said parallel laminæ.

3. A polyphase transformer comprising
70 coils side by side in the same plane, the interior surfaces of said coils having a gradual and continuous curvature throughout, and a laminated transformer core having all of its laminæ in planes parallel to each other and having a lengthwise portion
75 extending along each end of the coils respectively, and having intermediate portions connecting said lengthwise portions and extending through the coils, and also having end portions located at the outside
80 of the end coils respectively and connecting the said lengthwise portions, the cross section of each of said end portions being approximately half that of one of said intermediate portions, and the magnetism
85 created in the said intermediate portions of the core all passing in said parallel laminæ.

4. A polyphase transformer comprising
90 coils side by side in the same plane, and a laminated transformer core having a lengthwise portion extending along each end of the coils respectively, and having intermediate portions connecting said lengthwise portions and extending through
95 the coils and also having end portions located at the outside of the end coils respectively and connecting the said lengthwise portions, the said intermediate portions of the core comprising laminæ parallel to the
100 plane of the coils and having greater depth of said parallel laminæ in a direction perpendicular to the plane of the coils than width, and the interior dimension of said
105 coils in a direction perpendicular to the plane of said coils being greater than the dimension in a direction parallel to their plane, said coils being of general elliptical form.

5. A polyphase transformer comprising
110 coils side by side in the same plane, and a laminated transformer core having a lengthwise portion extending along each end of the coils respectively, and having intermediate portions connecting said
115 lengthwise portions and extending through the coils and also having end portions located at the outside of the end coils respectively and connecting the said lengthwise portions, the said intermediate portions of
120 the core comprising laminæ parallel to the plane of the coils and having greater depth of said parallel laminæ in a direction perpendicular to the plane of the coils than width, the interior dimension of said coils
125 in a direction perpendicular to the plane of the coils being greater than the dimension in a direction parallel to their plane, and the interior surface of the coils having gradually and continuously curved end por-
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tions, and the central portion of each core conforming in general outline to the inner surface of each of the coils respectively.

6. A polyphase transformer comprising 5 coils side by side in the same plane, and a laminated transformer core having a lengthwise portion extending along each end of the coils respectively, and having intermediate portions connecting said 10 lengthwise portion extending along each the coils and also having end portions located at the outside of the end coils respectively and connecting the said lengthwise portions; the said intermediate and end portions of the core comprising laminae parallel 15 to the plane of the coils and having greater depth of said parallel laminae in a direction perpendicular to the plane of the coils than width the interior dimension of 20 said coils in a direction perpendicular to the plane of the coils being greater than the dimension in a direction parallel to their plane, and the interior surface of the coils having gradually and continuously curved 25 end portions; and the said intermediate portions conforming in general outline to the inner surface of each of the coils respectively.

7. A polyphase transformer comprising

coils side by side and having their axes 30 parallel to each other in the same plane, and a core having a portion within each of the coils respectively, an end portion outside each of the end coils, and a portion joining the ends of each of said portions respec- 35 tively, each of said coils having an interior surface of general elliptical form, and the general contour of the portions of the core passing through the coils conforming to the interior surface of each of the coils respec- 40 tively.

8. A polyphase transformer comprising coils side by side and having their axes substantially parallel to each other in the same plane, and a laminated core having 45 all its laminae in planes parallel to each other and having a portion within each of the coils respectively, an end portion outside each of the end coils, and a portion joining the ends of each of said portions 50 respectively, each of said coils having an interior surface of general elliptical form, and the general contour of the portions of the core passing through the coils conforming to the interior surface of each of the 55 coils respectively.

SAMUEL HORELICK.