Dec. 13, 1932. G. L. PORTER 1,891,178

ELECTRIC TRANSFORMER

Filed Dec. 1, 1930

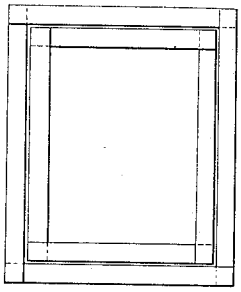


Fig. 1

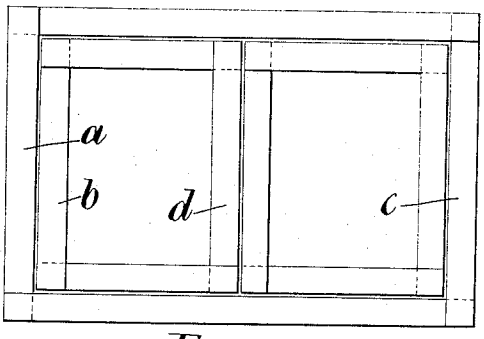


Fig. 2

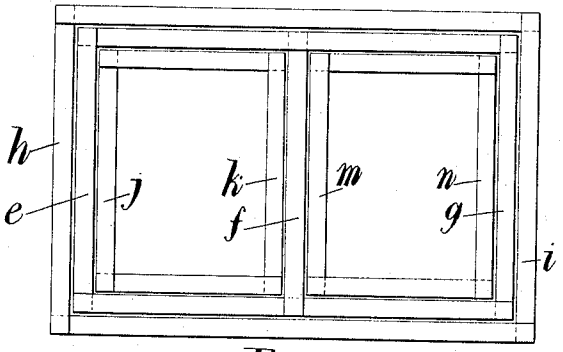


Fig. 3

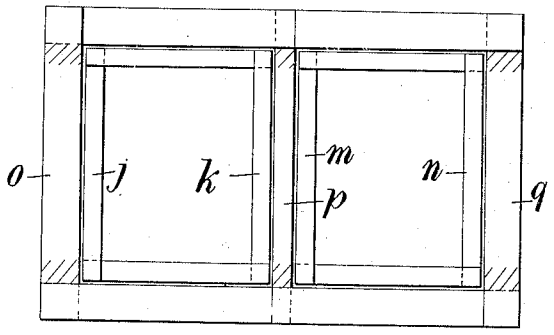


Fig. 4

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UNITED STATES PATENT OFFICE

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ELECTRIC TRANSFORMER

Application filed December 1, 1930, Serial No. 499,363, and in Great Britain January 30, 1930.

This invention relates to electric transformers and more specifically to the magnetic cores thereof.

In constructing electrical transformers difficulty is experienced in interleaving the laminations at the joints of the iron circuit when the area, and in particular the depth of the overlap exceeds certain dimensions.

Referring to the accompanying diagrammatic drawing:—

Figures 1 and 2 illustrate known arrangements of transformer cores.

Figure 3 illustrates one convenient embodiment of the present invention, and

Figure 4 illustrates a modification thereof.

It is well known that in single-phase transformers this difficulty can be reduced by dividing the iron circuit into two parts forming one rectangular core section (in side elevation) inside another as shown in Figure 1. It has been proposed to apply this method to three-phase transformers as shown in Figure 2 but this arrangement results in a considerable increase in the maximum flux density unless a greater total cross-section of iron is used. For example if the cycle of variation of the total flux in say limb *a*, *b* be considered, it is found that when the flux rises to approximately 87 per cent. of its maximum value the whole of it has to return by the limb component *c*; whereas when it falls again to 87 per cent. after passing through its maximum, the flux now has to return through the limb component *d*; therefore, if magnetic leakage through the air-gap between the three separate core sections of iron is negligible, the maximum flux density would be increased by 74 per cent. as a result of this form of subdivision since 87% of the total flux has to be carried by 50% of the iron.

The object of the present invention is to provide systems of subdivision of the magnetic cores of three-phase electric transformers whereby the maximum flux density and losses are reduced as compared with non-subdivided cores.

The invention consists in a three-phase electric transformer core subdivision system wherein the core is divided into a three-limbed core section and either two two-limbed core sections or three two-limbed core sections.

The invention also consists in a three-phase electric transformer core subdivision system as set forth above wherein the cross-sectional areas of the various core sections are equal.

The invention also consists in a three-phase electric transformer core subdivision system as set forth above wherein the cross-sectional area of the three-limbed core sections is 5½ times that of each of the other parts.

The invention also consists in a three-phase electric transformer core subdivision system as set forth above wherein the relative cross-sectional area of the three-limbed core sections and that of each of the other core sections lies between the limits of about 5½:1 and 1:1.

In carrying the invention into effect in one convenient form illustrated by way of example in Figure 3, I provide a core composed of a core section having three limbs *e f g*, a second core section having two limbs *h i*, a third core section having two limbs *j k*, and a fourth core section having two limbs *m n*, the cross-sectional area of all the limb components *h*, *e*, *j*, *k*, *f*, *m*, *n*, *g* and *i* being equal. The arrangement is such that regarded as a whole the composite core limbs are divided into three components *h e j*, *k f m* and *n g i*, respectively, each composite core limb having an equal cross-sectional area and the limb component *e* being linked magnetically with limb components *f* and *g*, the remaining limb components *h* and *j*, however, being linked magnetically with the limb components *i* and *k* respectively. The various limb components are connected together by yoke components as indicated in Figure 3 to complete the various core sections. The splitting of the core does not affect the maximum total flux in any composite limb but does prevent the flux from spreading itself uniformly over the total cross section of iron in that limb and in consequence the maximum flux density in individual components of the limb is increased. The windings, which are omitted from the drawing for the sake of clearness, comprise an equal number of turns on each of the three composite limbs, the windings

being connected respectively to the individual phases of a three-phase electricity supply. According to this arrangement the increase in maximum flux density is only about 30 per cent. (assuming negligible leakage across the air-gaps separating the sections from one another) since 87% of the maximum flux is carried by 67% of the iron. If, however, it is desired that there shall be no increase in maximum flux density by the method of subdivision described, then 87 per cent. of the iron in any one composite core limb must be continuous with 87 per cent. of the iron in each of the other composite core limbs (87 per cent. being the approximate maximum value of the flux in any one composite core limb when the whole of the flux returns by way of one of the other composite core limbs) which means that 74 per cent. of the cross-sectional area of iron in each composite core limb must be constituted by a limb component of the three-limbed section *e*, *f*, *g*, each of the two-limbed sections *h*, *i*; *j*, *k* and *m*, *n* carrying 13 per cent. Accordingly, limb and yoke components of the three-limbed section will require to have a cross-sectional area approximately 5½ times that of the limb and yoke components of each of the two limbed sections.

No advantage is to be gained by making this ratio greater than 5½:1, but it may be that the mechanical difficulties in interleaving, etc., may render it inadvisable to make the cross-sectional area of the three-limbed section as much as 5½ times that of the other sections, and it may therefore be preferable to reduce the ratio somewhat, although the maximum flux density will be increased by such reduction. In the extreme case of very large transformers the ratio might have to be reduced to unity as in the example given above. In that case 87 per cent. of the flux is being carried by 67 per cent. of the iron which results in an increase in flux density of about 30 per cent., as stated above.

In general, the ratio of the cross-sectional area of three-limbed section to two-limbed sections is preferably given a value lying between 5½:1 and 1:1, the larger the transformer the greater the mechanical difficulties and the more nearly the ratio will approach unity.

According to a modification illustrated in Figure 4 the two-limbed section *h*, *i* of Figure 3 is embodied in the three-limbed section *e*, *f*, *g* thereof without any division between these two thus forming the section *o*, *p*, *q*, this arrangement possessing certain advantages in the case of transformers omitting tie-bolts between the top and bottom clamping structures and in which the coil clamping stresses and weight are taken by the outer portions of the three limbs of the iron circuit.

The construction last described increases the area of overlap at certain of the joints but in many cases the difficulties are not serious since the shaded portions indicated in Figure 4 need not be clamped until after the interleaving has been effected.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:—

1. A three-phase electric transformer core subdivision system wherein the core is divided into a three-limbed section and a plurality of two-limbed sections.

2. A three-phase electric transformer core subdivision system wherein the core is divided into a three-limbed section and two two-limbed sections.

3. A three-phase electric transformer core subdivision system wherein the core is divided into a three-limbed section and three two-limbed sections.

4. A three-phase electric transformer core subdivision system as claimed in claim 1 wherein the cross-sectional areas of the various sections are equal.

5. A three-phase electric transformer core subdivision system as claimed in claim 1 wherein the cross-sectional area of the three-limbed section is 5½ times that of each of the other sections.

6. A three-phase electric transformer core subdivision system as claimed in claim 1 wherein the relative cross-sectional area of the three-limbed part and that of each of the other parts lies between the limits of about 5½:1 and 1:1.

7. A 3-phase electric transformer core subdivision system including a three-limbed section and a pair of two-limbed sections disposed within the three-limbed section and lying in the same plane as said section.

8. A 3-phase electric transformer core subdivision system including a three-limbed section and a pair of two-limbed sections disposed within the three-limbed section and lying in the same plane as said section and a two-limbed section disposed outside but in the same plane as the said three-limbed section.

In testimony whereof I have signed my name to this specification.

GRAHAM LEIGH PORTER.