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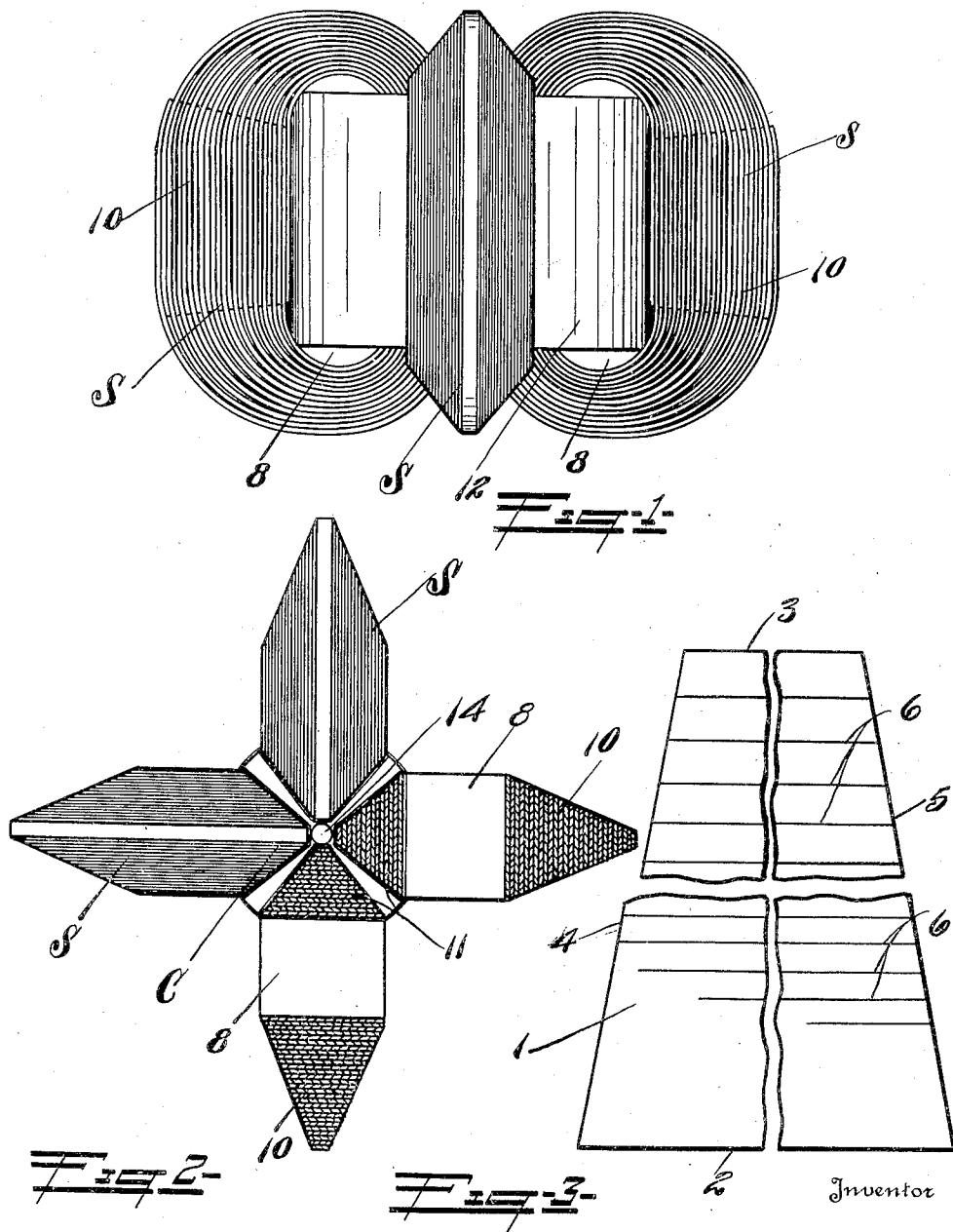
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TRANSFORMER AND METHOD OF MAKING SAME

Filed Jan. 29, 1929

2 Sheets-Sheet 1



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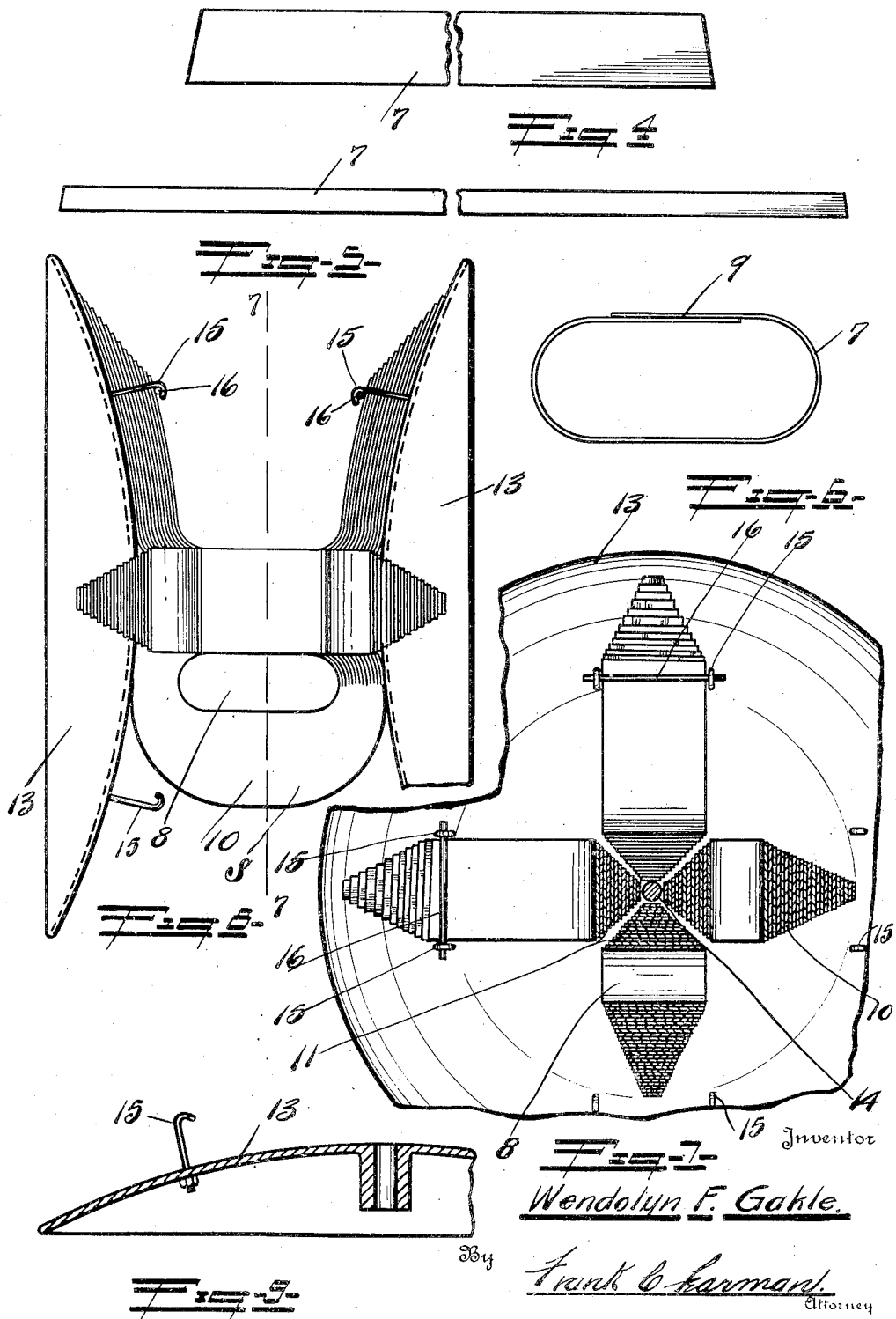
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UNITED STATES PATENT OFFICE

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TRANSFORMER AND METHOD OF
MAKING SAME

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This invention relates to an electric transformer and a method of making the same.

It is an object of the invention to improve the magnetic circuit of electric transformers and to facilitate the assembly of the laminations of which this magnetic circuit is composed.

Another object of the invention is to provide a magnetic circuit of reduced weight, as compared with the magnetic circuit of known transformers of similar capacity, and to assemble for this purpose the laminations of the core in loop form so that the major part of the core material is at the short perimeter of the loop.

Another object of the invention is to provide a method for assembling laminations which will facilitate the positioning of the transformer windings in proper relation to the core, and to provide greater facilities for the insulation of the windings from the core.

It is also an object of the invention to provide a novel method of assembling laminations for a transformer core in such manner that they can readily be deformed to facilitate the windings of the coils in loops of the core, and may be returned again to the position in which they constitute closed magnetic circuits.

It is, further, an object of the invention to simplify the contour and shape of the laminations of which the core and yoke is composed, and to eliminate the great amounts of waste and scrap which heretofore were unavoidable in the formation of these cores.

With these and numerous other objects in view, the invention is described in the following specification in which reference is made to the accompanying drawings.

In the drawings:

Fig. 1 is a side elevation of an assembled transformer produced in accordance with the present invention.

Fig. 2 is partly a top plan view and partly a horizontal section of the transformer core, the transformer coils being omitted.

Fig. 3 shows on a different scale a sheet of metal in plan view to illustrate the method of cutting the various laminations.

Fig. 4 is a plan view of one of the short laminations.

Fig. 5 is a plan view of one of the longer laminations.

Fig. 6 is an edge view showing one of the laminations bent to shape.

Fig. 7 is a fragmentary sectional view taken on the line 7—7 of Fig. 8.

Fig. 8 is a front view of a form to which the

core is secured to permit the application of the coil, two of the core loops being shown closed, the others being shown in opened position, with means for holding the laminations in open position.

Fig. 9 is a fragmentary transverse sectional view through one of the form discs.

In transformer practice as formerly followed by all manufacturers the magnetic circuit consists of rectangular or L-shaped pieces assembled in various forms, some with single circuits, others with multiple circuits, but all functioning in the same manner, which is to form a closed magnetic circuit around a coil which is placed on a part of said magnetic circuit, this part is called the core and the remaining part is called the shell or yoke.

Now in order to project the core section that is within the coil around the outside thereof, it is necessary to have part of this core close to the coil and other parts progressively more distant, the side which is close to the coil being termed the short perimeter, while the side farthest from the coil is termed the long perimeter of the magnetic circuit, and it is in these perimeters that the important feature of this invention resides. In my construction the short perimeter or adjacent surface of the coil is more thoroughly used than heretofore thereby causing more of the core section to be projected around the coil on its short perimeter, leaving progressively less material to be projected around the coil as the core progresses away from the coil and towards the long perimeter.

The net result is a reduction in weight of magnetic material for a given coil enclosure, this in turn results in lower core loss and also presents the designer with means whereby he can maintain former performance, and reduce the weights very materially of the magnetic circuit, the electric circuit, and the insulation. The cross-section of the assembled core also is utilized economically to a higher degree than heretofore, since the portion of the core having the smaller perimeter and being closer to the coil is broader than the portion of the core adjacent the outer perimeter.

For this purpose the core sections of the transformer are each composed of strips which are bent into loop shape, the loops formed of a plurality of strips nested one in the other, and being preferably of elongated shape to receive the coil therein. A plurality of these sections are then assembled with one part of the loop in the central part of the coil of which the transformer is built up, and the other part of the loop on the outer side of the coil. To reduce the cross-section

of the core portions adjacent the central part of the coil the cross-sections of the core parts gradually decrease in direction towards the axis of the coil, and they also decrease in direction towards the outer perimeter of these individual loop core sections.

This form of cross-section is produced by building up the core of individual laminations or strips, the width of which decreases in each core portion in proportion to the approach of the respective strip to the outer perimeter of each loop, so that for instance the outer perimeter of each loop is formed by the narrowest strip which must be the longest, while the inner perimeter of the loop is formed by the widest strip, which naturally also will be the shortest of all of the strips of which the core is being built up.

It has been found that the proper variation of the length and of the width of the different strips can best be produced by cutting them from a sheet of metal having two parallel sides and two sides which are converging. The form of this sheet, therefore, may be that of a trapezoid. The longer and narrower strips are cut from near the base of the trapezoid, the width of the strips increasing coincidentally with the decrease of their length when progressing from the base of the sheet in direction towards the opposite parallel side.

This method of cutting the strips has been indicated diagrammatically in Fig. 3, in which 1 indicates a trapezoidal shaped sheet of metal having the base 2 and the opposite parallel side 3, while the two non-parallel sides are indicated at 4 and 5 and are shown here as sides of a regular trapezoid forming angles with the base 2. This sheet 1 is then subdivided by cuts 6 extending parallel to the base, whereby strips 7 of unequal length are produced. The strips cut from adjacent the base 2 are considerably longer than those cut from that portion of the sheet which is adjacent the opposite parallel side 3. These strips 7, however, also are cut of non-uniform width, each strip having equal width throughout its length, but the longer strips being narrower than the shorter ones. All of the strips 7 produced in this manner are similar to each other but have different length at the base line and also different height.

The strips may then be piled on each other in such manner that the shortest and widest strip 7 is at the bottom of the pile, the other strips being superimposed so that the narrowest and longest strip constitutes the top of the pile. This entire stack of strips may then be held together in a suitable way by wires or the like, not illustrated in the drawings. This stack is then bent into the form of a loop, the bending force being exerted in a direction at right angles to the planes of the greater transverse dimension of the strips or laminae, so that the greater transverse dimensions of the laminae will be, in the completed core, substantially concentric with the coil instead of radial with respect to the coil as heretofore and the narrowest and longest strip will be located at the outer perimeter of the loop, while the shortest and broadest strip will constitute the inner perimeter, the intermediate strips by their assembly forming the body of the loop. The opening of the loop may be circular or of any other desired formation, corresponding preferably to the cross-sectional contour of the coil to be placed in the core window 8. The ends of the individual strips are placed in overlapping relation, as clearly shown at 9 in

Fig. 6, of the drawings. The proportion of the parts is selected in such manner that the extent of the overlap 9 is approximately the same with all of the strips or gradually converging either way.

It will, furthermore, be noted that owing to this overlap of the projecting ends and the inter-linkage of these ends with the strips, the leg 10 of the loop containing two overlapping portions 9 of each strip will have a thickness about twice as great as the other leg 11 in which this section is formed of the central portions of the strips only.

The sections having been assembled and bent as above described are held together by suitable elements, such as clamps or steel wire (not shown) to prevent their deformation, and in this condition the various sections are annealed. The bending of the individual strips is somewhat injurious to the electric characteristic of the iron, and this detrimental effect of the bending operation is eliminated by the annealing operation which takes place after the strips have been bent to shape.

Several of these core sections S each composed of a plurality of strips 7 bent into loop shape, may then be assembled to form a star or cross-shaped transformer core C, Fig. 2. The central part of the core will be constituted by the inner legs 11 of the sections S, which inner legs in cross-section are reduced towards the outer perimeter of each loop. This assembly is indicated in Fig. 2, where it is shown that the inner legs 11 are placed in close relation to each other, leaving between them and the outer legs of the same section, a window through which the transformer coil 12 may be placed.

In order to facilitate the winding of the coil 12 in the assembled core, the outer legs 10 of the section S are opened, this is accomplished by means of a suitable clamping device such as shown in Figs. 7 and 8 of the drawings, which comprises spaced apart disk members 13 convex shaped and so proportioned that the "opening" stresses do not exceed the elastic limit, these members are connected together by means of the centrally disposed bolt 14, which projects through the center of the core. After the assembled sections are placed in position in the clamping device, the ends of the laminations are bent outwardly against the face of the members 13 to form open loops in which the coil may be wound, the laminations being held in this position by means of clamps comprising spaced apart bolt members 15, the upper ends of which are hook shaped to accommodate a cross member 16, the lower end of the bolts being preferably threaded and are provided with conventional nuts for adjustment, a suitable crank (not shown) being provided for turning the device so that the winding of the coil is facilitated. After the coil 12 of the transformer has been positioned, the portions of the legs which were "opened" are returned again to their original position, and secured therein, and in that way the section is closed.

It will therefore be obvious that for a given core section and required window space for the coil that the weight of the iron copper and insulation is materially reduced, it further serves to eliminate scrap which is unavoidable with L-shaped laminations or laminations consisting of a pair of spaced legs, and it is obvious that also the production of the core from these trapezoid shaped strips eliminates the necessity of

using dies for cutting the laminations. The trapezoidal sheet may be subdivided automatically into strips of gradually decreasing length and proportionately increasing width by a simple automatic attachment which can readily be secured to an ordinary shears, and which affects the feeding of the material to the tool.

It is also obvious that owing to this construction of the core, the number of the pieces is reduced as compared with the present-day construction, and that in this manner it is feasible to obtain satisfactory results with less material or better results with the same amount of material that went heretofore into the construction of the cores.

The assembly of the strips also can be carried out in less time and with less labor than the assembly of laminations having irregular shapes. The reduction of the cross-section of the core in width towards the center of the transformer also induces a more uniform and better radiation of heat, because joints are eliminated and better edge presentation to cooling oil is provided. The assembled core is more accessible for repairs, and the opening of the loop where it should become necessary, would require less effort than the separation of sheets which are inserted between the free ends of the legs of laminations as has been done in standard practice.

The coils are wound into the loops after they have been opened to the desired extent, thereby removing the space factor and inducing a greater rigidity than was known heretofore. The provision of these loops also make it possible to place insulating material against the laminations on the inner perimeter, permitting the insulating material to project beyond the coils.

What I claim is:—

1. The method of making the magnetic core of a transformer, consisting of forming a plurality of loops each composed of laminæ, or strips bent to required form, assembling the loops so that their inner legs are proximate to one another, opening the outer legs of the loops, winding the coil on the inner legs of the loops through the open outer legs thereof and restoring the outer legs of the loops to their initial closed condition.

2. The method of making the magnetic core of a transformer, consisting of forming a plurality of loops each composed of laminæ, bent so that the minor portion of the metal is at the long perimeter thereof, assembling the loops so that their inner legs are proximate to one another, opening the outer legs of the loops, winding the coil on the inner legs of the loops through the open outer legs thereof, and restoring the outer legs of the loops to their initial closed condition and arranging the ends of each laminæ in overlapping relation.

3. The method of forming a loop, for the magnetic core of a transformer, consisting in ar-

ranging a plurality of strips in superimposed relation and bending said strips so that the intermediate portions of the strips form an inner core leg and the outer portions of the strips form an openable outer core leg, arranging the ends of each strip in overlapping relation, and annealing the bent strips.

4. The method of making the magnetic core of a transformer, consisting of forming a plurality of loops each composed of strips bent so that the minor portion of the metal is at the long perimeter of the loop, and so that the intermediate portions of the strips form an inner core leg, and the outer portions of the strips form an openable outer core leg, arranging the ends of each strip in overlapping relation, and then annealing the bent strips.

5. A transformer core comprising an assembly of loops composed of laminæ of progressively varying widths and lengths, said laminæ being bent in the direction at right angles to the planes of the greater transverse dimensions of the laminæ, and so that the minor portion of the metal is at the long perimeter of the loop.

6. A core as claimed in claim 5, in which the intermediate portions of the laminæ form a continuous inner leg and the end portions of the laminæ form an openable outer leg.

7. A core as claimed in claim 5, in which the intermediate portions of the laminæ form a continuous inner leg and the end portions of the laminæ form an openable outer leg, and the end portions of each laminæ being arranged in overlapping relation.

8. A transformer core comprising a plurality of loops each composed of laminæ of varying widths and lengths, producing in the complete core a cross section of substantially triangular shape with the major part of the metal at the short perimeter of the loop, and a coil inter-linked with the loop of the core.

9. A transformer core comprising a plurality of loops each composed of laminæ bent in the direction at right angles to the planes of the greater transverse dimensions of the laminæ, said laminæ progressively diminishing in width from the inner to the outer perimeter of the loop.

10. A transformer having the cross section of its core divided into sections, each of said sections being composed of laminæ or strips, the narrowest and longest strips being at the center of the combined cross section, said strips gradually widening as they approach the rim of the coil opening.

11. A transformer having the cross section of its core divided into sections, each of said sections being composed of laminæ or strips of varying widths and lengths, the narrowest and longest strips being at the center of the combined cross section, said strips gradually widening as they approach the rim of the coil opening.

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