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2,997,567

MAGNETIC LAMINATIONS FOR HIGH FREQUENCY INDUCTORS

Original Filed Oct. 3, 1957

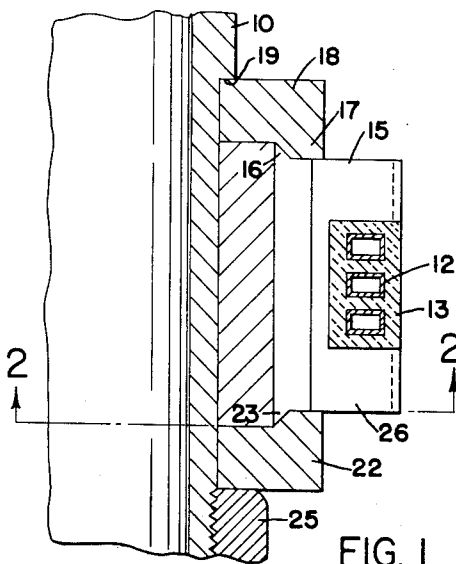


FIG. 1

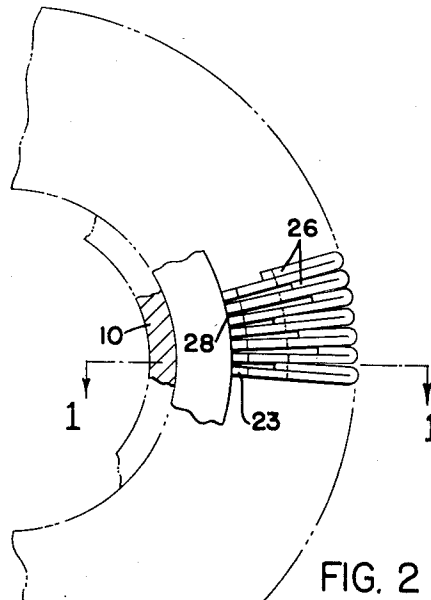


FIG. 2

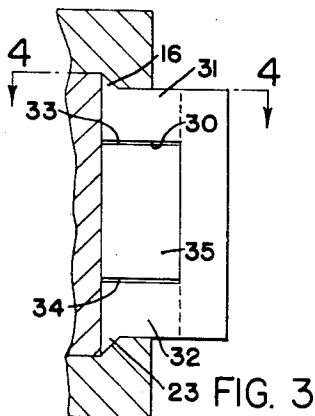


FIG. 3

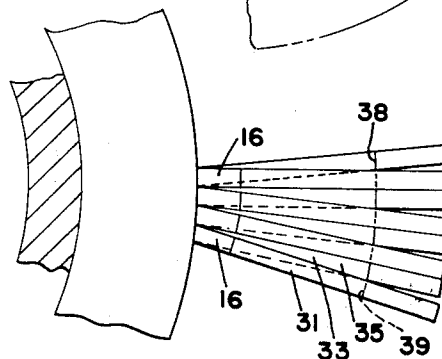


FIG. 4

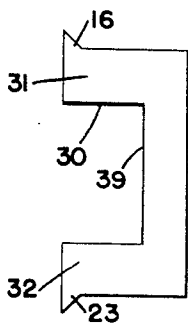


FIG. 5

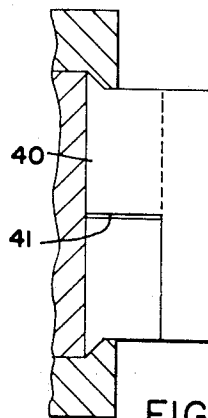


FIG. 7

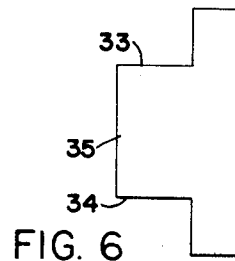


FIG. 6

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MAGNETIC LAMINATIONS FOR HIGH FREQUENCY INDUCTORS

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Original application Oct. 3, 1957, Ser. No. 688,026, now Patent No. 2,929,906, dated Mar. 22, 1960. Divided and this application May 15, 1959, Ser. No. 813,409 10 Claims. (Cl. 219—10.79)

This invention pertains to the art of induction heating, and more particularly to a construction and arrangement of magnetic laminations for use with alternating current induction heating coils.

In the art of induction heating, it is often necessary to position the magnetic laminations about a helical coil with the plane of the laminations disposed generally in the axial, radial plane. With such an arrangement, in order for the laminations to be packed in tightly in a circumferential direction so as to obtain a high stacking factor, i.e., the maximum amount of magnetic material in a circumferential direction, it has heretofore been necessary to resort to expensive expedients in order to compensate for the increasing circumference in a radially outward direction. Thus, it is known to grind the laminations to a wedge or pie shape. This is an expensive operation, and is difficult to perform on relatively thin sheets of magnetic material. Furthermore, the grinding operation oftentimes affects the orientation of the grains of metal to impair the magnetic characteristics of the material.

It is also known to provide some of the laminations having a full radial width and other laminations of a lesser radial width which are stuffed into and between the full width radial laminations. This is an expensive operation and requires the handling of a large number of different sizes of parts, and makes difficult the retaining of the narrow laminations in position.

The present invention contemplates a magnetic lamination construction which overcomes all of the above-referred to difficulties, and enables a high stacking factor to be obtained using lamination material of uniform thickness and of uniform radial width.

In accordance with the present invention, a plurality of magnetic laminations are provided adapted to be disposed to form a general cylinder with the planes of the laminations in the axial radial plane of the cylinder, the laminations having a uniform radial dimension and being formed from a sheet of uniform thickness and so constructed and arranged that when assembled the laminations will abut at least along the inner periphery of the cylinder, and at least at a point close to the outer periphery thereof.

In accordance with the present invention, portions at the inner edges of alternate laminations are cut away so that the corresponding remaining portions of neighboring laminations may nest therein in a circumferential direction so as to provide circumferential contact of adjacent laminations at the inner periphery and adjacent to the outer periphery thereof.

The principal object of the invention is the provision of a new and improved lamination arrangement having a high stacking factor and employing lamination material of a uniform radial width and employing lamination stock of a uniform circumferential thickness.

Another object of the invention is the provision of a new and improved magnetic lamination arrangement of the type described wherein all the laminations may have the same radial width.

Another object of the invention is the provision of a new and improved arrangement of magnetic laminations

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wherein a high stacking factor can be obtained without the use of laminations ground to a tapering thickness.

The invention may take physical form in certain parts and arrangements of parts, preferred embodiments of which will be described in detail in the specification, and illustrated in the accompanying drawing which is a part hereof and wherein:

FIGURE 1 is a fragmentary side cross-sectional view of a high frequency inductor which is related to the present invention and which is the subject of my co-pending application Serial No. 688,026, filed October 3, 1957, this figure illustrating the manner in which the present invention may be used and being taken approximately along the line 1—1 of FIGURE 2;

FIGURE 2 is a cross-sectional view of FIGURE 1 taken approximately in the line 2—2 thereof;

FIGURE 3 is a view somewhat similar to FIGURE 1 and showing one embodiment of the present invention;

FIGURE 4 is a cross-sectional view of FIGURE 3 taken approximately on the line 4—4 thereof;

FIGURES 5 and 6 are plan views of the individual laminations employed in the embodiments of FIGURE 3; and

FIGURE 7 is a view similar to FIGURE 3 but showing a further alternative embodiment of the invention.

Referring now to the drawing wherein the showings are for the purposes of illustrating preferred embodiments of the invention only and not for the purposes of limiting the invention, the figures show a high frequency inductor construction particularly intended for internal heating and comprised of a hollow shaft or tube 10 having mounted on the lower end thereof the inductor per se which with the exception of the lamination arrangement is relatively conventional in the art. Thus the inductor consists of a multi-turn helical coil 12 of hollow copper tubing embedded in suitable electrical insulating material 13. The outer surface of the coil is adapted to face a metallic workpiece and induce high frequency electrical currents to flow therein. Surrounding the upper, lower, and inner sides of the coil 12 are magnetic laminations constructed in accordance with the invention, and in particular, consisting of a plurality of individual laminations stacked into a circular stack with the plane extending parallel to the axis of the coil and generally parallel to the radius of the coil. Each of the laminations have on their inner corner axially extending lugs 16 which are overlapped by a shoulder 17 on a ring 18 mounted on the tube 10. Thus, the ring 18 fits against a shoulder 19 on the tube 10. In a like manner, a lower ring 22 is provided which is identical to the ring 18 which engages a lower projection 23 on the laminations. As shown in FIGURE 1, a nut 25 threaded on the lower tube 10 clamps the rings 18, 22 over the shoulders 16, 23 respectively, to hold the laminations in position.

There is thus a circular stack of laminations each disposed in the axial radial plane of the inductor. It will be appreciated that the circumference of the stack at its inner periphery is substantially less than that at the outer periphery. Thus, if the laminations 15 all had a uniform circumferential thickness, there would be substantial clearances between the outer edges of the laminations and thus a poor stacking factor. The present invention deals directly with this problem.

FIGURES 1 and 2 illustrate the complete assembly of a stack of laminations in an inductor construction and, as such, will be helpful to an understanding of the present invention. However, it is to be understood that the particular lamination arrangement shown in FIGURES 1 and 2 is the subject of my co-pending application already referred to. In FIGURES 1 and 2, each lamination has a portion 26 integral with the lamination which

doubles back on itself in close space relationship therewith. The effect of the portion 26 is to increase the circumferential width or thickness of each lamination adjacent its outer edge. The stacking factor at the outer edge is thus substantially improved. The individual length of the portions 26 may be as desired to give the improved stacking factor. Usually the individual laminations will be made so that the portions 26 will have a variety of different lengths so as to provide and improve the stacking factor over generally the entire radial width of the stack. The length of the portions 26 will vary depending upon the diameter of the inner and outer edges of the laminations stacked, but they should be made so that tight packing will occur on at least one circumferential point radially outwardly from the inner edge of the laminations. Thus, it will be apparent that the laminations will always have a tight stacking factor at the point 28. Furthermore, because of the portions 26, it will be possible to have a tight stacking factor at any desired point along the radial width of the laminations. By varying the length of the portions 26, it is possible to have a plurality of lines having a tight stacking factor circumferentially around the stack.

FIGURE 3 shows a first embodiment of the present invention. The laminations in this embodiment have generally the same radial width as that of the embodiment shown in FIGURES 1 and 2. However, the inner edge of one lamination is cut away, as at 30 in FIGURE 5, leaving radially extending portions 31, 32 in spaced relationship. These portions 31, 32 have the lugs 16, 23 formed thereon.

The adjacent lamination has a portion at both corners cut away as at 33, 34 to correspond with the portion 31, 32 and leaving a portion 35 to correspond with the cut-out portions 30 of the other lamination. Thus, the portion 35 nests into the cut-out portion 30. The effect is that the laminations can then have a tight stacking factor on the inner periphery and along the line 38 corresponding to the edge 39 of the cut-out portion 30. If desired, the radial depth of the cut-out portion 30 may be varied from each set of laminations to the other so as to improve the stacking factor over a multiplicity of points. Thus, generally alternate portions of at least one half of the inner edges are cut away.

FIGURE 7 shows a further embodiment of the invention wherein one corner 41 on the inner edge and of an axial length approximately equal to one-half the axial length of the lamination is cut away. Then by orienting the laminations one relative to the other, the remaining portion 40 of one can be made to nest into the cut away portion of the other. A result similar to the stacking of FIGURES 5 and 6 results.

Using the present invention, it will be appreciated that all of the laminations have a uniform radial width. This makes their handling and assembly much easier than if a plurality of different radial widths of laminations were employed. Also using the present invention, the need for grinding a taper onto thin lamination material is avoided.

Using the present invention, it has been found possible to obtain high stacking factors at a minimum expense. Such high stacking factors are desirable and necessary if high flux concentrations are to be employed with the induction heating coil 12.

Obviously, the invention is not limited to internal type inductors, but may be employed with external type inductors.

The invention has been described with reference to preferred embodiments. It will be appreciated that modifications and alterations will occur to others upon the reading and understanding of this specification, and it is my intention to include all such modifications and alterations insofar as they come within the scope of the present claims.

This application is a division of my co-pending application Serial No. 688,026, filed October 3, 1957, now Patent No. 2,929,906, issued March 22, 1960.

Having thus described my invention, I claim:

1. In combination with an induction heating coil, a cylindrical lamination stack composed of a plurality of separate magnetic laminations associated with said coil, each of said laminations being of uniform thickness and extending approximately in an axial radial plane of the coil, said laminations being arranged in pairs, the laminations of each pair interfitting at their inner radial ends and each lamination at its inner radial end terminating at a cylindrical inner circumference of the stack, the adjacent pairs of laminations engaging each other at said inner circumference of the stack to provide a high stacking factor thereat.

2. The combination of claim 1 wherein one lamination of each pair is formed with a gap extending outward from its inner radial edge and the other lamination of that pair has a portion at its inner radial end which nests in said gap.

3. The combination of claim 1 wherein the laminations have equal radial lengths.

4. The combination of claim 1 wherein the laminations of each pair engage one another at a location thereon closer to their outer radial ends than to their inner radial ends.

5. The combination of claim 4 wherein the neighboring laminations of adjacent pairs lie contiguous to one another substantially throughout their extent outward from their inner radial ends.

6. In combination with an induction heating coil, a cylindrical lamination stack composed of a plurality of separate magnetic laminations associated with said coil, each of said laminations being of uniform thickness and extending approximately in an axial radial plane of the coil, said laminations having equal radial lengths and being arranged in pairs, one lamination of each pair being formed with a gap extending outward from its inner radial edge and the other lamination of that pair having a portion at its inner radial end which nests in said gap, each lamination at its inner radial end terminating at a cylindrical inner circumference of the stack and the adjacent pairs of laminations engaging each other at said inner circumference of the stack, the laminations of each pair engaging one another at a location thereon closer to their outer radial ends than to their inner radial ends, and the neighboring laminations of adjacent pairs lying contiguous to one another substantially throughout their extent outward from their inner radial ends.

7. In combination with an induction heating coil, a cylindrical lamination stack composed of a plurality of separate flat magnetic laminations associated with said coil, each of said laminations being of uniform thickness and extending approximately in an axial radial plane of the coil, certain of said laminations having gaps therein which extend outward from their inner radial edges, and the remaining laminations at their inner radial ends having portions which nest in said gaps to provide a high stacking factor thereat.

8. The combination of claim 7 wherein neighboring laminations engage each other outward from their inner radial ends.

9. In combination with an induction heating coil, a cylindrical lamination stack composed of a plurality of separate magnetic laminations associated with said coil, each of said laminations being of uniform thickness and extending approximately in an axial radial plane of the coil, said laminations being arranged in pairs which interfit with one another at their inner radial ends and engage one another radially outward from their inner radial ends, one lamination of each pair being formed with a gap extending outward from its inner radial edge and the other lamination of that pair has a portion at its inner radial end which is received in said gap.

10. In combination with an induction heating coil, a cylindrical lamination stack composed of a plurality of separate magnetic laminations associated with said coil, each of said laminations being of uniform thickness and extending approximately in an axial radial plane of the coil, said laminations being arranged in pairs which interfit with one another at their inner radial ends and engage one another radially outward from their inner radial ends,

the laminations of each pair engaging one another at a location thereon closer to their outer radial ends than to their inner radial ends.

References Cited in the file of this patent

UNITED STATES PATENTS

1,644,729	Johannesen -----	Oct. 11, 1927
2,696,593	Dole -----	Dec. 7, 1954