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METHOD OF MAKING A MAGNETIC CORE

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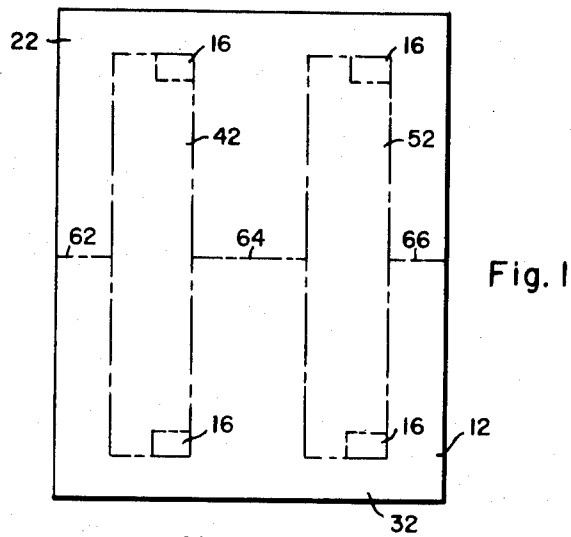


Fig. 1

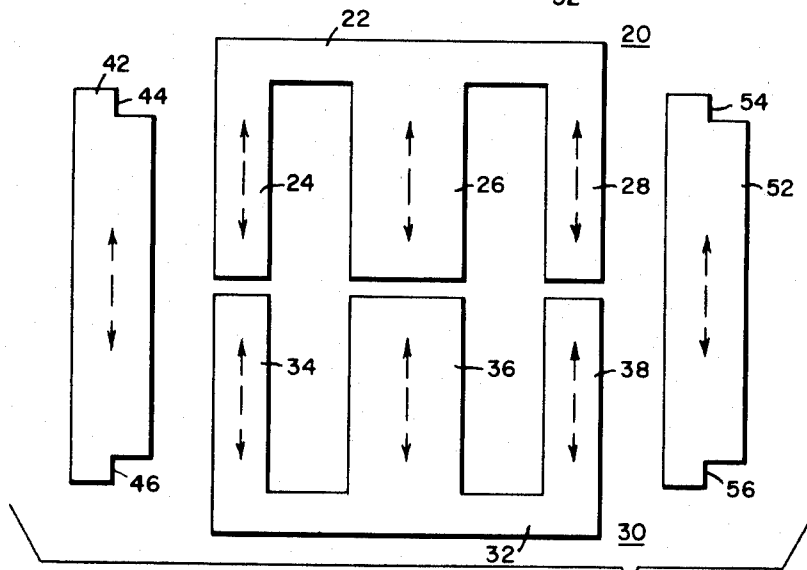


Fig. 2

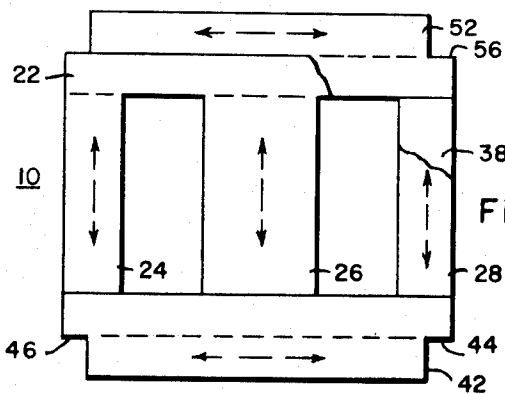


Fig. 3

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METHOD OF MAKING A MAGNETIC CORE
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237,438

4 Claims. (Cl. 29—155.61)

This invention relates to magnetic cores for use in electrical induction apparatus, such as transformers.

This application is a division of applicants' parent application filed August 27, 1958, Serial No. 757,516, now abandoned, and assigned to the assignee of the instant application.

In electric induction apparatus, such as transformers, a magnetic core is provided for certain applications including a plurality of layers of E-shaped and I-shaped laminations. When the laminations are formed from magnetic material having a preferred direction of orientation or grain, such as cold-rolled silicon steel, the reluctance of the magnetic core is increased since at least part of the magnetic flux must travel across or at substantially a right angle to the preferred direction of orientation in portions of the core. This is because of the back or yoke portions of the E-shaped laminations are normally formed at right angles to the preferred direction of orientation of the magnetic strip or sheet material rather than parallel to the preferred direction of orientation in which the permeability of the material is considerably higher. In a conventional magnetic core of the type described, the width of the back or yoke portion of the E-shaped lamination is substantially the same as the width of the I-shaped laminations. As mentioned, the reluctance of the magnetic core is increased by the fact that the flux must travel at substantially right angles to the preferred direction of orientation in the back or yoke portions of the E-shaped laminations. It is, therefore, desirable to provide a magnetic core built up from a plurality of E-shaped and generally I-shaped laminations having a lower reluctance for a particular quantity of magnetic material included in said core.

It is an object of this invention to provide a new and improved magnetic core for use in electrical apparatus.

Another object of this invention is to provide a new and improved magnetic core built up from a plurality of layers of laminations.

A more specific object of this invention is to provide a magnetic core built up from a plurality of layers of E-shaped and generally I-shaped laminations and having a lower reluctance for a particular quantity of magnetic material included in said core.

Other objects of this invention will in part be obvious, and will in part appear hereinafter.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawing, in which:

FIGURE 1 is a plan view of a portion of magnetic strip material illustrating how the laminations for a magnetic core of the type disclosed are produced;

FIG. 2 illustrates the various laminations obtained from the magnetic strip material shown in FIG. 1; and

FIG. 3 is a top plan view of a magnetic core illustrating how the various laminations are stacked or assembled.

Referring now to the drawing and to FIGURE 1 in particular, there is illustrated a portion of magnetic strip or sheet material 12 having a preferred direction of orientation or grain parallel to the longitudinal dimension of the strip material. As shown, a pair of E-shaped lami-

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tions and a pair of I-shaped laminations are punched or cut from the magnetic strip material 12 as a group in one or more successive stages or operations. The width of the magnetic strip material 12 may be conveniently made to be the same as the height of the E-shaped laminations.

In particular, the magnetic strip material 12 is punched and cut or sheared in one or more operations along the dotted lines shown in FIG. 1. For example, the scraps or waste pieces 16, each having a substantially rectangular shape, may be punched out in a first stage or operation. The generally I-shaped laminations 42 and 52 may be next punched out of the magnetic strip material 12 in a second operation. Finally, the E-shaped laminations may be cut or sheared along the dotted lines 62, 64 and 66 and along the outer edges of the back portions 22 and 32 of the E-shaped laminations. It is to be noted that the manner in which the laminations are produced from the magnetic strip material 12 is substantially scrapless except for the small scrap pieces 16, the purpose of which will be explained hereinafter.

Referring now to FIGURE 2, the E-shaped laminations 20 and 30 and the generally I-shaped laminations 42 and 52 obtained from the magnetic strip material 12 shown in FIG. 1 are illustrated. The E-shaped lamination 20 includes a back or bight portion 22 and three leg portions 24, 26 and 28. The leg portions 24, 26 and 28 of the E-shaped lamination 20 are substantially parallel to the preferred direction of orientation of the magnetic strip material 12 as indicated by the dotted arrows. The back or yoke portion 22 of the lamination 20 is formed at substantially right angles to the preferred direction of orientation of the magnetic strip material 12. Similarly, the E-shaped lamination 30 includes a back or yoke portion 32 and three leg portions 34, 36 and 38.

The generally I-shaped or rectangular-shaped lamination 42 includes the recessed surfaces 44 and 46 at the ends thereof, for reasons which will be discussed hereinafter. Similarly, the I-shaped lamination 52 includes the recessed surfaces or portions 54 and 56 at the ends thereof. The longitudinal dimensions of the I-shaped laminations 42 and 52 are substantially parallel to the preferred direction of orientation of the magnetic strip material 12 as indicated by the dotted arrows.

It is to be noted that in a magnetic core of the type disclosed, the width of the I-shaped laminations 42 and 52 as shown in FIG. 2 is made greater than the width of the back portions 22 and 32 of the E-shaped laminations 20 and 30 respectively as will be explained hereinafter. The ratio of the width of the I-shaped laminations 42 and 52 to the width of the back or yoke portions 22 and 32 of the E-shaped laminations 20 and 30 respectively is preferably greater than 1.2. It is to be understood that positioning or indexing holes (not shown) may be provided in the E-shaped laminations 20 and 30 and in the I-shaped laminations 42 and 52 to facilitate the production of the laminations or for other reasons.

Referring to FIG. 3, there is illustrated a magnetic core 10 built up from a plurality of layers of laminations, such as the E-shaped laminations 20 and 30 and the I-shaped laminations 42 and 52 shown in FIG. 2. As illustrated, each layer of laminations of the magnetic core 10 comprises an E-shaped lamination, such as the E-shaped lamination 20 including the leg portions 24, 26 and 28, and an I-shaped lamination, such as the I-shaped lamination 42, which is disposed to abut against the ends of the leg portions 24, 26 and 28 of the associated E-shaped lamination 20. In the adjacent layer of laminations there is provided similarly, the E-shaped lamination 30 having the leg portions 34, 36 and 38 and an I-shaped lamination 52 which abuts against the ends of the leg portions 34, 36 and 38 of the associated E-shaped lamination 30. The

back or yoke portions of the E-shaped laminations 20 and 30 are positioned or disposed at opposite ends of the magnetic core 10 in alternate or adjacent layers. It is to be noted that the side of the I-shaped lamination 42 which abuts the ends of the leg portions 24, 26 and 28 of the associated E-shaped lamination 20 is the side of the I-shaped lamination 42 away from the recessed surfaces 44 and 46 of the I-shaped lamination 42. Similarly, the side of the I-shaped lamination 52 which abuts the ends of the leg portions 34, 36 and 38 of the associated E-shaped lamination 30 is the side opposite from the recessed surfaces or portions 54 and 56 of the I-shaped lamination 52.

The I-shaped laminations 42 and 52 are provided with the recessed surfaces 44 and 46 and 54 and 56, respectively, whereby pressure or force may be applied to the back portions of the adjacent E-shaped laminations, such as the E-shaped laminations 20 and 30 during assembly or stacking of the layers of laminations of the magnetic core 10. The magnetic core 10 may include any plurality of layers of laminations as required in a particular application. It is to be understood that the I-shaped laminations 42 and 52 may be provided without the recessed surfaces as illustrated in FIG. 2 and FIG. 3 where other means are provided for applying pressure or force to the E-shaped laminations and the I-shaped laminations of the magnetic core 10 during assembly in order to obtain the most desirable magnetic characteristics of the magnetic core 10. The reason that the I-shaped laminations 42 and 52 are provided with the recessed surfaces whereby the adjacent E-shaped laminations may be tamped during assembly of the magnetic core 10 is that the I-shaped laminations 42 and 52 are wider than the back or yoke portions of the E-shaped laminations 20 and 30 and therefore extend beyond the back portions of the E-shaped laminations 20 and 30 at the ends of the magnetic core 10 after the laminations are assembled.

It has been found that a magnetic core 10, such as shown in FIG. 3, has a lower reluctance than a conventional magnetic core of the same general type in which the width of the I-shaped laminations is the same as the width of the back or yoke portions of the E-shaped laminations. A magnetic core as disclosed, having the width of the I-shaped laminations greater than the width of the back portions of the E-shaped laminations, has a lower reluctance than a conventional core for a particular given quantity of magnetic material included in each of said cores. This is because of the manner in which the flux travels in a magnetic material having a preferred direction of orientation.

As shown in FIG. 3, the flux travels substantially parallel to the preferred direction of orientation in the leg portions 24, 26 and 28 of the E-shaped lamination 20 and in the leg portions 34, 36 and 38 of the E-shaped lamination 30. However, in the back or yoke portions 22 and 32 of the E-shaped laminations 20 and 30, the magnetic flux travels at substantially right angles or across the preferred direction of orientation or grain and the reluctance of the magnetic core 10 and of similar conventional magnetic cores is thereby increased. The higher reluctance paths of the back portions of the E-shaped laminations in the magnetic core 10 are bridged or shunted by the I-shaped laminations in the adjacent layers of the magnetic core 10 in which the magnetic flux travels in a direction substantially parallel to the preferred direction of orientation of the magnetic strip material. Since the width of the I-shaped laminations 42 and 52 in a core as disclosed is wider than the width of the back or yoke portions of the adjacent E-shaped laminations, the higher reluctance path in the back portions of the E-shaped laminations are bridged or shunted by parallel magnetic paths in the adjacent I-shaped laminations which have a greater width and a much lower inherent reluctance because of the direction of flux travel in the I-shaped laminations.

It has been found that the reluctance of a magnetic core incorporating the teachings of this invention and including I-shaped laminations having a greater width than the width of the back portions of the associated E-shaped laminations is lower than the reluctance of a conventional magnetic core of the same general type having the same quantity of magnetic material included in the core. The core construction disclosed decreases or reduces the reluctance of the yoke or end portions of a core of the type described and therefore reduces the overall reluctance of such a core. In other words, a magnetic core as disclosed has a lower reluctance than a conventional magnetic core of the same general type and having the same quantity of magnetic material included in the core. This means that a magnetic core of the type disclosed having the same overall reluctance as a conventional core of the same general type would require less magnetic material or if it had the same quantity of magnetic material would have a lower overall reluctance.

As hereinbefore stated, in a conventional magnetic core having a plurality of layers of E-shaped and I-shaped laminations, the width of the back portion of the E-shaped lamination is substantially the same as the width of the I-shaped lamination. To construct a magnetic core according to the embodiment of this invention where the quantity of magnetic material in the improved core is the same as the quantity of magnetic material in the conventional core, the width of the I-lamination is increased to a width greater than the I-lamination in the conventional core, and the width of the back of the E-lamination is decreased to a width narrower than the width of the back of the E-lamination in the conventional core. In order to maintain the quantity of material in the magnetic core the same as in the conventional magnetic core, the reduction in the width of the back of the E-shaped lamination is the same as the increase in the width of the I-shaped lamination. The ratio of the width of the I-shaped lamination to the width of the back portion of the E-shaped lamination, as hereinbefore stated, is preferably greater than 1.2.

It is to be noted that the magnetic core 10 as shown in FIG. 3 is of the shell form type and that associated electrical coils or windings (not shown) for an electrical apparatus would be disposed or mounted on the middle leg portions of the E-shaped laminations which are included in the magnetic core 10. It is to be understood that a magnetic core incorporating the teachings of this invention could be provided in which the width of the middle leg portions of the E-shaped laminations would be substantially the same as the width of the two outer leg portions of the E-shaped laminations. The latter core would be of the core form type and the associated electrical windings would be mounted on all three leg portions of such a core. It is also to be understood that the I-shaped laminations included in a core of the type disclosed might include only a single recessed surface whereby pressure might be applied to the E-shaped laminations during the assembly of the core. It is to be noted that the recessed surfaces of the I-shaped laminations included in the magnetic core 10 are preferably in substantial alignment with the outside surface of the back portions of the adjacent E-shaped laminations.

It is to be understood that the width of the magnetic strip material from which the I-shaped and E-shaped laminations are formed may be such as to accommodate a plurality of E-shaped laminations in the production of the laminations. Other conventional methods of producing the E-shaped and I-shaped laminations for a core of the type disclosed may be employed also. During the stacking or assembly of the layers of laminations which make up a particular magnetic core, it is to be understood that two or more laminations of the same shape may be stacked or assembled simultaneously to facilitate assembly either manually or by automatic machines.

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A magnetic core for electrical apparatus embodying the teachings of this invention has several advantages, for example, for a given quantity of magnetic material, the reluctance of a magnetic core as disclosed is lower than the reluctance of a conventional magnetic core of the same general type. For a given reluctance in a particular application, the quantity of magnetic material required in a magnetic core of the type disclosed is less than the quantity of magnetic material required in a magnetic core of the same general type. In addition, the method of producing the E-shaped and I-shaped laminations is substantially scrapless and even the small amount of scrap involved in providing recess surfaces on the I-shaped laminations may be eliminated in a particular magnetic core. The lower reluctance associated with the magnetic core of the type disclosed also results in a lower exciting current with lower associated losses.

In summary, it has been found that the relative width of the back portions of the E-shaped laminations in a magnetic core of the type described may be reduced compared to the width of the I-shaped laminations for a given quantity of magnetic material and that greater benefits with respect to reluctance are obtained than for a corresponding increase in the width of the back portions of the E-shaped laminations. The latter benefit, as previously discussed, is a direct result of the manner in which the magnetic flux travels in the lamination of magnetic strip material having a preferred direction of orientation.

Since numerous changes may be made in the above described apparatus and different embodiments of the invention may be made without departing from the spirit and scope thereof, it is intended that all the matter contained in the foregoing description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

We claim as our invention:

1. The method of making a substantially scrapless low loss laminated magnetic core from a single sheet of grain oriented material comprising the steps of cutting a pair of E-shaped laminations from said sheet of material, utilizing the material removed from the sheet in forming the legs of said E-shaped laminations to provide a pair of I-shaped laminations, said I-shaped laminations having a width greater than the width of the back of said E-shaped laminations by a ratio of at least 1.2, the legs of said E-shaped laminations being substantially parallel with the grain orientation of said material, the backs of said E-shaped laminations being substantially transverse to said grain orientation, each layer of laminations of said magnetic core having an E-shaped lamination with its leg portions disposed to abut against an I-shaped lamination, the back portion of said E-shaped lamination being positioned at opposite ends of said magnetic core in alternate layers of said laminations, said I-shaped laminations overlapping the backs of said E-shaped laminations.

2. The method of making a substantially scrapless low loss laminated magnetic core from a single sheet of grain oriented material comprising the steps of cutting a pair of facing E-shaped laminations from said sheet of material, utilizing the material removed from the sheet in forming the legs of said E-shaped laminations to provide a pair of I-shaped laminations, said I-shaped laminations, said I-shaped laminations having a width greater than the width of the backs of said E-shaped laminations by a ratio exceeding 1.2, the legs of said E-shaped laminations and the longitudinal dimension of said I-shaped laminations being formed substantially parallel with the grain orientation of said material, the backs of said E-shaped laminations

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being formed substantially at right angles to said grain orientation, each layer of laminations of said magnetic core having an E-shaped lamination with its leg portions disposed to abut against an I-shaped lamination, the back portion of said E-shaped lamination being positioned at opposite ends of said magnetic core in alternate layers of said laminations, said I-shaped laminations overlapping the backs of said E-shaped laminations.

3. The method of making a substantially scrapless low loss magnetic core comprising a plurality of layers of laminations of magnetic material, said magnetic material having a preferred direction of magnetic orientation, the steps of cutting a pair of E-shaped laminations from a sheet of said material, utilizing the rectangular portions removed from said sheet in forming the legs of said E-shaped laminations to provide a pair of I-shaped laminations, said I-shaped laminations having a width greater than the width of the backs of said E-shaped laminations by a ratio of at least 1.2, the legs of said E-shaped laminations and the longitudinal dimension of said I-shaped laminations being formed substantially parallel with the preferred direction of magnetic orientation of said material, the backs of said E-shaped laminations being formed substantially at right angles to the preferred direction of magnetic orientation of said material, each layer of laminations of said magnetic core having an E-shaped lamination with its leg portions disposed to abut against an I-shaped lamination, the back portion of said E-shaped lamination being positioned at opposite ends of said magnetic core in alternate layers of said laminations, said I-shaped laminations overlapping the backs of said E-shaped laminations, said I-shaped laminations having recesses therein for indexing said laminations during the assembly of said core.

4. The method of making a substantially scrapless low loss laminated magnetic core from a sheet of grain oriented material comprising the steps of cutting a pair of E-shaped laminations from said sheet of material, utilizing the material removed from the sheet in forming the legs of said E-shaped laminations to provide a pair of I-shaped laminations, said I-shaped laminations having a width greater than the width of the back of said E-shaped laminations by a ratio of at least 1.2, the legs of said E-shaped laminations and the longitudinal dimension of said I-shaped laminations being formed substantially parallel with the grain orientation of said material, the backs of said E-shaped laminations being formed substantially transverse to said grain orientation, each layer of laminations of said magnetic core having an E-shaped lamination with its leg portions disposed to abut against an I-shaped lamination, the back portion of said E-shaped lamination being disposed at opposite ends of said magnetic core in alternate layers of said laminations, said I-shaped laminations overlapping the backs of said E-shaped laminations, said I-shaped laminations having recessed surfaces at the ends thereof for indexing the back portions of the E-shaped laminations during the assembly of said core.

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