Oct. 29, 1957 H. L. GARBARINO 2,811,203

METHOD FOR FORMING EI LAMINATION FOR SHELL-TYPE CORE

Filed May 27, 1952 2 Sheets-Sheet 1

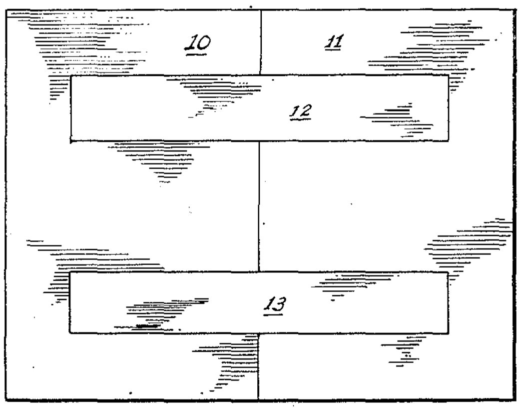

Fig-1

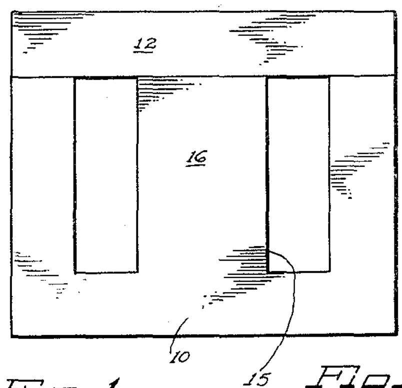

Fig-2

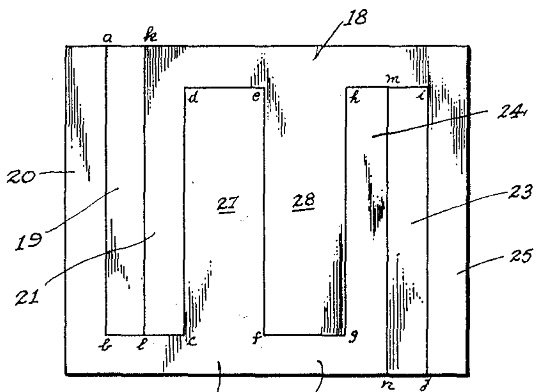

Fig-3

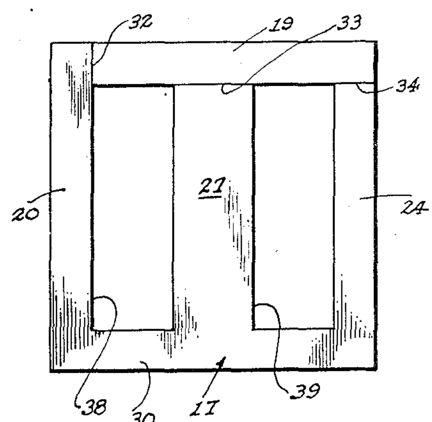

Fig-4

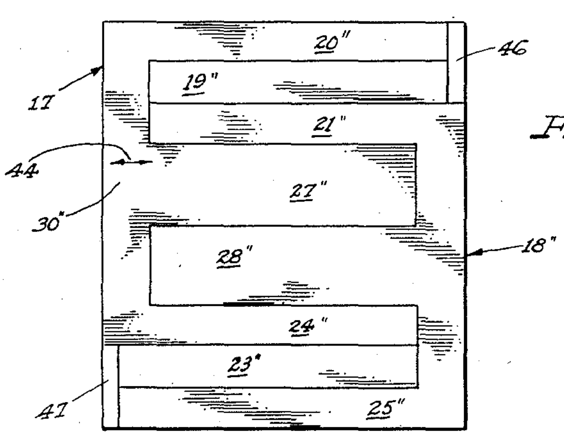

Fig-7

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METHOD FOR FORMING EI LAMINATION FOR SHELL-TYPE CORE

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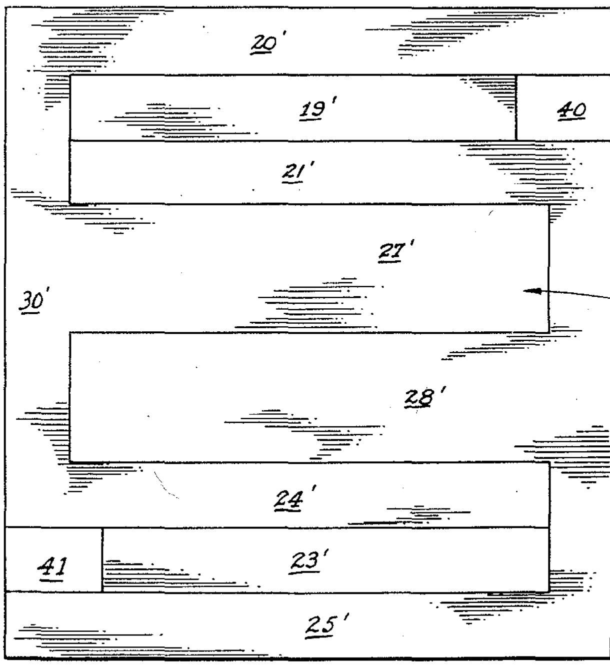


Fig-5

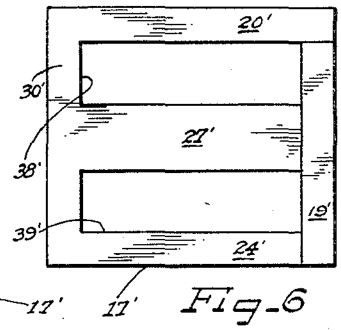


Fig-6

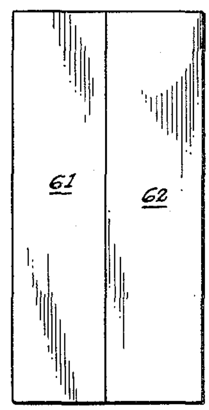
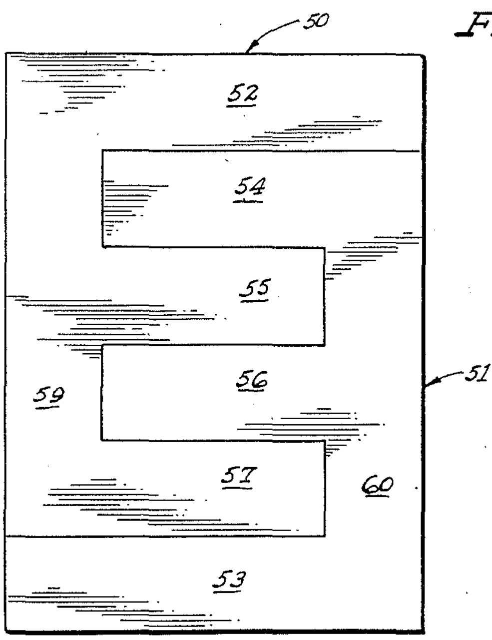


Fig-8

Fig-9



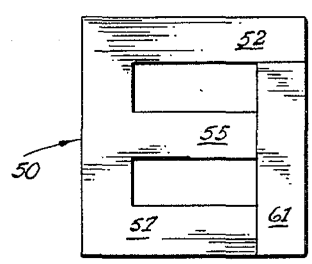


Fig-10

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METHOD FOR FORMING EI LAMINATION FOR SHELL-TYPE CORE

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3 Claims. (Cl. 164—18)

This invention relates to a lamination for a shell-type core and more particularly to such a lamination which may be manufactured from an elongated sheet without substantial amounts of scrap.

Transformer manufacture has been guided in the past and probably will continue to be guided principally by considerations of cost. It appears that cost has made the conventional shell-type core using scrapless punchings predominant in the small power transformer business. However, use of scrapless-type laminations of conventional construction has, in the past, allowed variations in proportions only by changing the stack height. The ratio of stack height to center leg width is normally in the range of 1:1 to 3:1 with the lower ratios in the range being most commonly used for design and manufacturing reasons. Thus, the core proportions available to a designer are relatively fixed, and the designer cannot apply in a general manner the criteria leading to an optimum design of lamination.

It is particularly desirable that a scrapless-type lamination be provided having a larger ratio of window width to leg width, as compared with the conventional scrapless-type lamination. This relatively increased window width makes possible a greater volume of winding for a given size core and is particularly desirable, for example, with high voltage and multi-secondary units in which the space factor tends to be low. A greater proportion of insulation in the total winding space tends to reduce the costs, losses and weight per volume of the winding giving a pronounced advantage over the conventional scrapless-type lamination.

It is, therefore, an important object of the present invention to provide a novel scrapless-type lamination having a relatively large ratio of window width to center leg width.

It is a further object of the present invention to provide a novel lamination for a shell-type core.

It is another object of the present invention to provide a novel core having a lower ratio of gaps to bridging laminations at the corner joints to reduce the flux density in the overlapping laminations.

It is another object of the present invention to provide a novel lamination for a shell-type core having improved magnetic characteristics.

It is a further important object of the present invention to provide a novel lamination of the scrapless-type especially adapted for use in magnetic amplifiers.

It is a further important object of the present invention to provide a novel lamination which can be formed in a variety of proportions with a minimum of scrap.

Other novel features which are believed to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization, manner of construction and method of operation, together with further objects and advantages thereof may be best understood by reference to the following description taken in connection with the accompanying drawings, in which:

Figure 1 is a plan view of a pair of conventional scrapless-type laminations for shell-type cores as cut from sheet magnetic steel;

Figure 2 is a plan view of an assembled conventional scrapless lamination;

Figure 3 is a plan view of a pair of laminations as formed from sheet magnetic steel in accordance with the teachings and principles of the present invention;

Figure 4 is a plan view of an assembled scrapless lamination in accordance with the teachings and principles of the present invention;

Figure 5 is a plan view of a modified lamination layout according to the present invention wherein the legs are proportionally longer than in the scrapless type of Figure 3;

Figure 6 is a plan view of an assembly of a lamination of the type shown in Figure 5;

Figure 7 is a plan view of a second modified form of lamination lay-out according to the present invention wherein the base of the E-member is relatively wide;

Figure 8 is a plan view of the E-members of a third type of lamination construction according to the present invention;

Figure 9 is a plan view of a pair of I laminations for use with the E-members of Figure 8; and

Figure 10 is a plan view of an assembled lamination composed of the parts of Figures 8 and 9, according to the present invention.

As illustrated in Figures 1 and 2, in the conventional scrapless-type lamination, the laminations are formed from a strip with two E-members **10** and **11** opposing each other in abutting relation with the bridging members **12** and **13** being cut from between the legs of the E's. It will be observed from Figure 2, that the width of the windows **15** is one-half the width of the center leg **16**, while the ratio of the length of the windows **15** to their width is 3:1.

The laminations according to the present invention may be cut from a sheet of magnetic material as indicated in Figure 3. It will be observed that according to the teachings of the present invention, the E-members **17** and **18** are facing and overlapping with the bridging member **19** being cut from between the long outer leg **20** of the E-member **17** and the short outer leg **21** of the E-member **18**, while the bridging member **23** is cut from between the short leg **24** of the E-member **17** and the long outer leg **25** of the E-member **18**. Thus the bridging members **19** and **23** are of the same length as the long legs **20** and **25** and of equal width, while the center legs **27** and **28** are twice the width of the outer legs and are of the same length as the shorter outer legs **21** and **24**. It will also be observed that the length of the base **30** of each E is four times the width of the center leg, while the length of the long leg is three and one-half times the width of the center legs, the shorter legs being three times the width of the center legs. As illustrated in Figure 4, the bridging member **19** in assembled relation with E-member **17** has an end abutting the side edge of the long leg **20** along a juncture indicated at **32**, while the ends of the shorter legs **24** and **27** abut the bridging member **19** along junctures **33** and **34**.

The windows **38** and **39** of the assembled lamination will be observed to be proportionally larger than those of the conventional type in Figure 2, the windows being as wide as the center leg **27** rather than being the width of the outer legs as in Figure 2.

It will also be observed that by virtue of the dissymmetry of the E-member **17** the laminations in a stack may be interleaved so that the junctures **32**, for example, will be disposed successively at the four corners of the stack. It will thus be seen that the ratio of gaps to bridging laminations at each corner of a core formed from the laminations illustrated will be 1:3 rather than 1:1 as in the conventional type lamination. The flux density in the overlapping laminations is thereby reduced, and a distinct improvement in magnetic characteristics is obtained. One method of producing the lamination shown in Figures 3 and 4 would be by means of a die cutting operation along the line *a—b—c—e—f—g—h—i—j* of Figure 3, then two shearing operations along the lines *k—l* and *m—n*.

In Figures 5 and 6 is illustrated a manner of increasing the height of the stacks, that is the length of the legs of the E's with a minimum amount of scrap. Since the general arrangement is similar to that of Figures 3 and 4, corresponding primed reference numerals have been applied to corresponding parts in Figures 5 and 6. It will be observed that the main difference between this form and the previous one is that the overall length of each E-member is greater than four times the width of the center leg **27'** so that a small amount of scrap indicated at **40** and **41** is formed adjacent the bridging members **19'** and **23'**. Functionally speaking, it will be observed that the reason for the scrap is that the longer leg **20'** is made longer than the sum of the widths of the windows **38'** and **39'** plus the widths of the short outer leg **24'** and the center leg **27'**, so that the bridging piece **23'**, which is normally formed the same length as the long leg **20'** would be too long unless cut down as indicated at **40**.

In Figure 7 is illustrated a further modification wherein the base such as **30''** is made wider than the outer legs. In the modification of Figures 5 and 6, the ratio of window length to window width is increased over that of Figures 3 and 4, while in Figure 7 the window ratio is maintained at 3:1. The increased base width in Figure 7 may be desirable as, for example, when the lamination is to be manufactured from reels of magnetically grain-oriented silicon steel because when the cut-out pattern utilizes favorable directional properties of this steel, it will be observed that in the base **30''**, the magnetic fields will be perpendicular to the grain indicated by the arrow **44** which is an unfavorable situation. Widening of the base **30''** thus improves the performance of the laminations. Since the bridging members are maintained at a width one-half the width of the windows, it will be appreciated that the long legs **20''** and **25''** are still to be three and one-half times the window width with a window length of three times the width. Thus increasing the width of the base beyond one-half the window width provides small amounts of scrap as indicated at **46** and **47** since both the length of the bridging members **19''** and **23''** and of the long legs **20''** and **25''** must be reduced to form an assembled lamination identical to that shown in Figure 4 except for the increased width of the base.

It will thus be observed that the pattern shown in Figure 3 can be modified with a slight amount of scrap to alter its dimensions and proportion in a number of ways. There is thus provided in accordance with the present invention a novel highly adaptable lamination pattern which can be adapted to a number of designs not possible with the conventional scrapless-type laminations.

In Figures 8 and 9, there is illustrated a method of manufacturing the E-members separately from the bridging members. In this case, it will be observed that the E-members **50** and **51** are simply interlocked with the windows being of a width equal to that of each of the legs of the E's. The longer legs **52** and **53** are longer than the short legs **54**, **55**, **56** and **57** by the widths of the bases **59** and **60** which are equal to the widths of the bridging members **61** and **62**, Figure 9. It will also be understood that there is no limitation on the overall height of the stack, or on the length of the legs, so that the window ratio can be adjusted as desired. This design shown in Figures 8, 9 and 10 is particularly useful in magnetic amplifiers, however, it may also be used for three-phase transformers, especially of smaller size where die-cutting is feasible and economical.

It will, of course, be understood that various details of construction may be varied through a wide range without departing from the principles of this invention, and it is, therefore, not the purpose of this specification to limit the patent granted hereon otherwise than necessitated by the scope of the appended claims.

I claim as my invention:

1. The method of forming shell-type laminations which comprises selecting a generally rectangular strip of sheet magnetic material, cutting said strip to define a pair of facing and overlapping E members, and cutting said strip to define generally rectangular I members between adjacent outer legs of the respective E members to form a pair of shell-type laminations.

2. The method of forming EI laminations which comprises selecting a strip of sheet magnetic material, making cuts in said strip to define a pair of facing and overlapping E members with one window of each E member having the center leg of the other E member therein and with the other window of each E member having an outer leg of the other E member and an I member therein, whereby the width of said windows may be equal to the width of said outer leg plus the width of said I member.

3. The method of forming scrapless EI laminations which comprises selecting a strip of sheet magnetic material, making cuts in said strip to define an E member having a center leg twice the width of the two outer legs and with windows of a width equal to the width of said center leg and to define one outer leg of said E member of length greater than the length of the center leg and of the other outer leg by the width of one outer leg, making cuts to define an identical second E member having a center leg in one window of said first E member and having its shorter outer leg in the other window, and making cuts to define two I members one in said other window of each E member.

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