Jan. 1, 1963 A. E. FEINBERG ETAL 3,071,744

ELECTROMAGNETIC CORE CONSTRUCTION

Original Filed Dec. 14, 1954 2 Sheets-Sheet 1

Fig. 1.

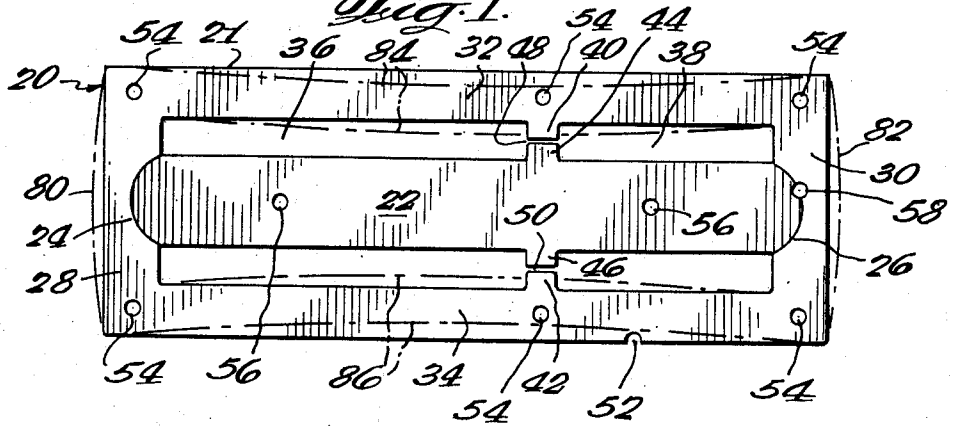
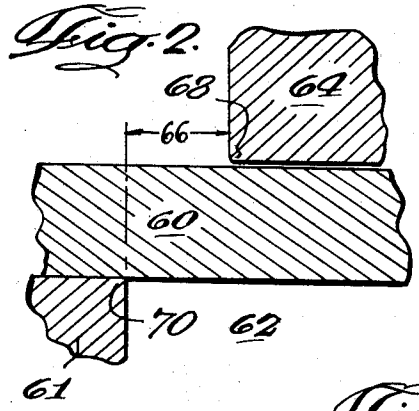


Fig. 2.



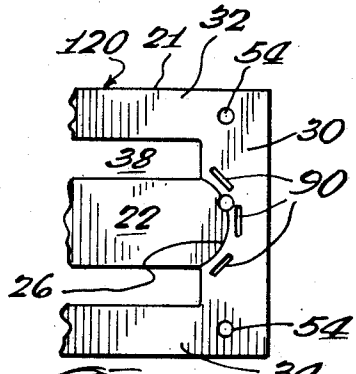
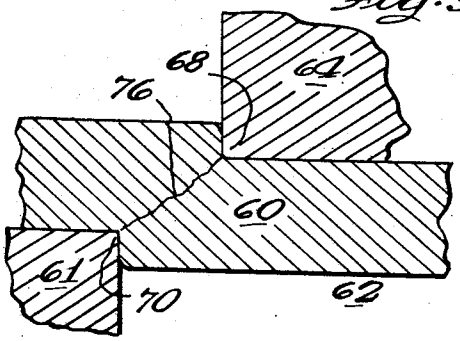


Fig. 5.

Fig. 3.



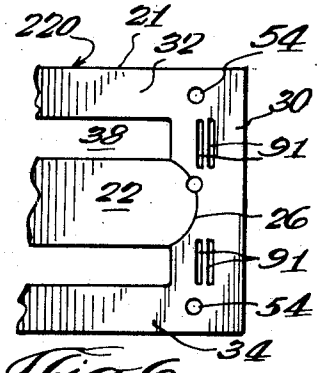


Fig. 6.

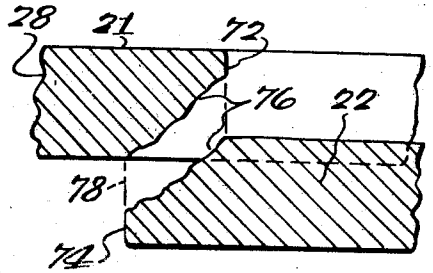


Fig. 4.

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Jan. 1, 1963 A. E. FEINBERG ETAL 3,071,744

ELECTROMAGNETIC CORE CONSTRUCTION

Original Filed Dec. 14, 1954 2 Sheets-Sheet 2

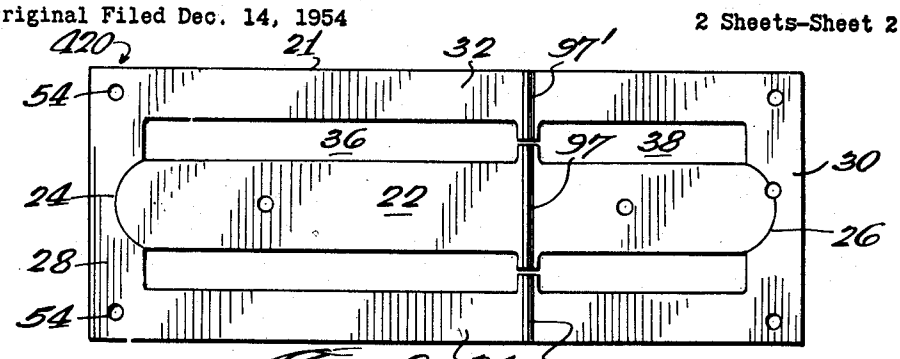


Fig. 8.

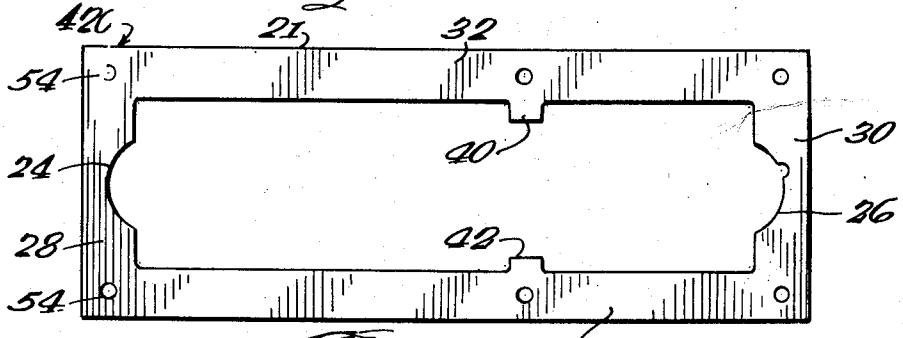


Fig. 9.

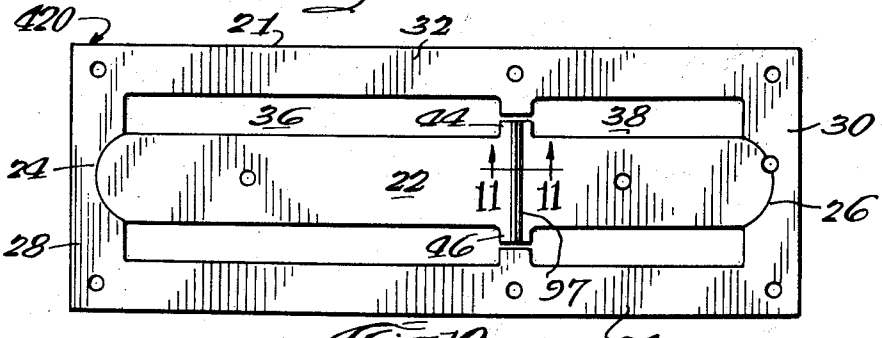


Fig. 10.

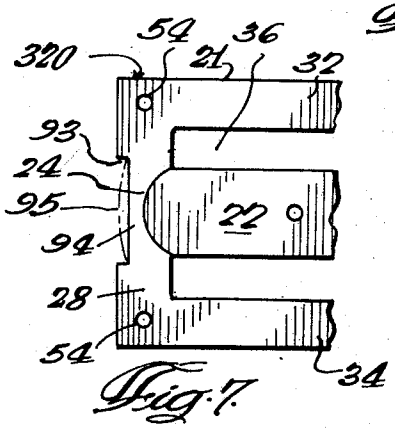


Fig. 7.



Fig. 11.

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ELECTROMAGNETIC CORE CONSTRUCTION

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Original application Dec. 14, 1954, Ser. No. 475,043, now Patent No. 3,002,263, dated Oct. 3, 1961. Divided and this application Dec. 19, 1957, Ser. No. 707,075
13 Claims. (Cl. 336—212)

This invention relates generally to a core construction for electromagnetic devices such as transformers, chokes and the like and in addition is concerned with a novel method of constructing a core of this type.

The invention is particularly applicable to shell type cores constructed of laminations and in which there is a generally rectangular outer frame or shell, having elongate sides and ends bridging the sides, and in addition there is a central winding leg which is disposed between the ends extending the length of the interior of the outer shell. In practice, a core of this structure is formed of a stack of laminations, each stamped out of silicon steel sheeting, held together by rivets or clamps. The difficulties which will be referred to occur principally in the riveted cores but are not exclusive thereto. In stamping the individual laminations, the central winding leg lamination is punched out of the blank simultaneously that the windows and outer frame portions are formed. This may occur in a progressive sequence, with the various parts separated by the punch press.

Thereafter, the frame laminations and winding leg laminations are separately stacked and riveted together. The air gap or gaps are formed during the punching operations, usually by a cutting operation known as shaving. This operation establishes the dimensions of the air gap or gaps, by means of which the eventual electrical characteristics of the device are established. The stacked winding leg is now provided with pre-wound coils that are slipped over the ends and positioned in alignment with the windows of the shell or frame stack, and thereafter the assembled winding leg and coils are forced into the center of the frame or shell. Means are provided for positive alignment and seating of the central winding leg.

The above describes a method of producing the cores which is in common use. The further processing of the device is not involved in this invention.

Theoretically, since the central leg is re-fitted back into the opening formed when it was punched out, there should be no problem in so assembling the transformer or choke. Thus, predetermined gaps should not vary for any reason. This is not the case, however. In any shearing die which includes male and female portions, there must be clearance no matter how little. The workpiece is therefore acted upon above and below by shearing members which are moving along different parallel planes. A certain amount of cutting will take place, depending upon the sharpness of the die halves, but separation eventually occurs along a tear which extends diagonally from the contours defined by the male die portion to the contours defined by the female die portion. Considering the definition of the resulting pieces by the contours of the male portion of the die, the punched out part will have an outward extension, and the perforated part will have an undercut.

Obviously, fitting a single thickness of a winding leg lamination to a single thickness of a frame or shell lamination presents little or no problem. The aligned members are assembled in the direction opposite that in which they were separated during the punching operation. When a plurality of members are stacked, obviously there can be no nesting in assembling, since the

largest contour of the one must pass the smallest contour of the other during the pressing-in process, resulting in either crushing of the edges or deformation of one part or the other.

Since the stacked winding legs are engaged with the shells only at their ends, deformation which occurs during the pressing in of the central winding leg in practically all cases affects the bridging ends of the shell, bowing them outward. This results in distortion of the unsupported elongate side walls with resultant change in the gap dimensions. Thus the electrical characteristics of the device are changed resulting in unsatisfactory performance of the transformer or choke. Since die sharpness is an important factor and this varies, it is next to impossible to compensate for the change in gap thickness by, for example, shaving more material from gap forming extensions than necessary if there were no distortion.

It is the primary object of the invention to offset the above disadvantages otherwise inherent in the pressed-in shell type core structure, by preventing distortion of the elongate sides of the core during the pressing-in of the winding leg.

A further object of the invention lies in the provision of means on the bridging ends of the outer shell or frame of the core to prevent distortion of the elongate sides of the shells, and in connection with this object various means comprise weakened portions which will absorb or take on any distorting strain without transmitting the same to the sides.

A still further object of the invention lies in the provision of means on the central winding leg to accomplish the elimination of distortion in the elongate sides, and specifically the said means may consist of a formation shortening the length of said winding leg.

Still a further object of the invention lies in the proviison of a novel method for accomplishing the shortening of the central winding leg.

Many other objects will occur to those skilled in the art as a description of the invention proceeds in which preferred embodiments of the invention have been described in some detail in order to comply with the patent statutes relating thereto. A preferred embodiment of the method has also been described.

In the drawings:

FIG. 1 is a top plan view of a lamination for a shell type core showing the manner in which the central winding leg portion matingly engages with the shell or frame portion and illustrating the conventional construction.

FIGS. 2 and 3 are diagrammatic views on a greatly enlarged scale showing in section what occurs in the punching operation during formation of the lamination of FIG. 1.

FIG. 4 is an enlarged and exaggerated sectional view showing the formation resulting along the edges of the parts of the lamination of FIG. 1 as a result of the punching operation.

FIGS. 5 and 6 are fragmentary plan views of the right hand ends of laminations formed in accordance with the invention to eliminate distortion of the sides of the shell core during the pressing-in operation.

FIG. 7 is a fragmentary plan view of the left hand end of another lamination formed in accordance with the invention and illustrating a third form.

FIGS. 8 and 9 illustrate steps in the formation of the lamination of FIG. 10, the latter illustrating a fourth form of the invention.

FIG. 11 is a sectional view along the line 11—11 of FIG. 10.

As stated above, the invention generally lies in preventing the distortion of the elongate sides of the shell of the core and thereby maintaining uniform gaps notwithstand-

ing the "growing" of the winding leg laminations during punching. In order to obtain a clear picture of the problems solved attention is invited to FIGS. 1 through 4.

FIG. 1 illustrates a lamination **20** having a shell or frame part **21** of rectangular construction, and a central winding leg portion **22** which is punched out of the same blank forming the lamination **20**, with its ends matingly engaged at **24** and **26** with the bridging ends **28** and **30** respectively of the frame part **21**. The sides are designated **32** and **34**. Windows **36** and **38** are formed between the winding leg part **22** and the frame part **21** for the reception of the coils (not shown). The windows are separated by juxtaposed spaced apart extensions **40** and **42** on the frame part **21** extending inwardly toward the outwardly extending counterparts **44** and **46** on the winding leg part **22**. The separation forms the gaps **48** and **50** the spacing of which is critical in most electromagnetic devices, since the reluctance of the shunt (that is the combined extensions and gaps) affects the reactive relationship between the coils in the respective windows.

The contours of the lamination **20** are identical to the contours of the transformer which is manufactured from a plurality of such laminations. Only the windings and fastening means are not shown. Thus, a predetermined number of parts **21** are stacked together in perfect alignment through the assistance of an indexing notch **52** on an edge of the side **34**, and riveted together. Rivet holes are shown at **54**. The same number of parts **22** are also stacked together and riveted, the rivet holes being shown at **56**. An indexing hole **58**, part of which is in the bridging end **30** and part of which is in the end of the winding leg part **22**, serves the dual purpose of enabling proper alignment of the stack of winding leg parts **22** one with the other, and indicating proper alignment of the assembled stack of parts **22** with the assembled stack of parts **21**. The direction of pressing-in of the winding leg into the frame is easily ascertained by reason of the burrs on both parts. The smooth surface of the winding leg stack is to be inserted into the burred side of the frame part stack.

As described thus far, the construction is conventional and the manner of inserting the winding leg in the core is well-known. This method of assembly gives rise to distortion of the sides **32** and **34** with attendant changes in the width of gaps **48** and **50**.

In FIG. 2 there is illustrated a blank or workpiece **60** from which the lamination **20** is to be punched. For the sake of description, it will be presumed that the diagram illustrates in exaggerated dimension, the formation of the mating junction **24**. The workpiece **60** is shown upon a lower die part **61** which has therein an opening **62** of the configuration of the winding leg part **22** (either with or without the windows). This is then the female portion of the die. The punch **64** is shown poised over the workpiece preparatory to being pressed upon the same and driven into the opening **62**. Obviously, it has the same contours as the opening **62**, but must be slightly smaller to permit such downward movement. The clearance between die parts **61** and **64** is represented by the space **66**.

As the male die part **64** is driven downward, the sharp edges **68** and **70** at first bite into the workpiece **60**, giving rise to pure shear surfaces **72** and **74**. This pure shear continues until the movement of the separating parts of the workpiece **60** produces a stress across the edges **68** and **70** that exceeds the tensile strength of the material. At this point the material yields, tearing across this diagonal along the line **76**. The exact position of this tear surface (it is actually a surface formed about the edges of both of the separated pieces) depends upon many factors among which are: tensile strength of the steel, clearance **66** of the die parts, thickness of the workpiece **60**, sharpness of the dies, type of workpiece padding, etc. The resulting pieces are illustrated in FIG. 4, forming the bridging end **28** and the end of the central leg part **22**.

Although the illustration of FIG. 4 indicates that moving the two parts together along the dotted lines **78** would probably not result in the mating engagement of the parts of even a single lamination, it should be appreciated that the drawing is somewhat exaggerated. Normally it is not difficult to force the two together. The purpose is to show that the opening at **24** defined by the edge **72** of the part **21** is smaller than the contour of the winding leg **22** defined by the edge **74**. Certainly the greatest distance between the mating junction **24—26** of the frame part **21** is substantially less than the greatest distance between the ends of the winding leg part **74**. When a stack of winding leg laminations is forced into the center of the frame something must give.

It has been found that the bridging ends **28** and **30** tend to bow outward when the winding leg stack is pressed home. This is illustrated in exaggerated form by the broken lines **80** and **82** in FIG. 1. The resulting distortion of the stacked frame laminations is usually an inward bowing of the elongate sides. This is exaggeratedly illustrated by the broken lines **84** and **86**. The inward bowing of the sides **32** and **34** of the frame stack will materially decrease the width across gaps **48** and **50**, and as explained, the amount of change of the gaps will not be controllable. Material changes in electrical characteristics of the transformer or choke over original design will result from this alteration in gap dimension. Gap materials may in some way offset this change, but the forces applied are great and some change is bound to result notwithstanding.

In any event, electrical changes result from such distortion which in many cases are intolerable. The difficulties are aggravated where a close tolerance of gaps is required for some particular characteristic of the electromagnetic device, and where more than one gapped shunt is affected.

Generally the invention comprises providing some means to prevent distortion, and this takes two specific forms. In one form, there are provided means which will absorb deformations caused when the winding leg is pressed home. In a second form, the winding leg is shortened slightly during manufacture to compensate for its "growing."

In FIGS. 5 and 6, means are provided in the bridging end **30** capable of absorbing deformation. In the lamination **120** of FIG. 5 there is a series of slots **90** which are punched completely through the bridging end and generally are arranged at right angles to the forces exerted when the winding leg **22** is driven into place. Thus the slots are in an arc about the junction **26**. The slots **90** provide a weakened portion in the bridging end which will be somewhat crushed, perhaps slightly closing the slots when the winding leg is pressed home. Obviously if the distortion is all localized in the bridging end **30**, there will be no distortion or bowing inward of the sides **32** and **34** and the gaps **48** and **50** will be unaffected.

In the lamination **220** of FIG. 6, the slots **91** serve the same function as slots **90**, but these are arranged geometrically different. A greater amount of weakening is provided at local areas adjacent the inner corners of the end member **30**. The function and operation is the same as slots **90**.

In slotting the end **30**, care must be taken to provide sufficient iron to handle the normal flux designed to thread the core. Note that the width of the end **30** is larger in FIGS. 5 and 6 than in FIG. 1 for the same design of electromagnetic device. Obviously the slotting decreases the cross section in places. The exact number and formation of slots is a matter of design, probably best ascertained by experiment, especially in view of the complex nature of the electrical characteristics of this kind of apparatus. Care must be taken to avoid any areas where extreme high flux density may result in saturation.

In the lamination **320** illustrated in FIG. 7, instead of slotting the end **28**, a shallow recess or notch **93** is formed

along the outer edge of the end, so that when distortion occurs as it might in forcing the winding leg home, the narrow strip **94** between the juncture **24** and the recess **93** will tend to bow out or flex as indicated at **95** rather than the entire bridging end **28**. The same salutary effects are obtained as in FIGS. 5 and 6.

In FIG. 10 there is illustrated a lamination **420** in which the construction is identical to that of the lamination **10** of FIG. 1 with one exception. There is a crimp **97** of simple formation which extends across the central winding leg part **22** at the extensions **44** and **46**. The crimp may be of any configuration **30** that a stack of members **22** will nest, one such formation being triangular in cross section as shown in FIG. 11. Obviously the crimp **97** will shorten the length of the winding leg **22** slightly, and thereby offset the "growth" thereof during stamping. This can prevent the distortion of the ends **28** and **30** during assembly of stacks. Obviously there must be no crimp in the frame portion **21**.

The crimp may be formed in the lamination **22** in any of a variety of ways and at any of the stages in the punching of the lamination, but for high speed production, a novel method of forming said crimp has been evolved. During the production of the lamination, at any suitable stage of the stamping operation, say during the first blanking step, or even before blanking, if desired, the entire lamination is crimped across the position of the shunt, that is, at the extensions **40**, **42**, **44** and **46**. The crimp is more easily formed in a large and imperforate member. Thereafter, the crimps **97'** in the sides **32** and **34** are flattened. The final result will be the same as FIG. 10. The illustration in FIG. 8 shows the lamination assembled together prior to the flattening of the frame part **21**. Obviously before this occurs, the winding leg part **22** drops out of the press so that FIG. 9 illustrates the result of the flattening step. By illustrating both parts **21** and **22** in FIG. 8 it is not intended to imply that the entire lamination is completely punched to shape before the crimps **97** and **97'** are formed (although this might be done). Preferably the crimping should be done at a stage of the progressive punching process at which there will be a minimum of distortion of the extensions forming the shunt and gaps.

The only reason for the crimp **97** being where shown in FIG. 10 is that it interferes least with the insertion of the stacked winding leg into the coils from opposite ends. The crimp **97** will, however, be quite small, and may be located in other places along the member **22** where convenience and practicability permit. Obviously there may be several crimps, if desired.

What it is desired to secure by Letter Patent of the United States is:

1. An electromagnetic core construction of the shell type comprising an integral substantially rectangular outer shell having elongate sides and continuous bridging end parts connecting said sides, a central winding leg installed on the interior of the shell extending the length of said interior and having each end face thereof disposed in intimate engagement with a said end part, said elongate sides and winding leg having extensions thereof on opposite sides of the winding leg and aligned to provide air gaps of predetermined dimension between end faces of aligned extensions, said shell and winding leg each comprising a stacked assembly of individual electrical steel stampings of which each winding leg stamping has been stamped from a said shell stamping, and means for simultaneously preventing change in the predetermined dimension of the air gaps and preventing the distortion of said elongate sides notwithstanding inherent discrepencies in the dimensions of individual winding leg and shell stampings capable of causing such change and distortion when the stampings are stacked and assembled to form said core, said means being provided on one of said elongate leg and shell components advantageously located to absorb forces exerted during said assembly capable of causing such change and distortion.

2. A core construction as described in claim 1 in which said means is provided in the said winding leg.

3. A core construction as described in claim 1 in which said means is provided in the said winding leg, comprising a crimp in said leg extending transversely of the leg at said extensions.

4. A core construction as described in claim 1 in which said means is provided in a said bridging end.

5. An electromagnetic core construction of the shell type comprising, an integral substantially rectangular outer shell having substantially parallel elongate sides and continuous bridging end parts connecting said sides, a central winding leg on the interior of the shell extending the length of said interior and having each end face thereof intimately abutting a said end part, said shell and winding leg each comprised of a stacked assembly of individual electrical steel stampings of which the winding leg stampings each has a physical length and end face contour complementary with the distance between bridging end parts and the contour of a lateral edge of each shell stamping such that each winding leg stamping is capable of being stamped from a shell stamping, and means provided on said bridging end parts preventing distortion of said elongate sides notwithstanding inherent discrepancies in dimensions and contours of individual winding leg and shell stampings capable of effecting such distortion when the stampings are stacked and assembled to form said core, said means comprising at least one of said bridging end parts having a cut-out formation located with respect to the abutting juncture of a said end face and end part to absorb deformation normally arising during such assembly.

6. A core construction as described in claim 5 in which said cut-out formation is provided in a lateral surface of said one bridging end part and said one bridging end part has its opposite lateral surface engaged with a said end face.

7. A core construction as described in claim 5 in which said cut-out formation comprises at least one recess formed in an edge of said one bridging end part opposite a second edge of said end part engaged with a said end face.

8. A core construction as described in claim 5 in which said cut-out formation is provided in the lateral surface of said one bridging part and comprises notch means extending inwardly of the bridging part and thereby decreasing the lateral thickness of the said part.

9. A core construction as described in claim 8 in which said notch means includes two inwardly extending cuts spaced apart a distance greater than the depth of said cuts, and there being portions of said surface indented between said cuts whereby to provide said decreased lateral thickness between the cuts of said notch means.

10. An electromagnetic core construction of the shell type comprising, a substantially rectangular outer shell having elongate sides and ends bridging said sides and a central winding leg installed on the interior of the shell between said ends extending the length of said interior and having each end face thereof frictionally engaged against a said bridging end, said elongate sides and winding leg having extensions thereof on opposite sides of the winding leg and aligned to provide air gaps of predetermined dimension between end faces of aligned extensions, said shell and winding leg each comprising a stacked assembly of individual electrical steel stampings, each winding leg stamping being struck from a said shell stamping, and means for preventing change in the predetermined dimension of the air gaps to alter the desired electrical characteristics of the electromagnetic device for which the core construction is used resulting from said predetermined dimension of the air gap when the central winding leg is installed on into the interior of the shell, and said means is provided in a said bridging end, comprising weakened portions formed in said end capable of ab-

sorbing deformation thereof normally arising when the winding leg is so forced into the shell.

11. An electromagnetic core construction of the shell type comprising, a substantially rectangular outer shell having elongate sides and ends bridging said sides and a central winding leg installed on the interior of the shell between said ends extending the length of said interior and having each end face thereof frictionally engaged against a said bridging end, said elongate sides and winding leg having extensions thereof on opposite sides of the winding leg and aligned to provide air gaps of predetermined dimension between end faces of aligned extensions, said shell and winding leg each comprising a stacked assembly of individual electrical steel stampings, each winding leg stamping being struck from a said shell stamping, and means for preventing change in the predetermined dimension of the air gaps to alter the desired electrical characteristics of the electromagnetic device for which the core construction is used resulting from said predetermined dimension of the air gap when the central winding leg is installed on into the interior of the shell, and said means is provided in a said bridging end, comprising weakened portions formed in said end capable of absorbing deformation thereof normally arising when the winding leg is so forced into the shell, comprising a plurality of perforations extending through said bridging end and arranged in an arc about the junction between the winding leg and said bridging end.

12. An electromagnetic core construction of the shell type comprising, a substantially rectangular outer shell having elongate sides and ends bridging said sides and a central winding leg installed on the interior of the shell between said ends extending the length of said interior and having each end face thereof frictionally engaged against a said bridging end, said elongate sides and winding leg having extensions thereof on opposite sides of the winding leg and aligned to provide air gaps of predetermined dimension between end faces of aligned extensions, said shell and winding leg each comprising a stacked assembly of individual electrical steel stampings, each winding leg stamping being struck from a said shell stamping, and means for preventing change in the predetermined dimension of the air gaps to alter the desired electrical characteristics of the electromagnetic device for which the core construction is used resulting from said predetermined dimension of the air gap when the central

winding leg is installed on into the interior of the shell, and said means is provided in a said bridging end, comprising weakened portions formed in said end capable of absorbing deformation thereof normally arising when the winding leg is so forced into the shell, comprising a plurality of perforations extending through said bridging end and arranged adjacent the inner corners of said bridging end on opposite sides of the junction between the winding leg and said bridging end.

13. An electromagnetic core construction of the shell type comprising, a substantially rectangular outer shell having elongate sides and ends bridging said sides and a central winding leg installed on the interior of the shell between said ends extending the length of said interior and having each end face thereof frictionally engaged against a said bridging end, said elongate sides and winding leg having extensions thereof on opposite sides of the winding leg and aligned to provide air gaps of predetermined dimension between end faces of aligned extensions, said shell and winding leg each comprising a stacked assembly of individual electrical steel stampings, each winding leg stamping being struck from a said shell stamping, and means for preventing change in the predetermined dimension of the air gaps to alter the desired electrical characteristics of the electromagnetic device for which the core construction is used resulting from said predetermined dimension of the air gap when the central winding leg is installed on into the interior of the shell, and said means is provided in a said bridging end, comprising weakened portions formed in said end capable of absorbing deformation thereof normally arising when the winding leg is so forced into the shell, comprising a recess formed in the edge of said bridging end removed from the junction of the winding leg and said bridging end.

References Cited in the file of this patent

UNITED STATES PATENTS

2,209,811	Dierstein	July 30, 1940
2,346,621	Sola	Apr. 11, 1944
2,509,187	Feinberg	May 23, 1950
2,671,951	Sliwiak	Mar. 16, 1954
2,713,666	Henderson	July 19, 1955
2,725,616	Epstein	Dec. 6, 1955
2,756,398	Feinberg	July 24, 1956