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York

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[54] WIRE CORE STRUCTURE FOR SANDWICH MATERIAL

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[73] Assignee: **Wire Core Development Corp.**

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[52] **U.S. Cl.** **29/191.6**, 52/664

[51] **Int. Cl.** **B21c 37/00**, E04c 2/42

[58] **Field of Search** 29/191–193.5; 52/664, 665, 669, 648, 650

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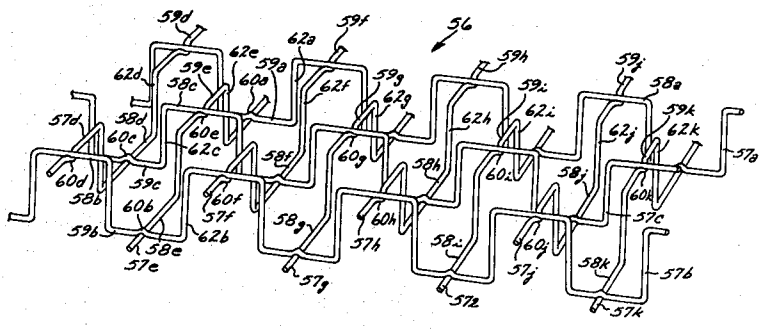
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[57] **ABSTRACT**

A wire core structure for sandwich material including a plurality of planar wire core ribbons which are formed of wire bent at right angles to form anchor sections on opposite sides of the core to engage the face sheets of the sandwich material—said core anchor sections being joined by joinder sections which extend at a right angle to the plane of the core structure. A notch is provided on the outside of some anchor sections to receive a cross wire extending in the plane of said core structure at a right angle to said core ribbons. Such notches are related to the diameter of said cross wires so that the cross wires will project slightly beyond the notch into which is received the cross wire, which spacing provides space for an adhesive, and yet, the cross wires may be deformed enough in welding to make the outer side of the cross wires generally flush with the outer sides of the anchor sections. In one embodiment there is a core ribbon which is serpentine and in one embodiment the ribbons are used in pairs which are offset to form a series of closed sections and a series of downwardly open sections and a series of upwardly open sections with a series of cross wires being received into said last mentioned downwardly open and upwardly open sections.

5 Claims, 13 Drawing Figures

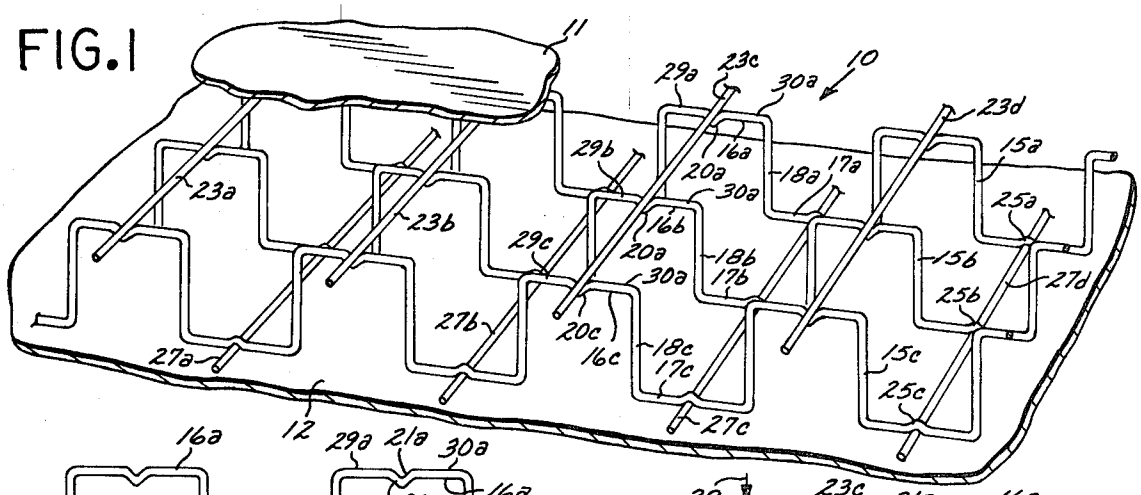


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SHEET 1 OF 3

FIG. 1



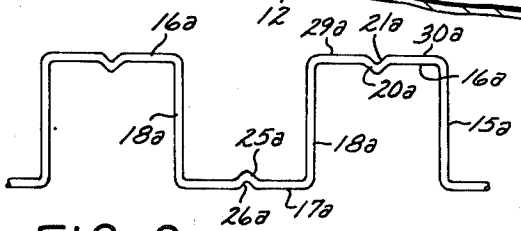


FIG. 2

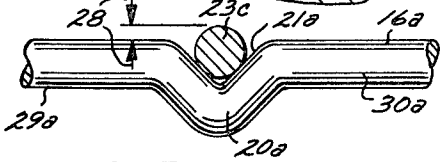


FIG. 3

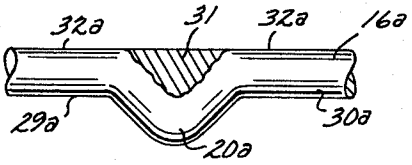


FIG. 4

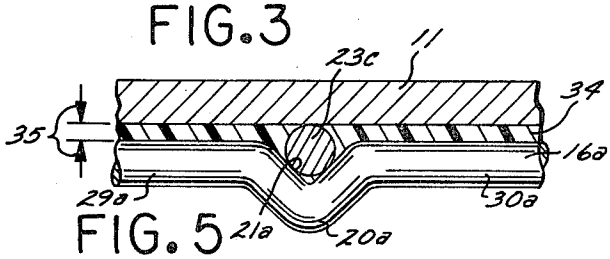


FIG. 5

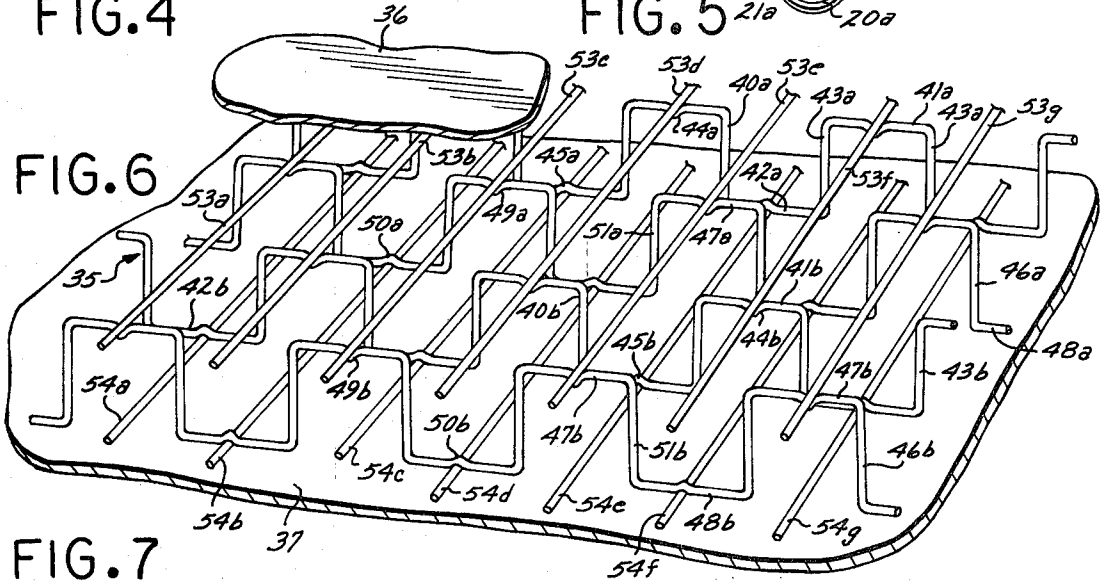


FIG. 6

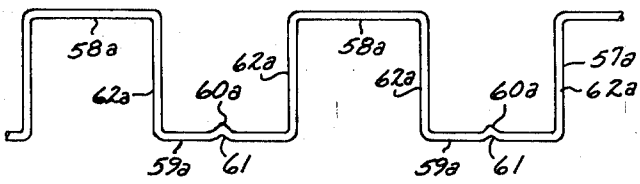


FIG. 7

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FIG. 8

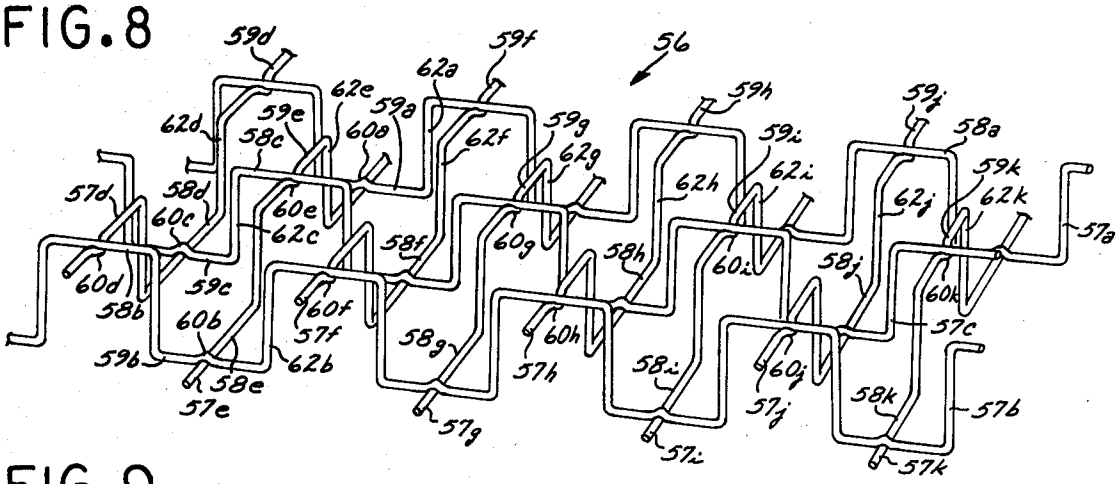


FIG. 9

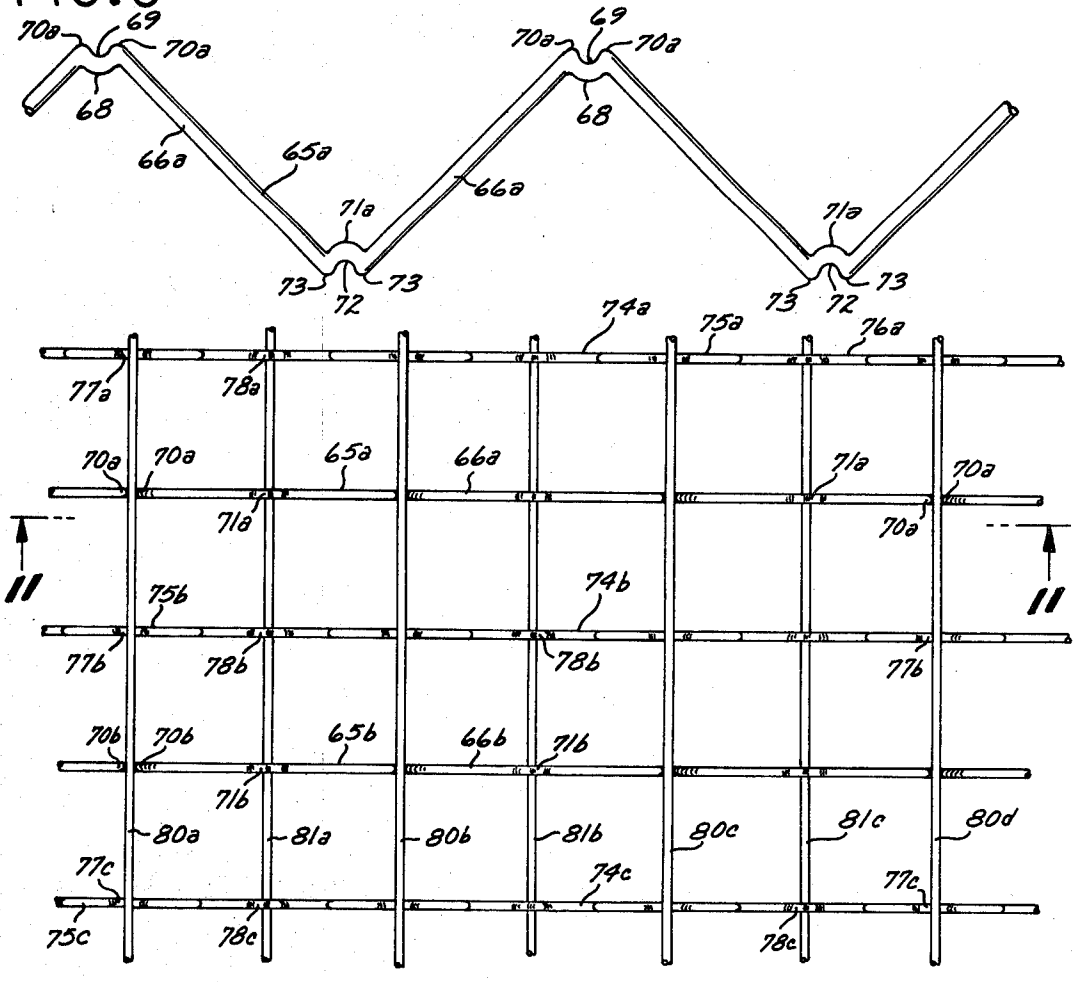


FIG. 10

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FIG. 11

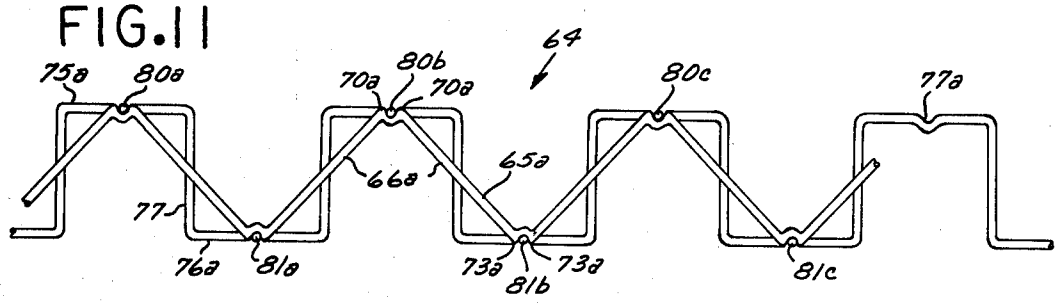
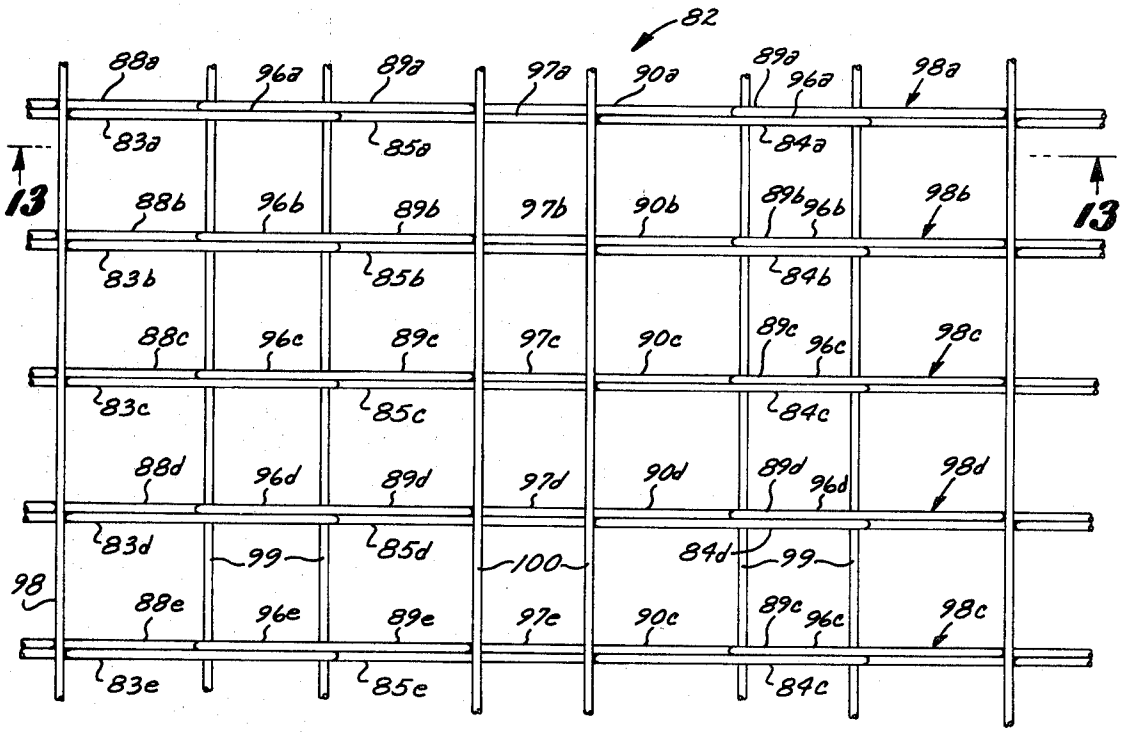


FIG. 12



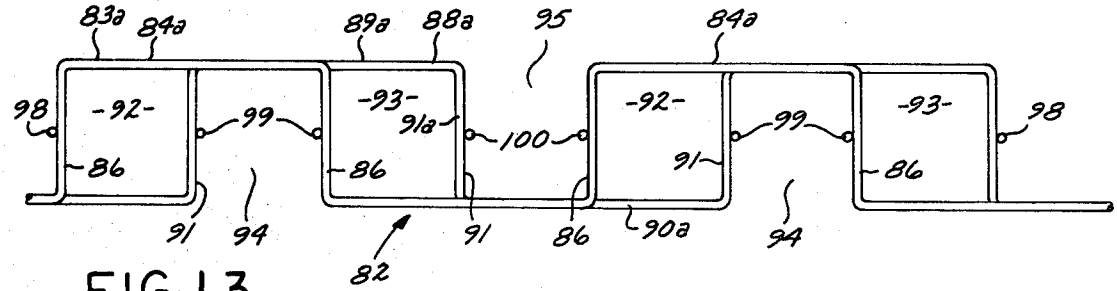


FIG. 13

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WIRE CORE STRUCTURE FOR SANDWICH MATERIAL

This invention relates to core structure for sandwich material, and more particularly to such core structure constructed of wire which has been bent and then joined together in order to provide the rigid low density core desired in sandwich material.

The present invention is used in sandwich material to provide a core structure of very light weight and yet very rigid construction. This core structure lies in a plane and has a face sheet joined to either side of the core material by means such as adhesive, or welding. Core structure has been previously constructed for sandwich structure, however, such core material has had the disadvantage of expense of manufacture and quality control.

Solely for purposes of establishing a frame of reference to relate together more easily the various components being described in this specification and the appended claims, the core structure will be described in terms of being placed in a position where the plane of the core structure forms a horizontal plane. The terms "upper" and "lower", and "upwardly" and "downwardly", "above", and "below", are used herein solely for purposes of relating the various components together and are not to be deemed limitive of the invention except as they relate the components together.

One principal aspect of the present invention is that it uses low cost wire material to form a series of core ribbons which are bent at right angles so as to look quite similar to a square wave. In the above mentioned horizontal orientation, these core ribbons have upper and lower anchor sections which extend generally parallel to the plane of the core material, and joinder sections extending perpendicular to the plane of the core material and joining the adjacent ones of the anchor section. This reduces the length of the joinder section, and thereby increases their ability (for any given diameter or structural strength) to resist forces tending to crush the face sheets of the sandwich material together. Additionally, the anchor sections are made sufficiently long that there is excellent area for adhesion between the said anchor sections and the face sheets.

Another aspect of the present invention is that the anchor sections of the core ribbons are provided with offset sections at approximately the mid-portion thereof, which offset sections form notches to receive cross wires of the core material, which cross wires extend at a right angle to the core ribbons and serve to join together adjacent parallel core ribbons. Thereby, the core ribbons are held in their desired orientation for purposes of fabrication of the sandwich material. And, after the sandwich material has been constructed, the cross wires assist in holding the core ribbons against motion relative to each other.

These notches are provided by offsetting a portion of the anchor section inward toward the center line of the core ribbon, and therefore, the center of the resultant core structure. Thereby, the notch is provided on the outer side of the anchor section which outer side is at a position to be engaged by, or juxtaposed to a face sheet when the resultant sandwich material is constructed.

Another aspect of the present invention is that said notches in the anchor sections have an effective depth which is slightly less than the diameter of the cross wires. The term "effective depth" as used herein means the distance that a cross wire is received in the notch. In measurement, a straight edge is placed across the particular anchor section on the outer side of the anchor section on which the notch is formed, i.e., the face sheet side of the anchor section.

This wire material has the advantages that the wire is readily available at comparatively low cost in a wide range of materials and sizes to provide a wide selection of strengths and characteristics in the final core structure. Further, the desired shapes can be constructed at very low cost. Further, the present core structure has the advantage that—as compared to, e.g., honeycombed core material, it has very few areas where the component elements of the core structure are joined together (and therefore, fewer areas for imperfect fabrication). And, the wire material is of such size that it can be easily, economically, and very reliably joined together by means such as welding.

Another aspect of the present invention is that resultant structure tends to minimize the paths for conducting heat from one face sheet to the other. This aspect of the invention is particularly useful in areas such as high speed aircraft.

Another aspect of the present invention is that there may be included between adjacent ones of the above described core ribbons, a core ribbon wherein the core ribbon is made in a serpentine shape and the joinder sections extend diagonally between anchor sections which are little longer than the width of the notches formed therein. Such structure has the advantage that the last mentioned core ribbons will assist in thwarting lateral movement of the face sheets relative to each other in the plane of such core ribbons.

Another major aspect of the present invention is that there can be provided core ribbons which are used in pairs laying along side each other. And, by offsetting said ribbons, there can be formed a resultant ribbon with a series of closed sections with upwardly and downwardly open sections alternately interspaced between adjacent ones of said closed sections. Then, by arranging such resultant box beam ribbons with said upwardly open sections in line and said downwardly open sections in line, the cross wires may be rapidly assembled for purposes of providing the desired core structure.

With the foregoing in mind, it is a major object of this invention to provide a new low cost core structure fabricated of wire material.

A further object of this invention is to provide wire core structure having extra strength with joinder sections extending at a right angle to the plane of the core structure.

It is still another object of this invention to provide a core structure wherein the core structure may be more securely secured to the face sheets of the sandwich material in which the core structure is used.

It is a still further object of this invention to provide an improved core structure having means for spacing core ribbons in the structure slightly away from the face sheets of the sandwich material with which the core structure is used in order to permit an adhesive to cover the entire area between the core ribbon anchor sections and the face sheet of the sandwich structure.

A further object of this invention is to provide an improved core structure having anchor sections of increased length in order to maximize the area for joinder of the core ribbons of the core structure to the face sheet of the sandwich structure.

It is still another object of this invention to provide a core structure wherein the component parts of the core structure may be more reliably joined together.

It is a still further object of this invention to provide a wire core structure wherein the core ribbons are so arranged as to provide a series of closed sections which may be aligned to form effective box beams in the core structure for additional strength in one direction of the core structure.

Another object of this invention is to provide an improved sandwich material resulting from the use of an improved core structure.

A further object of this invention is to provide an improved core structure wherein the heat transfer through the core structure is minimized.

A still further object of this invention to provide an improved core structure having anchor sections with notches formed therein for receiving cross wires of the core structure, which notches augment the securing of the cross wires to the core ribbons.

Still another object of this invention is to provide an improved core ribbon which may be manufactured in many different modified forms of the basic structure with little cost and adjustment in the machine making the core ribbon.

Other and furtherobjects of the invention will become apparent in the detailed description below in connection with the attached drawings wherein:

FIG. 1 is a perspective view of a first preferred form which may be taken by wire core structure incorporating principles of the present invention;

FIG. 2 is a somewhat enlarged fragmentary elevation view disclosing some further details of the wire core ribbon used in the core structure shown in FIG. 1;

FIG. 3 is a further enlarged fragmentary view disclosing detail of the manner in which the effective depth of a notch on an anchor section of the core ribbon is related to the diameter of a cross wire of the core structure;

FIG. 4 is an enlarged fragmentary view showing details in the deformation of a cross wire cross section after the process of joining the core ribbon to a cross wire by a welding process;

FIG. 5 is an enlarged fragmentary view disclosing in further detail the manner in which a cross wire will act as a spacer between an anchor section of a core ribbon and a face sheet;

FIG. 6 is a perspective view of a second preferred form which may be taken by wire core structure incorporating principles of the present invention, which wire core structure includes wire core ribbons like in the first embodiment but with the core ribbons being alternately offset with respect to each other;

FIG. 7 is a somewhat enlarged elevational view of a second preferred form that may be taken by a wire core ribbon incorporating principles of the present invention;

FIG. 8 is a perspective view of a third preferred form which may be taken by wire core structure incorporating principles of the present invention;

FIG. 9 is an enlarged fragmentary elevational view of a third preferred form that may be taken by a wire core ribbon incorporating principles of the present invention;

FIG. 10 is a plan view of a fourth preferred form which may be taken by wire core structure incorporating principles of the present invention, which core structure incorporates the wire core ribbon shown in FIG. 9;

FIG. 11 is a fragmentary core sectional view of the wire core structure shown in FIG. 10, taken along line 11—11 in said Fig.;

FIG. 12 is a plan view of a fifth preferred form which may be taken by wire core structure incorporating principles of the present invention; and,

FIG. 13 is a cross sectional view of the core structure shown in FIG. 12, taken along line 13—13 in said Fig.

Referring now to FIGS. 1 to 5, there will be described a first preferred form which may be taken by wire core structure incorporating principles of the present invention. In FIG. 1, there is shown such a first preferred form on the wire core structure, indicated generally by the arrow 10, which core structure is shown lying in a horizontal plane with an upper face sheet 11 on the upper side of the core structure and a lower face sheet 12 on the lower side of the core structure. Said face sheets 11 and 12 are secured to the core structure 10 by some desired means. The core structure 10 comprises a set of first core ribbons 15*a–c* which extend parallel to each other and lie in a plane which is at a right angle to the plane of the core structure. Each of these core ribbons are substantially identical. Accordingly, they have been given the same numeral designation with the difference being indicated by a letter. Each of the wire core ribbons 15*a–c* include a series of upper anchor sections 16*a–c*, and a series of lower anchor sections 17*a–c* which extend generally in the plane of the core structure 10. These anchor sections 16*a–c* and 17*a–c* are joined together in said core ribbons 15*a–c* by spacer sections 18*a–c*. For purposes of structural quality, it is preferred that the joinder sections 18*a–c* are substantially the same length as the anchor sections 16*a–c* and 17*a–c*. Accordingly, as can be seen, the wire core ribbons 15*a–c* are formed with the wire being bent at right angles in order to form structure which looks much like a square wave. This serves to maximize the area which is available for securing the anchor sections 16*a–c* and 17*a–c* to the face sheets 11 and 12 respectively, and serves to minimize the length of the joinder sections 18*a–c*. It will also be noted that each of the core ribbons 15*a–c* lie in a plane which is at a right angle to the plane of the core structure 10, i.e., with the upper anchor sections 16*a–c* respectively in line with the lower anchor sections 17*a–c*. Also, the anchor sections 16*a–c* and 17*a–c* are spaced apart equally.

For purposes which will be described, there is provided in each of the anchor sections 16*a–c* and 17*a–c* means for assisting in the securing of the cross wires to the core ribbons 15*a–c*. Referring now to FIGS. 2 and 3 which disclose details of the core ribbon 15*a*, it can be seen that each upper anchor section 16*a* has an offset portion 20*a* offset toward the center of core ribbon in order to provide a notch 21*a* on the outer side of the anchor section. At such position it faces the face sheet 11. Each such notch, as notch 21*a*, serves during the manufacture of the core structure 10 to index cross wires. As can be seen in FIG. 1, upper cross wires 23*a–d* extend parallel to each other in the plane of the core structure 10, and at a right angle to the various core ribbons 15*a–c*. Each of these cross wires 23*a–d* are received in a corresponding notch 21*a* on a corresponding anchor section 16*a*.

As in the case of the upper anchor sections 16*a–c*, the lower anchor sections 17*a–c* are deformed toward the center of the core structure as at 25*a–c* in order to provide notches on the outer side facing the face sheet 12.

In FIG. 2 which shows the core ribbon 15*a*, it can be seen that offset 25*a* provides a notch 26*a* on the bottom side of each anchor section 17*a*, which bottom side would be the outer side of the anchor section.

Referring now to FIGS. 2 and 3, the qualities of the notches will be described in further detail as related to a particular notch 21*a* in one of the upper anchor sections 16*a*. As can be seen, it is preferred that the offset portion 20*a* be approximately mid-way of the length of the anchor section 16*a* in order to divide the said anchor section into a left portion 29*a* and a right portion 30*a*. It will also be noted that the effective depth of the notch 21*a* is such that the cross wire 23 projects above the upper side of the anchor section 16*a* by a distance indicated by dimension arrows 28. The term "effective depth" as used herein has relation to the distance into the particular notch that a particular cross wire will extend as measured from the outer side of the anchor section.

In practice, the notches are oftentimes not formed in the anchor sections as nicely as shown in said FIG. 3. More particularly, many times the portions 29*a* and 30*a* are joined to the offset portion 28 by a section of greater curvature than those shown in said FIG. 3. Because of this, the term "effective depth" of the notch is meant that the depth which the cross wire can extend into the particular notch which depth is measured from a straight line extending across the outer side of the anchor sections. In other words, the distance which would be measured if a straight edge were laid across the outer side of the anchor section (which straight edge would be uneffected by any curvature occurring in the anchor section) and then measuring the amount of the cross diameter of the cross wire which extends into the notch from such straight edge.

One primary means of joining the cross wires 23*a–d* and 27*a–d* to the core ribbons is that of welding. Referring now to FIG. 4, the manner of joining one of the cross wires to an upper anchor section 16*a* will now be described. The weld is accomplished by applying pressure electrodes on the top side of the cross wire into the bottom of the offset portion 20*a*. This causes the cross wire to deform during the heat of the weld process, and take on a resulting cross section which looks like weld cross section 31 which fills the notch. Preferably, the upper edge of the weld section 31 is flush with the upper or outer edge 32*a* of the anchor section 16*a*. In those cases where the notch is not formed as sharply as shown, and there is additional curvature between the offset portion (e.g., 20*a*) and the left and right hand portions (e.g., 29*a* and 30*a*) of an anchor section (e.g., 16*a*) the weld cross section 31 would not take on the substantially triangular cross section shown if FIG. 4. Rather, there would only be partial deformation of the cross section of the wire core. However, it is preferred—even in such latter mentioned cases— that the outer side of the cross

wire be flush with a straight line extending across the outer edge of the corresponding anchor section, or project beyond said line a desired amount. If the face sheets **11** and **12** are going to be welded to the core structure **10**, it would be preferred that the cross wires be flush with such straight line across the outer side of the anchor section. If the face sheets **11** and **12** are going to be connected to the core structure **10** by means of brazing, or adhesive, it is preferred that the cross wire project beyond such last mentioned straight line approximately one-eighth of the diameter of the cross wire.

Referring now to FIG. **5**, there is shown details of the manner of connecting the core structure to the upper face sheet **11** by means of adhesive. In this Fig., it can be seen that the effective depth of the notch **21a** is such that the cross wire **23***c* projects beyond the outer side of the anchor section **16***a*. Preferably, this is approximately one-eighth of the diameter of the cross wire **23***c*. Therefore, the face sheet **11** is spaced slightly away from the anchor section **16***a*. This slight spacing is desired in order that an adhesive **34** can cover the entire area between the face sheet **11** and the anchor section **16***a*. The thickness of the adhesive **34** (as demonstrated by dimension arrows **35**) is greatly exaggerated in FIG. **5**. The cross wires may be joined to the core ribbons by means of welding. Or, if desired, the cross wires may also be held to the respective anchor sections by means of adhesive. In such latter case, it would be preferred that the cross wires be adhesively bonded to the core ribbons in order to form a core structure which will maintain the proper relationship between its components during the adhesion of the face sheets to the core structure.

Referring now to FIG. **6**, there is shown a second preferred form which may be taken by wire core structure incorporating principles of the present invention. In said FIG. **6**, there is shown a wire core structure, indicated generally by the arrow **35**, located between upper and lower face sheets **36** and **37** respectively, to which the core structure is secured by some desired means. The core structure **35** is made of exactly the same components as the core structure **10** except that the wire core ribbons have been alternately offset. More particularly, the core structure **35** includes a plurality, or set, of first core ribbons **40***a–b* which are just like the core ribbons **15***a–c* and are positioned in parallel, equidistant relation. Such first core ribbons **40***a–b* include upper anchor sections, **41***a–b* respectively, and lower anchor sections, **42***a–b* respectively. Additionally, offset portions **44***a–b* in the upper anchor sections, **41***a–b* respectively, and the lower offset portions, **45***a–b* respectively, in the lower anchor sections, **42***a–b* respectively are provided to supply notches for the purposes described above in relation to the wire core ribbons **15***a–c*.

The core structure **35** also includes a set of second core ribbons **46***a–b*, and are positioned in parallel, equidistant relation. More particularly, the set of second core ribbons **46***a–b*, include upper anchor sections, **47***a–b* respectively, and lower anchor sections, **48***a–b* respectively, each lying in the plane of the core structure **35**, and each including offset portions, **49***a–b* respectively and **50***a* respectively. Joinder sections **51***a–b* join the upper anchor sections, **47***a–b* respectively, and the lower anchor sections, **48***a–b*, respectively.

Extending across the top side of the core structure **35** are a plurality of upper cross wires **53***a–g* which are received in the corresponding notches in the upper anchor sections **41***a–b* of the first core ribbons, **40***a–b* respectively and the upper anchor sections **47***a–b* of the second core ribbons, **46***a–b* respectively. As can be seen, the second core ribbons **46***a–b* are offset from the first core ribbons **40***a–b* a distance equal to the length of an anchor section. Accordingly, each of the upper cross wires **53***a–g* is only secured to every other core ribbon. More particularly, upper cross wires **53***b*, *d*, and *f* are connected to the upper anchor sections **41***a–b* of the second core ribbons, **46***a–b* respectively. Positioned between the core ribbons **40***a–b* and **46***a–b*, and the lower face sheet **37**, there are provided a series of lower cross wires **54***a–g*. Individual ones of these cross wires **54***a–g* are directly below corresponding individual ones of the upper cross wires **53***a–g*. For the same reason as mentioned in connection with the upper cross wires **53***a–g*, every other lower cross wire, to wit, lower cross wires **54***a*, *c*, *e*, and *g*, are connected to the lower anchor sections **42***a–b* of the first core ribbons, **40***a–b* respectively. And, the remaining alternate lower cross wires, to wit, lower cross wires **54***b*, *d*, and *f*, are connected to the lower anchor sections **48***a–b* of the second core ribbons, **46***a–b* respectively.

As can be seen, there are twice as many cross wires in the core structure **35** as in the core structure **10**. Although this does add to the weight, the core structure **35** is stronger than the core structure **10**.

The relationship between the notches formed by offset portions **44***a–b*, **45***a–b*, **49***a–b*, and **50***a–b* with their associated cross wires **53***a–g* and **54***a–g* is substantially the same as previously described. Therefore, it will not be described again in connection with the core structure **35**.

Referring now to FIGS. **7** and **8**, there will be described a third preferred form which may be taken by wire core structure incorporating principles of the present invention. In FIG. **8**, there is shown such third preferred form of wire core structure, indicated generally by the arrow **56**. The core structure **56** is made up of wire core ribbons which are all the same, some of which extend in one direction, and the others of which extend at a right angle thereto. And, the core structure **56** does not include cross wires as in the previously described core structures **10** and **35**.

The core structure **56** includes a set of parallel and equidistant first core ribbons **57***a–b* which are interspaced between a set of parallel and equidistant second core ribbons (of which only second core ribbon **57***c* is shown). And, as in the case of the core structure **35**, the second core ribbons, e.g., **57***c*, are offset longitudinally from the first core ribbons **57***a–b* a distance equal to one anchor section. Extending at a right angle to the core ribbons **57***a–c* there are provided a set of parallel and equidistant third core ribbons **57***d*, *f*, *h*, and *j* which are parallel to each other and spaced between a set of parallel and equidistant fourth core ribbons **57***e*, *g*, *i*, and *k*, which are also parallel to each other and equidistant apart. As can be seen, each of the core ribbons **57***a–k* lie in a separate plane which is perpendicular to the plane of the core structure **56**.

Referring now to FIG. **7**, the further details of the core ribbon **57***a* will be described in further detail. As in the prior core ribbons **15***a–c*, **40***a–b*, and **46***a–b*, the core ribbon **57***a* is formed of a wire which is bent at a series of right angles in order to provide a ribbon looking rather like a square wave with the anchor sections being equal to the joinder sections between the anchor sections. More particularly, the core ribbon **57***a* has a series of plane anchor sections **58***a* and notched anchor sections **59***a*, each of which lie generally in the plane of the core structure **56**. The notched anchor sections **59***a* are offset inward toward the center of the ribbon, **60***a*, in order to provide a notch **61** at the mid-portion of the notched anchor section. These anchor sections **58***a* and **59***a* are joined together by joinder sections **62***a* extending at a right angle to the anchor sections **58***a* and **59***a* as in the previously described core ribbons. It will be noted that the core ribbon **57***a* is different from the core ribbons **15***a–c*, **40***a–b*, and **46***a–b* in that there is a notch provided only on the anchor sections on one side of the core ribbon, to wit, notched anchor sections **59***a* and not on the other side, to wit, plain anchor sections **58***a*. This is for a purpose which will be described.

Referring back to FIG. **8**, it can be seen that the various portions of the various wire core ribbons **57***a–k* are all identical, and therefore, they have been given the same number with a different letter suffix for purposes of reference. More particularly, in FIG. **8**, it can be seen that the core ribbons **57***a–k* have plain anchor sections **58***a–k* and notched anchor sections **59***a–k* which anchor sections are joined by joinder sections **62***a–k*. Additionally, each of the notched anchor sections **59***a–k* is provided with an offset at **60***a–k* for the purpose of providing the notch for the anchor section.

The purpose for providing a notch in the anchor sections on only one side will now be described. By way of example, it can be seen that the plain anchor section **58***c* extends through the particular notch provided by offset portion **60***e* in the notched anchor section **59***e*. If both the anchor section **58***c* and the anchor section **59***e* were notched, there would not be a proper matching of the parts.

The diameter of the plain anchor sections **59***a–k* are related to the notches provided in the notched anchor sections **59***a–k* in the same manner as the prior embodiments and the core ribbons **57***a–k* are joined together by means of welding or adhesives such as described previously. Therefore, they will not be described herein again.

It can be seen that substantially the same machine which would make wire core ribbons **15***a–c*, **40***a–b* and/or **46***a–b* could be used to easily make the wire core ribbons **57***a–k*. This reduces the cost of manufacture of the core structure.

Referring now to FIGS. **9** to **11**, there will be described a fourth preferred form which may be taken by core structure incorporating the principles of the present invention. In said Figs., there is shown such a third preferred core structure, indicated generally by the arrow **64**. This core structure **64** has as its every other core ribbon a third preferred form which may be taken by core ribbons incorporating principles of the present invention. As can be seen in said FIGS. **9** to **11**, said third preferred form of the core ribbon is a serpentine core ribbon. More particularly, there are provided serpentine core ribbons **65***a–b;* said ribbons having the same number with a separate letter suffix as they are the same. As best seen in FIG. **9**, the serpentine core ribbon **65***a* has very short anchor sections at each apex of the serpentine form. More particularly, the serpentine ribbon **65***a* has joinder sections **66***a* extending diagonally between the apex portions where the sections are located. At each upper apex, there is located an offset portion **68** in order to provide a notch **69** for purposes which will be described. On either side of said notch **69**, there is a protuberant portion **70***a*. At the lower apexes of the core ribbon **65***a*, there is provided offset portions **71***a* in order to provide a downwardly facing notch **72** having a protuberant portion **73** on either side thereof.

Between each pair of adjacent serpentine core ribbons, there is provided a core ribbon like the first preferred form **15***a–c*. In FIGS. **10** and **11**, it can be seen that core ribbons **74***a–c* each include upper anchor sections **75***a–c* and lower anchor sections **76***a–c* lying generally in the plane of the core structure **64**. In the upper anchor sections **75***a–c*, there are provided upper notches **77***a–c* for purposes to be described, which notches are the same as notch **21***a*. In the lower anchor sections **76***a–c* there are provided offset portions at **78***a–c* for purposes of providing downwardly facing notches which are the same as notch **26***a*. For purposes of holding the serpentine core ribbons **65***a* and *b* in their desired parallel relationship with the core ribbons **74***a–c*, there are provided a plurality of upper cross wires **80***a–d* which are the direct parallel of the upper cross wires **23***a–d*. That is, the upper cross wires **80***a–d* extend through the notches in the upper apex of the serpentine core ribbons **65***a–b* and the notches **77***a–c* in the upper anchor sections **75**a-c of the core ribbons **74***a–c;* said cross wires being joined to said core ribbons in any desired manner such as, for example, previously described.

Correspondingly, the lower cross wires **81***a–c* are the direct counterpart of the cross wires **27***a–d*, and extend through the notches in the lower apexes of the serpentine core ribbons **65***a–b* (such as notch **72** in FIG. **9**), and through the downwardly facing notches provided by the offset portions **78***a–c;* said cross wires being connected to said core ribbons in a manner such as described in connection with the cross wires **27***a–d*.

The relation of the cross wires **80***a–d* and **81***a–c* to the notches through which they extend is substantially the same as described in connection with the core structure **10** and need not be described further except as follows. In the case of the serpentine core ribbons **65***a* and *b*, the protuberant portions **70***a* and **73** provide what is equivalent of the outside edge of the anchor sections in the core ribbons **15***a–c*.

Referring now to FIGS. **12** and **13**, there will be described a fifth preferred form which may be taken by core structure incorporating principles of the present invention. In said FIGS. **12** and **13**, there is shown a fifth preferred form of core structure which incorporates the principles of the present invention, which core structure is indicated generally by the arrow **82**. As will be described, the core ribbons of this core structure **82** are very similar to the previously described core ribbons **15***a–c* with the exception that each anchor section is preferably twice as long as compared to the joinder sections of the core ribbon. Then, by using such core ribbons in pairs and offsetting one core ribbon of each pair relative to the other can be provided a resultant box beam core ribbon having a series of closed sections which are alternately spaced apart by upwardly open and downwardly open sections.

Referring to said FIGS. **12** and **13** in more detail, it can be seen that there are provided a set of first core ribbons **83***a–e* extending parallel to each other in equidistant relation. Each of these core ribbons **83***a–e* has a series of upper anchor sections **84***a–e* and lower anchor sections **85***a–e* which lie generally in the plane of the core structure. As in the prior embodiments, the anchor sections **84***a–e* and **85***a–e* are joined by vertical joinder sections (only joinder sections **86***a* can be seen in the drawings—in FIG. **13**).

The core structure **82** also includes a set of second core ribbons **88***a–e* which are substantially the same as the first core ribbons **83***a–e*. More particularly, each of the second core ribbons **88***a–e* includes a series of upper anchor sections **89***a–e* and lower anchor sections **90***a–e* extending generally in the plane of the core structure **82**. Said upper anchor sections **89***a–e* and lower anchor sections **90***a–e* are joined by joinder sections (however, only joinder sections **91***a* can be seen in the drawings—in FIG. **12**).

As can be seen, each of the second core ribbons **88***a–e* are positioned along side and in contiguous relationship with a corresponding one of the first core ribbons **83***a–e*. Further, each of said second core ribbons **88***a–e* are offset from the associated one of the first core ribbons **83***a–e* a distance approximately equal to the thickness of the core structure **82** (i.e., the length of the joinder sections of the core ribbons). As best seen in FIG. **13** in relation to the core ribbons **83***a* and **88***a*, there is provided a plurality of closed box sections **92** which are enclosed by a joinder section **86***a* and part of an upper anchor section **84***a* of the first core ribbon **83***a* and a joinder section **91***a* and part of a lower anchor section **90***a* of the second core ribbon **88***a*. Additionally, there is provided a series of closed box beams sections **93** which are enclosed by a joinder section **86***a* and part of a lower anchor section **85***a* of the first core ribbon **83***a* and a joinder section **91***a* and part of an anchor section **89***a* of the second core ribbon **88***a*.

Further, there is provided a downwardly open section **94** between each pair of joinder sections **86***a* and **91***a* which downwardly open sections are closed at their upper sides by portions of said upper anchor sections **84***a* and **89***a*. Further, there is provided a series of upwardly open sections **95** which are partially surrounded by said joinder sections **86***a* and **91***a* and are closed portions of lower anchor sections **85***a* and **90***a*.

As best seen in FIG. **12**, the first core ribbons **83***a–e* are joined to the second core ribbons **88***a–e* along portions of their respective anchor sections. More particularly, the anchor sections **84***a–e* are joined to the anchor sections **89***a–e* along joinder lines **96***a–e* respectively. And, the lower anchor sections **85***a–e* and **90***a–e* are joined together along joinder lines **97***a–e* respectively. The joinder is accomplished by welding, or adhesive, means. With the core ribbons **83***a–e* and **88***a–e* thus joined together there are provided resultant box beam core ribbons, indicated generally by the arrows **98***a–e*. These resultant box beam core ribbons **98***a–e* give extra strength.

In order to hold the resultant box beam core ribbons **98***a–e* in their desired parallel relations, they are placed so that the downwardly open sections **94** are in line. In this relation, a pair

of cross wires **99** may be received up into the downwardly open sections **94** and then connected to the joinder sections **86** and **91** on either side of said downwardly open section. Such connection can be accomplished simultaneously by having movable welding electrodes which can force the respective cross wires **89** outwardly against their respective joinder sections **86** and **91**. Received in each of the upwardly open sections **95**, there are a pair of cross wires **100**. Said cross wires **100** are connected to the joinder sections **86** and **91** on opposite sides of the upwardly open section in the same manner described in connection with the downwardly open section **94**.

While only a few embodiments of the present invention have been shown and described in detail, it will be apparent to those skilled in the art that such is by way of illustration only, and numerous changes can be made thereto without departing from the spirit of the present invention.

I claim:

1. A core structure of predetermined thickness adapted to be placed between two face sheets to form sandwich material, said core structure defining a horizontal plane and comprising:

a set of first core ribbons extending generally parallel to each other in a first direction, each of said first core ribbons having alternating upper and lower anchor sections extending generally parallel to said plane with a spacer section joining each adjacent upper and lower anchor section, each of said first core ribbons defining a vertical plane, at least some of said spacer sections on at least some of said ribbons extending at substantially a right angle to said plane of said core material, at least some of said anchor sections having on their outer sides which face away from the center of the core material a notch;

a set of cross wires extending parallel to each other in the plane of said core material and at a right angle to said first core ribbons, said cross wires being rigidly connected to said core ribbons so as to stabilize said core ribbons relative to each other, each of said notches at least partially receiving therein one of said cross wires;

and including a set of second core ribbons extending parallel to each other and to said first core ribbons, core ribbons of said second core ribbons being spaced alternately between adjacent ones of said first core ribbons, said second core ribbons having alternately upper and lower anchor sections joined by spacer sections, said anchor sections and spacer sections of said second core ribbons being substantially the same as said first core ribbons, said second ribbons being offset from said first ribbons such that a first one of said cross wires extending across the upper anchor sections of two adjacent ones of said first ribbons will be in line with a lower anchor section of a second core ribbon which is located between the last mentioned two first core ribbons.

2. The core structure set forth in claim **1** wherein:

said first one of said cross wires is in line with but spaced above said last mentioned lower anchor section.

3. The core structure set forth in claim **1** wherein said first one of said cross wires is shaped like said core ribbons and has upper and lower anchor sections extending generally in plane of the core structure with a spacer section joining each adjacent pair of upper and lower anchor sections, and each upper anchor section of said last mentioned cross wire is connected to an upper anchor section of a core ribbon and each lower anchor section of said last mentioned cross wire is connected to a lower anchor section of a core ribbon.

4. A core structure of predetermined thickness adapted to be placed between two face sheets to form sandwich material, said core structure defining a horizontal plane and comprising:

a set of first core ribbons extending generally parallel to each other in a first direction, each of said first core ribbons having alternating upper and lower anchor sections extending generally parallel to said plane with a spacer section joining each adjacent upper and lower anchor section, each of said first core ribbons defining a vertical plane, at least some of said spacer sections on at least some of said ribbons extending at substantially a right angle to said plane of said core material;

a set of second core ribbons extending parallel to each other and to said first core ribbons, core ribbons of said second core ribbons being spaced alternately between adjacent ones of said first core ribbons, said second core ribbons having alternately upper and lower anchor sections joined by spacer sections, said anchor sections and spacer sections of said second core ribbons being substantially the same as said first core ribbons, said second core ribbons being offset from said first ribbons such that the upper anchor sections of two adjacent ones of said first ribbons will be in the same vertical plane with a lower anchor section of a second core ribbon which is located between said last mentioned two first core ribbons;

and a set of cross wires extending parallel to each other generally in the plane of said core material and being at a substantial angle to said first and second core ribbons, said cross wires being rigidly connected to said core ribbons at said anchor sections so as to stabilize said core ribbons relative to each other, at least some of said cross wires being shaped like said core ribbons and having upper and lower anchor sections extending generally in the plane of the core structure with a spacer section joining each adjacent pair of upper and lower anchor sections, and each upper anchor section of said last mentioned cross wires is connected to an upper anchor section of a core ribbon and each lower anchor section of said last mentioned cross wires is connected to a lower anchor section of a core ribbon.

5. The core structure set forth in claim **4** wherein at least some of said anchor sections are connected together by a weld of the material of which the core ribbons and cross wires are made.

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