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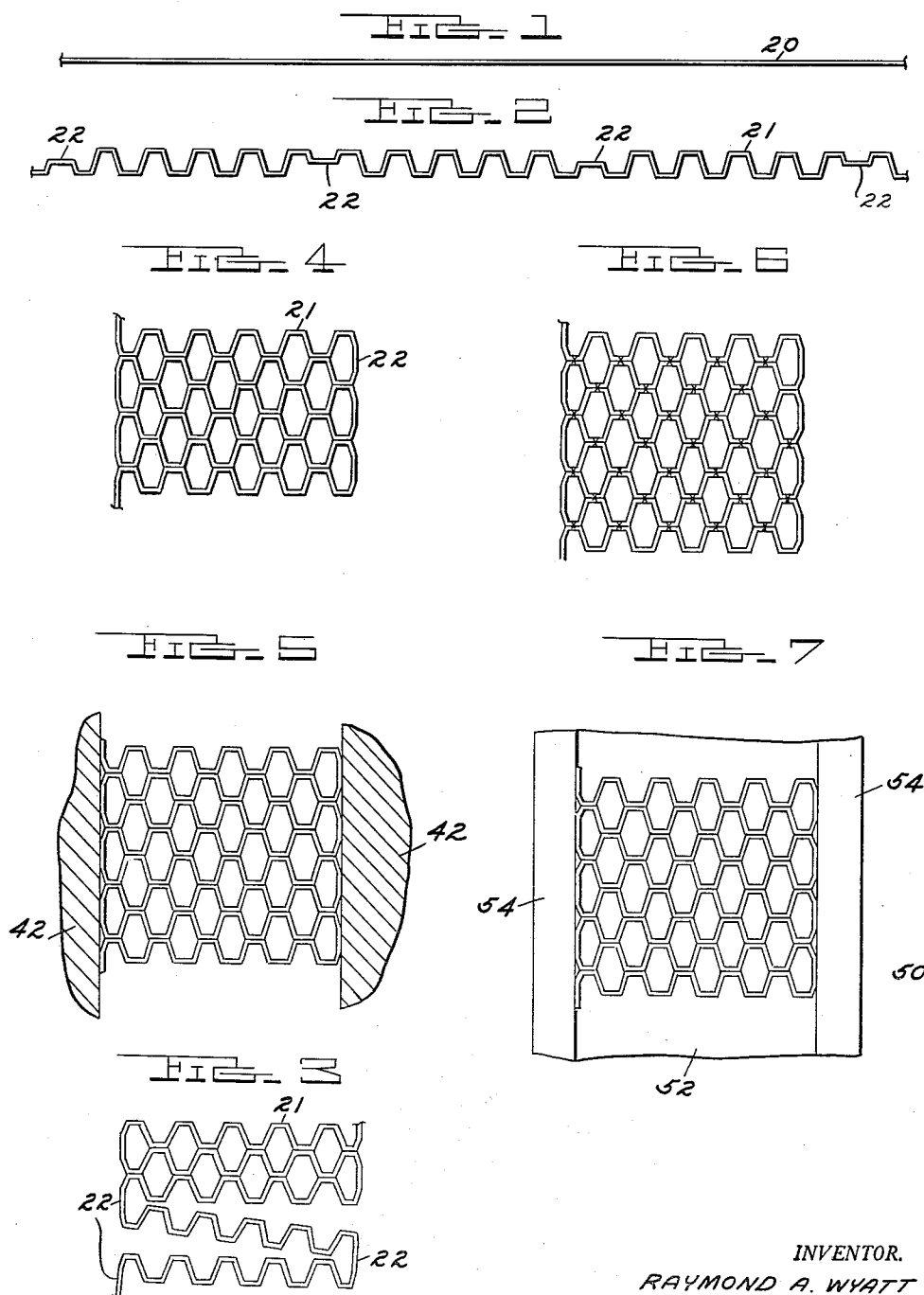
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CELLULAR CORE AND PROCESS OF MAKING IT

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2 Sheets-Sheet 1



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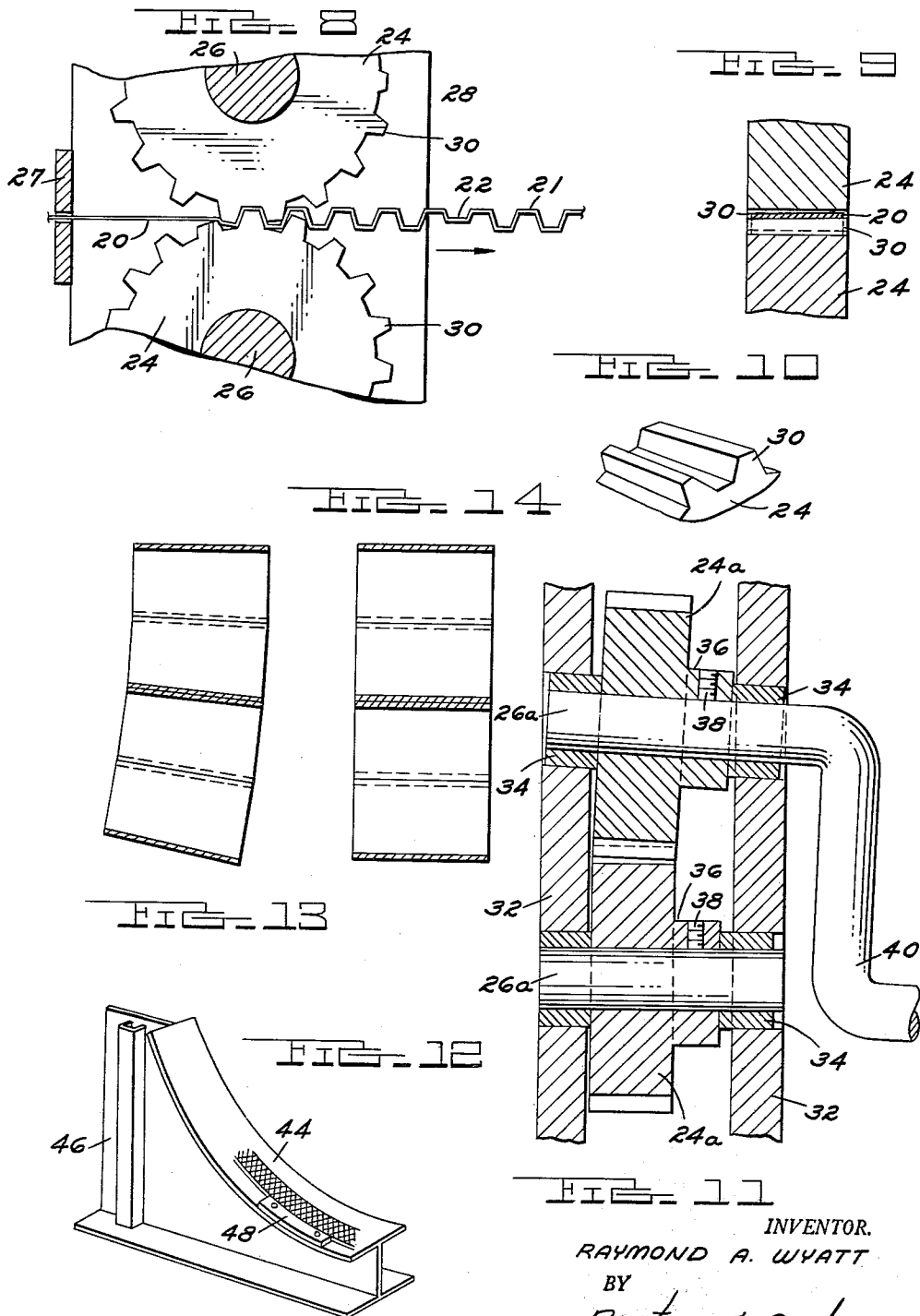
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CELLULAR CORE AND PROCESS OF MAKING IT
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8 Claims. (Cl. 189-34)

This invention relates to an improved cellular core and to an improved process of fabricating the same.

An object of the invention is the provision of a cellular core formed from a metal ribbon in such manner as to exhibit a multitude of similar honeycomb-like cells secured together to provide a unitary structural core of a desired shape, and the provision of an improved method of shaping the metal ribbon to so fabricate such a core from the ribbon.

One particular object is the provision of an annular core of the character described wherein the inner surface of the annulus is formed by one edge of the ribbon, which ribbon has been shaped into honeycomb-like cells, and the outer circumference of the annulus is formed by the outer edge of the ribbon. Preferably, in order to hold the core built up out of the ribbon in its determined annular shape, it is mounted within an annular supporting band, which band may be generally channel-shaped in cross section. The several cells of the core may be welded or brazed or otherwise secured together and the assembled core structure may be brazed or otherwise secured within the channel-shaped supporting band.

In the formation of a cellular core in the shape of an annulus, the core may be formed of a ribbon of suitable material such as stainless steel, which ribbon is so corrugated and then so fan-folded that the individual honeycomb cells which make up the core have a greater interior dimension in one direction at one end than at the other, being individually somewhat wedge-shaped lengthwise of the cells whereby, when the corrugated ribbon is fan-folded to form the cellular core, the ends of the cells of lesser dimension form the inner circumference of the annulus and the ends of the cells of greater dimension form the outer circumference of the annulus.

A cellular annular core of the character hereinabove referred to has one particular use in turbine type aircraft engines and is commonly referred to as an engine core. The turbine blade assembly rotates within the core and the ends of the blades sweep the inner circumference of the engine core.

It is also an object of this invention to provide an improved process of fabricating a core of the character above defined and a process wherein a single ribbon of suitable metal having a desired width is corrugated to provide a succession of substantially equally spaced corrugations extending transversely of the ribbon, and wherein such corrugations are separated into successive groups of corrugations by linear ribbon intervals so formed that the ribbon may be readily fan-folded at the intervals to bring the nodes of corresponding corrugations of adjacent fan-fold sections into back-to-back abutment for securement together.

A feature of importance is that the ribbon intervals between successive groups of corrugations each includes a corrugation of less height than the corrugations which make up the groups, and the fan-folding is so carried out that the lines of bend occur at the intervals and the corrugation of less height included within the interval is somewhat flattened out during the fabrication of the core, so that the resulting honeycomb cells are substantially uniformly shaped.

An important step in the process of fabricating an annular core of the character set forth is the corrugating of the ribbon in such a manner that the ends of the corru-

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gations adjacent to one edge of the ribbon are of less height than the ends of the corrugations adjacent to the opposite edge of the ribbon. As a result of this, when the corrugated ribbon is fan-folded and the nodes of corresponding corrugations of adjacent groups of corrugations are brought into abutment back to back to form the honeycomb cells, such honeycomb cells exhibit a transverse dimension along one edge of the fan-folded ribbon less than the corresponding transverse dimension of the same cells along the opposite edge of the corrugated fan-folded ribbon and the ends of the cells of less dimension define the inner circumference of the annulus and the opposite ends of the cells define the outer circumference of the annulus.

Other objects, advantages, and meritorious features of the invention will more fully appear from the following description, claims, and accompanying drawing, wherein:

FIG. 1 shows an edge elevation of a metal ribbon such as is suitable for use in fabricating my cellular core;

FIG. 2 shows the same ribbon and edge elevation after it has been corrugated to carry out the process of the application as herein set forth;

FIG. 3 is an edge elevation of the same ribbon in the process of being fan-folded as herein set forth;

FIG. 4 is an edge elevation of the same ribbon following the fan-folding thereof into a compact cellular honeycomb character;

FIG. 5 is a view of the structure clamped in a vise to bring the same to a determined size;

FIG. 6 is a view of a structure similar to FIG. 4 showing the nodes of corresponding corrugations and adjacent fan-fold sections not only brought into back-to-back engagement but also welded together;

FIG. 7 is a view similar to FIG. 6 but showing the honeycomb cellular core disposed within a supporting channel-shaped band;

FIG. 8 is a fragmentary schematic illustration of suitable corrugating mechanism operating on a flat ribbon to corrugate it;

FIG. 9 is a fragmentary sectional view through the teeth of FIG. 8 showing the sloping character of the outer face of the teeth required to impart the desired taper to the corrugations;

FIG. 10 is a fragmentary perspective showing two teeth of one of the rolls as the same are tapered from a greater height at one end to a lesser height at the opposite end;

FIG. 11 is a sectional view through a modified form of corrugating mechanism as compared with that in FIG. 8;

FIG. 12 illustrates a simple arcuate jig upon which a length of cellular core may be supported to carry out the welding of the honeycomb cells together;

FIG. 13 is a fragmentary section through a honeycomb cellular core of the character described showing the arcuate contour thereof.

FIG. 14 is a fragmentary section through a honeycomb cellular core of the character herein described but showing the same in a flat planar form.

In the drawings a flat ribbon, which may be made of stainless steel or any other suitable metal, is shown in edge elevation in FIG. 1 and indicated by the numeral 20. Such ribbon may be corrugated as hereinafter described into the shape illustrated in FIG. 2 wherein it will be noted that every tenth corrugation is of a lesser height. Normally the corrugations are equal and equally spaced but each tenth corrugation, or as desired, which is indicated by the numeral 22, is shown of a height about one-half the height of the remaining corrugations. The normal corrugations are indicated by the numeral 21.

One manner in which this corrugating may be carried out is illustrated in FIG. 8. Such figure illustrates co-

operating complementary rolls 24. Each roll is mounted upon an axle 26, and supported within a suitable frame, a part of which is indicated at 27. These rolls are adapted to mesh together as shown. It will be noted that each roll shows a low tooth 28 followed by a series or group of teeth of normal height. Such series or group here consists of nine teeth though any desired number might be used. The arcuate extent of the rolls shown here is not sufficient to show such ten teeth in succession.

The roll teeth taper in height from one side of the roll to the other as shown in FIGS. 9 and 10. This inclination of the teeth may be most easily seen in FIG. 10 in which it will be noted that each of the teeth slopes from the right toward the left on the sheet. This inclination of the teeth is small but it is such that when the ribbon is corrugated between such teeth of meshing rolls, the corrugations taper from one edge of the ribbon to a less height at the opposite edge of the ribbon.

In FIG. 11 there is illustrated another mechanism slightly modified from that shown in FIG. 8 to accomplish the same result as shown in FIG. 8 of not only corrugating but of tapering the corrugations of the ribbon. In FIG. 11 a portion of a frame is indicated as 32. Roll wheels 24a, mounted upon shafts 26a, are supported between the frame elements 32 for rotation. These rolls may be secured upon the shafts by and between suitable bushing bearing elements 34. Each roll is shown as having a hub portion 36 secured by a set screw 38 to the shaft to rotate with the shaft. The shaft of the uppermost roll shown in the figure is provided at one end with a hand crank or the like 40.

It will be noted that the shaft provided with the crank 40 is inclined with respect to the shaft of the other roll so that the teeth of the rolls as they mesh are slightly inclined as shown in such figures with respect to each other. Due to this inclination of the teeth the ribbon, which is passed between these rolls to be corrugated, has its corrugations tapered in a manner similar to that hereinabove described in connection with FIGS. 8-10. It is to be understood that the successive roll teeth of the rolls 24a resemble the successive roll teeth of the rolls 24 in that every tenth tooth 28 is of a lesser height than the remaining teeth 30. It will further be understood that the teeth of the rolls 24a do not have inclined outer faces as do the teeth of the rolls 24. The relative inclination of the supporting shafts 26a accomplishes the corrugating of the ribbon so that its corrugations taper from one edge of the ribbon to the opposite edge in height. The taper, therefore, that is produced on the corrugating mechanism of FIG. 11 will be substantially the same as the taper produced on the corrugating mechanism of FIGS. 8 and 9.

When the ribbon has been corrugated as hereinabove set forth, it is then fan-folded upon itself as illustrated in FIG. 3. These fan-fold sections are formed by bending the ribbon transversely along the interval lines established by the low height corrugations 22. The ribbon, of course, is bent transversely on these interval lines into fan-fold sections of substantially equal length. In the fan-folding or zigzag bending of the ribbon, it will be observed that the nodes of corresponding corrugations of adjacent groups of corrugations are brought into back-to-back abutment as shown in FIG. 3.

Such length of cellular core may then be placed upon the arcuate face plate 44 of the jig 46 as shown in FIG. 12. A guide or stop 48 may be mounted upon such face plate. Due to the tapering character of the honeycomb cells, which is illustrated best in FIG. 13, it will be seen that the assembled structural core, when compacted as described, will be of an arcuate shape and such arcuate contour will be so arranged that this compacted core section will rest upon the arcuate face plate 44. The arcuate face plate 44 determines, however, the precise arcuate contour.

When the section of cellular core has been mounted

upon the face plate 44, it may be clamped throughout or otherwise held and the several honeycomb cells may be welded together as shown in FIG. 6. This welding or brazing or the like is through the nodes of the corrugations which have been brought back to back as hereinabove described. When all of these corrugations have been so welded, a unitary annular cellular core is provided. The ends of the annulus may then, if desired, be welded together.

Such welded annulus of fan-folded ribbon may, if desired, then be gripped by a vise-like tool or the like as illustrated in FIG. 5 where the two jaws of the vise are indicated as 42. This gripping of the assembled fan-fold sections may be carried out to the point of establishing the desired length of the cellular core.

The core structure itself may then be mounted within a suitable supporting band. Such a band is indicated as 50 in FIG. 7. It is generally channel-shaped in cross section, having a bottom 52 and side wall or flange portions 54. If the core is desired to be formed in an annulus as has been hereinabove described, the supporting band will be of an annular shape. The core will be mounted therein by brazing or the like. The core structure will be securely fastened within the band. The brazing metal will migrate by capillary action along the back-to-back engagement of the nodes of the corrugations but without filling the interior of the honeycomb cells so that the cellular core will be securely fastened within the channel-shaped band. Preferably the side walls or flanges 54 of the band have a height less than the width of the ribbon so that the inner circumference of the cellular core itself projects above the side walls of the band.

The structure and process hereinabove described has been directed primarily to the production of a honeycomb core of an annular shape. As heretofore stated, the core might be so fabricated as to be in a flat planar shape. If the teeth shown in FIG. 10 of the fragment of the roll were of uniform height throughout their extent, i.e., equal height at opposite sides of the roll, the corrugations formed in the metal ribbon would likewise be of uniform height throughout their extent. Considering that the ribbon produced by these teeth is otherwise as herein described, i.e., the corrugations are divided into groups by an interval which includes a corrugation of less height, when such a ribbon was fan-folded and the nodes of corresponding corrugations of adjacent groups brought into back-to-back abutment and there secured together, such a cellular core would present a flat planar shape. FIG. 14 illustrates a fragment of such a core. Such a core might be mounted within a channel-shaped support if desired. Such channel shape support would likewise be planar. Such a core might be used in many places where a light weight, strong cellular structure was desired.

Instead of making the structure out of a continuous ribbon, successive fan-fold sections might be separated each from the other and then stacked and welded together in the manner herein described so as to provide a cellular honeycomb-like core of the character herein shown but wherein the structure was not built up out of one length continuous ribbon.

What I claim is:

1. That process of fabricating a cellular core comprising: shaping a metal ribbon into a linear succession of similar substantially equally spaced substantially equal height corrugations extending transversely across the ribbon, said succession of transverse corrugations separated into linearly successive spaced groups of an equal number of corrugations by an interval of ribbon including a corrugation of less height than the corrugations which make up the successive groups, and fan folding the corrugated ribbon transversely through said intervals so that the nodes of the corrugations of one group are brought into abutment back to back with the nodes of oppositely disposed corrugations of adjacent groups, and flattening

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somewhat the corrugations of less height in said intervals whereby said intervals form with the opposed sides of adjacent corrugations a cell of substantially the same area as the remaining cells of the core.

2. That process of fabricating a cellular core as defined in claim 1 characterized in that the corrugation of the ribbon included within each interval between successive groups of corrugations has a height approximately no greater than one-half of the height of a single corrugation within an adjacent group and is somewhat flattened during the fan-folding.

3. In the process of fabricating a cellular core, that method which comprises corrugating a ribbon transversely into a succession of substantially equally spaced corrugations separated into a succession of spaced groups of an equal number of corrugations and wherein successive groups are separated from each other by an interval of ribbon length which includes a single corrugation of a less height than the height of the individual corrugations which make up said groups, and wherein said interval and included corrugation is of a length not less than the sum of the length of the two sides of a corrugation.

4. That process of fabricating a cellular core as defined in claim 3 characterized in that the several corrugations formed in the ribbon in the several groups of corrugations are so shaped as to have a height along one edge of the ribbon greater than the height along the opposite edge of the ribbon so that when the ribbon is fan-folded and the nodes of corresponding corrugations of adjacent groups are brought back-to-back the fan-folded ribbon core exhibits throughout its opposed areas defined by opposite edges of the ribbon an arcuate contour.

5. That element in the fabrication of a cellular core which comprises a corrugated ribbon embodying a succession of equally spaced transverse corrugations and wherein the corrugations which make up the ribbon are separated into a succession of groups of corrugations and wherein each group consists of the same number of corrugations and wherein successive groups of corrugations are separated from each other by intervals each of which intervals includes a single corrugation which is of less height than the height of the individual corrugations within the groups.

6. An arcuate cellular core structure formed of a continuous linear ribbon provided with a succession of similar corrugations extending transversely across the ribbon, said corrugated ribbon being fan-folded upon itself into a succession of substantially equal length, linear fan-fold sections and with the nodes of corresponding corrugations of adjacent fan-fold sections brought into back-to-back engagement and there secured together, said corrugations having substantially equal in-

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dividual heights along one linear edge of the ribbon greater than the substantially equal individual heights of the same corrugations along the opposite linear edge of the ribbon, whereby the several corrugations taper uniformly from one edge of the ribbon to the opposite edge and whereby the opposite surface areas of the core formed by the opposite edges of the ribbon are arcuate and one constitutes an inner concave surface area and the other constitutes an outer convex surface area.

7. That element in the fabrication of a cellular core which comprises a corrugated ribbon embodying a succession of groups of substantially equally spaced substantially equal height corrugations extending transversely across the ribbon, adjacent groups of corrugations separated from each other by intervals of ribbon, each of which includes a single corrugation which is of less height than the height of individual corrugations within the groups, all of said corrugations tapering in height from one linear margin of the ribbon to the opposite linear margin of the ribbon.

8. That process of fabricating a cellular core comprising shaping a metal ribbon into a linear succession of similar substantially equally spaced and substantially equal height corrugations extending transversely across the ribbon, said linear succession of corrugations separated into linear successive spaced groups of an equal number of corrugations by an interval of ribbon between each two adjacent groups, fan-folding the ribbon transversely at said intervals into substantially equal length fan-fold sections and bringing the nodes of corresponding corrugations of such successive fan-fold sections into back-to-back relationship forming a cellular core, said corrugations so formed in the ribbon as to have equal heights along one linear edge of the ribbon greater than the equal heights of the corrugations along the opposite linear edge of the ribbon so that when the corrugated ribbon is fan-folded and the nodes of corresponding corrugations of adjacent groups are brought into back-to-back relationship this cellular core exhibits throughout opposed areas defined by opposite edges of the ribbon similar arcuate contours.

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