

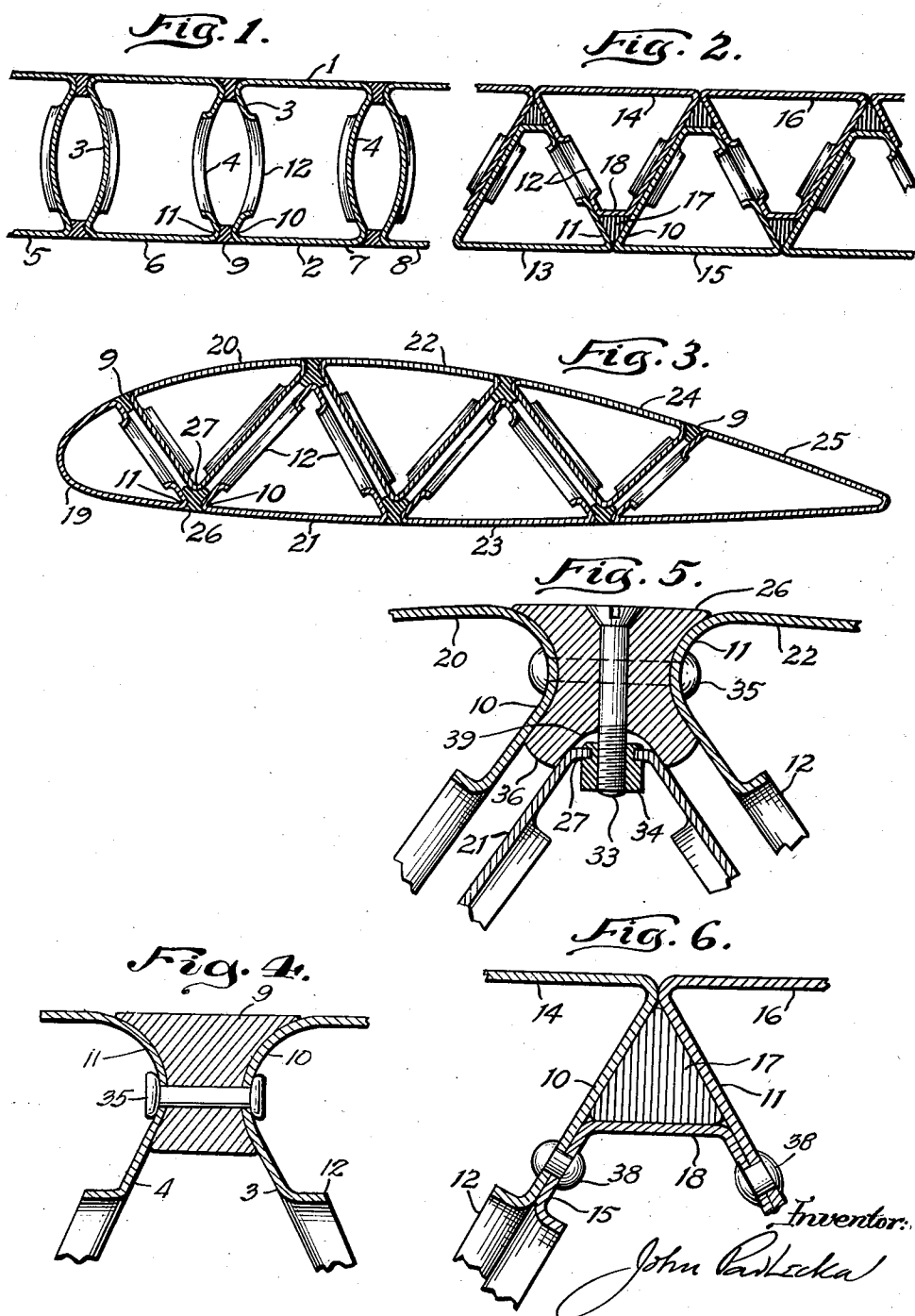
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J. PAVLECKA

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CELLULAR STRUCTURE

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CELLULAR STRUCTURE

John Pavlecka, Detroit, Mich.

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My present invention relates to a structure comprising sheet material and linear members in a novel combination.

Among the objects of my invention is, first, to provide an inexpensive, light and strong construction for such purposes as walls, floors, wings of aircraft, and girders.

A further object is to devise a closed structure which can be assembled easily with a minimum of riveting.

Another object is to devise a structure of great strength and least weight in which pre-fabricated spars of sheet material cooperate with linear stress members in load carrying.

A still further object is to provide a retaining structure, such as a wall in a house, which is built up of a number of individual box elements of sheet material with linear insulating members confined between the elements.

These and other objects and aims of my invention are materialized, in a general way, by producing a number of individual tubular cells or spars of sheet material, all of them being alike if the resulting structure is to be symmetrical about at least one plane; or, they may be of divers shapes and varying sizes if the structure is to be irregular in contour wherein each cell or spar occupies a predetermined position. The spars are preferably fabricated with flanged perforations in their sides for lightness and increased stiffness, and furthermore, for accessibility of the interior in riveting the seam of the spars and assembling them into the structure in the manner disclosed hereinafter.

The spars are integrated into unity by being lined up alongside one another so that their side webs will either abut on or will confront each other at a close distance, and between spars so disposed are confined or wedged linear members, or stringers, or struts or filler strips, as the case may be, preferably in such a manner that the spars will clinch the linear members between them directly at the exterior of the structure whereby the members will function as spacers between the spars and will provide a portion of the exterior surface of the structure between them.

The manner of retaining the spars and the linear members in entity may be varied to suit individual preference, the most expedient method, though not the only one here proposed, being to rivet the spars together with the rivets passing through and retaining the linear members in-between them.

The principle of integrating stressed bodies of a plurality of tubular spars with linear stress or

insulating members confined between them in the manner above disclosed, yields itself to a considerable variety of modifications and embodiments, certain typical of which will now be described with reference to the drawing forming an integral part of this specification. In the drawing,

Fig. 1 represents a transverse cross-section through a structure of uniform depth and comprising generally rectangular spars, with linear members clamped between their corners.

Fig. 2 is a similar cross-section through a structure made up of triangular spars so disposed to one another that they form sockets between them, with linear members inserted and wedged in the sockets.

Fig. 3 is a transverse cross-section through the wing of an aircraft, the airfoil body being constituted of triangular spars similar to those of Fig. 2 but assembled with linear members between them in a manner analogous to that of Fig. 1.

Fig. 4 represents one of the linear members and the shoulders of the spars engaging same as well as the rivets tying the spars together, shown on an enlarged scale, appertaining to the structure of Fig. 1.

Figs. 5 and 6 are approximately full-size sectional reproductions of the linear members and their vicinity of Figs. 3 and 2, respectively, and disclose exemplary methods of retaining the linear members in place and the spars in unity.

The same numerals in different figures designate identical component parts.

All of the structures shown in the drawing are distinguished by certain features generic to all of them, and by others characterizing each individual embodiment but equally well applicable to the rest of them.

The generic features distinguishing the structure of Fig. 1 reside in the individually fashioned tubular spars or elements 5 to 8, and in the linear members 9 confined between them in such a manner that the spars have a retaining and restraining hold on them, thus reinforcing them against failure under strain, and being, in turn, reinforced by the members by virtue of the latter's strategic location at the exterior surfaces of the structure. The individual characteristics of this structure include the shape of the spars 5 to 8, the profile of the linear members 9, and the spacing of the spars in such a manner that the members 9 function as filler strips between them and provide a portion of the exterior surface of the structure.

The spars 5 to 8, all alike, have each two sides 1 and 2 substantially parallel, and with these sides provide the major portion of the exterior of the structure; the spars have, furthermore, two side webs 3 and 4 which are shown as being, by way of example, arched inwardly whereby their stiffness against buckling is materially increased. The side webs 3 and 4 are perforated with flanged openings 12 which provide access into the spars during their fabrication and on their assembly, and further add stiffness to the side webs. The spars 5 to 8 are spaced from each other so that a cavity results between each two confronting side webs 3 and 4, which cavity is relatively narrow at the corners 10 and 11 of the spars but wide in the interior as the arched webs 3 and 4 bow away from each other. In this cavity are lodged, at and between the rounded corners 10 and 11 of each two confronting spars, the struts or linear members 9.

The linear members 9 are either solid or hollow and have recessed flanks closely conforming in profile to the corners 10 and 11, and have a flat surface flush with the exterior surface of the structure of which they provide a part. The material of which the members 9 are made may be either extruded or rolled metal for strength and rigidity or, if the structure is to serve as a wall, they may be molded of fibrous substances or of rubber so as to reduce heat transfer, deaden noise and exclude moisture.

In their extreme location at the exterior of the structure the members 9, when made of rigid material, provide effective reinforcing means for the spars 5 to 8 in all conditions of loading, i. e., endwise, beamwise and chordwise, and are in turn constrained against buckling by the clamping grip that the stiff corners 10 and 11 have on them. Moreover, when considered with the joining means as disclosed presently between the spars 5 to 8 and the members 9, it will be seen that both the spars and the members cease to exist as individual and independent elements, and instead, the structure resolves itself mechanically as well as functionally into a series of stress girders, each consisting of two linear members 9 and truss webbing 3 and 4 between them, while the exterior sides of the spars connect and steady the girders.

A simple manner of assembling the spars 5 to 8 and the linear members 9 is represented in Fig. 4, wherein spars 6 and 7, representative of any two adjacent spars of Fig. 1, clinch between them the member 9, and are conjoined with this member and with each other by means of rivets 35 inserted in place through the flanged perforations 12. These perforations can have any shape, such as round or triangular, and should be aligned in confronting sides but can be overlapped or staggered in opposite sides, as in sides 3 and 4 of spar 6 of Fig. 1, for purposes of providing uniformly easy access for riveting tools for all rivets, particularly those between successive perforations.

Fig. 2 is another embodiment of my invention wherein the shape of the spars 13 to 16 is different from that in Fig. 1, as is the manner of retaining the linear members 17 in place. The spars 13 to 16 are triangular with well-defined apices 10 and 11 at the exterior surface, and with a truncated apex 18 away from it. The spars are interposed so that all upright ones, 13 and 15, jointly form one side of the structure while the complementary inverted spars 14 and 16 form the opposite side; the upright and the in-

verted spars abut one onto each other along a portion of their sides whereby the converging apex portions 10 and 11 of each two upright spars 15 and 13, respectively, in conjunction with the truncated apex 18 of the inverted spar 14 therebetween jointly define a sheath, socket or cavity in which is confined the linear wedge member 17. The overhanging apex portions of all inverted spars in conjunction with the blunt apices of the upright spars form similar cavities at the opposite side of the structure.

The linear members 17 are triangular in profile to fill in closely the cavity formed by the spars, and are retained in place by the converging apex portions 10 and 11 of these spars, as illustrated on an approximately full-size scale in Fig. 6. In this figure is also shown an exemplary mode of assembling the spars, residing in that the abutting sides of one upright and one inverted spar are riveted together by means of rivets 38 for which purpose, and also for reasons of increased stiffness and reduced weight, flanged holes 12 are punched out in approximately opposite relation in abutting sides, and in staggered relation in opposite sides in order to provide a more uniform means of access to the rivets at and between the flanged holes 12.

Referring now to Fig. 3, the airfoil structure represented herein has its curvilinear contour derived from a plurality of substantially triangular cells or spars or elements 19 to 25, each of which constitutes a predetermined sector in the airfoil. This structure is a combination of the previously disclosed two embodiments in that it makes use of triangular spars like those of Fig. 2, joined together in the manner of those of Fig. 1. Similarly as in Fig. 2, the upright spars 19, 21, 23, and 25 provide one side of the structure while the inverted spars 20, 22 and 24 provide the opposite side. The spars forming one side as well as the intermediate spars forming the other side are distanced from each other, thereby forming gaps or crevices at the exterior of the structure and a series of diagonal trusses with spaced double webs in its interior. At the extreme point of each truss, in the crevice formed by each two spars associated at one side, is lodged the rigid linear member 26; this member is employed wherever two diagonal trusses meet at one crevice, while in the end trusses at the terminal spars 19 and 25 members 9 are used, such as shown in Fig. 4.

A detail view of the linear members 26 and the manner of confining them between the confronting spars 20, 21, and 22 is illustrated in Fig. 5. In this particular assembly the spars 20 and 22 defining one exterior surface are characterized by profiled, such as rounded, corners 10 and 11 respectively, between which corners is clinched the member 26; the profile of this member has recessed sides so as to fill up completely the crevice between the corners 10 and 11 and to form a smooth continuation of the exterior surface between the respective spars. The spars 20 and 22 are held together preferably through the instrumentality of rivets 35 which join the spars at the point where they are closest to each other, i. e., in their apices, and at the same penetrate through the linear members 26 and clinch them securely between the spars.

The profile of the linear members 26 is furthermore characterized by two prongs 36 which form a groove or saddle between them; into this saddle is drawn up the apex 27 of the intermediate spar 21. For this purpose there is secured, 75

in spaced relation in the apex 27, a number of clinch nuts 34, which nuts are in alinement with and engage the screws 33 that penetrate through members 26 from the exterior of the structure.

5 It will now be seen that the spars 19, 21, 23, and 25, all constituting one side of the structure, can be joined conveniently, on assembly, into a unit by means of rivets 35 made accessible through the opposite flanged holes 12 therein; 10 the spars 20, 22 and 24 constituting the other side are likewise riveted together into a sub-assembly through the aligned flange holes therein, and then the two opposite and complementary rows of spars with the members 26 between them are 15 intermeshed and joined together by means of screws 33 driven in from the exterior. The members 9 are riveted in place through an open end in the structure or through holes for ailerons, tanks, lights, controls, etc., in the leading and 20 trailing spars 19 and 25 of the wing.

I claim:

1. A cellular structure comprising, tubular cells of sheet material having side walls forming jointly wedge-shaped gaps therebetween, tying 25 means joining said cells through said side walls thereof, and linear wedges inserted in said gaps, retained therein by said walls and constrained against dislocation by the clinching action of said walls due to said tying means.

30 2. A cellular structure composed of individual cells of sheet material having opposing side walls, said side walls of each two associated cells having angularly profiled corner portions inwardly of the surface of the structure, a linear member 35 having angular flanks conforming to said corner portions and being inserted therebetween, and means for joining each two associated cells together and thereby causing said profiled corner portions to engage said members bodily and grip 40 them tightly against dislocation under strain.

3. A cellular structure comprising, individual tubular cells of sheet material confronting one another with protruding corners at the surface of the structure, and between said corners having 45 side walls receding inwardly away from each other, linear members having a flared section and being inserted between said cells whereby said flared section thereof will fit between said receding side walls at and underneath said protruding 50 corners, and means for joining said cells together and thereby retaining said members between them and causing said side walls to clamp them tightly therebetween.

4. A structure comprising, a number of individual tubular elements arranged in parallel 55 relation and being formed with longitudinal side portions angularly inclined away from each other from the surface of the structure inwardly, linear members having a profile conforming to said angular portions of said tubular elements and being 60 inserted therebetween, and means for conjoining said tubular elements and thereby wedging said linear members in place and causing them to abut on said angular side portions for their support when subject to stress.

5. A structure having a dorsal and a ventral side comprising, a number of individual tubular elements of sheet material arranged side-by-side, said elements having confronting side portions 70 converging toward the exterior surfaces of the structure, linear members having a profile with tapering flanks corresponding to said converging side portions of each two adjacent elements and being inserted therebetween, and means for 75 securing said tubular elements together and there-

by causing said linear members to be wedged tightly between said converging portions of said elements and restrained from dislocation under strain.

6. A structure comprising, a plurality of individual tubular elements having rounded protruding corners, said elements being arranged in parallel spaced relation whereby a gap having convergent-divergent sides results between the 10 corners of each two adjoining elements, a number of linear members, said members having a profile narrowed at center to conform to said gap, one member being confined in each gap, and means for conjoining said elements into unity 15 and thereby forcibly clamping said members between said rounded corners to prevent their dislocation under load.

7. A structure comprising, a number of individual tubular elements arranged in parallel spaced relation and having confronting sides 20 shaped to form constricted longitudinal gaps therebetween at the exterior of the structure, linear rigid members having a constricted profile corresponding to said gaps and being lodged apiece therein whereby said tubular elements 25 will have a bodily engagement with said linear members against relative motion under strain, and means passing through said linear members for conjoining said tubular elements into unity 30 and thereby clamping said linear members firmly therebetween.

8. A structure comprising, a number of individual tubular elements arranged in side-by-side relation and having sides forming protruding 35 shoulders in spaced and opposite longitudinal relation to each other at the exterior of the structure, linear members having hollow flanks, said members being inserted between said shoulders of the tubular elements whereby said elements 40 will have a constraining hold thereon against failure under load, and means for fastening said tubular elements together and thereby gripping said linear members between said protruding 45 shoulders.

9. A cellular structure comprising, an exterior 50 shell of sheet material, a series of double-webbed trusses integral with and extending lengthwise in said shell, said double webs of said trusses forming laterally constricted crevices at said shell, linear members having indented sides lodged in 55 said crevices, and tying means for joining said double webs of said trusses together and thereby clamping said linear members firmly between them.

10. A cellular structure comprising, tubular 60 cells of sheet material having side walls, said side walls of each two associated cells having convergent-divergent directions from the surface of the structure inwardly, linear members having a double-wedge profile lodged between said walls so that said convergent-divergent portion thereof 65 will have a bodily engagement therewith, and means for tying said walls together and thereby clamping said members firmly therebetween.

11. In a structure, an exterior shell substantially all of sheet material, a series of double webbed trusses extending in said shell and being 70 integral therewith, said trusses being inclined one to each other and having the webs thereof provided with stiffening means against buckling, a number of linear members, one of said members being confined at the juncture of each two of said trusses at said shell and held 75 firmly therein by a clinching action of said webs.

12. A structure comprising, a plurality of in-

dividual tubular spars, said spars being substantially triangular in shape and being arranged in parallel relation longitudinally and in inverse and staggered relation transversely whereby each two alternate spars and one intermediate spar therebetween jointly define a triangular cavity at the exterior of the structure, a number of linear members having a triangular profile, one of said members being inserted in each cavity, and means for conjoining said spars into unity and retaining said members in said cavities.

13. A cellular structure comprising, an exterior shell of sheet material, a series of double-webbed trusses integral with and extending lengthwise in said shell, said trusses being diagonally inclined toward one another and made to form jointly between the remote webs thereof, at the surface of the structure, wedge-shaped gaps, linear members having tapering sides lodged in said gaps and being retained therein by the joined near webs of said trusses, and means for securing said truss webs together and thereby clamping said members firmly between them.

14. A cellular structure comprising, a number of triangular tubular cells confronting one another along their sides in inverted relation, each two alternate cells with one intermediate cell therebetween jointly forming a crevice with slanted sides at the surface of the structure, a linear filler strip having corresponding slanted sides occupying said crevice, and means for securing said cells together through said sides thereof and thereby constraining said filler strips in place between said slanted sides and said cell therebetween.

15. A structure comprising, a plurality of individual tubular elements having side webs and chord webs meeting in a number of apices, said side webs confronting one another and having diverging directions from said apices inwardly, two linear members confined between each two elements at said chord webs thereof, said members having a profile conforming to said apices and said converging sides of said elements and forming a smooth portion of the exterior between said chord webs thereof, and means for conjoining said elements and thereby locking said members between said side webs.

16. A structure comprising, a plurality of individual tubular spars having each two side webs and two chord webs meeting in four rounded apices, said spars defining the major portion of the exterior of the structure with said chord webs thereof and confronting one another at a relatively small distance along said side webs thereof, said side webs of each spar being indented inwardly between said rounded apices and being perforated with flanged holes, a number of linear members having concave sides, one of said members being confined between said corners of each two confronting spars and between said indented walls and made to provide the portion of the exterior of the structure therebetween, and means in the interior of the structure for conjoining said spars into unity and thereby clamping said members therebetween.

17. A structure comprising, a number of individual tubular elements arranged in side-by-side spaced relation and having convex portions in opposite longitudinal relation to each other, linear members having concave flanks, said members being fitted between said convex portions of said tubular elements whereby said elements will have a constraining hold thereon against failure under load, and means for fastening said tubular

elements together and thereby clinching said linear members therebetween.

18. A structure comprising, a plurality of individual tubular elements, a number of triangular linear members, and means for fastening said elements together in parallel relation, said tubular elements having sides formed so that at least each two of them jointly define one triangular cavity having one apex at the exterior of the surface and the other two apices inwardly thereof, one of said linear members being confined in each cavity and forcibly constrained by said elements therein against dislocation under strain.

19. A cellular structure comprising, a number of tubular cells having certain corners thereof protruding and others truncated, each two of said cells approaching each other at the exterior surface of the structure with said protruding corners thereof and including one truncated corner of a third cell therebetween to form a triangular sheath, a triangular linear member conforming to said sheath and being thrust therein, and means for tying said cells together and thereby exerting a tight hold on said member between said corners thereof.

20. A cellular structure comprising, tubular cells of sheet material meeting one another along the surface of the structure and having sides sloping in opposite directions inwardly from said surface, other cells between said first named cells having sides conforming to said sloping sides thereof and having truncated apices therebetween, triangular linear members in the space between said sloping sides of said first cells and said truncated apices of said second cells, and means for tying said first cells together with said second cells through said sloping sides thereof and thereby wedging said triangular members between said sides and apices.

21. A cellular structure comprising, a row of tubular triangular cells having contacting corners at the exterior of the structure and truncated corners in the interior thereof, another row of like cells inverse to and alternating with said first row and having the sides thereof confront said first row whereby a triangular gap results between the contacting corners of two cells in one row and the truncated corner of one cell of the other row, triangular linear members inserted in said triangular gaps, and means for tying said two rows of cells together and thereby constraining said linear members between said contacting and said truncated corners of said cells.

22. A structure comprising, a plurality of individual tubular spars, said spars being substantially triangular in shape with at least two well-defined apices and being disposed inversely to each other in spaced relation whereby alternate spars will confront intermediate spars along their sides at a relatively small distance, said well-defined apices of each two alternate spars and the intermediate spar therebetween jointly defining a crevice at the exterior of the structure; a linear member inserted in each crevice between said well-defined apices therein to provide spacing means for said spars and complementary means to the exterior of the structure between said spars, and means for conjoining said spars into unity and thereby clinching said members therebetween.

23. A cellular structure comprising, a number of tubular cells having protruding corners, each three of said cells approaching one another at

the exterior surface of the structure with said corners thereof in spaced relation and forming a constricted crevice therebetween, a linear member having three sides thereof conforming to said corners of said cells, said member being inserted in said crevice with said corners fitting in and against said three sides of said member, and means for tying said cells together through said corners thereof and through the body of said member therebetween.

24. A cellular structure comprising, a row of tubular triangular cells having aligned corners in spaced relation at the exterior of the structure and their third corners away therefrom, another row of like cells inverse to and alternating with said first row and having the sides thereof confront said first row whereby a constricted gap results between said spaced corners of each two cells in one row and the third corner of a cell from said second row therebetween, linear members having tapered sides conforming to said constricted gaps and being inserted therein, and means for tying said cells in each row with one another through said linear members therebetween, and means for tying said first row of cells with said second row through said linear members therebetween.

25. A cellular structure comprising, a row of triangular tubular cells having spaced corners from each other at the surface of the structure, linear members having recessed sides and having a groove between them in the interior of the

structure, said members fitting between said spaced corners of said cells and being bodily engaged thereby in said recessed sides thereof, tying means extending through said linear members for joining said cells together in said corners thereof; another row of like cells complementing said first row in inverted relation, said second row having corners fitting into said grooves in said linear members, and tying means extending from the surface of the structure through said linear members and engaging said corners of said inverted cells and pulling them into engagement with said grooves in said linear members.

26. In a cellular structure, a row of tubular cells having sloping sides and having spaced corners from one another at the surface of the structure, linear members fitting between said spaced corners, and means for tying said cells and said linear members together; another row of cells having sloping sides and complementing said first row in inverted relation, said second row of cells having corners protruding between each two cells of said first row toward said linear members therebetween, nuts located in said protruding corners of said cells, and screw means projecting through said linear members and engaging said nuts and thereby pulling said cells of said second row into place between said cells of said first row.

JOHN PAVLECKA.