Nov. 2, 1937. J. PAVLECKA 2,097,600

COLUMN STRUCTURE

Filed Dec. 31, 1934

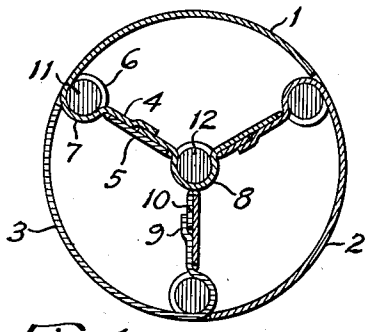

Fig. 1.

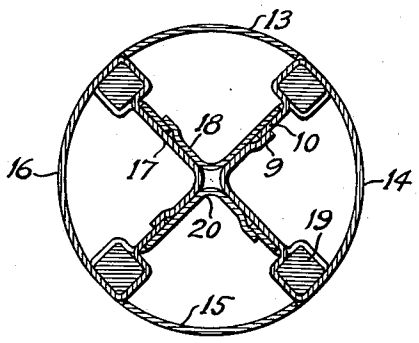

Fig. 2.

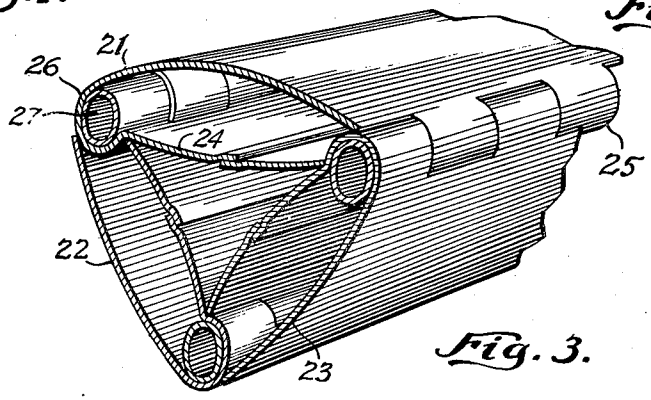

Fig. 3.

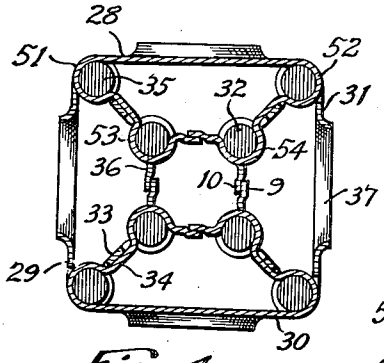

Fig. 4.

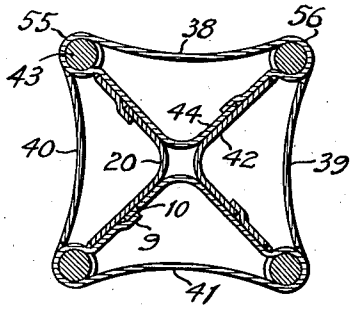

Fig. 5.

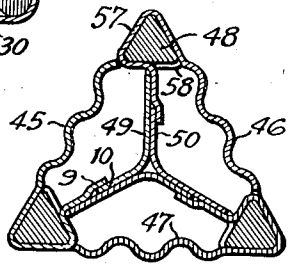

Fig. 6.

INVENTOR:

John Pavlecka

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2,097,600

COLUMN STRUCTURE

John Pavlecka, Detroit, Mich.

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22 Claims. (Cl. 189—38)

My present invention relates to thin walled and axially extended closed structures, such as columns, beams and girders.

The object of my invention is to devise a structure of the above named type that will have the greatest resistance to failure in either pure compression, torsion, bending, or under any combination of these stresses.

A still further object is to provide a structure relatively slender and internally inaccessible that can be assembled with little or no riveting from a number of pre-fabricated elements.

Another object of my invention is to present a column or girder having a large section modulus and in which an exterior shell of sheet material is reinforced internally by a number of radial or arched webs forming a spar, and furthermore, in which both the shell and the spar are strengthened by a number of rigid struts incorporated into the sheet webbing and, preferably, made to hold the structure together in the manner disclosed herein further.

For accomplishing these and other objects I make use of the principle of interlocked tubular cells or spars as disclosed in my original co-pending application Serial No. 651,494, filed January 13th, 1933, in which application I have presented several embodiments of the "plane" type of structure as distinguished from the present columnar type.

In the following description I propose to present several typical embodiments of the new columnar structure as illustrated in the drawing accompanying this specification and forming an integral part thereof.

In the drawing,

Fig. 1 is a transverse cross-section through a cylindrical column consisting of three identical cells and four struts.

Fig. 2 is a cross-section through a round column or girder wherein four cells are conjoined into a unit by as many rigid struts.

Fig. 3 is a perspective view of a generally triangular girder in transverse cross-section, the body of the girder being made up of three cells and three tubular struts as interlocking members.

Fig. 4 is a rectangular column in transverse cross-section incorporating four trapezoidal cells and eight interlocking struts, one strut in each corner between the cells; the shell of the column is perforated with flanged apertures for lightness and stiffness.

Fig. 5 is another generally rectangular column wherein four cells are interlocked by four struts, the exterior webs of the cells being arched between the struts for greater stiffness.

Fig. 6 is a triangular embodiment in which three triangular cells are united by three triangular struts, and the exterior webs of the cells are corrugated for increased stiffness under load.

Referring jointly to all the figures in the drawing, any one of the structures represented therein is integral of a relatively small number of individual, tubular cells, all of them alike if the structure is to be symmetrical about at least one axis; the cells are grouped centrally into a closed and compact assembly of any geometrical or irregular pattern in which each cell constitutes one sector. The cells are tubular elements extending the whole length of the column, and with what is hereinafter referred to as chord webs, providing the exterior shell or envelope of the column, and with one or two arched or radial webs forming a reinforcing cross or star shaped spar in the interior of this shell. The chord and the radial webs in each cell meet in at least two well-defined apices, which apices are profiled cross-sectionally in such a manner as to form a longitudinal sheath with the corresponding apices of the associated cells; each cell will have two such apices adjacent its chord web, and if desired, may have one or more of such apices in the interior at the very center or thereabouts. In the structure as assembled, rigid struts of suitable cross-section are positioned one in each sheath formed by each two contacting cells, these struts providing essential reinforcing elements in the complete structure. In the preferred embodiments as represented in Figs. 1 to 6, these struts are further utilized to hold the cells together, which is accomplished by transversely serrating the profiled apex portions of the cells, intermeshing the serrated apices of each two associated cells, and inserting a strut in each sheath formed by the intermeshed apices.

The cells of which the various structures shown in the drawing are integrated are fabricated of sheet material such as steel, duralumin, etc., by bending or rolling up a strip of the material into any required tubular shape, and joining the edges by riveting or welding; the serrating of the profiled apices of the cells resides in cutting out alternate lengths of the apex portions to a predetermined depth whereby the full apex portions of one cell will fit into the serrated portions of the associated cells. On assembly, the pre-fabricated cells are abutted laterally so that the full apex portions of each pair of cells will be intermeshed

and lined up into a sheath into which a strut is thrust which interlocks the cells into unity.

It will be seen that in a structure of this configuration the struts take up a certain percentage of the stresses in any kind of loading, as does the exterior shell and the interior reinforcing webbing, and due to the disposition of the struts in the pattern of sheet material and due to the restraining hold that this material has on the struts, these elements cooperate in bracing each other against collapsing and thus jointly are able to sustain more load than they could carry individually.

The embodiments presented in the several figures are distinguished by the same basic construction, their shape and number of cells and struts being the principal variables.

Fig. 1 shows a cylindrical column built up of three cells and four struts **11**. Each of the cells is characterized by the circular chord web, **1**, **2** and **3**, respectively, each of which constitutes an equal segment of the exterior shell of the column, and two radial webs **4** and **5**. The chord webs **1**, **2** and **3** meet the radial webs **4** and **5** in each cell in two apices **6** and **7** on their underside, and the radial webs themselves meet each other in the third apex **8** which, in this particular embodiment, falls in the center of the column. All three of the apices **6** to **8** are profile grooved outwardly into a circular shape, and all are transversely serrated. In embodiments of this character wherein more than two cells are interlocked at the center, the serrated apex portions of each cell are a multiple of the length of the full apex portions, and are staggered lengthwise so that they will include the full apex portions of the two or any other number of associated cells. The peripheral intermeshed apices **6** and **7** of each two associated cells accommodate the interlocking strut **11**, while the central apices **8** of all the cells in the pattern collectively form a single sheath for the strut **12**.

The radial webs **4** and **5** of each two adjoining cells combine to form a wall of double thickness in the interior between the central strut **12** and each peripheral strut **11**. The closing edges **9** and **10** in each cell are shown as being seam or spot-welded together and located in one of the radial webs.

In contrast to this structure, the one in Fig. 2 comprises four cells **13** to **16** and four interlocking struts **19**, there being no central strut and all of the struts **19** being located peripherally. The radial webs **17** and **18** of each two associated cells meet at the apex **20**, and with the corresponding webs of the other cells form a cross-shaped spar of double thickness in the interior, the struts **19** being positioned at the outer extremities of this spar in the sheaths formed by its webs underneath the exterior shell.

Fig. 3 presents a generally triangular column or girder having a shell with oblique sides as provided by the arched chord webs **21**, **22** and **23** of three cells. These cells are all alike and, aside from their outwardly arched chord webs, each cell is characterized in that its normally radial sides are blended with a radius into a single arched web **24**, which web meets the outer chord web, **21** to **23** respectively, in two profiled apices **25** and **26**. The inner webs **24** are bowed away from the chord webs **21** to **23** so that in conjunction with each other these inner webs **24** form a star-shaped tubular spar; the struts **27** which interlock each two intermeshed cells are most advantageously interposed between the outer extremities of this concave spar and the convex exterior shell of the column in the sheaths formed by the apices **25** and **26**.

The interlocking struts **27** are represented in this embodiment as being, by way of example, hollow rather than solid as in the other figures.

The embodiment in Fig. 4 shows a further development of the one of Fig. 1, residing in that a number of struts **32**—four in this case—are disposed around the center of the structure in addition to four other struts **35** that are positioned peripherally. The cells in this structure are trapezoidal in shape with one inner web **36**, one chord web **28** to **31**, respectively, and two radial sides **33** and **34**; assembled, the four cells form a rectangular pattern. All four apices **51** to **54** of each cell are profile grooved outwardly and are transversely serrated whereby in the assembled relation the inner webs **36** jointly form a tubular rectangular spar around the center of the column at each corner of which stands one interlocking strut **32**. The four chord webs **28** to **31** jointly form the exterior shell around the four struts **35**. The radial sides **33** and **34** of each two associated cells provide radial reinforcing webbing of double thickness between the struts **32** and **35** and thus complete the pattern between the inner spar and the exterior shell.

The structure of Fig. 4 is further characterized in that the chord webs **28** to **31** of the cells are perforated by flanged openings **37** which feature materially increases the stiffness of the shell, reduces the weight of the column and provides access into the interior of the structure.

Another means for achieving additional rigidity of the thin walls is represented in Fig. 5; this is a generally rectangular column constituted of four substantially triangular cells which are interlocked with each other in their two apices **55** and **56** adjacent the chord webs **38** to **41**, respectively. For purposes of greater stiffness under load the chord webs **38** to **41** are arched inwardly between the interlocking struts **43**, which is in the direction opposite to that of the webs **21** to **23** in Fig. 3, which latter webs are arched outwardly for the same purpose of imparting greater resistance to the sheet material against buckling.

Fig. 6 illustrates a structure comprising three generally obtuse-angled triangular cells which have their two apices **57** and **58** at the hypotenuse profiled into the shape of an equilateral triangle; in the assembly, the three cells themselves jointly compose an equilateral triangle. The apices **57** and **58** are interlocked by the triangular struts **48**, and between them in the interior the sides **49** and **50** of each two abutting cells form a three-pointed spar. In addition to the characteristic triangular profile of the cells, struts and the whole column, this embodiment is distinguished in that the exterior webs **45**, **46** and **47** of the cells are longitudinally corrugated between the profiled apices **57** and **58** in each cell for increased stiffness, which feature can, obviously, be employed in any of the aforementioned structure for increasing their section modulus, and is not only alternative with that of arched webs as shown in Figs. 3 and 5 for greater rigidity, but can be applied supplementarily with it.

Through the above embodiments I have disclosed the scope of my invention, within which scope and the scope of the claims appended hereto I have in purview not only the several basic structures shown, but an endless number of other patterns of any geometrical or irregular shape.

I claim:

1. A column structure comprising, a closed exterior shell and an interior spar, both of sheet material, said spar having a number of webs meeting in pairs at a number of extremities, and between said extremities and said shell each pair of webs forming a sheath, and linear rigid struts inserted in said sheaths as stress members.

2. A column structure comprising, a closed exterior shell and an interior spar, both of sheet material, said spar having a number of webs confronting each other in pairs between a number of extremities, and between said extremities and said shell each pair of webs forming a sheath, and linear rigid struts inserted in said sheaths as stress members.

3. A column structure comprising, a closed exterior shell and an interior spar, both of sheet material, said spar having a number of webs meeting in pairs at a number of extremities, and between said extremities following curvilinear paths, and between said extremities and said shell each pair of webs forming a sheath, and linear rigid struts inserted in said sheaths as stress members.

4. A column structure comprising, a closed exterior shell and an interior tubular spar, both of sheet material, said spar having a number of webs converging from the center of the column in pairs toward a number of extremities, and between said extremities and said shell each pair of webs forming a sheath, and linear rigid struts inserted in said sheaths as stress members.

5. A column comprising, a number of tubular cells of sheet material grouped in laterally confronting relation to provide a closed shell and double sheet webbing therein, said cells having each two profiled apices at said shell whereby each pair of associated cells will jointly form a sheath thereat, rigid struts inserted in said sheaths as stress members, and means for joining said cells together through the instrumentality of said struts.

6. A column comprising, a number of tubular cells of sheet material having each at least two opposed sides and being grouped in laterally contacting relation whereby said sides of said cells will provide a closed exterior shell and an interior tubular spar therein, said cells having each two profiled apices at said shell whereby each pair of contacting cells will jointly form a sheath thereat, rigid struts inserted in said sheaths as stress members, and means for joining said cells together through the instrumentality of said struts.

7. A column comprising, a number of tubular cells of sheet material having each a number of profiled apices and sides extending between them, said cells being grouped in laterally confronting relation whereby certain of said sides thereof will provide an exterior closed shell and others webbing of double sheet thickness therein, and said profiled apices of said cells will complement one another to form sheaths at said shell and in the interior thereof, rigid struts inserted in said sheaths as stress members, and means for joining said cells together through the instrumentality of said struts.

8. A column structure comprising, a number of tubular cells of sheet material extending lengthwise of the structure, said cells having each one chord web and at least one side web meeting in a minimum of two well-defined apices, both of them at said chord web, said webs of said cells being formed with means for stiffening said sheet material thereof, said cells being grouped contiguous to each other whereby said chord webs thereof will form a closed exterior shell and said side webs a reinforcing spar in said shell, said apices of said cells being outwardly profiled, transversely serrated and intermeshed with the apices of the associated cells, and a number of struts, each strut interlocking two intermeshed apices.

9. A column structure comprising, a plurality of individual tubular cells of sheet material and a number of linear stress members, said cells having each a number of sides meeting in apices and being grouped to form, transversely, a closed shell and double sheet webbing therein, said apices of said cells being outwardly profiled and transversely serrated, and said sides between said apices being formed with means recessing from the plane thereof for stiffening same, each two associated cells at said shell being intermeshed in said serrated apices thereof, each of said stress members interlocking two intermeshed apices.

10. A column structure comprising, a plurality of individual tubular cells of sheet material and a number of linear stress members, said cells having each a number of sides meeting in apices and being grouped to form, transversely, a closed shell and double sheet webbing therein, said apices of said cells being outwardly profiled and transversely serrated, and said sides between said apices being provided with flanged perforations for lightness and stiffness, each two associated cells at said shell being intermeshed in said serrated apices thereof, each of said stress members interlocking two intermeshed apices.

11. A column structure comprising, a plurality of individual tubular cells of sheet material and a number of linear stress members, said cells having each a number of sides meeting in apices and being grouped to form, transversely, a closed shell and double sheet webbing therein, said apices of said cells being outwardly profiled and transversely serrated, and said sides being formed to recess from the plane of said webbing for greater stiffness, each two associated cells at said shell being intermeshed in said serrated apices thereof, each of said stress members interlocking two intermeshed apices.

12. A column comprising, a number of tubular cells of sheet material extending lengthwise of the structure, each cell having one chord web and at least one side web meeting in a minimum of two well-defined apices, both of them at said chord web, said cells being grouped to form jointly a closed pattern wherein said chord webs of said cells constitute an exterior shell and said side webs provide a reinforcing spar in said shell, the two apices of each cell at said chord web thereof being outwardly profiled and transversely serrated and intermeshed with the apices of the associated cells, and a number of struts, each strut interlocking two intermeshed apices.

13. A column comprising, a number of tubular cells of sheet material extending lengthwise of the structure, each cell having one chord web and two side webs meeting in at least two well defined apices, both of them at said chord web, said cells being abutted laterally whereby said chord webs thereof will jointly form an exterior closed shell and said side webs will provide a reinforcing spar in said shell, the two apices of each cell at said chord web thereof being outwardly profiled and transversely serrated and intermeshed with the apices of the abutting cells, and a number of

struts, each strut interlocking two intermeshed apices.

14. A column comprising, a number of tubular cells of sheet material extending lengthwise of the structure, said cells having each one chord web and at least one side web meeting in a minimum of two well defined apices, both of them at said chord web, said chord webs of said cells being arched between said apices, said cells being grouped contiguous to each other whereby said chord webs thereof will form a closed exterior shell and said side webs a reinforcing spar in said shell, said apices of said cells being outwardly profiled, transversely serrated and intermeshed with the apices of the associated cells, and a number of struts, each strut interlocking two intermeshed apices.

15. A column comprising, an exterior tubular shell and an interior spar, both of sheet material, said spar having double sheet webs and a number of extremities, a sheath formed by said webs between each of said extremities and said shell and one sheath formed by said webs in the center of said spar, and a number of linear stress members inserted one in each sheath.

16. A column comprising, a number of tubular cells of sheet material grouped into a closed pattern and extending lengthwise thereof, said cells having each three apices profile grooved whereby each two abutting cells in said pattern will form jointly one sheath therebetween at the periphery of said structure and all of said cells will form jointly one sheath in the center thereof, and a number of substantially rigid struts inserted one in each sheath.

17. A column comprising, a number of tubular cells of sheet material extending lengthwise of the structure, each cell having one chord web and two side webs meeting in three apices, said cells being abutted one onto each other laterally whereby said chord webs thereof will jointly form an exterior closed shell and said side webs will provide radial webs of double thickness in said shell, said cells having their two apices at the chord web and the third apex in the center of said structure outwardly profiled, transversely serrated, the two apices of each cell at said chord web thereof being intermeshed with the apices of the abutting cells, said central apex of each cell having serrations so wide as to accommodate the full apex portions of the other cells in the structure, and a number of struts, each strut interlocking two intermeshed apices at said shell, and one strut interlocking all of said cells in the center.

18. A column comprising, a number of tubular cells of sheet material extending lengthwise of the structure, each cell having one chord web and one side web meeting in two apices, said chord web and said side web being arched away from each other, said cells being grouped contiguous to each other whereby said chord webs thereof will provide a closed exterior shell and said side webs a hollow reinforcing spar in said shell, said cells having the two apices thereof profile grooved, transversely serrated and intermeshed with the apices of the associated cells, a number of struts, each strut interlocking two intermeshed apices.

19. A column comprising, an exterior tubular shell, an interior box spar and webbing connecting said spar with said shell, said shell, spar and webbing being of sheet material, plurality of sheaths formed by said webbing between said spar and said shell, and a number of linear stress members inserted one in each sheath.

20. A column comprising, a number of tubular cells of sheet material grouped into a closed pattern and extending lengthwise thereof, said cells having each four apices profile grooved whereby each two abutting cells in said pattern will jointly form two sheaths therebetween, one sheath at the periphery of said structure and the other at the center thereof, and a number of substantially rigid struts inserted one in each sheath.

21. A column comprising, a number of tubular cells of sheet material extending lengthwise of the structure, each cell having one chord web, one inner web and two side webs meeting in four apices, said cells being abutted laterally whereby said chord webs thereof will jointly form an exterior closed shell, said inner webs will provide a box spar in the center of said shell and said side webs will form radial walls of double thickness between said spar and said shell, said cells having their four apices outwardly profiled, transversely serrated and intermeshed with the apices of the abutting cells at said shell and at said spar, and a number of struts, each strut interlocking two intermeshed apices.

22. A column comprising, a number of tubular cells of sheet material extending lengthwise of the structure, said cells having each one chord web and at least one side web meeting in a number of apices, said webs of said cells being formed with flanged perforations, said cells being grouped contiguous to each other whereby said chord webs thereof will form a closed exterior shell and said side webs a reinforcing spar in said shell, said apices of said cells being profile grooved, transversely serrated and intermeshed with the apices of the associated cells, and a number of struts, each strut interlocking two intermeshed apices.

JOHN PAVLECKA.