Oct. 17, 1967 J. R. HALE 3,347,007

EMBEDDED SPACED TRUSS STRUCTURES

Filed Dec. 18, 1964 4 Sheets-Sheet 1

Fig. 1

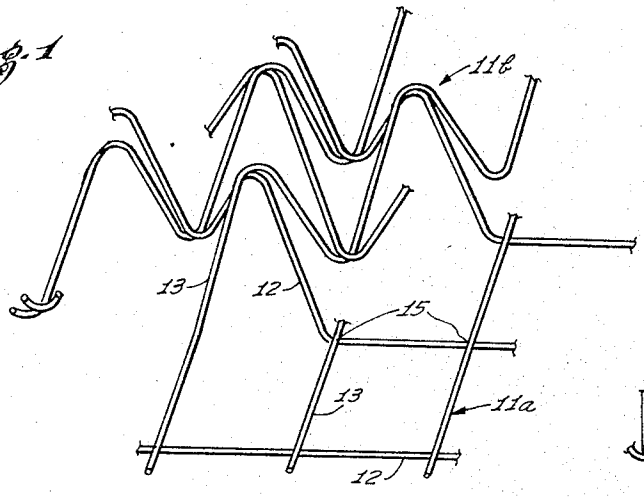


Fig. 2

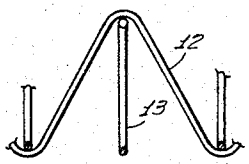


Fig. 3

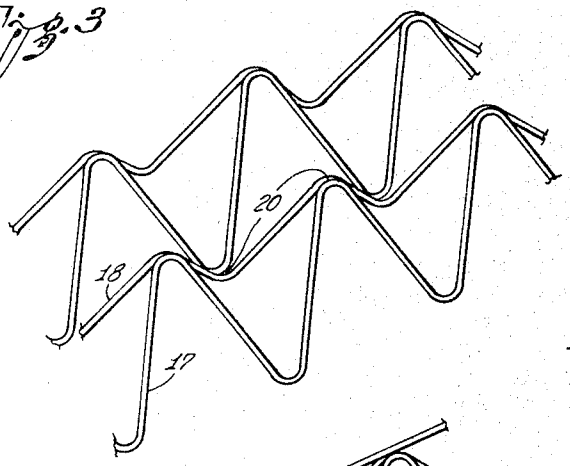


Fig. 4

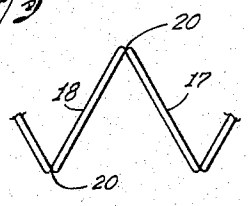


Fig. 6

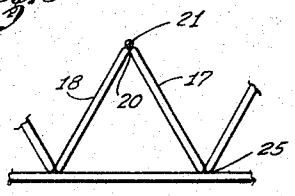


Fig. 5

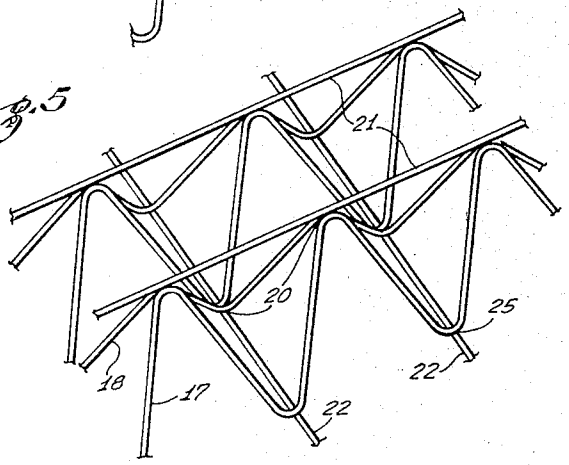
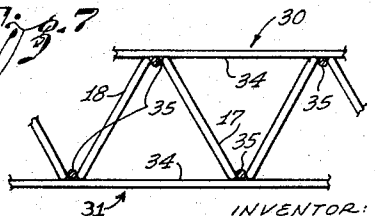


Fig. 7



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Oct. 17, 1967 J. R. HALE 3,347,007

EMBEDDED SPACED TRUSS STRUCTURES

Filed Dec. 18, 1964 4 Sheets-Sheet 2

Fig. 8

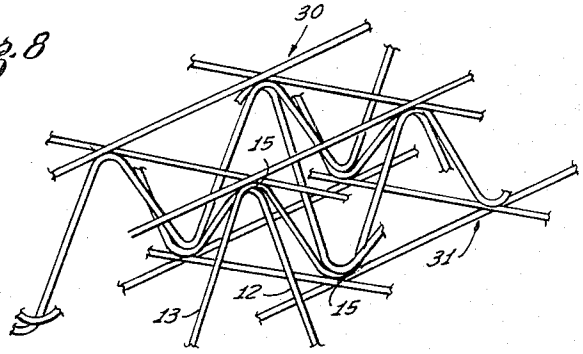


Fig. 9

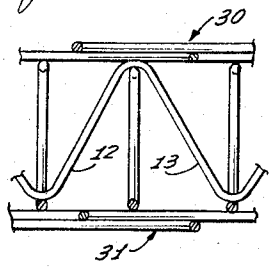


Fig. 10

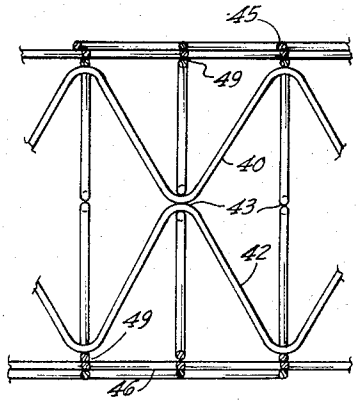


Fig. 11

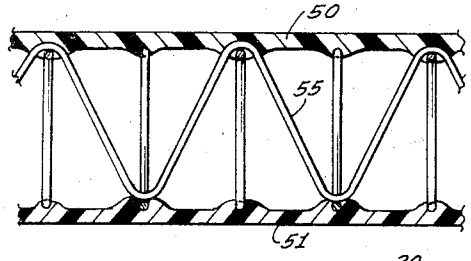


Fig. 12

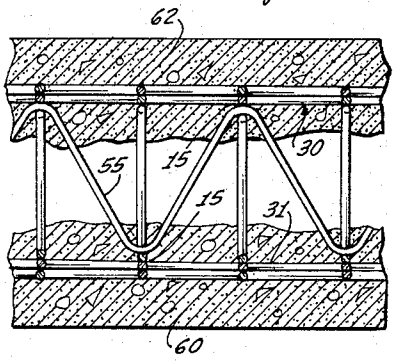
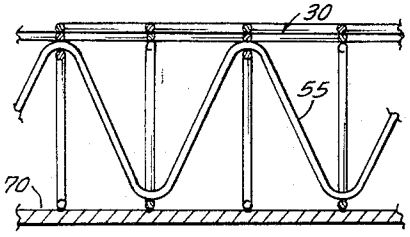


Fig. 13



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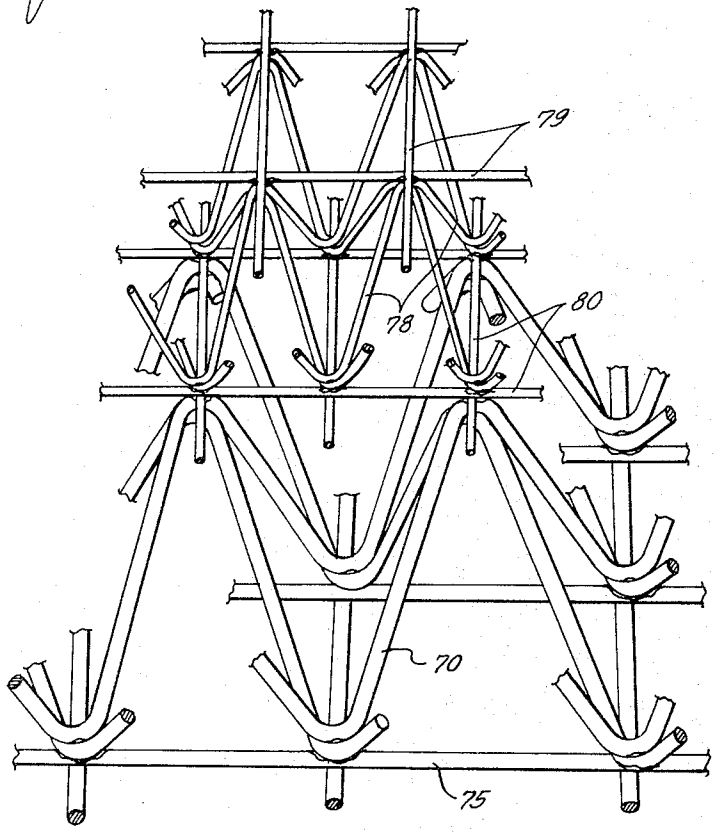
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EMBEDDED SPACED TRUSS STRUCTURES

Filed Dec. 18, 1964 4 Sheets-Sheet 3

Fig. 14



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EMBEDDED SPACED TRUSS STRUCTURES

Filed Dec. 18, 1964 4 Sheets-Sheet 4

Fig. 15

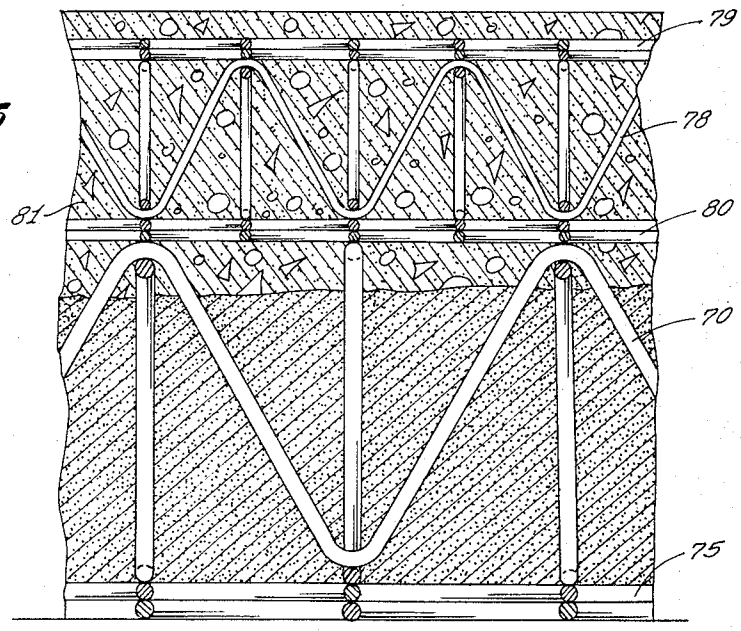
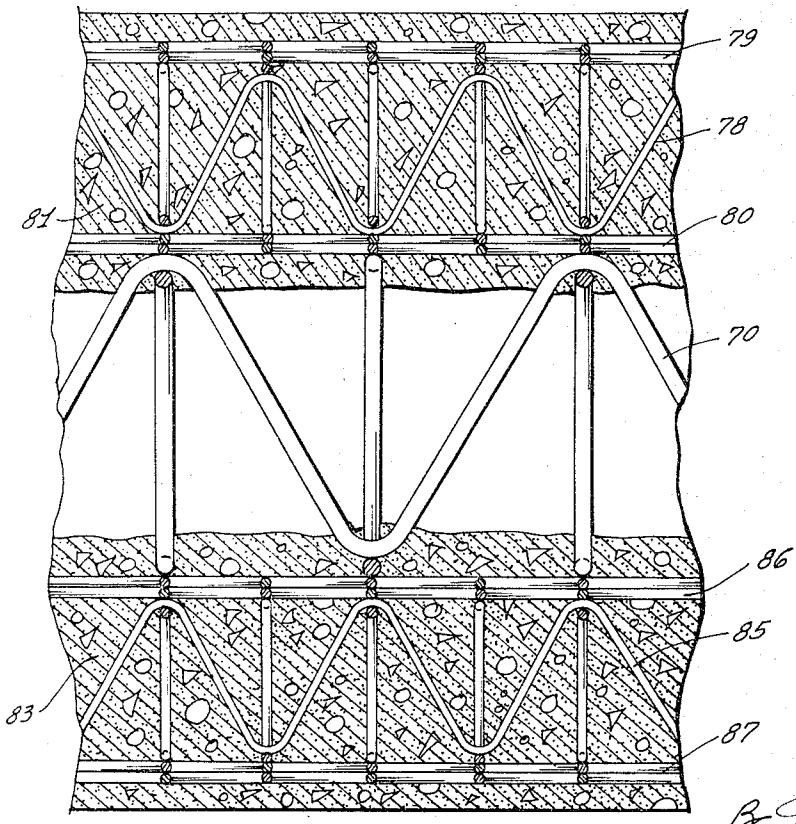


Fig. 16



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3,347,007

EMBEDDED SPACED TRUSS STRUCTURES

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Filed Dec. 18, 1964, Ser. No. 419,357
9 Claims. (Cl. 52—380)

This invention relates to the space structures and methods for fabricating same, and more particularly to such structures having the structural characteristics of a multipartite monolith.

Space structures which comprise truss members joined together to form a multiplanar framework have come into widespread use in many types of constructions such as, for example, bridges, buildings, towers, etc. This type of structure has the advantage of providing an improved strength to weight ratio and is generally much cheaper and easier to fabricate and assemble than devices having equivalent structural characteristics.

The methods used in the prior art for assembling space structures often involve the piecemeal assembly of space truss units on the erection site. Such techniques leave much to be desired in the way of economy and ease of fabrication. The method of this invention involves prefabrication by a novel method which greatly facilitates and lessens the cost of the initial fabrication of such units as well as their assembly into final form. Furthermore, the basic prefabricated structural units are such that they can readily be combined in various forms to meet a multitude of application requirements.

From the basic structural units fabricated by applicant's novel method, several structures novel in themselves have been evolved which provide substantial improvement over prior art space structures. Such structual improvements are related primarily to improved strength and superior load distribution characteristics which are those of a multipartite monolith (i.e., structural load distribution characteristics similar to those of a homogeneous slab).

The improvement is achieved in the method of the invention by fabricating a basic space truss comprising a plurality of pyramid-shaped units by either bending a flat wire mesh to such form or forming straight lengths of wire in a generally sinusoidal shape and then joining such sinusoidal elements together at their apices. Applicant's method also involves the addition of grid members joined to the apices of the pyramidal units and also includes various techniques for adapting this basic structure to particular forms for special application requirements.

Applicant's novel structure includes the combination of the basic space trusses just described in various novel forms and in conjunction with sheet-like members which are attached to the apices of the pyramidal truss members and which in some instances envelop such apices.

It is therefore an object of this invention to provide an improved method for fabricating space structures.

It is a further object of this invention to provide a method for fabricating space structures which provides greater economy and ease of fabrication than prior art methods.

It is a further object of this invention to provide an improved method for fabricating space structures having the characteristics of a multipartite monolith.

It is still another object or this invention to provide an improved method for fabricating a sandwich-type srtuctural member utilizing space trusses for the support of two substantially flat members.

It is still a further object of this invention to provide improved space structures having superior structural characteristics to those of prior art structures.

It is still another object of this invention to provide an improved space structure having the characteristics of a multipartite monolith in which such space structure is integrally combined with rigid broad surfaced building material.

Other objects of this invention will become apparent from the following description taken in connection with the accompanying drawings of which,

FIG. 1 is a perspective view illustrating a method foı fabricating the basic truss elements from wire mesh,

FIG. 2 is an elevation view of the device illustrated in FIG. 1,

FIG. 3 is a perspective view illustrating a method for fabricating the basic truss elements from straight wire units,

FIG. 4 is an elevation view of the device shown in FIG. 3,

FIG. 5 is a perspective view showing wire grids added to the basic structure of FIG. 3,

FIG. 6 is an elevation view of the device shown in FIG. 5,

FIG. 7 is an elevation view illustrating the addition of wire mesh members to the structure shown in FIG. 3,

FIG. 8 is a perspective view illustrating the addition of wire mesh members to the device shown in FIG. 1,

FIG. 9 is an elevation view of a device similar to that of FIG. 8 but with the wire mesh running at a 45 degree angle, with respect to the sinusoidal truss plane,

FIG. 10 is an illustration of a space truss comprising a pair of basic pyramidal truss elements joined together at their apices,

FIG. 11 illustrates an embodiment of the device of the invention involving a basic pyramidal space truss sandwiched between a pair of flat plastic plates,

FIG. 12 illustrates an embodiment of the device of the invention involving a pyramidal space truss with its apex portions enveloped in sheets or cast material,

FIG. 13 illustrates an embodiment of the device of the invention comprising pyramidal truss members attached to a metal plate at the apices thereof,

FIG. 14 illustrates an embodiment of the device of the invention combining large and small pyramidal space truss units,

FIG. 15 illustrates the modification of the embodiment of FIG. 14 to form a solid support structure especially suitable for handling non-static loads, and

FIG. 16 illustrates an embodiment or the device of the invention utilizing a large pyramidal space truss unit sandwiched between two small truss units.

Referring now to FIGS. 1 and 2, the formation of the basic space truss unit of the device of the invention from welded wire mesh is illustrated. Flat welded wire mesh shown as **11***a* comprising stringer wires **12** and **13** welded together at their juncture points are folded at such juncture points at an angle which may be between 35° and 70° with respect to the original plane of stringers **12** and **13**. Pyramidal space trusses **11***b* are thus formed. Such folding can be accomplished in an appropriate bending machine.

A space truss structure similar in configuration and structural characteristics can also be formed as illustrated in FIGS. 3 and 4. In this instance, elongated wire members **17** and **18** are first formed into a generally sinusoidal shape and these uniplanar sinusoidal members are joined together by welding or other appropriate means at their apices **20**. As for the space structure illustrated in FIGS. 1 and 2, the apex angles of the pyramidal truss members may have a suitable magnitude which may be between 35° and 70°.

Referring now to FIGS. 5 and 6, the structure illustrated in FIGS. 3 and 4 can be modified to provide greater strength and rigidity by adding longitudinal wire grids **21** and transverse wire grids **22**, such wire grids being welded to the pyramidal units at apices **20** and base corners **25**.

The addition of grid wires **21** and **22** adds both strength and rigidity to the structure. Grid wires **21** and **22** can either be placed as shown in FIG. 5, i.e., running normal to the sinusoidal truss plane of the core, or can be placed at a 45° angle with respect to the sinusoidal truss plane.

Referring now to FIG. 7, the space truss structure of FIGS. 3 and 4 can be modified to give even greater rigidity and strength by the addition of wire meshes **30** and **31** sandwiching the truss member. Wire meshes **30** and **31** each include stringer wires **34** and **35** welded to the apices of the pyramidal space trusses. The wire meshes may be joined to the space trusses at the time such trusses are formed with a single operation being used to join sinusoidal wires **17** and **18** to each other and to mesh units **30** and **31**.

Referring now to FIGS. 8 and 9, the addition of wire meshes **30** and **31** to the structure of FIGS. 1 and 2 is illustrated. Wire mesh units **30** and **31**, which may comprise welded wire mesh, are welded to the space truss members formed by wires **12** and **13** at the apices **15** thereof. This provides a similar structural configuration to that of FIG. 7 which has greater rigidity and strength than a basic space truss unit by itself. FIG. 9 is an elevation view illustrating the alternative placing of the mesh units **30** and **31** at a 45° angle with respect to the sinusoidal plane of the core rather than normal to and in such plane as shown in FIG. 8.

In view of the fact that welded wire mesh is at present available only for meshes up to six inches square, the method for forming the truss cores of FIGS. 1 and 2 has been used for forming space trusses having smaller sized elements while for larger sized elements, the technique illustrated in FIGS. 3 and 4 has been found more practicable.

Referring now to FIG. 10, an embodiment of the device of the invention utilizing a double truss core configuration is illustrated. In this embodiment, a first space truss member **40**, formed as shown in FIGS. 1 and 2 is joined to a second similar space truss core **42** by welding these two units together at their apices **43**. Welded wire mesh units **45** and **46** are attached to truss members **40** and **42** respectively by welding to the apices **49** thereof. The embodiment may also be formed from the units illustrated in FIGS. 3 and 4.

Referring now to FIG. 11, the formation of a sandwich panel unit with the basic truss cores of FIGS. 1–4 is illustrated. Here again, the units of FIGS. 1 and 2 are shown for illustrative purposes. The apices of truss core **55** are attached to the surfaces of sheets **50** and **51**, thereby forming a rigid panel member of very high strength. Boards **50** and **51** may be of plaster board, fiber glass, asbestos sheet, metal, glass, or any other suitable material, and the attachment of truss members **55** thereto may be achieved by welding, bonding, or mechanical locking.

Referring now to FIG. 12, an embodiment of the device of the invention in which the truss core structure of FIG. 8 is cast in a material such as concrete and plaster to form a sandwich unit is illustrated. The core unit having wire grids **30** and **31** running at an angle of substantially 45° with respect to the sinusoidal plane of the core and welded to the apices thereof is placed in material such as plaster or concrete **60** when such material is still plastic. Material **60** envelops both grid **31** and truss core apices **15**. Material **60** is then allowed to set so that it rigidly holds the truss member. After mesh unit **31** and its associated truss apices have been joined to slab **60**, the unit is turned upside down and wire mesh **30** and its associated apices **15** are similarly set into slab **62**. The sandwich structural unit thus formed has exceptionally good structural characteristics and can be utilized, for example, in preforming ceiling and floor units, adjacent wall structures and the like. Having the joints at apices **15** submerged within the material of slabs **60** and **62**, effectively enables the translation of bending shear loads on the truss into compression loads in the enveloping material. The bending loads applied to the mesh units **30** and **31** are similarly translated into compression loads in the enveloping material. In view of the fact that most constructional materials, such as concrete, gypsum and the like, exhibit their greatest strength in compression, the translation of the loads on the truss cores into such compression loads maximizes the effective strength of the composite structure and minimizes the chances of "membrane" members **60** and **62** buckling.

Referring now to FIG. 13, an embodiment of the device of the invention utilizing a truss core attached on one side thereof to a metal plate is illustrated. Core **55** has a wire mesh **30** welded to one side thereof and is welded at the other side thereof to metal plate **70**. Metal plate **70** thus provides a base plate for the truss member.

Referring now to FIG. 14, an embodiment of the device of the invention utilizing two truss core sections having truss units of different sizes and depths is illustrated. A first larger core section **70** has a mesh **75** fixedly attached to the bottom apices thereof by suitable means such as welding. Smaller truss core section **78** has meshes **79** and **80** attached to the top and bottom apices thereof respectively. The bottom mesh **80** and truss core section **78** are attached to the larger core section **70** at the top apices thereof.

The structure illustrated in FIG. 14 can be utilized as shown in FIG. 15 to form a structure suitable for handling very high non-static loads such as, for example, highways and aircraft runways. Referring to FIG. 15, truss core section **78** and its associated meshes **79** and **80** are set in concrete slab **81**, their welding joints and the upper apices of core section **70** all being enveloped by the concrete material. Larger truss core section **70** which rests on the ground is completely filled with sand. Sand not only supports truss core section **70** but also acts as a hydrostatic load distribution medium, i.e., the sand effectively operates like a liquid in distributing the load, tending to shift therewith to create equal load distribution at all times. Thus, with changing loads, the support structure of FIG. 15 self adapts itself to handle such loads in ideal fashion.

Referring now to FIG. 16, an embodiment of the device of the invention utilizing a large truss unit sandwiched between two small truss units is shown. The embodiment of FIG. 16 includes small truss units **78** and **85** having mesh structures **79**, **80** and **86**, **87** respectively attached thereto. The truss units and their associated mesh structures are attached to opposite sides of large truss unit **70** at the apices thereof to form a unitary structure. Truss unit **78**, its associated meshes **79** and **80** and the upper apices of large truss unit **70** are all set in concrete slab **81**, while truss unit **85**, its associated meshes **86** and **87** and the lower apices of unit **70** are similarly set in concrete slab **83**. Such concrete envelopments effectively translate loads on the truss cores into compression loads in the concrete slabs as explained in connection with FIG. 12. The structure of FIG. 16 can be utilized to advantage, for example, in fabricating floor and ceiling members and wall members in building construction.

It is to be noted that while the device of the invention has been described in conjunction with wire mesh and wire elements, plastic or fiber material can be utilized to equal advantage where application demands so indicate.

The device and method of this invention thus provide a multipartite structure generally rectangular in form which has characteristic such that it produces monolithic energy dispersement patterns, i.e., it has load distribution characteristics similar to those of a homogeneous slab. A novel method for producing the basic truss units utilized in the device of the invention which makes such fabrication more economical and easier to accomplish is described. The various embodiments of the device of the invention provide a space structure having superior struc-

tural characteristics which is substantially cheaper and easier to fabricate than similar prior art structures.

While the method and device of this invention has been described and illustrated in detail, it is to be clearly understood that this is intended by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of this invention being limited only by the terms of the following claims.

I claim:

1. A space structure comprising:
- a first space truss section including a plurality of wire-like elements joined together to form a plurality of pyramidal truss units,
- a mesh attached to the pyramidal apices on one side of said first truss section,
- a mesh attached to the pyramidal apices on the other side of said first truss section,
- a second space truss section similar in configuration to said first space truss section, the pyramidal truss units of said second section being substantially larger in width and depth than those of said first truss section, and
- a mesh attached to the pyramidal apices on one side of said second truss section,
- the pyramidal apices on the other side of said second truss section being attached to one of the meshes attached to said first truss section.

2. The structure as recited in claim 1 and additionally including a slab, said first truss section and the pyramidal apices on the other side of said second truss section being set in said slab and completely enveloped thereby.

3. The structure as recited in claim 2 and additionally including sand completely filling the core of said second truss section.

4. A space structure comprising:
- a first space truss section including a plurality of wire-like elements joined together to form a plurality of pyramidal truss units,
- a uniplanar mesh attached to the pyramidal apices on one side of said first truss section,
- a uniplanar mesh attached to the pyramidal apices on the other side of said first truss section,
- a second space truss section substantially identical in size and configuration to said first space truss section,
- a separate uniplanar mesh respectively attached to the pyramidal apices on each or the sides of said second truss section,
- a third space truss section similar in configuration to said first and second truss sections, the pyramidal truss units of said third section being substantially larger in width and depth than those of said first and second sections, and
- said third truss section being sandwiched between said first and second sections with the pyramidal apices on one side of said third section attached to one of the meshes of said first truss section and the pyramidal apices on the other side of said third section attached to one of the meshes of said second truss section.

5. The space structure as recited in claim 4 and additionally including a first and second slab unit, said first truss section and the apices of said third section attached thereto being set in and completely enveloped by one of said slab units, said second truss section and the apices of said third section attached thereto being set in and completely enveloped by said second slab unit.

6. A space structure comprising:
- a first space truss section having a plurality of pyramidal truss units, said truss units being formed from a plurality of uniplanar substantially sinusoidally shaped wire-like elements joined together at their apices,
- a pair of uniplanar mesh units, one of said mesh units being attached to the pyramidal apices on one side of said first space truss section, the other of said mesh units being attached to the pyramidal apices on the side of said first space truss section opposite said one side thereof, and
- a second space truss section similar in configuration to said first truss section, said second truss section having pyramidal truss units substantially larger in width and depth than those of said first truss section, the pyramidal apices of one side of said second truss section being attached to one of the mesh units of said first truss section.

7. The structure as recited in claim 6 and further including a slab member, said first truss section, its associated mesh units and said pyramidal apices of said one side of said second truss section being set in said slab member and enveloped by the material of said slab member.

8. The structure as recited in claim 7 wherein the spaces between the wire elements of said second truss section are filled with sand.

9. The structure as recited in claim 7 and further including a third truss section substantially identical to said first truss section with substantially identical mesh units attached thereto, one of the mesh units of said third truss section being attached to the pyramidal apices on the other side of said second truss section, said third truss section, a second slab member, its associated mesh units and the apices of said second truss section attached thereto being set in said second slab member and enveloped by the material of said second slab member,
- whereby said second truss section is sandwiched between said first and second truss sections and said slabs and bending shear loads on said truss sections and bending loads on said mesh units are translated into compression loads in the slab members.

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