

[54] **ERECTABLE BUILDING STRUCTURE**
[76] Inventors: **Vincent M. Kelly**, 67 West Lessig Circle, Prescott, Ariz. 86301; **John R. Scudder**, 740 Farmer Ave., Tempe, Ariz. 85281
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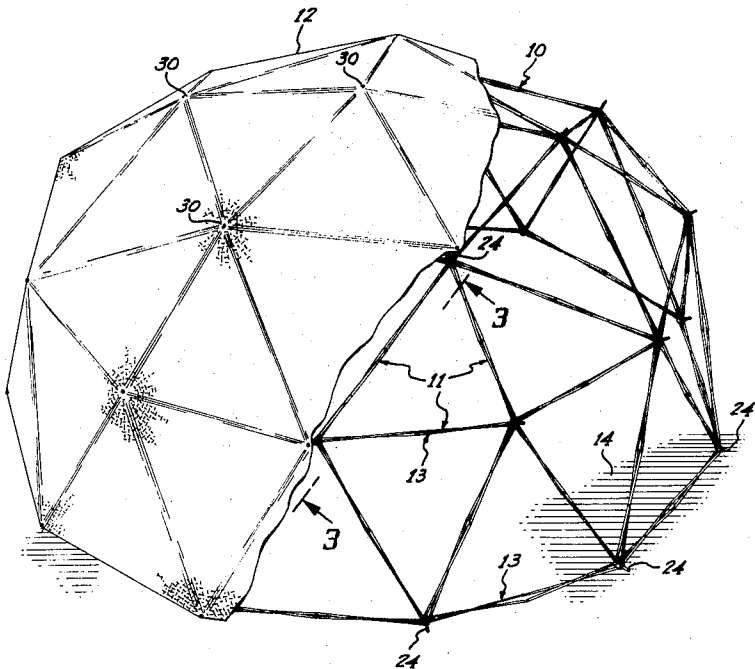
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Primary Examiner—Peter M. Caun
Attorney—Warren F. B. Lindsley

[57] **ABSTRACT**
An expandable structure employing multihinged, scissor type mechanical linkages for supporting an associated flexible skin for providing a building expandable, collapsible and movable at will, and also providing a skeleton framework for rigid panels.

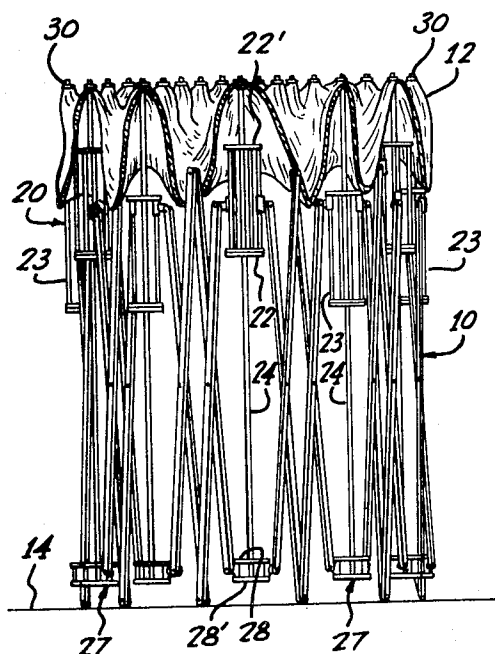
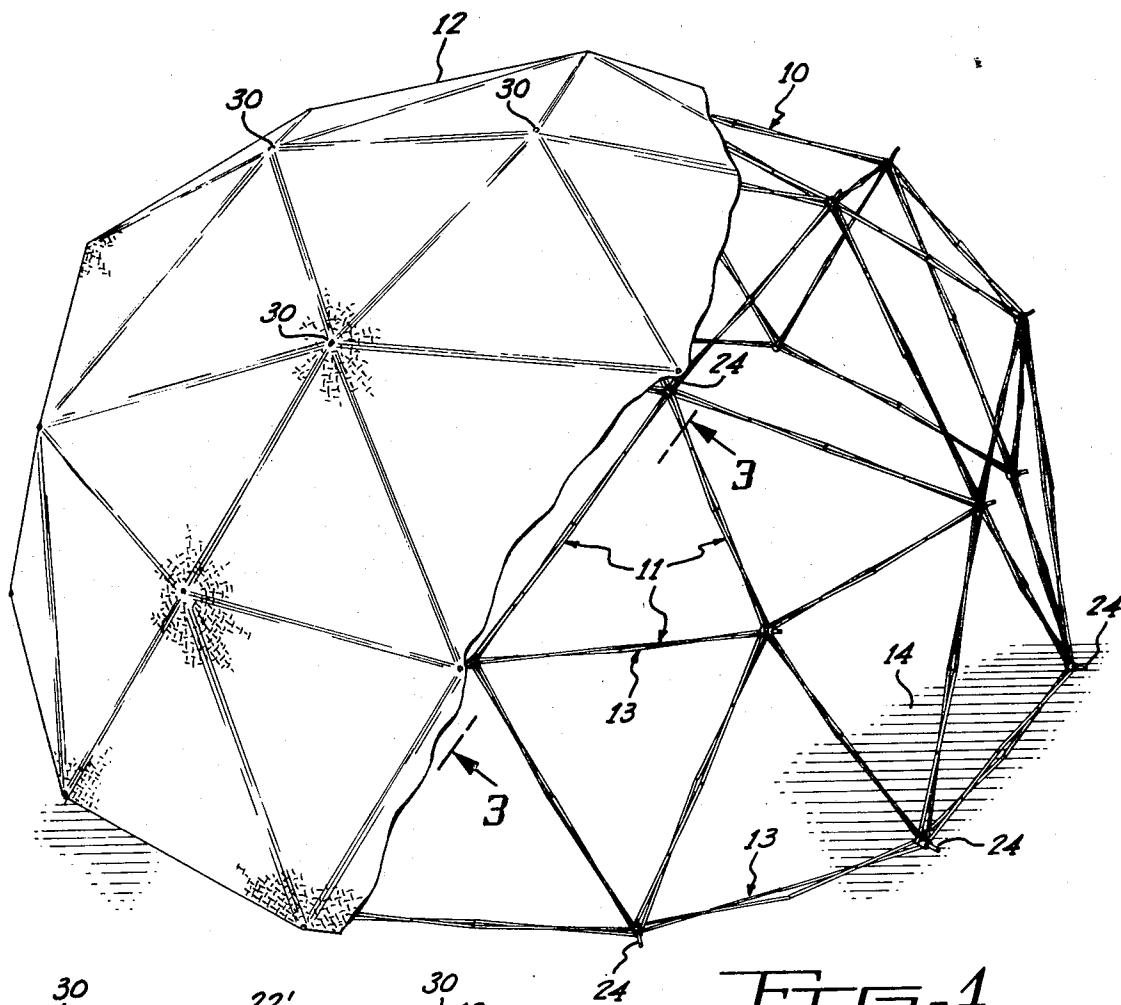
10 Claims, 7 Drawing Figures



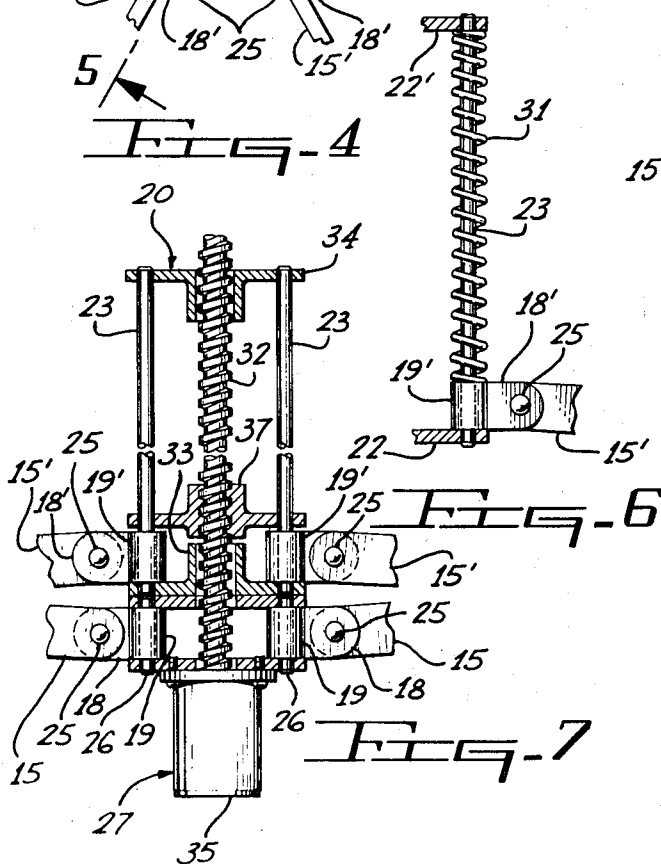
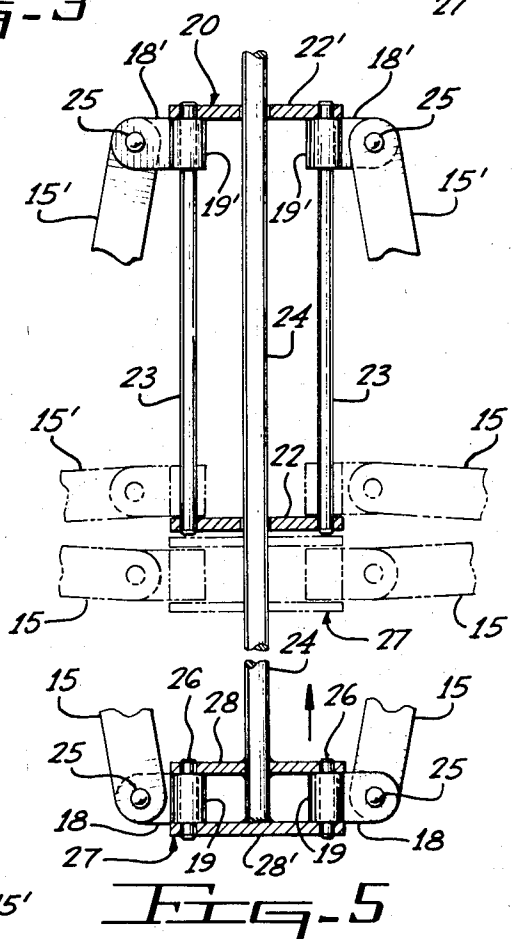
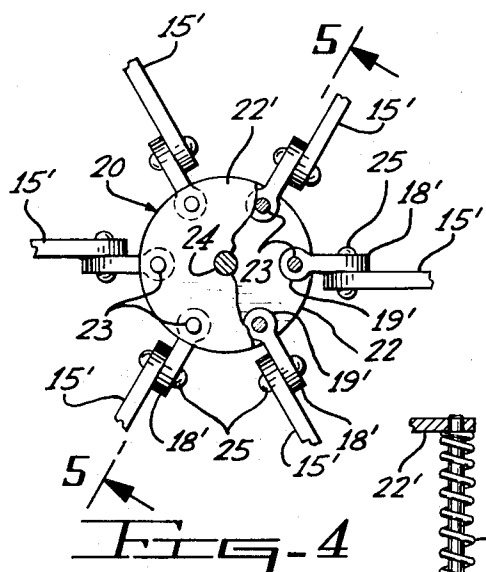
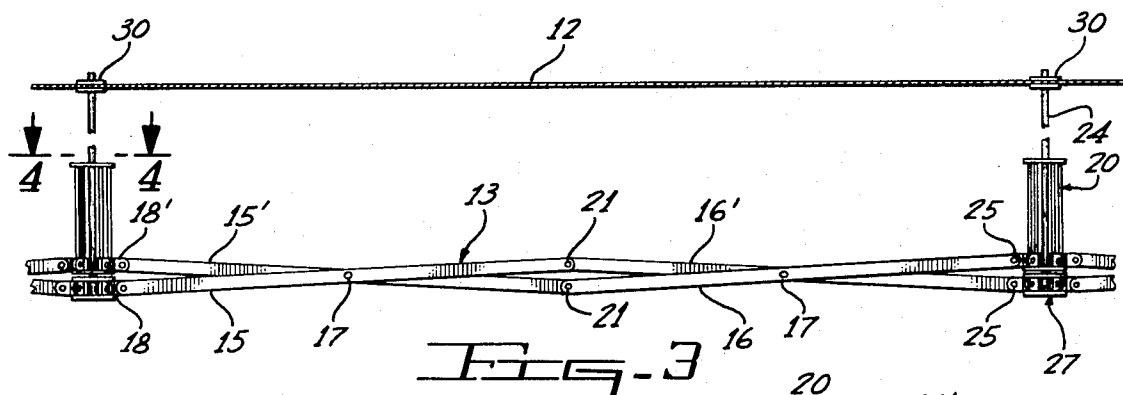
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INVENTORS
VINCENT M. KELLY AND
BY JOHN R. SCUDDER
Walter F. B. Lindley
ATTORNEY



INVENTORS
VINCENT M. KELLY AND
BY JOHN R. SCUDDER
Warren F. B. Sincley
ATTORNEY

ERECTABLE BUILDING STRUCTURE**BACKGROUND OF THE INVENTION**

This invention is directed to erectable structures for housing or business needs which are rigid, thermally stable and structurally useable under any weather condition. The structure disclosed is collapsible at will to be readily moved to other locations where building needs exist whether of a permanent or temporary nature.

Multihinged, scissor type mechanical linkages have been used for supporting expandable structures; however, they have been inadequate for basic building needs, since they lacked the rigidity needed for beam or column use.

FIELD OF THE INVENTION

Tubular struts arranged to form triangulated frames employing axial loading of its component members have been widely used. Knee joints provided at the mid-span of each of the upper and lower members of such a classic engineering structure with pin joints at each end provided folding structures. This use essentially resulted in a two-dimensional girder structure known in the art as a "Warren Girder" described in the publication entitled **LARGE SPACE ERECTABLE STRUCTURES** by Desmond H. Vaughan appearing in the papers of the Joint National Meeting of the American Astronautical Society and Operations Research Society of June 17-20, 1969.

If three Warren Girder structures are merged at a 60° spacing, a three-dimensional structure in the shape of a tetrahedron may be provided at their intersection. By adding more girders an expandable truss structure results.

DESCRIPTION OF THE PRIOR ART

There has been considerable interest in recent years in large space erectable structures such as, for example, antennas. Compared to conventional earth based structures, these structures operate in zero gravitational environment and are free of many of the distorting forces present on the earth's surface. Further, the space structures are expanded once and left in that condition.

On earth, however, expandable structures must stand a variety of weather conditions and must be collapsible so as to be moved and erected at other sites.

SUMMARY OF THE INVENTION

Thus, in order to provide a commercially feasible expandable, erectable structure, the expandable truss structure must be packaged in its collapsed configuration so that it can be easily expanded. Any skin mounted on the trusses must cover the geometrical configuration defined by the expanded truss members.

With so many expandable truss members, the resulting shape of the structure must be so oriented that the building is rigid. Thermal distortion must be considered, and since the building formed by the disclosed invention may be collapsed and moved, weight of the material selected for the trusses must be considered.

In accordance with the invention claimed, an improved erectable building structure is provided for home, government and business purposes.

It is, therefore, one object of this invention to provide an improved erectable, expandable and collapsible building structure.

Another object of this invention is to provide a new erectable dome structure.

A further object of this invention is to provide an erectable and expandable framework for a building formed of multihinged, scissor type mechanical linkages.

A still further object of this invention is to provide an erectable building employing multihinged scissor type mechanical linkages having flexible panel members fastened to said linkages which cover at least a part of the profile of the building when erected.

A still further object of this invention is to provide an improved dome structure of a plurality of interlocking parts which, when expanded, form a dome configuration capable of being collapsed and erected in a minimum period of time.

Further objects and advantages of the invention will become apparent as the following description proceeds and the features of novelty which characterize this invention will be pointed out with particularity in the claims annexed to and forming part of this specification.

BRIEF DESCRIPTION OF THE DRAWING

The present invention may be more readily described by reference to the accompanying drawing in which:

FIG. 1 is a perspective view of an expandable truss structure and covering for a dome shaped building and embodying the invention;

FIG. 2 is a collapsed or package illustration of the dome shaped building illustrated in FIG. 1;

FIG. 3 is an enlarged view of a scissor type mechanical linkage shown in FIGS. 1 and 2;

FIG. 4 is a cross-sectional view of FIG. 3 taken along the line 4-4;

FIG. 5 is an enlarged view of the hubs of the scissor type joint;

FIG. 6 is a modification of the hub shown in FIG. 5 wherein the hub employs a spring biasing means for aiding in expanding the scissor type joint; and

FIG. 7 is a further modification of the hub structure shown in FIG. 5 wherein a motor and worm gear are used to expand and contract the scissor type joint.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring more particularly to the drawing by characters of reference, FIG. 1 discloses a dome type structure 10 formed of expandable trusses 11 and covered by a flexible sheathing or covering 12.

The expandable trusses comprise a plurality of scissor type mechanical linkages 13 which serve as the erectable and expandable support for the flexible covering 12. The scissor type linkages, when interlocked together as shown and later more fully described, adequately form and support the building configuration.

Although structure 10 is shown as being of a dome shaped configuration, it may form other suitable designs mounted on the ground or on a suitable foundation 14, which may conform to the outer walls of the structure.

Referring more particularly to the framework of the structure and with particular reference to FIGS. 1-5 of the drawings, it will be noted that each load supporting strut comprises expandable linkage structures 13, 13' which as shown in FIG. 3 comprise two pairs of linkages 15, 15' and 16, 16'. Each pair of linkages is pivotally connected by a pin 17 at a point near the middle of the linkage with their free ends being pivotally connected to lugs 18, 18' of collars 19, 19' of like cylindrical knee joints, junction point elements or hubs 20. The juxtapositioned ends of linkages 15, 15' and 16, 16' are pivotally connected by pins 21.

Hubs 20 comprise a cylindrical shaped member formed of two end discs 22, 22' separated by a plurality of pins 23 arranged to extend between discs 22, 22' around their periphery and all arranged substantially parallel to each other. A shaft 24 which, for example, may be of a telescope configuration, is arranged to extend through the centers of each of the discs 22, 22' in sliding arrangement therewith and parallel to pins 23. Thus, hub 20 comprises a fixed body member comprising the discs 22, 22' and pins 23 which as a unit are slidable movable along shaft 24.

As heretofore described, each of the linkages 15, 15' and 16, 16' are pivotally connected at one end to a pin 25 which is journaled in a bearing formed in lugs 18, 18', respectively. Each lug is attached to one of the collars 19, 19'. Collars 19' are each slidably mounted on one of pins 23, as shown more clearly in FIG. 5.

Collars 19 are mounted on pins 26 within a second knee joint, junction point element or hub 27 comprising a pair of discs 28, 28' spacedly arranged on pins 26 and fixedly attached to the lower end of shaft 24. Discs 28, 28' hold collars 19 in a given position on pins 26 but provide rotative movement of collars 19 around pins 26.

Thus, hubs 20 may be moved relative to hubs 27 on shafts 24 of the framework forming the dome type structure 10.

It should be recognized that the configuration of discs 22, 22' and 28, 28' are alike having the same number of collars 19, 19' spacedly arranged around their periphery.

By reference to FIG. 2 it is noted that when the framework of the dome type structure 10 is in its collapsed position, hubs 20 are slidably moved along shafts 24 to near their ends opposite to the ends at which hubs 27 are fixedly attached.

To expand the framework of the dome type structure 10, the hubs 20 are moved along shafts 24 toward the hubs 27, at which time the linkage structures 13, 13' are in their extended positions.

The expandable trusses 11 forming the framework of the dome type structure 10 are a repetition of hubs 20 and 27, shafts 24 and linkage structures 13, 13'. Thus, it is inherent that the operating characteristics of each joint and linkage arrangement are repetitive, since evenly distributed through the framework of the dome type structure. There is no one strong point such as a central hub in the dome structure shown, but there may be use of a central hub configuration in other structures embodying the inventive concepts disclosed. Each of the structural intersect points is a strong point and load applied directly to any of these points is distributed throughout the structure along numerous structural

paths. Accordingly, a high degree of structural integrity is provided.

Further, the repetitive nature of the structure provides almost unlimited design flexibility, i.e., any desired profile shape can be attained by simply matching the structure to the desired shape. It should be stated that triangular, elongated and angular configurations are possible with the disclosed hub and linkage configuration.

It is realized that one feasible application of the building components disclosed above is in a dome shaped building. To readily erect such a building the covering 12 may be fastened to the upper ends of one or more shaft 24 and held thereon by a suitable fastener 30. When the expandable trusses 11 are collapsed as shown in FIG. 2, the flexible cover settles over the top ends of shafts 24. When the trusses are expanded the covering is drawn taut over the trusses, forming a covering for the dome type structure in the manner shown in FIG. 1.

A dome type structure has been shown and described; however, other structural uses can be made of the inventive concept disclosed herein such as helical antenna structures for space and earth use, non-dome shaped structures for housing or product sheltering purposes and any other needs for coverage of a permanent or temporary nature. Covering 12 may be of a plastic or rubber material or it may be simply a flexible netting formed of any desirable material capable of supporting other materials.

In the deployed configuration shown in FIG. 1, one third of the expandable trusses including the linkage structures 13, 13' lie in a longitudinal orientation substantially parallel to the ground. The remaining linkage structures are angularly arranged thereto as shown. The knee joints or hubs are deployed at axial angles near the supporting platform or ground having shafts 24 extending substantially parallel therewith. The remaining shafts of the hubs are angularly arranged with the platform or ground with the centermost shaft extending substantially perpendicularly thereto.

FIG. 6 illustrates a modification of the structure shown in FIGS. 1-5 wherein a spring 31 is mounted around pin 23 bearing on disc 22' and collar 19 for biasing collar 19 toward disc 22. This action tends to aid in the erection or extension of the truss element formed of the interconnected linkages 15, 15' and 16, 16' as shown in FIG. 3. One or more pins may be provided with springs such as spring 31.

FIG. 7 illustrates a further modification of the joints shown in FIGS. 1-6 wherein shaft 24 is replaced with a worm gear 32 which is threadedly arranged to extend through discs 33 and 34, replacing discs 22 and 22' of FIGS. 1-6. A motor 35 is connected at the lower end of worm gear 32 as shown in FIG. 7 to rotate worm gear 32 when energized to move collars 19' relative to collars 19, thereby extending or lessening the length of the trusses formed by linkages 15, 15' and 16, 16' as shown in FIG. 3.

Motor 35 may comprise an electric, pneumatic or hydraulic means which may be operated through one or more gear trains. It should be recognized also that a hand-operated crank could be used in preference to the power-driven devices disclosed.

If desired, discs 33 and 34 may merely provide an aperture for receiving the worm gear loosely therein while plate 37 supports the worm gear in hub 20.

Although but a few embodiments of the present invention have been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

We claim:

1. A building component for the construction of an erectable framework employing a plurality of trusses comprising:

- a first junction point element for said trusses, said first element comprising a first pair of discs spacedly arranged from each other by a plurality of first pins parallelly arranged to extend between said discs around their peripheries,
- a shaft slidably extending through apertures in the centers of said first pair of discs,
- a second junction point element fixedly mounted on one end of said shaft, said second element comprising a second pair of discs spacedly arranged from each other by a plurality of second pins parallelly arranged to extend between said second pair of discs around their peripheries,
- a plurality of collars slidably and rotatably mounted on at least some of the pins of said first element,
- a plurality of collars rotatably mounted on at least some of the pins of said second element,
- a lug extending outwardly from each of said collars of said first and second elements,
- a scissor type mechanical truss comprising a pair of linkages pivotally connected at a point between their ends, and
- means for pivotally connecting a common end of one of said linkages to one of said collars of said first element and the common end of the other of said linkages to one of said collars of said second element, the relative position of said first element with reference to said second element on said shaft determining the distance between the common ends of the linkages of said truss.

2. The building component for the construction of an erectable framework as set forth in claim 1 in further combination with:

- a second identical component, and
- pivotal means for connecting like free ends of the linkages of the truss of each identical component together to form an expandable and contractable truss member.

3. The building component for the construction of an erectable framework as set forth in claim 1 in further combination with a biasing means arranged between one of the discs of said first pair of discs and one of said collars of said first element for biasing the ends of said linkages of said truss toward each other.

4. The building component for the construction of an erectable framework as set forth in claim 1 in further combination with spring biasing means arranged around each of said pins of said first element between one of said discs and one of said collars of said first element for biasing the ends of said linkages of said truss to a position toward each other.

5. The building component for the construction of an erectable framework as set forth in claim 1 wherein:

said shaft is replaced with a gear means in threaded engagement with the walls of said apertures in said discs of said first element, and

means connected to said gear means for rotating said gear means for moving said linkages connected to said collars of said first and second elements relative to each other.

6. The building component for construction of an erectable collapsible framework as set forth in claim 5, wherein said means connected to said gear means comprises a motor.

7. An erectable framework for a configuration employing a plurality of triangular sections formed of interconnected trusses, each of said sections comprising:

- three identical building components, each of said components comprising a first junction point element for said trusses, said first element comprising a first pair of discs spacedly arranged from each other by a plurality of first pins parallelly arranged to extend between said discs around their peripheries,
- a shaft slidably extending through apertures in the centers of said first pair of discs,
- a second junction point element fixedly mounted on one end of said shaft, said second element comprising a second pair of discs spacedly arranged from each other by a plurality of second pins parallelly arranged to extend between said second pair of discs around their peripheries,
- a plurality of collars slidably and rotatably mounted on at least some of the pins of said first element,
- a plurality of collars rotatably mounted on at least some of the pins of said second element,
- a lug extending outwardly from each of said collars of said first and second elements,
- a scissor type mechanical truss comprising a pair of linkages pivotally connected at a point between their ends,

means for pivotally connecting a common end of one of said linkages to one of said collars of said first element and the common end of the other of said linkages to one of said collars of said second element, the relative position of said first element with reference to said second element on said shaft determining the distance between the common ends of the linkages of said truss, and

pivotal means for connecting like free ends of the linkages of the truss of different building components together to form expandable and contractable triangular sections.

8. The erectable framework set forth in claim 7 wherein each of said shafts of each of said building components is replaced with a worm gear in threaded engagement with the walls of said apertures in said discs of said first element, and

motor means connected to each of said worm gears for rotating said worm gears for moving said linkages connected to said collars of said first and second elements relative to each other.

9. The erectable framework set forth in claim 7 in further combination with flexible covering attached to the other end of said shaft of each of said components for covering said triangular section when the trusses of said section are expanded.

10. A building component for the construction of an erectable framework employing a plurality of trusses comprising:

a first junction point element for said trusses, said first element comprising a first pair of interconnected members spacedly arranged from each other to form between them a firm cylindrical housing, 5
a shaft slidably extending through apertures in the centers of said first housing,
a second junction point element fixedly mounted on one end of said shaft, said second element comprising a second pair of interconnected members spacedly arranged from each other to form between them a cylindrical housing, 10
a plurality of collars moveably mounted on said first element,
a plurality of collars moveably mounted on said 15

second element,
a lug extending outwardly from each of said collars of said first and second elements,
a scissor type mechanical truss comprising one or more linkages pivotally connected at a point between their ends, and
means for pivotally connecting a common end of one of said linkages to one of said collars of said first element and the common end of the other of said linkages to one of said collars of said second element, the relative position of said first element with reference to said second element on said shaft determining the distance between the common ends of the linkages of said truss.

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