An improved joint for connecting the ends of tubes for the purpose of assembling a geodesic dome or truss structure (FIG. 6). The tube ends form top and bottom hooks (A4) which face away from each other. The hooked ends (A4) facilitate the attachment of adjacent tubes to the unifying joint by gripping a common top and bottom washer (3). The inner washers (3) are used as tension rings for restricting the movement of the tubes by which they are hooked. The structure is stiffened when the hooks are pressed down into a flattened position by the outer top and bottom washers (2). The outer top and bottom washers are sandwiched by a single nut and bolt assembly (1,5). As the nut and bolt assembly (1,5) is tightened pressure is applied to the outer washers which press the hooked ends (4A) of the tubes backwards into a flattened position. The initial condition of the joint is loose to allow adjustments of the positioning of the tubes within the structure. The final state of the joint after the nut and bolt assembly is tightened is stiff completing the structure assembly as a ridged structural frame (FIG. 9).
GEODESIC DOME ASSEMBLY JOINT

BACKGROUND

[0001] 1. Field of Invention

This invention relates to geodesic dome and space frame structure joint and assembly systems.

[0002] 2. Description of Prior Art

[0004] Tubular elements or pipes have advantages over other structural forms because of the load-transmitting qualities inherent in their circular cross section and their efficient strength-weight ratio. In the past the failure to employ them extensively in geodesic domes and trusses and truss-like structures was due to the lack of suitable connectors or coupling members for easily and efficiently joining their ends.

[0005] A current disadvantage of many geodesic domes and space frame structures presently in use is the high cost of connectors used to interconnect chord and strut members at each node and the high labor cost associated with the assembly of complicated structural systems.

[0006] Several current designs shown in the prior art attempt to solve the problems of joining tubes by flattening the ends of the tubes and restraining their movement with an attachment assembly. The first group gains an economic advantage through simple fabrication but loose that advantage in material and labor cost because multiple fasteners are required to complete the assembly. The second group gains economic advantage by reducing the number of fasteners to a minimum but loses this advantage by implementing non pre-existing components that are unique in form and require expensive manufacturing techniques to fabricate.

[0007] The prior art Johnson, Jr. U.S. Pat. No. 4,322,176, Mar. 30, 1982 is a patent where the ends of tubes have been formed in order to interlock into a housing with two opposite converging walls. The illustrations show flattened ends of tubes sandwiched together on top of the housings restraining the formed tubes. The sandwiched tubes and the restrained tubes are all held in place by a singular bolt. The bolt simultaneously passes through the housings and through holes in the individual flattened portion of the tubes. The design increases the number of different components and cost by having two different systems for restraining the tubes requiring two different shapes of formed tube ends. Manufacturing the housing a non pre-existing component, further increases cost.

[0008] The prior art A. E. Fentiman U.S. Pat. No. 2,964,147, Dec. 13, 1960 is a patent where the ends of tubes have been flattened in order to form a plane that can be received by a slotted connector. The flattened ends of the tubes are sandwiched inside the slot and held in place by a bolt that passes simultaneously through the hole in the slotted connector and the holes in the individual flattened portion of the angled tubes sandwiched to the top of the slotted connector. The prior art Fentiman U.S. Pat. No. 2,931,467 utilizes a similar system of flattened tube ends having their movement restricted by a slotted connector. Again, the design has only a few components uses only one bolt as a fastener but loses a portion or this cost advantage in the manufacturing of the a unique non pre-existing slotted connector.

[0009] The prior art Codd U.S. Pat. No. 4,622,795 Nov. 18, 1986 FIGS. 1,2,3,4,5,6 and Codd U.S. Pat. No. 4,704,836 Nov. 10, 1987 FIGS. 1,2,5,6 Are designs where the ends of tubes have been flattened in order to form planes that are sandwiched together by numerous bolts. The design gains a cost advantage by using pre-existing components in conjunction with modified pre-existing components but looses much of this advantage as a result of the numerous bolts that add material cost and labor cost during assembly.

[0010] Several current designs shown in the prior art attempt to solve the problems of joining tubes by attaching the tubes to a tension ring in order to restrict their movement. The first group gains an economic advantage through simple fabrication but lose that advantage in material and labor cost because multiple fasteners are used to complete the assembly. The second group gains economic advantage by reducing the number of fasteners to a minimum but loses some of this advantage by implementing non pre-existing components that are unique in form and require expensive manufacturing techniques to fabricate.

[0011] The prior art Woods U.S. Pat. No. 3,486,278 and Birkemeier U.S. Pat. No. 3,635,509 both use components whose movement are restricted by a tension ring. The restricted components act as a connector between the tension ring and the struts. The restricted components are bolted to the struts. Each individual assembly for each end of a strut uses 2 or more bolts to complete the connection adding material cost and most importantly labor cost during assembly.

[0012] The prior art Braccini U.S. Pat. No. 3,323,820 and Littlefield U.S. Pat. No. 4,194,851 both use hubs to restrict the movement of the struts. The upper and lower halves of the hubs clamp the restricted struts. The hubs are neither a pre-existing item used in a new way nor a pre-existing item modified for a new use. The manufacture of these hubs are expensive especially when the specifications of the hub change to accommodate the various geometries of different projects.

SUMMARY

[0013] This invention relates to a joint for connecting the ends of tubes for the purpose of assembling a geodesic dome or truss structure. The tube ends are modified to form top and bottom hubs which face away from each other. The hooked ends facilitate the attachment of the tubes to one another by loosely gripping a common top and bottom washer. The inner washers are used as tension rings for restricting the movement of the tubes. To stiffen the structure the hooks are pressed down into flattened position by the outer top and bottom washers that are sandwiched by a single nut and bolt assembly

OBJECTS AND ADVANTAGES

[0014] The invention uses tubular elements or pipes which have advantages over other structural forms because of the load-transmitting qualities inherent in their circular cross section and their efficient strength-weight ratio. In the past the failure to employ them extensively in geodesic domes and truss-like structures was due to the lack of suitable connectors or coupling members for easily and efficiently joining their ends.
The advantage of the invention is that it reduces the cost of geodesic domes and space frame structures by reducing the material and fabrication cost of connectors used to attach strut members at each node. A further advantage of the invention is the reduction of high labor cost associated with the assembly of complicated structural systems.

The invention combines the novel use of a pre-existing component; the washer, with the modification and transformation of another pre-existing component; the tube, in such a way as to minimize the cost of the system by minimizing the following items which affect cost:

1. total number of components in the joint
2. number of unique components
3. physical complexity of the components
4. difficulty of fabricating the components
5. complexity and time for assembly of the structure.
6. number of workers required to assemble the structure.

Using one system for attaching all the struts reduces the need for a variety of components. The need for many different components with different functions is further reduced by the consolidation of several functions into one component. The flattened angular shaped ends of each tube are bent to form around the tension ring. When the end of a strut is in its final position it becomes part of the restraining system for that strut and the adjacent struts. The angled edges of the flattened portions of the struts become abutments restraining the movement of the struts. The bolt while being tightened is being used as a tool for forming the bent ends of the struts into their final position.

The invention gains an economic advantage through a simple fabrication process of modifying pre-existing readily available tubes. The means by which the tubes are modified: flattening, cutting, and bending are fast, simple, and inexpensive to execute in any machine shop. The invention maintains an economic advantage by using a pre-existing readily available washer for a novel function as a tension ring.

The cost advantage is maintained in minimum labor cost on the construction site because the action of tightening a single bolt per connector completes the coupling of the tubes with the tension ring during assembly. Flexibility within the lightly tightened joint allows the structure to be manipulated in order to sequentially attach tubes at adjacent joints. A sequential assembly requires a minimal amount of workers to execute which further reduces labor cost.

**FIGURE REFERENCES**

**FIG. 1.** Shows a bottom perspective view of the joint.
**FIG. 2.** Shows a side elevation view.
**FIG. 3.** Shows a top perspective view.
**FIG. 4.** Shows the plan view with a portion of the outer washer and head of the bolt cut away to reveal the inside of the assembly.
tubes grip the inside surface of the hole in the washer. The bottom inner washer holds the tubes loosely in position allowing the adjustments to the angle between the tubes to facilitate the positioning of the top washer over the top hooks at the tube ends.

[0047] The second step of assembly is the sandwiching of the struts 4 between the inner washers 3 in a radiating pattern. The top and bottom outer washers 2 are placed in position and the bolt 1 and nut 5 are lightly tightened allowing flexibility within the structure. Flexibility within the joint allows for a sequentially assembly of the adjacent joints. Finally when all the tubes and joints are in place the bolts 1 and nuts 5 are further tightened to transfer pressure to the top and bottom outer washers 2 which in turn apply pressure to the strut tips 4 bending them backwards and flattening them against the outside surface of the inner washers 3. (FIG. 1.) Shows a bottom perspective view after the bolt 1 is tightened and the dome joint is completely assembled. (FIG. 2.) Shows an elevation view with the struts 4 sandwiched and restrained by the tension rings 3. (FIG. 3.) Shows a top perspective view with the struts 4 radiating from the dome joint.

[0048] (FIG. 4.) Shows an exploded top perspective view with the struts 4 radiating from the dome joint with the tips of the struts bent into their final position. The bent strut tips 4 in their final position form hooks that are restrained by the inner washers 3 that act as tension rings. The tension rings 3 restrict the movement of the struts 4 away from the center of the dome joint. The angled edges of the struts 4 act as abutments resisting their movement towards the center of the joint and maintain the angular relationships between the struts.

CONCLUSIONS, RAMIFICATIONS, SCOPE

[0049] Tubular elements or pipes have advantages over other structural forms because of the load-transmitting qualities inherent in their circular cross section geometry resulting in a superior strength-weight ratio. In the past the failure to use them extensively in the construction of geodesic domes and trusses and truss-like structures was due to the lack of suitable connectors or coupling members for easily and efficiently joining their ends at a common point.

[0050] In order to make the structural advantages of the tube more accessible for the use in domes and truss structures the simplest means by which a tube can be modified flattening, cutting, and bending were exploited in order to interlock the tubes with washers used as tension rings. The dome joint combines the novel use of a pre-existing inexpensive mass-produced component; the washer, with the simple modification of tubes, in such a way as to minimize the cost of the manufacture of the structural system.

[0051] A current disadvantage of many geodesic domes and space frame structures presently in use is high labor cost associated with the assembly of complicated structural systems.

[0052] The use of only one bolt per joint reduces the complexity and reduces the time needed for assembly of a structural dome or truss resulting in lower labor cost. The flexible nature of the joint before it is tightened allows the structure to be assembled sequentially which requires a minimal number of workers further lowering labor cost.

[0053] A geodesic dome and space frame structure joint and assembly systems.

1. A means by which tubular struts attach to a tension ring.
2. Said tubular strut with hooked ends for gripping said tension ring in a loose manner allowing flexure of the struts.
3. Said tubular strut with hooked ends for gripping said tension ring in a tight manner restricting the flexure and movement of the struts.
4. A means to deform said strut to complete the attachment to a tension ring.
5. A nut and bolt assembly tightened to apply pressure to and bend said strut angled tips to form top and bottom hooks for the purpose of gripping said tension ring.
6. A means of restricting the movement of said tubular struts.
7. A washer used as a common tension resistant juncture for resisting the movement of said tubular struts.

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