April 16, 1968 L. R. ZAMORANO 3,377,637

PRE-STRESSED TRUSS

Filed Aug. 26, 1965 3 Sheets-Sheet 1

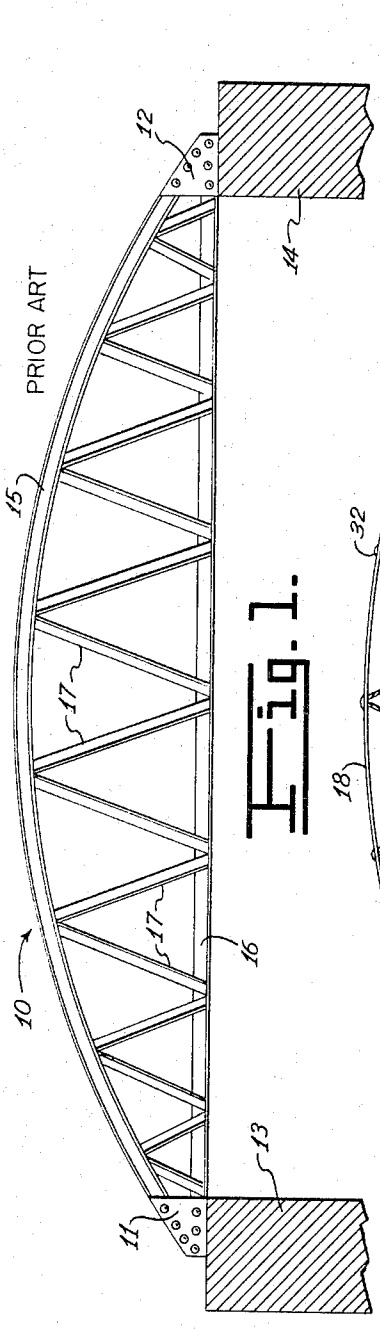


Fig. 1.

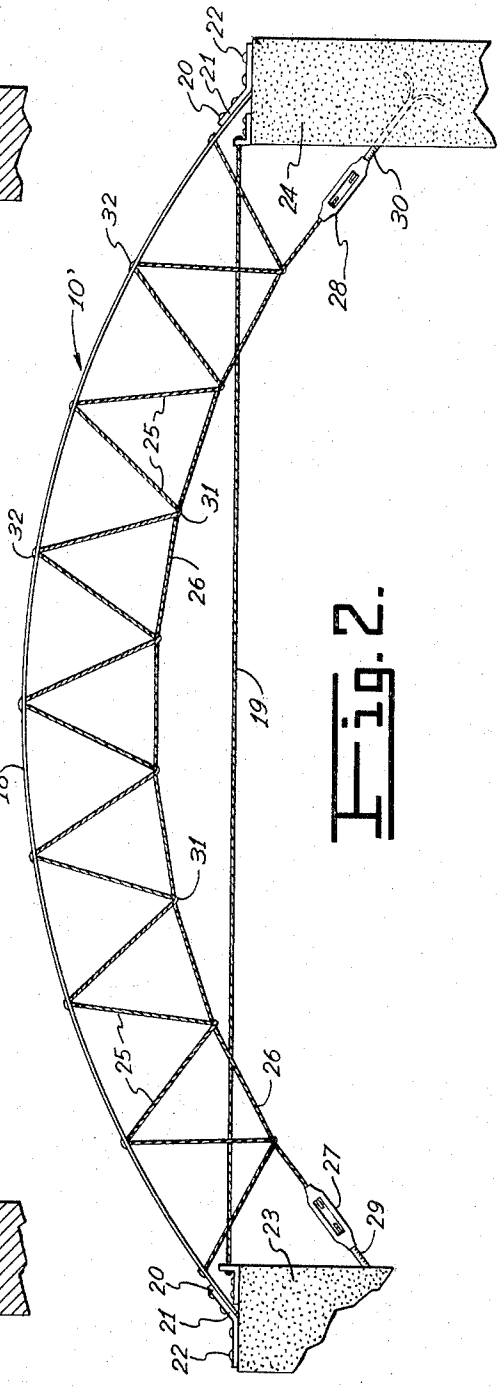


Fig. 2.

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PRE-STRESSED TRUSS

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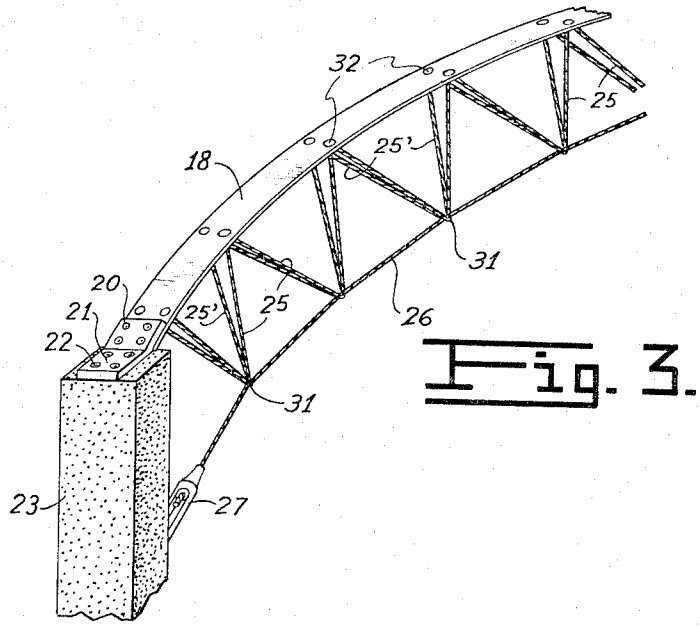


Fig. 3.

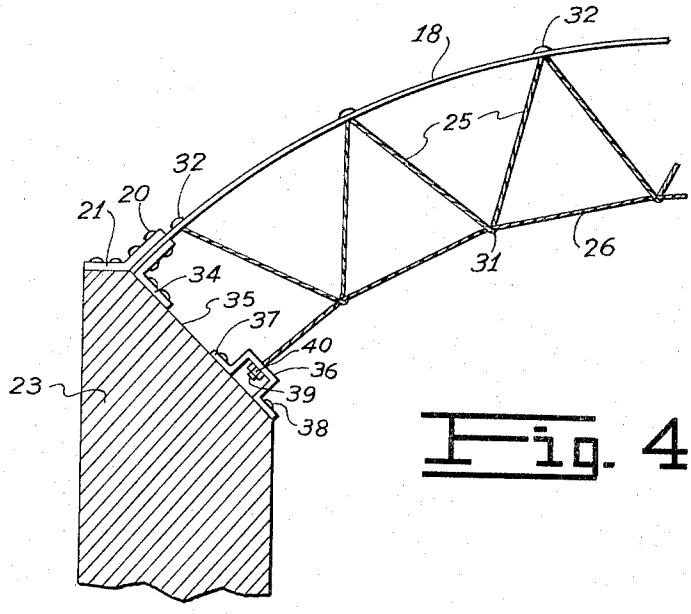


Fig. 4.

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PRE-STRESSED TRUSS

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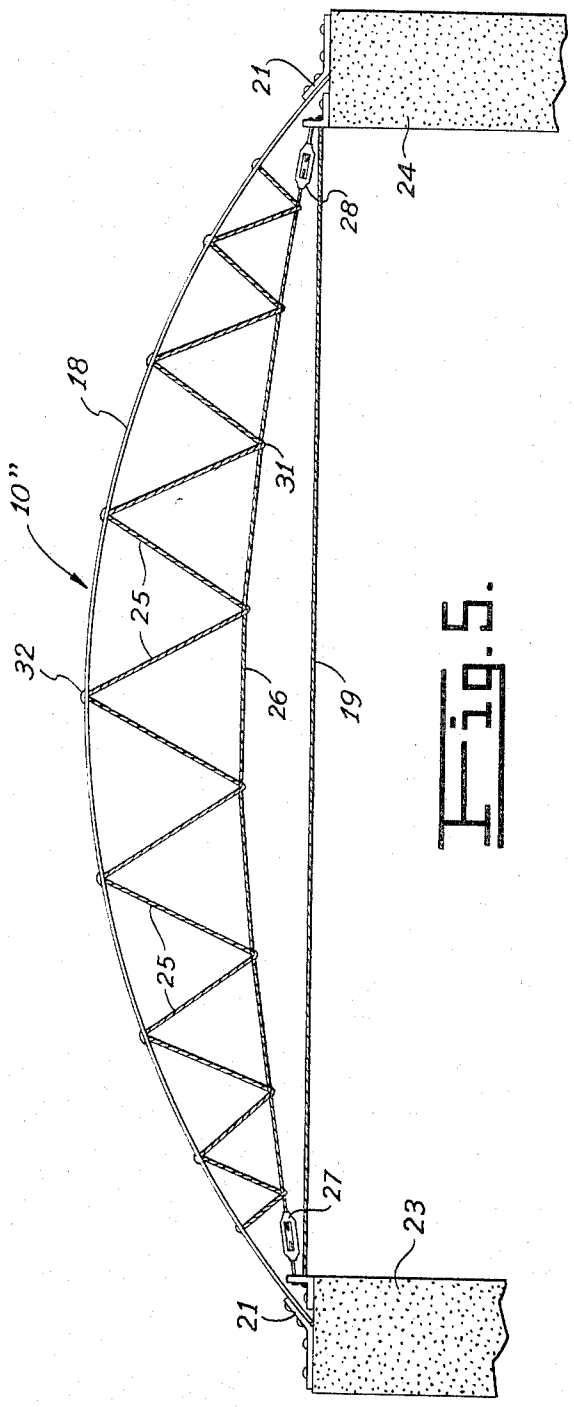


Fig. 5.

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3,377,637

PRE-STRESSED TRUSS

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83,024
6 Claims. (Cl. 14—24)

ABSTRACT OF THE DISCLOSURE

A truss having an upper arched member, a lower tensioning member and a plurality of diagonal reinforcing members forming a plurality of triangles between said upper and said lower members, the lower tensioning member being connected to the lower apex ends of the triangles and being provided with tensioning devices to prestress the truss so as to tension all the diagonal members with such a tensile force that said diagonal members will only work in tension under the design load applied to said truss. The truss is support on a pair of columns or pillars and it can be provided with a tie rod connected to the columns in order to avoid increase in the spacing thereof under a load applied to the arched member, the tensioning member being anchored in said pillars. The tensioning devices can be turnbuckles inserted adjacent each end of said lower tensioning member, and anchored to the pillars.

This invention relates to trusses and, more particularly, to a novel and improved truss which is provided with means to pre-stress all the members of the trusswork in order to make them work strictly in tension.

Hereinbefore, roof trusses which were built with an arch as the upper chord, necessitated the provision of a trussing arrangement having structural members in the upper and lower chords and in the inner reinforcement members, of sufficient section modulus to resist the unfavorable compressive stress arising from the accidental or non-accidental sudden or continuous application of sidewardly directed loads thereto, with the consequent economic disadvantage of needing large amounts of material to provide a thick section having a suitable form with a large moment of inertia to avoid failure.

Many different solutions have been proposed by the prior art in order to solve the above described problem and, more particularly, in order to keep the size required for compression members in trusses as low as possible, but up to now, as far as applicant knows, the erection of a pre-stressed truss having a simple and economic structure which will not require individually pre-stressing each one of the reinforcement members and which will not require the provision of sliding means under at least one of its supports has never been effected.

One of the solutions proposed to provide pre-stressed reinforcement members in a truss was to arrange, under the arch comprising the upper chord of the truss, a plurality of truss rods in a symmetrical array, attaching the ends of the truss rods to the upper chord by means of joints having individual tighteners or turnbuckles to pretighten all the above mentioned rods and have them work in tension. Another solution to the above mentioned problem was to provide the arch or upper chord with the above mentioned truss rods, the truss having an end of the arch freely or slidingly supported so as to let it have a lateral free displacement such that, when loads are applied thereon, said end is displaced with a resulting tightening of the above mentioned rods.

Having in mind the defects and drawbacks of the prior art trusses, including those provided with pretightened or prestressed individual members, it is an object of the present invention to provide a truss useful for bridging larg spans in a very economic manner, by the unique arrange ment of its elements and the simultaneous application o tension stresses to the inner reinforcement members o the truss.

It is another object of the present invention to provid a very light weight truss easy and economic to erect, an highly useful in walls, roofs, hangars, cellars and the like said truss being basically different from the prior ar trusses in that the inner elements which link the uppe and lower chords are only subjected to tension stresse with the consequent economy in building material.

It is a more particular object of the present inventio to provide a truss of the above mentioned character wherein no need is present to individually tighten or stres each one of the truss rods provided to reinforce the uppe chord.

The novel features considered as characteristic of th present invention are set forth with particularity in th appended claims. The invention itself, however, both as t its organization and its method of operation, togethe with additional objects and advantages thereof, will bes be understood from the following description of specific embodiments when read in connection with the accompanying drawings, wherein:

FIG. 1 is an elevational view of a conventional arc truss built of members calculated to resist compressive stresses;

FIG. 2 is an elevational view of an arch truss built in accordance with the teachings of the present invention and wherein all the reinforcement inner members work only in tension;

FIG. 3 is a perspective diagrammatic view of an arch truss built in accordance with the present invention, showing a particularly preferred embodiment thereof;

FIG. 4 is a fragmentary diagrammatic elevational view of an arch truss built in accordance with the invention, showing another preferred embodiment thereof; and

FIG. 5 is an elevational view of a truss built in accordance with still another embodiment of the invention.

Having now more particular reference to the drawings, and more specifically to FIG. 1 thereof, there is shown a truss generally designated by the reference character **10**, which is supported at its ends **11** and **12** on a pair of columns **13** and **14** respectively and comprised by an upper chord **15** working in compression, a lower chord **16** which, when the truss receives vertical loads works in tension, and a plurality of diagonal reinforcement or truss members **17**, some of which work in compression and others in tension, depending on the load and the direction thereof as applied to the truss, and in which the stresses can be reversed from tension to compression by the same reason.

From a common analytic or graphic analysis of the structural members forming the truss **10**, anyone skilled in the art will easily find out that some of the members **16** and **17** will work in tension, while others will work in compression, depending on the load applied to the truss. However, as trusses receive variable loads, specifically when they have to support live loads, earthquakes or strong wind, the stresses in each one of members **16** and **17** can be reversed in sign, such that said members can be stressed unfavorably in compresson; therefore, all the above mentioned members must be calculated to meet the most unfavorable conditions to which the system can be subjected, thus necessitating that said members, even when for most of the time it is not necessary, should have very high section moduli and predetermined slimness ratios to resist the maximum compressive stresses to which they can be subjected.

The above represents a very important disadvantage from an economical standpoint because most of the

ime the material in members **16** and **17** is not in use, ince when the truss is working with stationary vertical oads, said members always work in tension. Under these onditions, the amount of material used could have been reatly reduced since such large section moduli would ave not been required. However, because of the unavorable possible reversal of said stresses due to sidevardly acting or movable loads, it becomes necessary to se a greater amount of material to provide a sufficient ection modulus with the consequent economic drawbacks.

FIG. 2 shows an arch truss built in accordance with he present invention. The truss comprises an upper chord vorking in compression as shown at **18**, a lower chord 19 of course working in tension and serving for the sole urpose of opposing to the tendency of the upper chord 18 to flatten upon application of the loads, said upper hord **18** being attached by means of bolts **20** to a racket **21** at each end thereof, said bracket being in urn attached by means of bolts **22** or anchors of suitble and conventional character, to a pair of columns 23 and **24** such as is conventional in the art. When colmns **23** and **24** cannot resist flexure stresses, it becomes ecessary to incorporate the lower chord or tightening ar **19** which in other embodiments of the invention, as hown in FIGS. 3 and 4, can be omitted.

The truss is completed by a plurality of diagonal reinforcement members **25** which are arranged in a triangular fashion, the lower apex of each triangle being joined to members **26** which can be built of a single length of material, and these members **26** are joined at the ends of the truss to tighteners or turnbuckles **27** and **28** which in turn are anchored by bolts **29** and **30** respectively, to each one of columns **23** and **24** as clearly shown in FIG. 2 of the drawings.

The truss built in accordance with the present invention, generally designated by means of reference character **10'**, cannot carry any sidewardly directed load, since all members **25** and **26** are generally built of materials having a negligible strength to compressive stresses, such as wires, cables, thin tubular sections, round profiles, and the like. In order to cause the truss to work as a unitary assembly, it is necessary to tighten and subject to a tensile stress all members **25** and **26**, and use is made of tighteners or turnbuckles **27** and **28** (FIG. 2), in order to stretch member **26** which tends to pull downwardly from the apex corners **31** of the triangles formed by the diagonal truss members **25** thus also stretching said members **25** to a degree which can be easily calculated as will be readily apparent to anyone skilled in the art, so as to result in applying a general tensile stress throughout the truss such that regardless of the magnitude and direction of an accidental or intentional load applied upon the truss, said pre-stressing will overcome the thus introduced compressive stresses, and the members **25** and **26** will always work in tension. The above results in a truss having a very high stiffness, which can resist all types of loads, either vertical, sideward or combined loads, as well as movable or fixed, concentrated or uniformly distributed loads, the form of the truss remaining unaltered in its entirety. In other words, a completely rigid or stiff truss is produced providing great advantages in the erection and not needing individual tighteners or turnbuckles to stretch each one of the structural members thereof.

The object of the above combination of constructional elements to be used in the truss of the present invention, is to incorporate tensile stresses in all the reinforcement elements, such that when the truss is loaded and compressive stresses tend to appear, the latter will be overcome by the initial tensile stresses introduced, thus avoiding the design of the reinforcement members to resist compressive stresses, with the consequent decrease of the amount of material used, because the members which must resist tensile stresses can be much thinner than the members

designed to resist compressive stresses, and a considerably reduced section can be used for the tensile members.

FIG. 3 shows another particular and preferred embodiment of the invention and in this figure similar reference numbers are used to designate parts equivalent to those shown in FIG. 2. It can be seen that column **23** supports a bracket **21** which is attached thereto by means of bolts **22** and **20**, respectively, said bracket having a pair of wings, one attached to the top of the column and the other one attached to one end of the arch **18** which in this particular case is built of a web having a suitable thickness to resist compressive stresses. In the neighborhood of the edges of said web **18**, a plurality of fasteners **32** are arranged, to secure truss rods or members **25** and **25'** which form downwardly converging triangles provided with common apex joints **31** as clearly shown in FIG. 3, which are linked together by an integral member **26** which in turn is attached to tighteners or turnbuckles **27** anchored to the columns (such as **23**) by means of a suitable bolt or anchor (not shown).

The double array of members **25** and **25'** in the particular embodiment of the invention shown in FIG. 3, provides a truss with a high stability to sidewardly acting forces which are transverse to its axis, thus achieving the same above mentioned effects in addition to producing an additional strength in resisting forces applied crosswise to the plane of the truss. Otherwise, the truss shown in FIG. 3 is exactly similar to that illustrated in FIG. 2. The lower chord **19** has been omitted in FIG. 3 for the sake of simplicity.

FIG. 4 of the drawings shows another particularly advantageous embodiment of the invention, and is a fragmentary illustration of a truss having an upper web chord **18**, fasteners **32** arranged along the center line of said web **18**, reinforcement members **25** arranged in triangular fashion as described above in order to form apex joints **31** at the lower ends thereof, linked by means of a member **26**, the truss being supported on a pillar **23** which is sufficiently strong to resist sideward flexure stresses. Therefore, in this illustrative embodiment of the invention, the tensile member or lower chord **19** of the truss is not necessary, as pillar **23** will resist the sidewardly and outwardly directed stresses imposed by the load applied on arch **18**.

Arch **18** is attached to said pillar by means of bracket **21**, and bracket **34** preferably arranged under the upper chord **18**, to firmly fix it to an inclined wall **35** of said pillar **23**. At the lower portion of said inclined wall **35** a yoke bracket **36** is arranged, attached by means of flanges **37** with suitable anchors **38** to pillar **23**, to form a strong joint therebetween. The web portion of bracket **36** is provided with a hole (not shown) for the passage of member **26** therethrough, the end of said member **26** being tapped as illustrated at **39** and provided with a nut **40** to function as a tightener or stretcher which is exactly equivalent to turnbuckles **27** illustrated in FIGS. 2 and 3 of the drawings.

The truss shown in FIG. 4 works exactly the same as the trusses shown in FIGS. 2 and 3 of the drawings, except for eliminating the requirement of the lower chord member **19**, due to the fact that pillar **23** has a large flexure strength and will resist the sideward action applied by the loads supported on arch **18**.

FIG. 5 shows another preferred and highly advantageous embodiment of the present invention. In this particular case, the varying points of the upper chord **18** and the stretcher member **26** are the same, that is, both members are attached to a portion of bracket **21** in columns **23** and **24**.

The truss **10''** of this embodiment works the same as the above described trusses, but additionally having the advantage that it is not necessary to arrange means for providing two different bearing points, inasmuch as, by the proper design of brackets **21**, the upper chord **18**, the

lower chord **19** and the stretching member **26** can be supported in the same place.

In this particular case the reinforcement members **25** gradually decrease in length from the center of the truss toward the ends and the thus formed triangles which terminate at a short distance from turnbuckles **27** and **28** such that all of them can be stretched in the above described manner. Truss **10''** is otherwise of a completely similar structure as the trusses of FIG. 2 to 4 and works with the same efficiency and strength.

It will be apparent that, while in the embodiments of the invention particularly described in connection with FIGS. 2 to 4 and 5 the upper chord **18** has been shown as having a circular arch form, this member can assume the form of a parabolic arch, ellipsoidal arch and the like, without thereby precluding the advantages of the present invention.

Therefore, though certain specific embodiments of the invention have been shown and described, it will be apparent that many modifications thereof are possible. The invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the spirit of the appended claims.

Having thus described the invention what I claim as new and desire to protect by Letters Patent is:

1. A pre-stressed truss comprising, an upper arched member, abutment means supporting the arched member at the ends thereof and resisting increase in the distance spanned by said arched member when a load is applied thereto, a plurality of diagonal reinforcement members forming alternate triangles having apex ends downwardly and upwardly directed, the upper apex ends being attached to said upper member, a lower member engaging the reinforcement members at the lower apex ends of said triangles, said lower member having opposite ends, means engaging said lower member at said end thereof for applying tension to said lower member and thereby to all of said diagonal reinforcement members, and means for attaching said tension means to the abutment means.

2. A pre-stressed truss as claimed in claim **1**, wherein said abutment means comprises a pair of support pillars supporting respective ends of the arched member, and a tie member connected to the support pillars, the tension means comprising turnbuckles connected to the ends of the lower member, the means attaching the tension means to the abutment means comprising anchoring rods anchored in the support pillars and secured to the turnbuckles.

3. A pre-stressed truss as claimed in claim **1**, wherein said triangles progressively decrease in height from the center of the truss to the ends thereof, the array of triangles ending at a short distance from each end of the truss.

4. A pre-stressed truss as claimed in claim **1**, wherein said abutment means comprises a pair of support pillars supporting respective ends of the arched member, and a tie member connected to the support pillars, the tension means comprising turnbuckles connected to the ends of the lower member, the truss further comprising angular brackets on said pillars, said upper arched member being attached to one angular bracket on each pillar, the tie member and turnbuckles being attached to another of said angular brackets.

5. A pre-stressed truss comprising an upper arch member having opposite ends, a pair of columns, the ends of the arch member being connected to the columns, a lower member, diagonal reinforcement members connected to said upper and lower members and forming successive triangles having apexes connected alternately to said upper and lower members, said lower member having opposite ends connected to the columns, and means incorporated in the lower member to exert tension in said lower member and thereby to all of said diagonal reinforcement members, and a tie member connected to said columns to resist displacement thereof away from one another.

6. A pre-stressed truss comprising, in combination, an upper arched web member, abutment means supporting the web member to resist any increase in the distance spanned by said arched member when a load is applied thereto, a plurality of diagonal reinforcement members arranged in two series of alternate triangles having apex ends downwardly and upwardly directed, said triangles being slanted such that the upper apex ends thereof are attached to marginal portions of said web member and the lower apex ends are joined to form common apex ends for the two arrays of triangles, a lower member engaging the common lower apex ends of said triangles, said lower member having opposite ends, means engaging said opposite ends for applying tension to said lower member, and means attaching said tension means to the abutment means.

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JACOB L. NACKENOFF, *Primary Examiner.*