Feb. 25, 1964 PHOO-HWA CHENG 3,121,894

FABRICATED STRUCTURE FOR BRIDGES AND THE LIKE

Filed Feb. 5, 1957 4 Sheets-Sheet 1

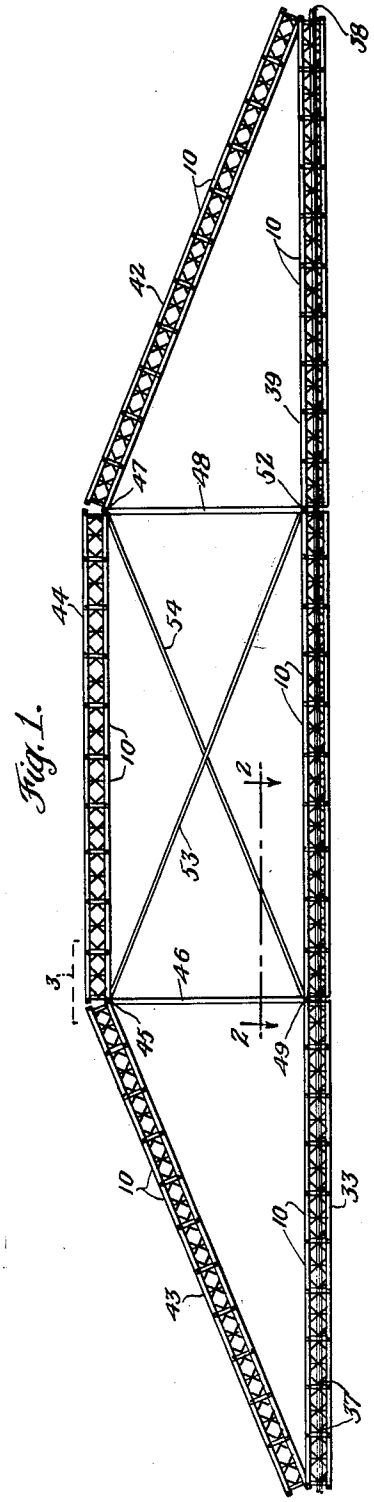


Fig. 1.

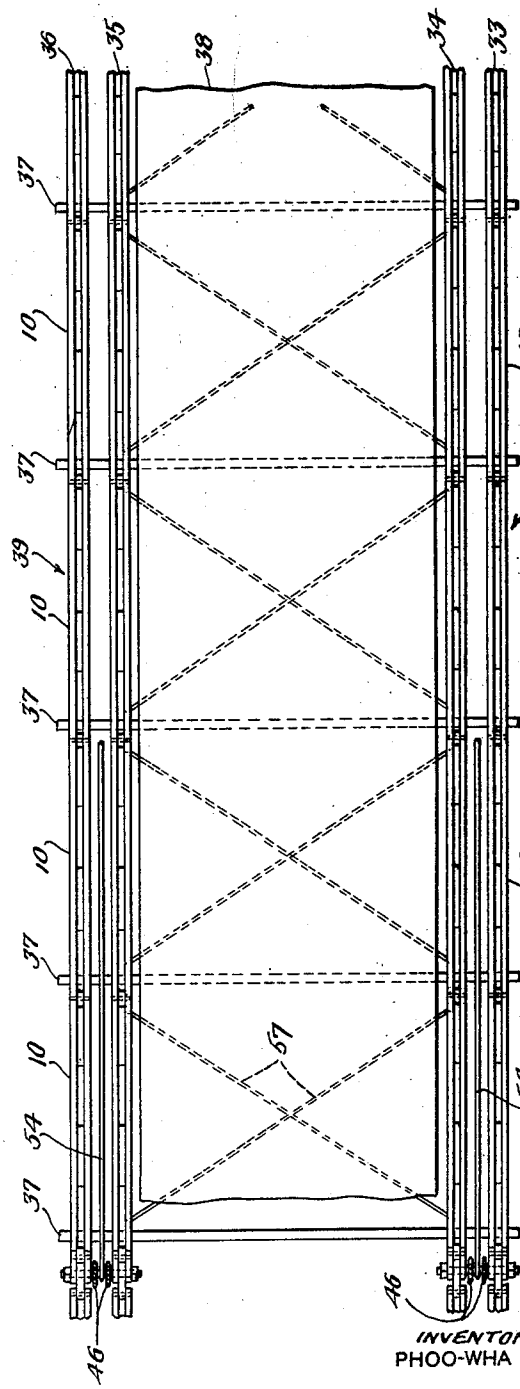


Fig. 2.

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FABRICATED STRUCTURE FOR BRIDGES AND THE LIKE

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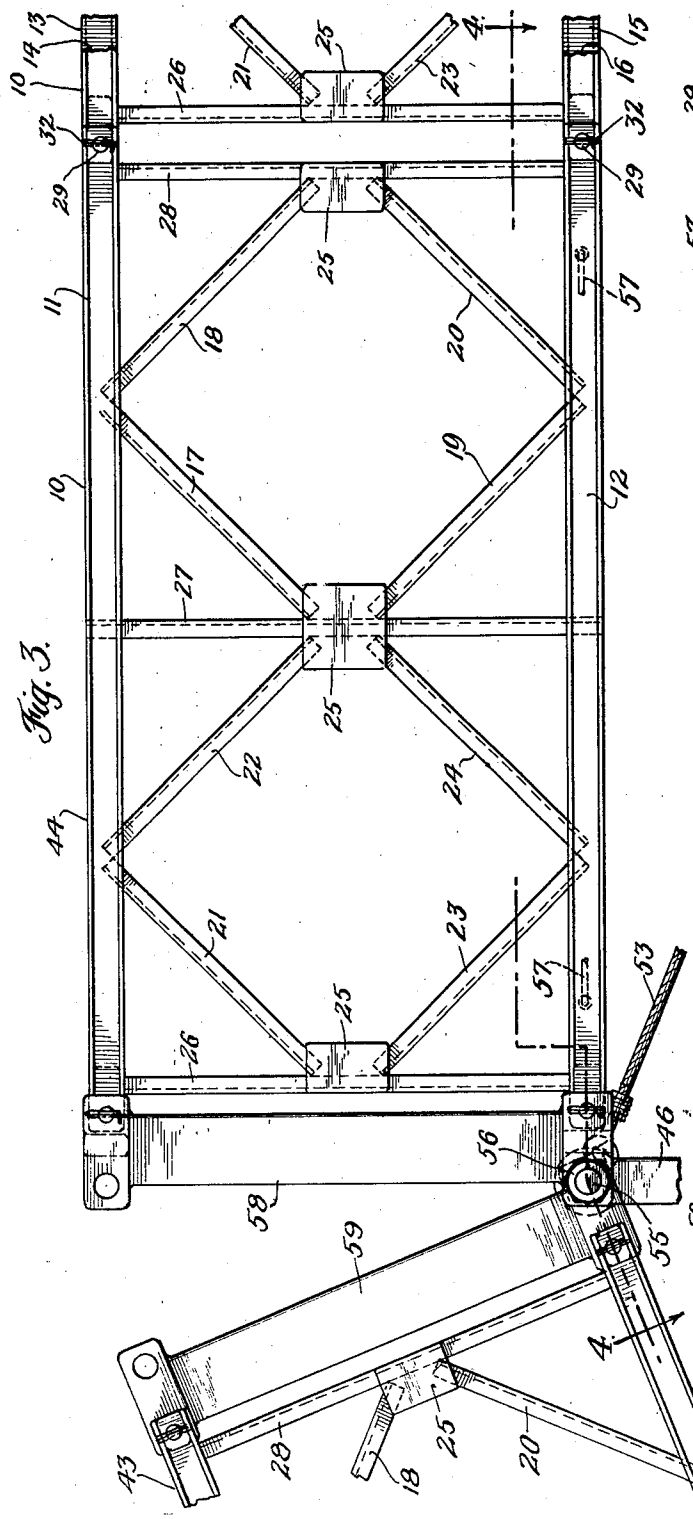


Fig. 3.

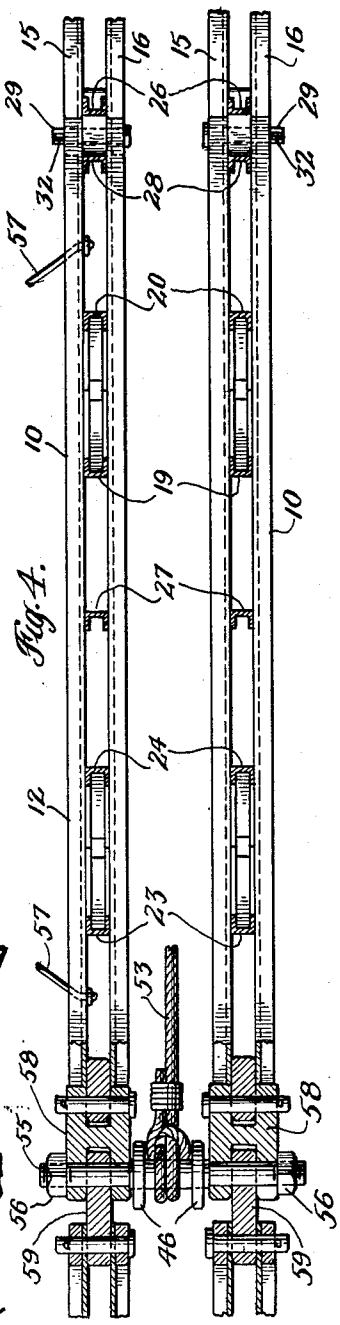


Fig. 4.

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FABRICATED STRUCTURE FOR BRIDGES AND THE LIKE

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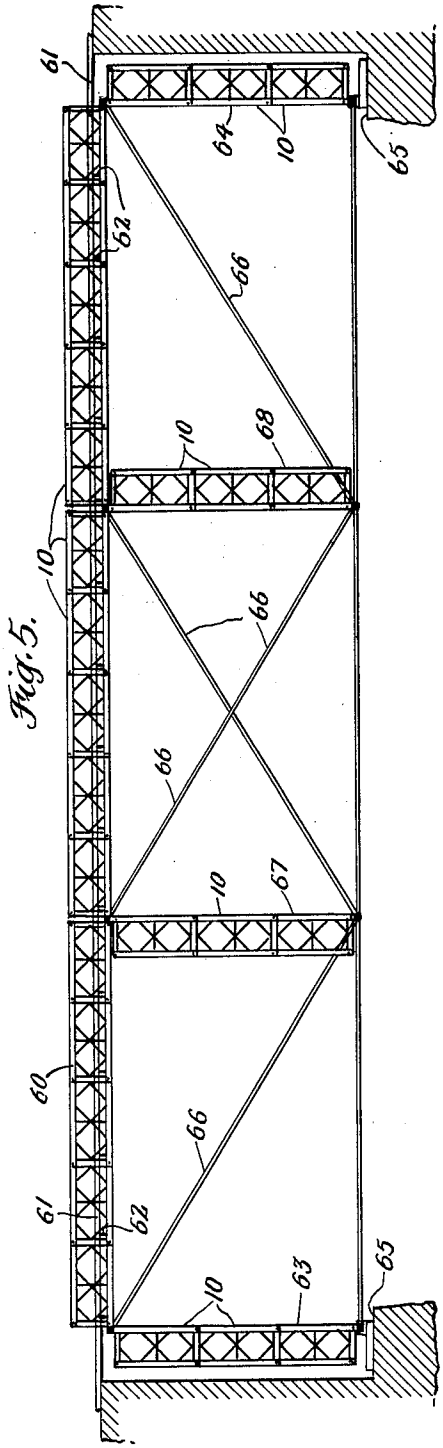



Fig. 5.

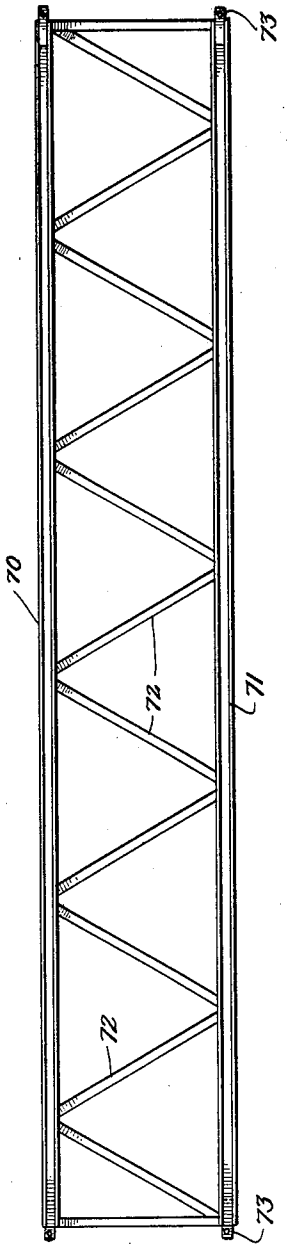



Fig. 6.

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FABRICATED STRUCTURE FOR BRIDGES AND THE LIKE

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Fig. 7.

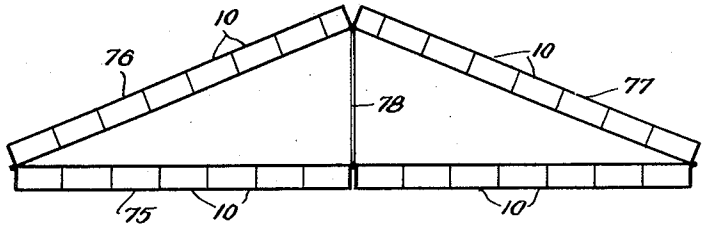



Fig. 8.

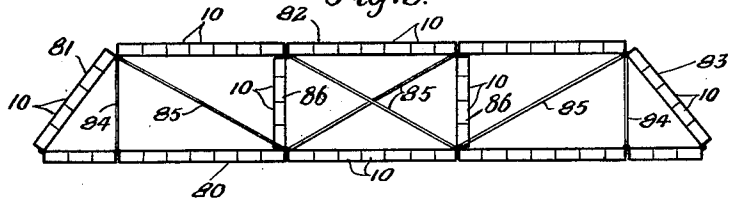



Fig. 9.

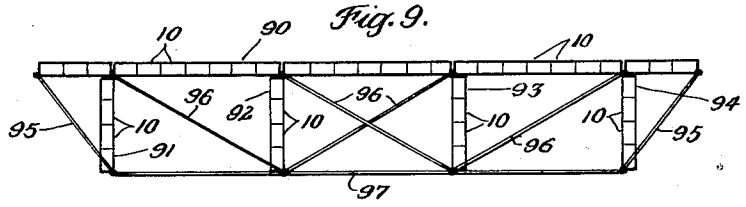
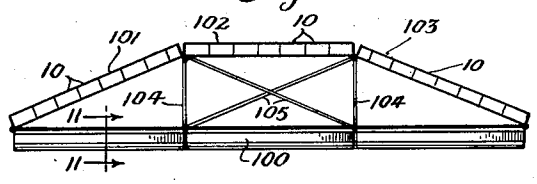



Fig. 10.



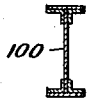




Fig. 11.

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United States Patent Office 3,121,894 Patented Feb. 25, 1964



3,121,894

# FABRICATED STRUCTURE FOR BRIDGES AND THE LIKE

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Filed Feb. 5, 1957, Ser. No. 638,404
7 Claims. (Cl. 14—13)

This invention relates to improvements in the manufacture of bridges and related structures and more particularly to a structure of this kind which includes, as a basic structural component, a beam or post of substantial length which is subjected to a high degree of compressive stress through loading imposed at its opposite ends. In its preferred form, the invention relates to a bridge embodying side structures based primarily upon trusses in which the parallel chords are interconnected by web members in a repetitive pattern providing in effect a succession of individual trusses rigidly interconnected end to end. One familiar form of such a truss is the Warren truss and another is the Bailey truss as illustrated and described in the U.S. patent to Bailey, 2,376,023, of May 15, 1945. Truss structures made according to this patent have been used in fabrication of bridges for both military and civilian use, and a discussion of the limitations heretofore imposed on such use by structural considerations should prove helpful in consideration of the background of the present invention. While this invention is by no means limited to the use of truss members built up from smaller trusses or panels by securement of these end to end as described in the Bailey patent, the versatility of the invention and facility with which it may be used are improved by this feature and it will accordingly be described primarily in relation to such a composite truss structure.

In typical use of the trusses of the so-called Bailey panels in bridge building, the individual truss units, which are ordinarily of about five feet in height and ten feet in length, are secured end to end progressively on the bank of the stream or other space to be bridged, with the structure which is to rest upon the left bank assembled and secured first on the right bank if that is the assembly location, and the structure moved progressively across the stream from right to left as successive portions are completed, with the last-completed portion anchored on the right bank. The individual truss members or panels incorporated into the structure may be bolted together through their upper and lower chords, respectively, to produce a structure two or three panels deep and/or be secured in parallel relation to produce a structure in which a plurality of panels extend in side by side trussed relationship, and such composite panels, which may be of single, double or triple width or depth, for example, are used as the basic structures at opposite sides of the bridge, for support of the floor beams and flooring, all as illustrated and described in the Bailey patent.

While structures of this type have been employed in bridges for some military uses and in emergency bridges for civilian use, structural considerations have limited their usefulness rather severely. Thus, when the width to be spanned was substantially in excess of two hundred feet or when the maximum expected load was quite heavy, this type of construction could not be employed.

A feature and object of this invention has been to provide a structure utilizing the basic features of construction discussed above, in which the foregoing limitation as to width to be spanned is eliminated.

A further feature and object has been to increase the load-sustaining capacity of a bridge constructed according to these principles and thereby increase the field of their usefulness greatly.

A further feature and object has been to increase the ratio of strength to weight in such structures to a remarkable degree, thereby effecting great savings of material and/or increases in strength.



A further feature and object has been to provide a side frame structure for bridges and the like in which these general advantages are attained, regardless of whether the floor-supporting structure is of the type discussed above. More particularly, the features of the invention are applicable for attainment of these advantages in various types of construction in which the floor-supporting structures at opposite sides of the bridge are interconnected with other members in a common vertical plane to produce individual side frame trusses at said opposite sides, and in which such side frame trusses include one or more beams of substantial length loaded by substantial compressive forces at their opposite ends. A feature and object has accordingly been to provide a substantial increase in strength or saving in weight in these various situations where this problem may exist, or opportunity for such advantages be offered.

In brief, the advantages in strength and rigidity of the bridge and the width which may be spanned are attained by fabrication of special side frame panel structures which combine the floor-supporting longitudinal structure with other structural members in common vertical planes to form these side panel structures. By forming these side frame panel structures themselves as a plurality of successive individual truss panels, each such individual truss panel may have sufficient rigidity to span a considerable width without being prohibitively heavy, and the combination of such truss panels may be used to span a much greater width than could otherwise be attained.

In attempting to increase the span by utilization of individual rigidifying and reinforcing trusses in this manner, however, there is necessarily entailed the problem of providing at some part of the truss one or more compression beams of substantial length, and the project as so far outlined becomes self-defeating except for utilization of another feature of the invention, because of the apparent necessity for making such beam or beams very massive to provide adequate strength against buckling. This problem is solved by use of a beam at such locations composed of a girder having parallel chords interconnected by web members to provide a succession of individual truss panels within the overall girder constituting the beam, as for example in a Warren truss or the composite Bailey trusses discussed above. These beams are loaded at their ends eccentrically, substantially on the line of one of their chords, with the consequence that the buckling-tendency moment is a function of the length of beam from the loading point or transverse line to the first repetition of the truss pattern, rather than a function of one half the beam length. These beams may therefore be made both lighter and stronger than would be feasible if they were loaded in such a way as to transmit the compressive forces directly from end to end.

Still further features and advantages of the invention will be apparent from reading of the following detailed description in the light of the attached drawing, in which:

FIGURE 1 is a side elevation of a bridge structure according to a preferred form of the invention, using a through truss,

FIGURE 2 is a plan view on larger scale, taken on the line 2—2 of FIGURE 1 and illustrating the floor supporting structure of FIGURE 1,

FIGURE 3 is a detailed side elevation of the structure within the broken line 3 of FIGURE 1,

FIGURE 4 is a cross-section on the line 4—4 of FIGURE 3,

FIGURE 5 is a side elevation of an alternative form of the invention, using a deck truss,

FIGURE 6 is a side elevation of a form of beam em-

bodying an alternative repetitive truss structure which may be used in practice of the invention,

FIGURE 7 is a side elevation of an alternative form of through truss bridge construction,

FIGURE 8 is a similar view illustrating a still further alternative,

FIGURE 9 is a similar view illustrating an alternative form of deck truss bridge,

FIGURE 10 is a similar view illustrating a still further form of through truss bridge, and

FIGURE 11 is a cross-section on the line 11—11 of FIGURE 10.

As noted above, the invention is not necessarily restricted to the use of truss structures as beams or struts in its practice except as pointed out specifically hereinafter. However, it may be practiced advantageously by use of the so-called Bailey panels as units both in the compression beams and other structural elements, and it will accordingly first be described in that setting. Such panels **10** are illustrated in FIGURES 1–5 and 7–10 of the drawing in various relationships and locations.

As illustrated in FIGURE 3, each individual panel or truss section may comprise chords **11** and **12** each consisting of channel sections **13** and **14**, **15** and **16**, which are held in laterally spaced back to back relation to each other by the opposed flanges of channel section web members **17–24**, extending angularly toward each other from the chords. These members **17–24** are also interconnected through gussets **25** with channel section members **26**, **27**, **28** which are interconnected similarly with the chords and extend perpendicularly from chord to chord. It will be seen that each such panel comprises a double truss structure of identical structural elements, so that the member **27** is duplicated in each of the two trusses. Each such double truss includes male coupling connections at one of the ends of its two chords and female coupling connections at the opposite ends so that when these connections are secured as by studs **29** and cotter pins **32** (FIG. 3), there will be provided a beam comprising a comprehensive truss which includes a succession of longitudinally extending individual trusses having interconnecting web members in a repetitive pattern, as for example the truss having members **26** and **27** as end members, that having members **27** and **28** as end members, etc.

By reference to FIGURES 1 and 2 of the drawing, it will be seen that in that form the floor-supporting structure of the invention comprises composite trusses of this type interconnected in side-by-side relationship at **33**, **34** and **35**, **36**, as familiar to persons skilled in this art, and that the floor-beams **37** are secured crosswise of these trusses to provide a generally horizontal support for the flooring **38**. Insofar as the floor-supporting structure itself is concerned, this is thus more or less conventional, and forms no feature of this invention except in combination with the other features discussed hereinafter. As noted above, the present invention relates to features by which the floor-supporting trusses **10** are reinforced so that they become parts of larger trusses providing side frame panel structures having the necessary strength, rigidity and lightness in weight to fulfill the objects of the invention.

As illustrated in FIGURE 1, there is secured to the ends of each side member **39** consisting of members **33** and **34**, of the floor-supporting structure a pair of compression beams **42**, **43** extending longitudinally toward each other and diagonally upwardly, and these are interconnected by a central compression beam **44**. Tension members in the form of rods or struts extend vertically downwardly from the joint **45** between beams **43** and **44** as indicated at **46** and downwardly from joint **47** as indicated at **48**, and support the side members **39**, consisting of members **33** and **34** at **49** and **52**, respectively. Diagonally extending tension members **53** and **54** interconnect joints **47** and **49** and **45** and **52**, to provide with beam **44** a strong central reinforcing structure.



It will be noted that beams **42**, **44** and **43** are compression members of substantial length and constituted of girders, and since they are heavily loaded they would have to be very heavy and rigid to resist buckling if they were loaded concentrically at their ends so as to cause them to react as rigid beams. In practice of the invention, each of these beams is loaded as illustrated in FIGURE 3, with the result that the structure may be made both lighter and stronger than could otherwise be accomplished. In practice of the invention, instead of coupling beam **43** with beam **44** through the male and female coupling connections at the ends of both upper and lower chords of these members, they are interconnected only through the lower couplings, at the line of intersection of their lower chords, as by bolt **55** and nuts **56** (FIG. 4), and the tension members **46** and **53** are secured at this same location by the same connection. The opposite end of beam **44** is similarly connected to beam **42** in the line of intersection of the bottom chords of these beams and the connection of the ends of beam **39** to the opposite ends of beams **42** and **43** is similarly at the line of their bottom chords, at their intersections with the top chord of beam **39**. By use of this feature, together with the repetitive web member pattern of beams **42**, **43**, and **44**, providing a succession of individual truss panels, an adequately strong and rigid structure is provided at great weight saving. It should be noted that the floor-supporting structure side members **39** are themselves formed in three sections interconnected only at **49** and **52** at their top chords. The beams **43** and **42** are connected to the opposite ends of beam **44** through junction post connections as illustrated at **58** and **59** in relation to beams **43** and **44**, and beam **39** is connected at its opposite ends to beams **42** and **43**, respectively, through end post connections, all as well understood by persons skilled in this art.

It will be understood that the individual members comprising the beams **42**, **44** and **43** should be of multiple construction in width. A double construction is illustrated in FIGURES 2 and 4 both in regard to the floor-supporting structure side members **33** and **34** and in regard to the beams **43** and **44**, the laterally spaced beam members being secured together by bolts and other bracing of which only the bolt **55** interconnecting adjacent beams is illustrated. The individual panels may also be secured to each other through their upper and lower edges to provide beams which may be two or three panels in height. It will also be understood that these identical structures extending longitudinally at opposite sides of the bridge will be connected by sway bracing and such other connections as are known or useful to the art, e.g., as illustrated at **57** in FIGURES 2 and 4.

In FIGURE 5, I have illustrated the invention in its relation to a deck type bridge as contrasted to the through type bridge of FIGURE 1. In this construction, the floor-supporting structure may include girders **60** supporting the flooring **61** upon beams **62**, as illustrated in FIGURE 5. The reinforcement for this floor-supporting structure is in the form of girders which form posts **63** and **64** extending downwardly from the ends of the truss structure **60** and resting upon supporting surfaces **65**. These posts are interbraced by tension members **66** extending diagonally between the upper and lower ends of adjacent posts, there being intermediate posts **67** and **68** between the ground supported posts **63** and **64** as may be required, and these intermediate posts serving as compression members to support the bridge through the truss combination provided by the tension members **66** and the post structure as discussed above. Each of the posts **63** and **64** is secured along the line of intersection of its inner chord with the lower chord of a girder **60**, and each of the posts **67** and **68** is also eccentrically loaded by interconnecting it to the structure of the girder **60** only at the line of one of its chords. The tension members **66** are also secured at their respective ends to the posts only in

the lines of the chords by which the posts and girders **60** are themselves interconnected, and upon which the posts **63** and **64** are supported at their lower ends. The connections between the chords of the girders and posts of this embodiment of the invention may be substantially identical to those discussed in connection with the previously discussed embodiments, and the comments regarding the fabrication of these posts and girders from individual truss panels are also applicable to both embodiments. It should be noted that the top chord of the bridge structure is formed in three sections by girders **60** which are interconnected with each other only at their bottom chords, and at the intersections of these chords with the chords of **63**, **64**, **67** and **68** to which they are interconnected.

As noted above, the invention is not limited in its application to use of composite posts and beams fabricated by end-to-end interconnection of relatively small trusses or panels, but may be applied through use of trusses initially fabricated in the desired beam length, so long as these have the desired repetitive tension member pattern and are eccentrically loaded as hereinabove explained. These girders may, for example, be Warren trusses having their parallel chords **70** and **71** interconnected by angularly interconnecting web members **72** and provided with male and female coupling connections at their opposite ends for interconnection with adjacent girders eccentrically through a single such connection or with adjacent members at both upper and lower connections to provide a longer beam, as described above.

In FIGURE 7 there is illustrated a through truss bridge construction embodying the principles of use of truss panels and girder connections as discussed above, but designed for use requiring shorter spans. In this bridge, the side frame floor supporting structure girder **75** is connected at its opposite ends to side frame truss girders **76** and **77** through its top chord and their bottom chords, and these girders **76** and **77** are connected to each other through their bottom chords and support a central portion of girder **75** through tension member **78**.

In FIGURE 8, the through truss is designed for a bridge carrying heavier loads, and includes compression members **86** interconnecting the successive sections of the floor supporting frame work **80** with overlying sections of the girder structure **82**. The individual girders comprising the structure **82** are connected to each other and to diagonal interconnecting girders **81** and **83** and tension members **84** and **85** according to the principles discussed above, and the individual sections of the floor-supporting structure **80** are also secured together only through their top chords as illustrated.

FIGURE 9 illustrates application of the same principles to a deck type bridge adapted to be supported only through the end sections of its floor-supporting structure **90**, and providing posts **91–94** and tension members **95–97** according to the principles of FIGURES 5 and 8.

As noted above, it is not necessary that all of the girders of the side frame truss structures be of the Bailey or repetitive pattern type. FIGURES 10 and 11 illustrate a construction in which a floor-supporting structure **100** composed of three plate girders is substituted for the floor-supporting structure of FIGURE 1 by combining it with girders **101–103** and tension members **104** and **105**.

While the invention has been described only in relation to certain preferred embodiments, persons skilled in the art will recognize that it may be modified and refined in various ways and I do not therefore wish to be limited except by the following claims.

I claim:

1. In a fabricated metal bridge structure or the like, the combination comprising a floor-supporting structure including side members extending in a generally horizontal plane and adapted to span the space to be bridged, structural members extending longitudinally and diagonally upwardly toward each other from opposite ends of each of the side members of said floor-supporting structure, and other structural members interconnecting said pairs of diagonally extending structural members at their ends to provide, together with said floor-supporting side members and diagonally extending members, a pair of individual side frame panels, each of said diagonal and interconnecting members of the respective side frame panels constituting a compression member of substantial length, said compression members being girders composed of top and bottom chords, web members interconnecting said chords in repetitive patterns and providing a longitudinal succession of individual truss panels as component parts of said compression members, said compression members being connected to each other at their adjoining ends only at locations substantially in the lines of intersection of their lower chord members, and the lower ends of said diagonal members being connected to said side members of said floor-supporting structure only at locations on the lower chord of said diagonal members, and tension means extending from the connections of adjacent ones of said compression members to points on said side members, said compression members being eccentrically connected with respect to one another.

2. A fabricated metal structure as defined in claim 1, in which tension members extend downwardly from said compression members into supporting relationship to longitudinally intermediate portions of the individual side members of said floor-supporting structure.

3. A fabricated metal structure as defined in claim 1, in which said tension members are secured to said compression members at the locations at which said compression members are interconnected with each other, and extend vertically into supporting relation to said individual side members of said floor-supporting structure.

4. A fabricated metal structure as defined in claim 1, in which tension members extend longitudinally and diagonally downwardly from each of the locations at which said diagonal compression members are secured to said interconnecting members and are secured to the respective side members of said floor-supporting structure adjacent the securement thereto of the tension member extending vertically from the location of securement of the other diagonally extending compression member to the interconnecting compression member.

5. In a fabricated metal bridge structure or the like, the combination comprising a floor-supporting structure including side members extending in a generally horizontal plane and adapted to span the space to be bridged, structural members extending longitudinally and diagonally upwardly toward each other from opposite ends of each of the side members of said floor-supporting structure, and other structural members interconnecting said pairs of diagonally extending structural members at their ends to provide, together with said floor-supporting side members and diagonally extending members, a pair of individual side frame panels, each of said diagonal and interconnecting members of the respective side frame panels constituting a compression member of substantial length, said compression members being girders composed of top and bottom chords, web members interconnecting said chords, said compression members being connected to each other at their adjoining ends only at locations substantially in the lines of intersection of their lower chord members, and the lower ends of said diagonal members being connected to said side members of said floor-supporting structure only at locations on the lower chord of said diagonal members, and tension means extending from the connections of adjacent ones of said compression members to points on said side members, said compression members being eccentrically connected with respect to one another.

6. In a fabricated metal bridge structure or the like, the combination comprising a floor-supporting structure including side members extending in a generally horizontal plane and adapted to span the space to be bridged,

and structural members extending in a common vertical plane with each of the side members of said floor-supporting structure and forming with said side members individual side frame panels of which each side frame panel includes at least one compression member of substantial length, said compression member of substantial length being a girder composed of top and bottom chords and an interconnecting web, said girders forming said compression members of substantial length being interconnected at their ends to associated girders of adjacent compression members solely at locations substantially in line with the bottom one of said chlords whereby said compression members are eccentrically connected with respect to one another, and tension means extending from the connections of adjacent ones of said compression members to points on said side members.

7. In a fabricated metal bridge structure or the like, the combination comprising a floor-supporting structure including side members extending in a generally horizontal plane and adapted to span the space to be bridged, and structural members extending in a common vertical plane with each of the side members of said floor-supporting structure and forming with said side members individual side frame panels of which each side frame panel includes a plurality of compression members of substantial length, said compression members of substantial length being girders composed of top and bottom flanges and an interconnecting web, said girders forming said compression members of substantial length being interconnected at their ends to associated girders of adjacent compression members solely at locations substantially in line with one of said flanges whereby said compression members are eccentrically connected with respect to one another, tension means extending from the connections of adjacent ones of said compression members to points on said side members, each of said side members of said floor-supporting structure comprising a longitudinally extending girder having upper and lower flanges, web members interconnecting said flanges, said floor-supporting girders being eccentrically connected to each other at their adjoining ends solely at locations substantially in line with the upper flanges thereof whereby said girders constitute tension members in said side frame panels.



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