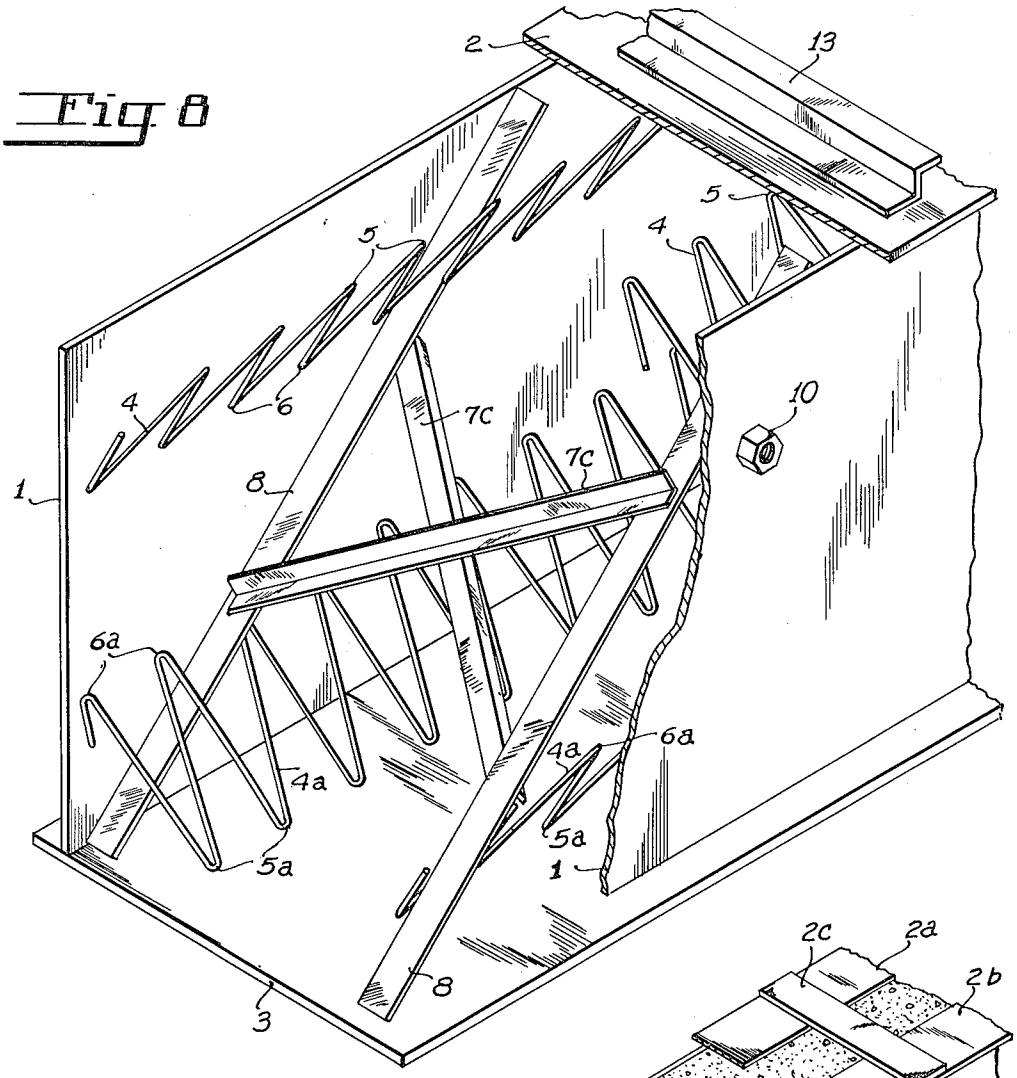
Jan. 24, 1956 H. M. HADLEY 2,731,824

BRIDGES AND BOX GIRDERS THEREFOR

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Fig. 8



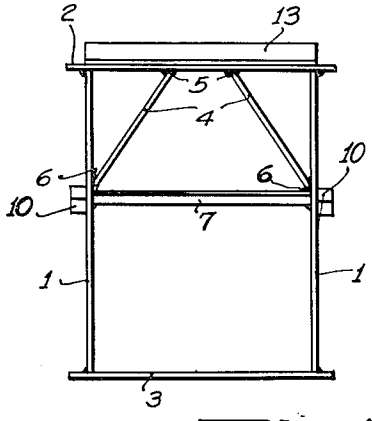


Fig. 1

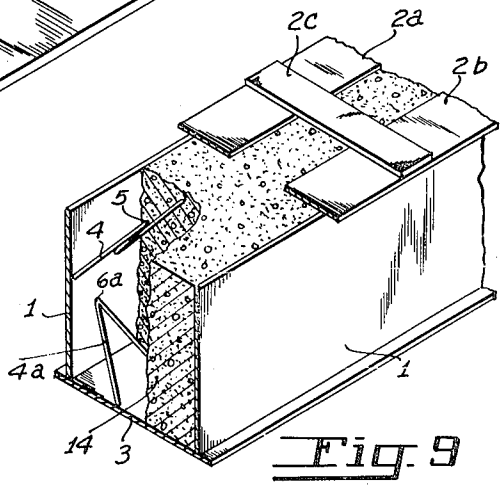


Fig. 9

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BRIDGES AND BOX GIRDERS THEREFOR

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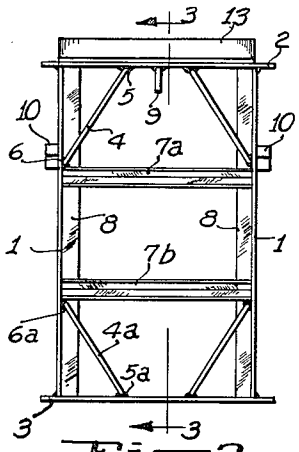


Fig. 2

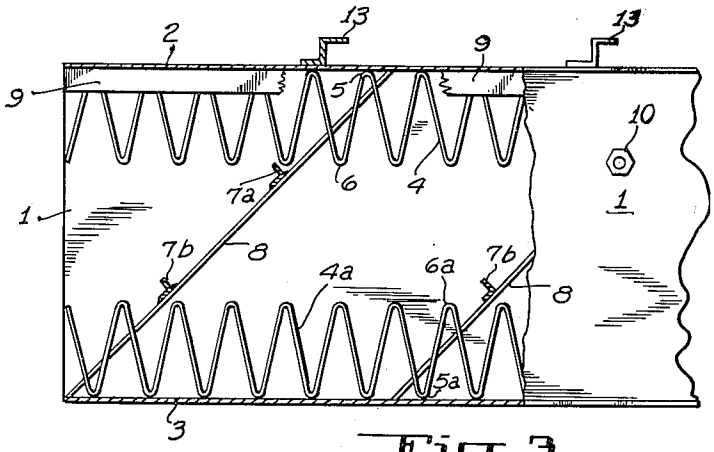


Fig. 3

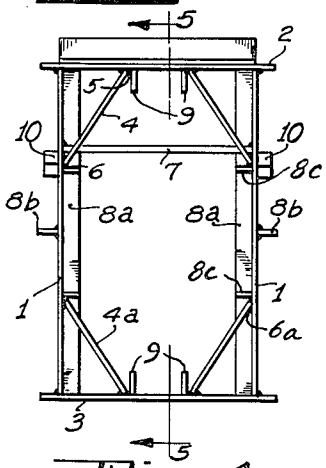


Fig. 4

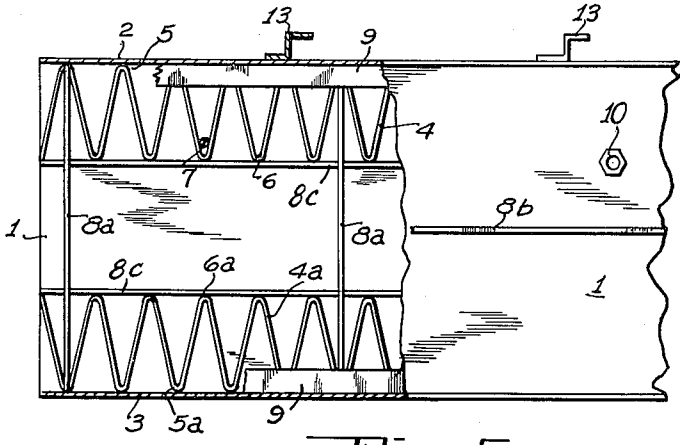


Fig. 5

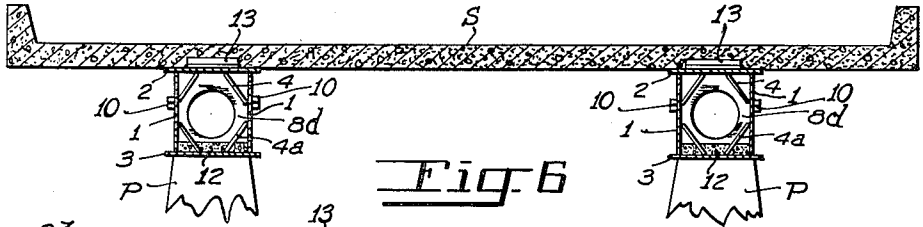


Fig. 6

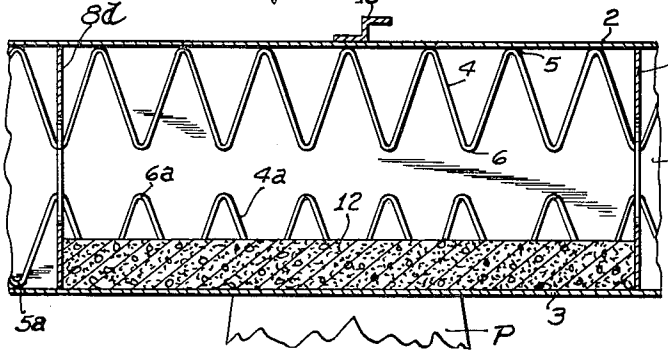


Fig. 7

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BRIDGES AND BOX GIRDERS THEREFOR

Homer M. Hadley, Seattle, Wash.

Application December 10, 1952, Serial No. 325,116

11 Claims. (Cl. 72—8)

Many two-lane highway bridges and viaducts require no more than the basic elements of a bridge in order to support applied loads, namely a slab for the bridge deck and two supporting girders. Whatever is included in the design more than these basic elements is required to support and stiffen the deck per se, to tie the deck to the girders, to tie the girders together transversely, and to stiffen each girder per se. All such additions add expense, labor and weight, and in turn require further strength in the design. It is possible, and the present invention discloses one way to do so, to employ a reinforced concrete slab as the deck, so reinforced internally as to require no additional reinforcing nor support, and so intimately tied to the two girders in the process of pouring as to require no additional ties, and acting, with its inherent strength including its reinforcement, as the sole tie between the girders. If, then, each girder is given sufficient inherent strength and rigidity as not in itself to require cross-bracing to the opposite girder, the bridge design can be reduced to the basic elements enumerated above, which is a primary aim of this invention.

Girders of essentially I-section have been most frequently employed in bridges of this general type. These lack inherent rigidity, hence must be cross-braced to the opposite girder. Box girders, on the other hand, can be made so inherently strong and rigid as to require no cross-bracing, and can be employed in the bridge design contemplated by this invention to effect the advantages outlined above in the design as a whole. However, box girders of known design have certain drawbacks in such service, and the present invention provides additionally a box girder design especially for such usage—although usable in other environments—in that it is light, being constructed of light plates and having a minimum of internal trussing and stiffening members, and these of light material, but each so located and arranged relatively to one another and to the web and flange plates as to afford the maximum of mutual stiffening as between the several plates, and of each such plate individually, especially the compression flange, and the optimum distribution of loads from one such plate to another. In addition, the box girder design of this invention is such as will eliminate the usual problems in box girders, of difficulty of access for inspection, repair and repainting of all interior parts, and consequent early deterioration from the effects of condensation in blanked-off spaces, or spaces otherwise difficult of access.

The objects of the invention having been indicated above, the invention comprises the novel bridge and the novel box girder such as may constitute an element of such a bridge, as shown in the accompanying drawings and as will be hereinafter more fully disclosed and claimed.

This application is a continuation-in-part of my application No. 52,473 filed October 2, 1948, and now abandoned.

The principles of the invention have been illustrated in connection with various typical forms or designs of the

girder as shown in the accompanying drawings, which principles will be brought out more fully hereinafter, and particularly in the appended claims.

Figure 1 is an end elevational view of a basic or minimum structural design of a girder incorporating the principles of this invention.

Figure 2 is a view similar to Figure 1, and Figure 3 is a side elevational view, with parts broken away in section along the line 3—3 of Figure 2, showing a somewhat more highly developed design of such a girder.

Figure 4 is a view similar to Figures 1 and 2, and Figure 5 is a view similar to Figure 3, being partly in elevation and partly in section along the line 5—5 of Figure 4, showing a different design incorporating similar principles.

Figure 6 is a transverse sectional view through a highway bridge embodying such box girders, the form of the girders being a further modification.

Figure 7 is an enlarged longitudinal sectional view on a vertical plane through such a girder as is shown in Figure 6.

Figure 8 is a broken-away isometric view of a further modified design of the girder embodying the same principles.

Figure 9 is an isometric view, partly broken away and partly in end elevation, of a girder slightly modified in design for use as an arch rib, and including a concrete filling and stiffening.

The requirements for using reasonably large sections for box girders in accordance with the load conditions, on the one hand, and on the other hand of employing plates as light as is practicable, are somewhat in conflict, except as the loads, and particularly compressional loads upon one of the flange plates, usually the top flange plate, are properly and adequately distributed to the other plates. If that is done, all the plates, though light and each in itself possibly subject to buckling, will become, by reason of the interbracing or trussing between the plates, adequately stiff, and the girder as a whole rigid. In designing such a girder, the recommendations of the Manual of the American Institute of Steel Construction should be kept in mind, particularly section 18(c) at page 289 (5th edition, 12th printing, 1951) relating to the unbraced length-depth ratio in compression members. It is there pointed out that in compression members the unsupported width of web, cover or diaphragm plates between the nearest lines of rivets or welds, shall not exceed forty times the thickness of the plate. Accordingly, in the present invention all the walls of the box girder are preferably constructed of simple, thin plate members, having great resistance in tension, and equally great resistance to compression provided they are kept from buckling by the use of stress-transmitting elements extending between the compression plate and the web plates, so located that the principle above referred to is not violated. Obviously the deeper or the wider such plates become, particularly the web walls 1 and the top flange plate 2, the more are they susceptible to buckling, and to torsional deformation, and of course the top flange plate, in the usual design, is in compression and always subject to buckling. In consequence it becomes necessary so to locate the stress-transmitting members as to transmit the compressional stresses between the plates at points sufficiently closely spaced from one another, and from the corner junctures, as to be within the vicinity of the 40:1 ratio mentioned, and thereby the several walls mutually assist one another in resisting deforming forces.

A basic form is illustrated in Figure 1. Here, as in other forms, it is preferred that the several plates be welded together at their intersections. The interior of the girder is hollow and completely enclosed, although this does not mean that lightening or drainage holes may not be cut in some of the enclosing walls if that be desired,

and can be done without unduly weakening the girder as a whole, or cutting it at points of specific stress. Without bracing the girder would be stiff at each corner, but otherwise weak in respect to torsional or buckling stresses. Only by the use of internal stress-transmitting members, whereby the load on one plate can be transmitted to another, and distributed therein, can a box girder of light plates and appreciable size become practicable. In the Figure 1 form the two upper corners are spanned by stress-transmitting elements 4, the particular nature of which will be pointed out shortly, in order to transmit compressional forces at frequent intervals from the compressionally stressed thin upper plate 2 to the web plates 1, which also are thin. The bottom plate 3 is in tension, which it is easily capable of resisting, and so it is not essential that there be stress-transmitting elements between it and the side walls 1, but they may be provided and in most designs would be included, for by their use the strength of the bottom plates can assist further in stiffening the side plates, particularly in reducing its unsupported vertical length. This form illustrates that where parts are in tension, as they are in this relatively shallow girder below the neutral axis, the 40:1 ratio is not applicable, for it applies only where parts are in compression.

The stress-transmitting elements which span the corners are primarily in the form of bars 4 which are bent or built up in zig-zag form, such as is well illustrated in Figure 8, for example. These are welded at their peaks 5 to the top flange plate 2, and reinforce that plate against compressional stresses, both transversely and longitudinally. However, in the longitudinal direction these compressional stresses may be further resisted by longitudinally directed stiffener strips 9, which are secured to the plate 2, as by welding, along the line of juncture of the bars 4 to the plate 2, or intermediate the two such lines of juncture. In all instances the 40:1 ratio should be reasonably observed in the location transversely of the points of juncture of the bars 4 to the flange plate 2, and if no longitudinal stiffener strips 9 are employed that ratio should be observed similarly in the longitudinal direction, but if the additional stiffeners 9 are employed the spacing longitudinally of the junctures of bars 4 with the flange plate 2 may much exceed that 40:1 ratio, for the stiffeners 9 assume in part the stiffening longitudinally which, in their absence, would have to be assumed wholly by the bars 4.

The lower peaks of each such zig-zag bar are similarly joined by welding at 6 to the web plates 1. This zig-zag trussing is not primarily a corner-bracing means, to stiffen and strengthen the corners, for the weld at the corners is itself adequate stiffening, but rather is a means of transmitting stresses between the web plates and the flange plates in the region where compressional stresses might otherwise cause buckling, so as to transmit the stresses from those parts most subject to buckling to the others which are more resistant, and so mutually to stiffen the girder as a whole, so that it will assume appreciably greater loads and resist distortion to a much greater degree than without such zig-zag bars. There is likewise the result, due to the inclination of these bars longitudinally of the girder, that they act in conjunction with the adjacent strips or zones of the flange and web plates to form what are in effect longitudinally extending inclined trusses which widely distribute heavy concentrated loads, such as wheel loads, lengthwise of the girder. The same effect, insofar as stress-transmission is concerned, might be accomplished if imperforate plates, similarly located and similarly connected to the web and flange plates, were employed in the interior of the box girder, but the zig-zag corner bars are much preferred in that they do not appreciably impede access to the corners within the girder, nor observation and inspection of this corner space, and are very much lighter than such plates would be.

By such means not only do these zig-zag bars prevent

hinging, as it were, about the junction between the connected edges of the web plate 1 and the top flange plate 2, but they likewise stiffen each of these plates, and particularly the top flange plate 2, against longitudinal compressive stresses such as cause buckling, and they stiffen the lighter plates used in the girder design so that the girder can be made lighter throughout, yet of plates of entirely adequate strength and rigidity when thus stiffened.

To complete the girder additional means should be provided for stiffening the web plates 1 in a general vertical direction. One means of so doing, but not necessarily the preferred means, is illustrated at the strut 7 in Figure 1. This may be a simple bar or angle inherently stiff to resist forces of compression or tension, welded at the opposite ends to the web walls 1. Preferably the connection is made at points in the vicinity of the connection to such web walls of the zig-zag bars 4—that is to say in the vicinity of the points 6. This arrangement most directly transmits stresses from the zig-zag bars and from the top wall 2 to the struts, and vice versa, and assists in making the structure as a whole rigid yet light. Such struts will ordinarily be needed only at intervals, and not at each of the lower peaks 6.

A more usual design of the girder, suited to a greater depth of web plate, is shown in Figures 2 and 3. Here the zig-zag bars 4 spanning the upper corners are employed as before, but in addition similar bars 4*a* are employed spanning the lower corners, and transmitting stresses as between the web plates 1 and the lower flange plate 3. Instead of the simple cross struts 7, struts 7*a* between opposite points 6, and struts 7*a* connecting opposite similar points 6*a*, are employed. Preferably, and regardless of whether or not the struts such as 7*a* and 7*b* are used, additional web stiffening means 8 are employed which extend in a general top-to-bottom direction from the top flange plate 2 to the lower flange plate 3, and connected at the ends to each thereof. These vertical stiffeners 8 may be simple, narrow plates welded to the side walls 1, extending either vertically or diagonally from the top flange plate to the lower flange plate, and welded at their ends to each thereof. One of the advantages of this type of stiffener in conjunction with the zig-zag bars 4 or 4*a* is that, as Figure 3 shows, and as is shown also in Figure 5 at 8*a*, these vertical stiffener bars can extend through the open spaces of the zig-zag bars 4 or 4*a* without necessarily touching any thereof, and yet can extend unbrokenly from the top flange plate to the bottom flange plate, or if desired, they can extend close to a peak, and thus assume most directly any stress transmitted from the zig-zag bars.

In Figures 2 and 4 additional stiffening elements 9 are shown also, extending lengthwise of the top plate 2 and preferably, also, lengthwise of the bottom plate 3. Preferably each of these stiffening elements 9 is also merely a narrow strip of metal plate outstanding from and welded to the plate which it stiffens. Preferably, also, these are located intermediate or at the weld points 5, where the zig-zag bars 4 are connected to the flange plate. In Figures 4 and 5 the location of the vertical stiffeners 8*a* is slightly different in that they extend intermediate the points of connection such as 6 and 6*a* of the zig-zag bars 4, and hence stiffen the web plate between such points. The extension of these vertical stiffeners 8 or 8*a* between the top and bottom flange plates greatly adds to the stiffness of the web plates and of the girder as a whole with but little added weight or labor, and these results flow from the open nature of the zig-zag bars 4, which requires no interruption of the stiffeners 8 nor interfitting of the latter with the zig-zag bars.

A still further feature illustrated in Figures 4 and 5 includes longitudinally directed stiffeners 8*b*. These might be located interiorly of the box girder, but for convenience of assembly and to avoid interference between or interruption of the vertical stiffeners 8*a* which are internally disposed, the longitudinal stiffeners 8*b* are ex-

ternally disposed. However, internally located longitudinal stiffeners 8*c* are also shown, and these when employed may make unnecessary the external stiffeners 8*b* and, if employed, are preferably located adjacent the weld points 6 or 6*a*, being cut in between the vertical stiffeners 8*a*.

As a variation, instead of or supplementing certain of the vertical stiffeners 8*a*, a superior result may be achieved by the employment of bulkheads 8*d* as shown in Figures 6 and 7. Where such vertical bulkheads are employed, they are apertured for passage of an inspector or workman, and preferably they are located at the junctures 6 of the zig-zag bars with the web walls for simplicity of construction and installation, and the better to transmit stresses to these bulkheads and thence to the remainder of the girder. Each bulkhead should be welded to the upper and the lower flange plates as well as to the webs.

In Figures 6 and 7, two such girders incorporating the principles of this invention are shown mounted upon simple piers P, and upon the girders and connecting them is a concrete slab S intended to constitute a roadway or the like, and which would naturally include reinforcing steel, but which preferably contains no other skeleton, support, form, or the like, and constitutes in itself the sole connection between the girders. Because the bottom plate 3 in the vicinity of the pier supports is under considerable compressional stress, it may be desirable, in such instances, to reinforce it against compression, additionally to the zig-zag bars, by a layer of concrete indicated at 12 at this point only. It is shown as extending within the bottom of the girder between two bulkheads 8*d*, and since it embeds the corner braces 4*a* at least partially, it is thereby very thoroughly tied into the girder structure.

If the slab S is to constitute the sole connection between the girders, as desirably it should, it is obvious that the slab and the respective girders must be thoroughly tied to one another at frequent intervals. To this end I employ shear connectors 13 extending transversely of the top plate 2, and preferably extending from one web wall 1 to the other, but located in the vicinity of the juncture of the upper peaks 5 with the upper flange plate 2. Such shear connectors 13 are needed only at intervals, but each one should be thus located in the vicinity of one of the peaks 5 of the zig-zag bars 4, to transmit the stresses from the slab to the girders, and vice versa, most directly, and thereby to distribute such stresses most efficaciously throughout the metal of the girder. The particular form which these shear connectors 13 take is of no especial importance, but preferably they form a good interlock in all directions with the concrete slab S, and are welded in place.

A further and somewhat more complex form of the girder is shown in Figure 8. Herein the diagonal stiffeners 8 are employed and, as previously stated, these are located to pass close to and pass the points of juncture 6 of the upper zig-zag bars 4, and to the upper junctures 6*a* of the lower zig-zag bars 4*a*, whereby to stiffen the unsupported portion of the web plate 1 both intermediate and outwardly of the zig-zag bars, and to transmit the stresses from top to bottom and to these zig-zag bars. Additionally crossed and angled braces or struts 7*c* are employed, these, too, being connected to the stiffeners 8 or to the web plate 1 in the vicinity of the same junctures of the peaks 6 and 6*a* of the zig-zag bars 4 and 4*a*.

There are occasions, for instance an arch member, wherein the element is subjected primarily to axial compressional forces, which are well resisted by concrete, and yet, for instance, where such arches are used for the support of bridges, it is necessary to cross-connect the arches at opposite sides by structural cross-bracing means which are not readily connected to or in concrete. The present invention lends itself well to the construction of such arch elements in the form shown in Figure 9. Herein the internal construction may be any desired—that is, it may be similar to any of those already described—but externally it differs primarily in that the top wall 2 is now divided into flange elements 2*a* and 2*b*, cross-connected at intervals by ties 2*c*, leaving the center opening at the top for pouring of the concrete filler indicated at 14. The concrete embeds the zig-zag bars and any cross-bracing or stiffening elements, and thus ties itself thoroughly to the metal, yet itself primarily assumes the compressional loads. The metal being left in place, however, lends itself well to the connection of cross-bracing elements as between two such arches.

The pouring of a slab such as is illustrated at S in Figure 6 is materially facilitated, and the cost of the operation is kept at a minimum, if it be unnecessary to erect scaffolding or the like to support the forms for the concrete, and if such forms can be supported readily upon the girders themselves. This result can be obtained in the present invention, by means not necessary to describe in detail, by securing an anchorage 10 for a tension member at intervals along the web plates 1. However, since the web plates are ordinarily of even lesser rigidity than I-beams or the like that might be employed instead of box girders, such anchorage as 10 should be located in registry with stiffener members 8*a*, 8*c* or bulkheads 8*d*, and the peaks 6 of the zig-zag bars 4.

A highway bridge incorporating two typical girders of this type and a simple concrete deck joining them spans the Snoqualmie River at North Bend, Washington. The girders have a span between abutment seats of 110 feet. Each main girder has steel web plates of ¼ inch thickness varying from 5 feet 6 inches to 4 feet 4 inches in depth, spaced 4 feet apart. The bottom flange plate is ⅜ inch to ⅝ inch thick, 4 feet wide, and the top flange plate is of ⅜ inch plate throughout, of like width. Bulkheads such as 8*d* are employed at intervals, and stiffeners such as 8*a* and 8*c*, all located within the girder. The zig-zag bars are made of bars of correct length, spanning the four interior corners and assembled in zig-zag fashion between the points of connection at their ends which correspond to the peaks 5 and 6, 5*a*, and 6*a*. Vertical stiffeners similar to 8*a* were welded to the web plates. Notwithstanding the light weight and considerable width of all the plates, each girder and all plates thereof have proven rigid and wholly strong enough because of the fact that the 40:1 ratio has not been exceeded. The structure has cost perhaps two-thirds or less what a more conventional design would have cost.

The stress-transmitting elements or trussing bars 4 or 4*a*, which are arranged in zig-zag fashion, are conveniently formed of steel bars such as are commonly embedded in concrete to reinforce the same, wherefore these stress-transmitting elements are sometimes referred to herein as reinforcing bars. Nevertheless, it is desired to make clear that it is not intended to restrict the invention to the use of the conventionally formed reinforcing bars. The zig-zag bars used may be exteriorly smooth, and of any suitable cross-sectional shape, since they are not, for the most part, embedded in concrete. They may be, for instance, of tubular cross section. Rather than forming a zig-zag trussing bar of a single such bar, bent at numerous points, individual straight lengths of bar stock may be welded in place to make up a zig-zag conformation, if that best serves the ends of convenience and economy. The result, when such a composite bar is in place, is the same as though the bar were of one continuous piece. Any such construction is intended when reference is made herein to zig-zag bars, to trussing bars, to reinforcing bars in zig-zag form, or to stress-transmitting elements across corners.

I claim as my invention:

1. A bridge construction comprising a plurality of box girders spaced apart transversely, each including two spaced-apart web plates and flange plates joined to and connecting the web plates at top and bottom, to form a box section, and zig-zag reinforcing bars slanted as a whole to span each of the two upper corners of the box section,

and joined at their successive apices to the web plate and to the flange plate which meet at such corners, respectively, at points located in each instance intermediate the edges of such plate, and successively spaced longitudinally from the preceding apical point of juncture, piers supporting said girders, a concrete deck extending between the two girders, resting directly upon the upper flange plate of each, and means at frequent intervals directly interconnecting said deck and the contacted flange plates at points substantially coinciding with selected apical junctures with such flange plates of the respective reinforcing bars, whereby the concrete deck serves for transmission of lateral stresses between the girders.

2. A bridge construction consisting of a pair of spaced-apart box girders formed of thin plates, means incorporated in each girder to inherently stiffen it, including zig-zag bars spanning the upper interior corners between the top flange plate and the two web plates, at distances from the corners in the vicinity of forty times the thickness of said flange plate, said bars being connected at their apices to the plates of the girder, a concrete deck resting directly upon the upper flange plates of and spanning the two girders, and shear ties joined to the girders at selected points of juncture between the top flange plate and said zig-zag bars, and embedded within the concrete deck, whereby the latter constitutes an effective stress-transmitting connection between the girders, wherein the zig-zag bars transmit stress from the respective top flange plates to the web plates, and the girders constitute the primary effective support for the deck.

3. A bridge construction comprising a plurality of box girders spaced apart transversely, each including two spaced-apart web plates and flange plates joined to and connecting the web plates at top and bottom, to form a box section, and two zig-zag reinforcing bars each slanted as a whole to span the respective upper corners of the box section, and each joined at its successive apices to the upper flange plate, at points located inwardly from the corners by distances in the vicinity of forty times the thickness of said flange plate, and to the web plates at points located sufficiently below the corners to constitute an effective brace, piers supporting said girders, a concrete deck extending between the girders, resting upon the upper flange plate of each, and means at frequent intervals directly interconnecting said deck and the respective upper flange plates at selected points which substantially coincide with the apical junctures with such flange plates of the respective reinforcing bars, whereby the concrete deck serves for transmission of lateral stresses between the girders, and itself assumes a portion of the compressional stress which is applied to the top flange plates.

4. A box girder for use as a deck support in a bridge construction, comprising two spaced-apart web plates and two flange plates joined to and connecting said web plates at top and bottom corners, to form a box section, at least two zig-zag bars constituting stress-transmitting members, and slanted as a whole to span at least the respective upper corners of the box section, and each theroef joined at its successive apices to the upper flange plate at spaced points located inwardly from the corners, and intermediate the edges of said plate, by distances in the vicinity of forty times the thickness of said upper flange plate, which points are also spaced longitudinally from the next adjacent apices, and the lower apices of said stress-transmitting members being spaced below the respective corners by a distance to constitute an effective brace, and being joined to the respective web plates intermediate the latters' edges, and stiffener elements outstanding from and joined to each web plate, and directed in a general up-and-down direction and extending from the top to the bottom flange plate through the zig-zag bars.

5. A box girder as in claim 4, characterized in that said stiffener elements are attached each to its web plate in the vicinity of an apical connection to such web plate of the zig-zag stress-transmitting member.

6. A box girder for use as a deck support in a bridge construction, said girder comprising two spaced-apart web plates and two spaced-apart flange plates joined to and connecting said web plates at top and bottom to form a box section, one flange plate whereof, in use, being subjected to compressive stress, zig-zag bars constituting stress-transmitting members, each slanted as a whole to span a corner between a web plate and a flange plate, there being at least two such stress-transmitting members, spanning a pair of horizontally aligned corners where the compressively stressed flange plate is joined to the respective web plates, the successive apices along one margin of each such zig-zag bar being joined to said compressively stressed flange plate at their points of contact located inwardly from the spanned corners by a distance in the vicinity of forty times the thickness of said compressively stressed flange plate, and the successive apices along the opposite margin of the same zig-zag bar being joined to the corresponding web plate, intermediate the latter's edges, at a vertical distance from the so-spanned corner to constitute an effective brace.

7. A box girder as in claim 6, wherein the compressively stressed flange plate constitutes the upper plate, and including stiffener strips directed longitudinally of said upper flange plate, adjacent the apical connections of the zig-zag bars, and joined to said upper flange plate.

8. A box girder as in claim 7, including similar longitudinally directed stiffener strips secured to the respective web plates in the vicinity of the apical connections of the zig-zag bars.

9. A box girder as in claim 6, including transverse diaphragms within the box section at longitudinal intervals, joined to the respective web and flange plates.

10. A box girder as in claim 6, wherein the compressively stressed flange plate constitutes the upper plate, and including shear-connecting elements, for embedment in a concrete slab, joined exteriorly to the upper flange plate at points in the vicinity of selected junctures of the respective zig-zag bars with said upper flange plate.

11. A box girder for use as a deck support in a bridge construction, comprising two spaced-apart web plates and two spaced apart flange plates joined to and connecting said web plates at top and bottom, to form a box section wherein, in use, the upper one of said flange plates is under compressive stress, and two stress-transmitting zig-zag bars slanted as a whole to span the two horizontally aligned corners which include the upper flange plate and the respective web plates, and each of the two zig-zag bars being connected at its successive apices along one margin to the upper flange plate at longitudinally spaced points located laterally inwardly from the corner which it spans by a distance at least forty times the thickness of said upper flange plate, and the successive apices along the opposite margin of each of the two zig-zag bars being also connected to the corresponding web plate, intermediate the latter's edges, at a distance, from the corner which it spans, sufficient to constitute an effective brace.

References Cited in the file of this patent

UNITED STATES PATENTS

1,740,053	Wehr	Dec. 17, 1929
1,979,643	Sahlberg	Nov. 6, 1934
1,994,716	Klemperer	Mar. 19, 1935
2,241,617	Rubin	May 13, 1941
2,296,414	Albrecht	Sept. 22, 1942

FOREIGN PATENTS

128,322	Great Britain	June 26, 1919