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METALLIC BRIDGE.

No. 384,196. Patented June 5, 1888.

FIG. 3.

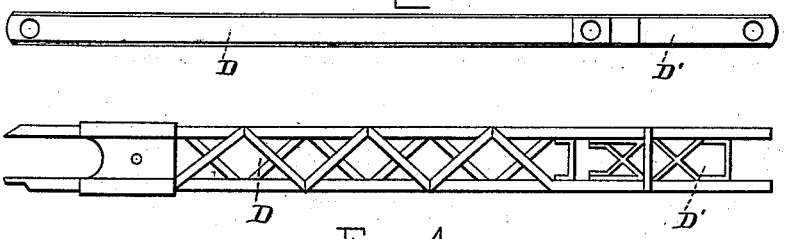


FIG. 4.

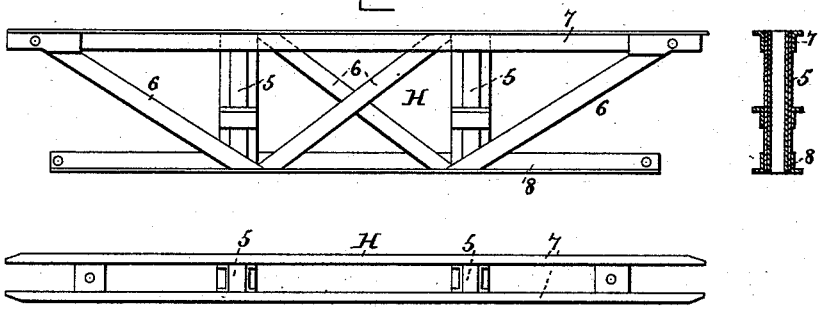


FIG. 2.

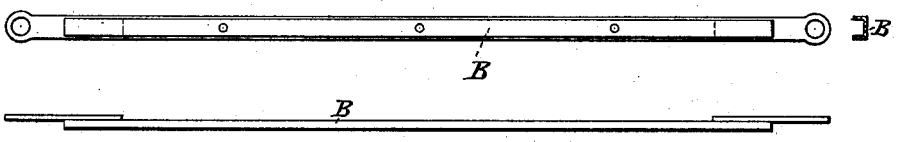


FIG. 1.

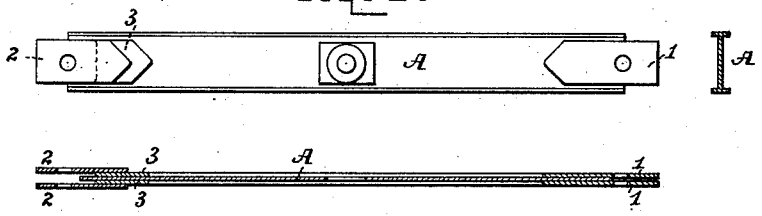
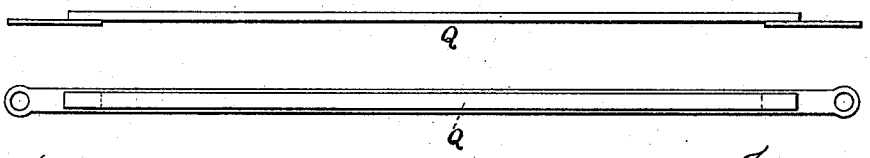


FIG. 5.



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METALLIC BRIDGE.

No. 384,196. Patented June 5, 1888.

FIG. 6.

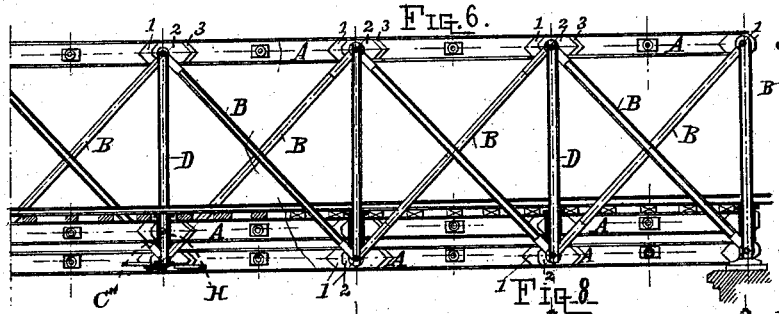


FIG. 7.

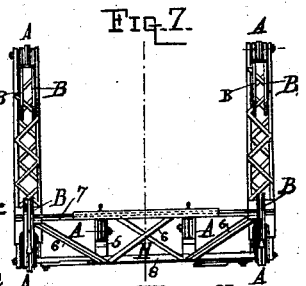


FIG. 8.

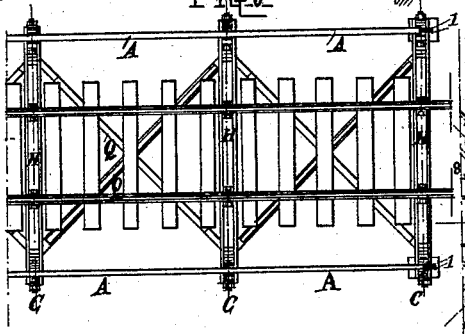


FIG. 11.

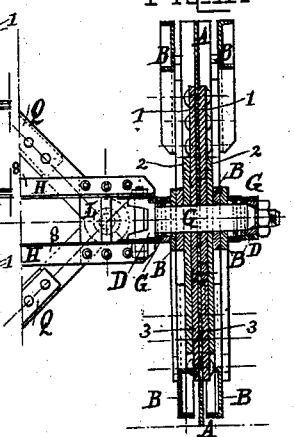


FIG. 9.

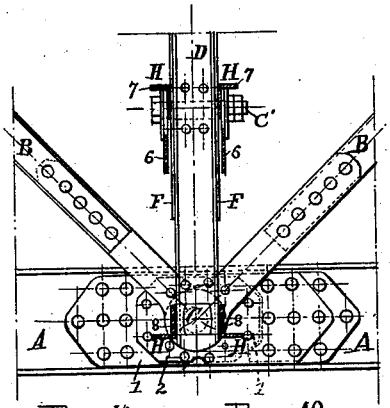


FIG. 10.

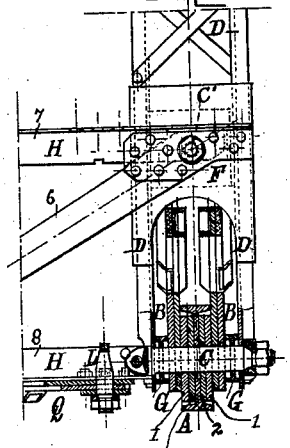


FIG. 18.

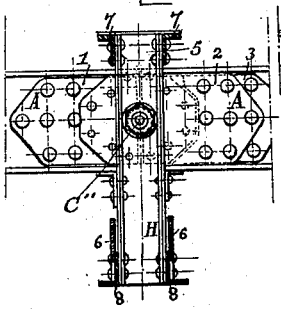
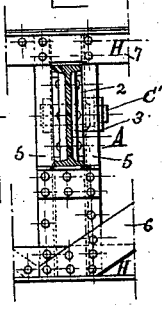


FIG. 19.



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METALLIC BRIDGE.

No. 384,196. Patented June 5, 1888.

Fig. 7 bis.

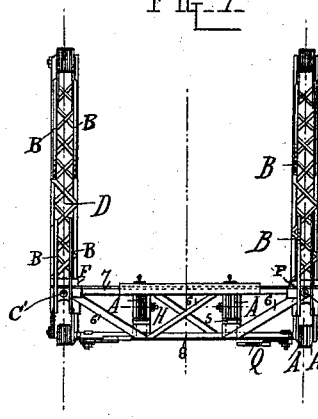


Fig. 6 bis.

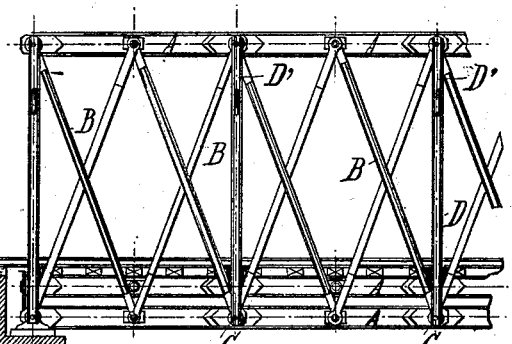
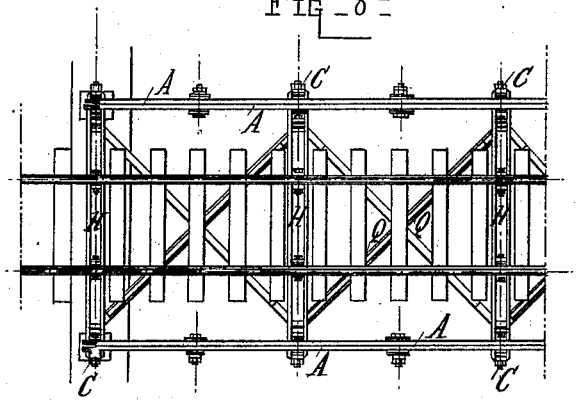


Fig. 8 bis.



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M. L. E. DUVAL.

METALLIC BRIDGE.

No. 384,196. Patented June 5, 1888.

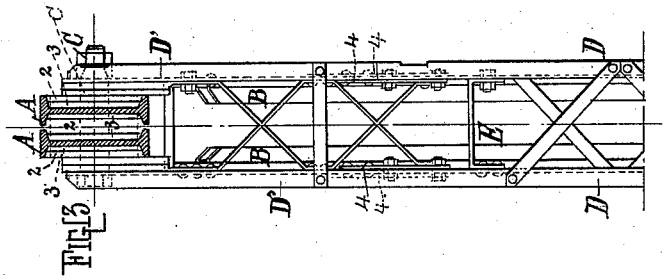

Fig 13

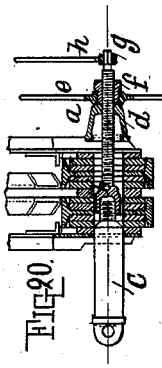

Fig 20.

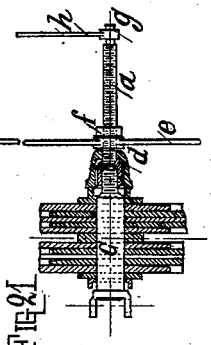

Fig 21

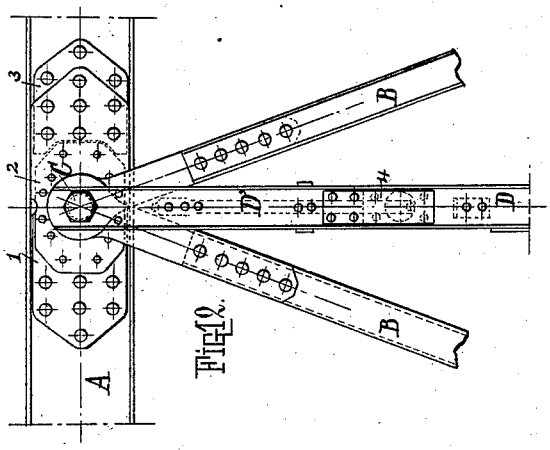

Fig 12.

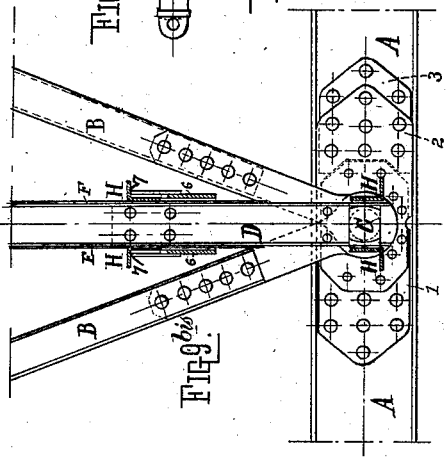

Fig 9bis.

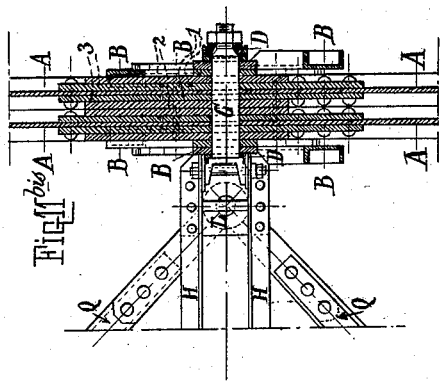

Fig 11bis A

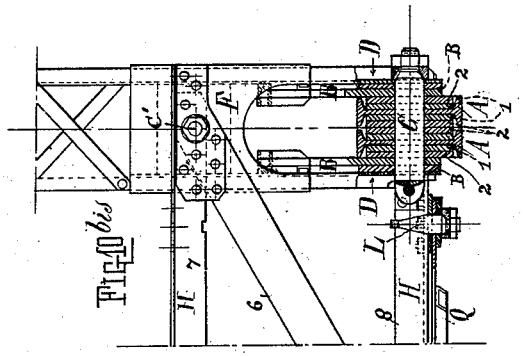

Fig 10bis

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METALLIC BRIDGE.

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Fig 14.

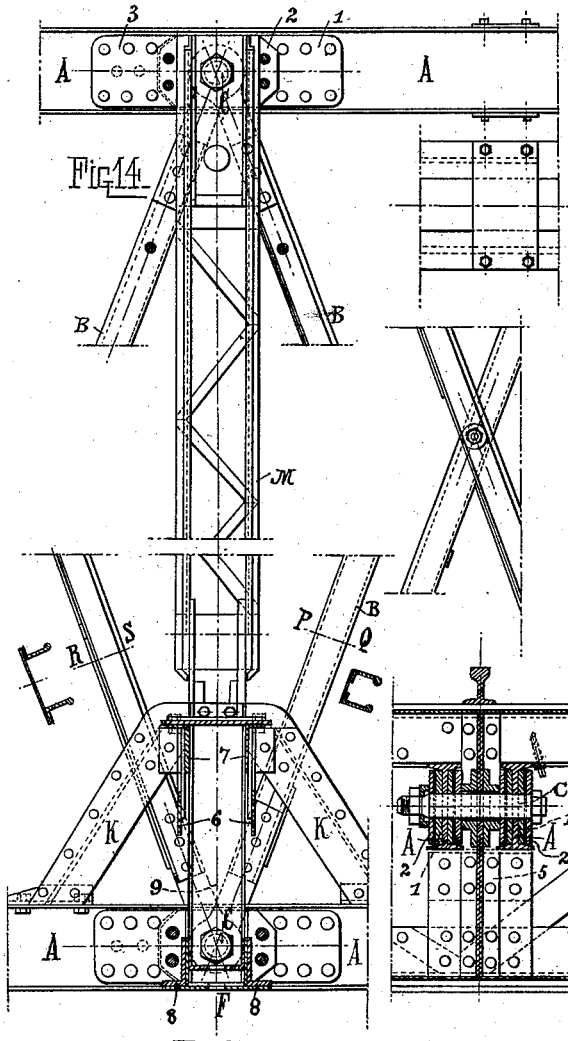


Fig 15.

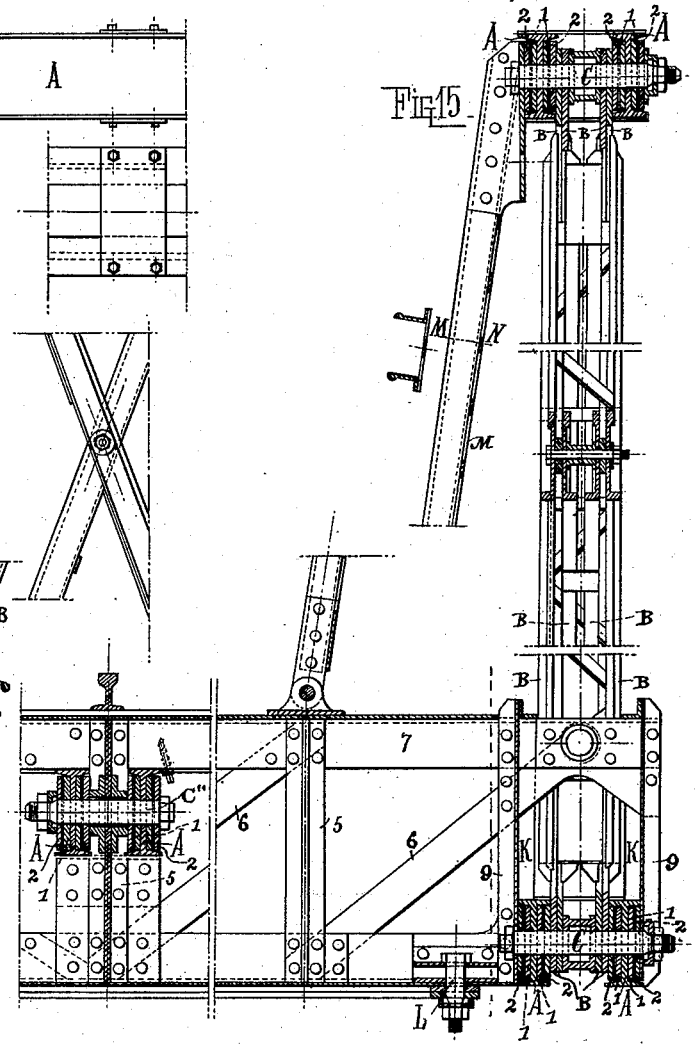


Fig 17.

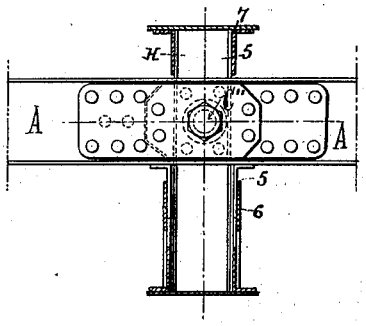
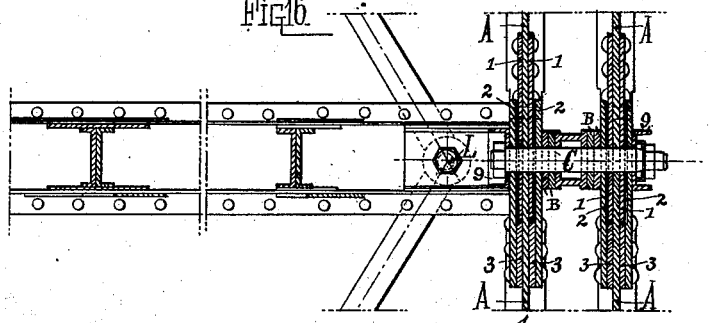


Fig 16.



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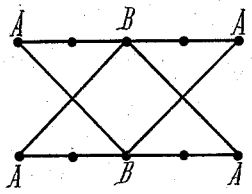
METALLIC BRIDGE.

No. 384,196. Patented June 5, 1888.

FIG 22.

No. 1.



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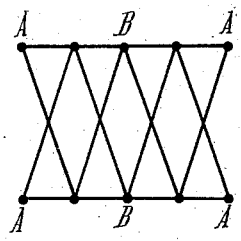

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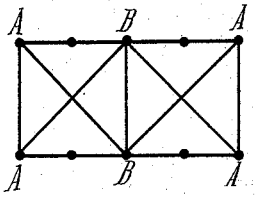

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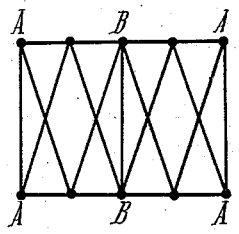

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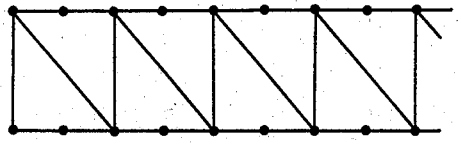
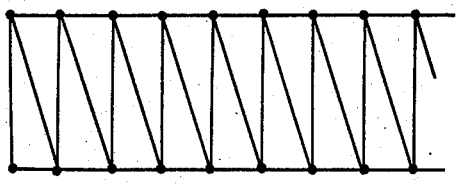


No. 6.



Witnesses.
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Philip Adams.

Inventor.
Martin L. E. Duval. by
A. Pollok.
his attorney.

UNITED STATES PATENT OFFICE.

MARTIN LÉONARD EDMOND DUVAL, OF PARIS, FRANCE, ASSIGNOR TO THE COMPAGNIE DE FIVES-LILLE, OF SAME PLACE.

METALLIC BRIDGE.

SPECIFICATION forming part of Letters Patent No. 384,196, dated June 5, 1888.

Application filed February 8, 1888. Serial No. 263,418. (No model.) Patented in France March 25, 1885, No. 167,879.

To all whom it may concern:

Be it known that I, MARTIN LÉONARD EDMOND DUVAL, a citizen of the Republic of France, residing at Paris, in the said Republic, have invented certain new and useful Improvements in Dismountable Metallic Bridges of Variable Height and Resistance, (for which I have obtained Letters Patent in France, dated March 25, 1885, No. 167,879,) of which the following specification is a full, clear, and exact description.

This invention relates to the production of special material which permits the building with constant elements prepared beforehand of metallic trusses over any desired opening of strength corresponding to the span, more surely, simply, and rapidly than by the means in use or heretofore known.

The improved trusses are composed, like ordinary bridges, of two principal girders or compound beams supporting the flooring of the way, which may be placed between the girders at their lower part or above at their upper part. The girders are of the lattice type, with large interspaces. The floor supporting the way is composed of cross-girders and longitudinal stringers underlying rails or a common roadway.

In carrying out the invention the lattice or skeleton web of the compound beams or principal girders is composed, in principle, of a simple cross or X whose height can be varied by opening or closing the arms, more or less, without altering their length. To this end each element of the chords is provided between the ends with as many holes, properly spaced and adapted to be attached to the ends of the lattice, as will correspond to the different lengths which it is desired to obtain with the same length of lattice bars or diagonals. An element of the chord may, for example, be pierced with attaching-holes, so as to be divided into two, three, or four equal parts, which provide for three different heights of girder, according as the ends of the lattice are secured at the holes of one or another of the divisions. With a single intermediate hole two girders, one double the height of the other, can be made with the same element.

The lattice, as so far described, is without vertical posts; but it will be readily understood that vertical post-girders can be made in the same manner by making the length of the vertical posts adjustable according to the different heights which it is desired to obtain. The increase in the height of the girders which can be obtained by this change of inclination of the lattice-bars enables the girders of different resistances or strength to be made from the same elements; but in order to enlarge still further the limits of this variation, the present invention provides means whereby each chord may at will be made up of one or several lines of elements placed side by side.

In the accompanying drawings, which form part of this specification, Figure 1 consists of views, in side elevation, longitudinal section, and cross-section, of an element of the chords and of stringers (they being composed of like elements) adapted for the building of girders two heights; Fig. 2, similar views of one of the lattice-bars; Fig. 3, similar views of one of the vertical posts; Fig. 4, edge and side elevation of one of the cross-girders; and Fig. 5, a plan and side elevation of one of the horizontal diagonal braces. Figs. 6, 7, and 8 are respectively an elevation, partly in longitudinal section, a cross-section, and a plan of a portion of a truss constructed in accordance with the invention by means of the pieces shown in Figs. 1 to 5; and Figs. 9, 10, and 11 are detail views in elevation, cross section, and horizontal section, respectively, illustrating, on an enlarged scale, the joints at the bottom of truss of Figs. 6, 7, and 8. Figs. 6^{bis}, 7^{bis}, 8^{bis}, 9^{bis}, 10^{bis}, and 11^{bis} are views corresponding to Figs. 6, 7, 8, 9, 10, and 11, each to each, of a truss built in accordance with the invention from the like elements, but of greater height and with double chords, and Figs. 12 and 13, additional detail views, in elevation and cross-section, respectively, illustrating the joint at the top of the truss of Figs. 6^{bis}, 8^{bis}. Figs. 14, 15, and 16 are partial views in elevation, cross-section, and horizontal section, respectively, of a truss without vertical posts in the principal girders. Fig. 17 is a detail view in sectional elevation, (taken longitudinally of the truss,) illustrating the connection between the double stringer and the cross-girders; Figs. 18 and 19, detail

views in longitudinal and cross section, respectively, of the same connection when a single stringer is used. Figs. 20 and 21 are detail views in vertical and horizontal section, respectively, illustrating the introduction of the pin to couple together the chord with the other portions of the girder. Fig. 22 is a series of diagrams, representing various dispositions of the elements. No. 1 shows the diagonals in the form of a cross. In No. 2 are shown two trusses of greater height. Nos. 3 and 4 are similar to Nos. 1 and 2, but include vertical posts, and in Nos. 5 and 6 the diagonals are represented as inclined in one direction.

Elements of the chords.—All the elements are of equal length. The upper and lower chords have the same section and the elements which compose them are identical and are in each connected together in the same manner by means of a single pin at each joint. As one of these chords undergoes compression while the other is exposed to tension, this connection is so made as to resist these two kinds of force and to assure the rigidity of the system in both cases.

Each element of the chord is composed of flanged iron, as shown. (See Fig. 1.) It is of I-iron, and is designated in all the views by A. At the ends of the several I-bars are jaws of plate-iron 1 and 2, riveted to the web of the I-bar, the jaws 1 being riveted directly to the web, and the jaws 2, with pieces 3, of plate-iron, interposed. In order to form a chord, bars A are placed in a line with their ends abutting, the jaws of each bar (see Figs, 6, 9, 10, and 11) inclosing the web of the adjacent bar, and being themselves inclosed by the jaws 2, and pins C are inserted through both sets of jaws, so as to bend the bars together. The bars A are each provided with the male jaws 1 at one end and the female jaws 2 at the opposite end, in order that any two bars may be connected together. From the form of this joint it follows that the successive bars are exactly in line one with another, while at the same time, from the overlapping of the double sets of jaws, the sections of the pins exposed to shearing-strains are multiplied, thus enabling the diameter or cross-section of the pins to be diminished, and great rigidity is imparted to the system. Moreover, the jaws form a filling between the flanges of the I-bars, which allows the lattice or diagonal bars of the panels to clear in said flanges.

Where greater strength of chord is required than would be furnished by a single line of elements, A, these may be duplicated or multiplied in even greater ratio. In this case the elements of the two or more lines are placed side by side and secured by one pin at each joint, as shown in Figs. 7^{bis} and 8^{bis}, and in detail in Figs. 10^{bis}, 11^{bis}, 13, 15, and 16.

Lattice-bars.—The lattice-bars B of the girders are composed each of two simple [or channel-irons provided at each end with eyes for securing them to the chords. One of these channel-bars is shown in Fig. 2. In the girders, with vertical posts, Figs. 6 to 13, the pair of channel-irons composing a lattice-bar are fastened together in the course of their length at these points, while in the no-post type of girder, Figs. 14 to 16, they are more firmly connected by a light lattice or cross-pieces (see sections M N and P Q, Figs. 14 and 15) in order to impart greater stiffness. The lattice-bars of the two sets which run in opposite directions and cross in the center of the panels have their channel-bars so arranged that the flat sides of the bars of one set are opposite those of the other set, and are applied thereto where they cross each other. The ends of the lattice-bars are connected with the chords by the same pins C which fasten together the elements of said chords. The pins are inserted through the eyes in the lattice-bars. By having a single pin at the ends of the lattice-bars these can be turned so as to adjust their inclination at will, as may be required to adjust the height of the girder, and the mode of connection thus receives a new application which forms a special feature of invention.

Vertical posts.—The vertical posts D (see Fig. 3) are formed each of two [or channel-irons turned back to back, with their flanges toward the outside and fastened together by light cross-pieces of such length and arrangement that the ends of the channel-irons will fit on opposite sides of the assemblage of chord elements A and lattice-bars B, to which they are connected by the same pins C that hold the other parts together. (See Figs. 10 and 11; also 10^{bis} and 11^{bis}; also Fig. 13.) The space between the ends of the channel-bars composing the upright posts D is fixed to conform to the greatest width of chord with which it is desired to use them, and for chords of less width the excess of space is filled with washers. Thus, as shown, the channel-bars of each post D are spaced to inclose a chord composed of a double line of elements, A, (see Figs. 10^{bis} and 11^{bis},) and where a single line of elements is used washers G are interposed. (See Figs. 10 and 11.)

In order that the height of the posts may be varied, the main portion D of each post is made conformable in length to the smallest height of girder with which they are to be used, and a separate portion, D′, is provided which can be fastened onto the main portion D to extend the post the proper distance for an increased height of girders. This separate portion D′ may be provided with intermediate holes for connection with the pins C if it is desired to form girders of a height between the extreme limits.

The two posts D D′ are fastened together by plates 4, riveted to the post D′, which forms the upper part of the post, and bolted to the post D. (See in Figs. 12 and 13.)

In Figs. 6, 7, and 8 the shorter posts are used, the lattice-bars B being connected with the chord elements A only at the ends of the latter, while in Figs. 6^{bis}, 7^{bis}, and 8^{bis} the longer posts, D D′, are employed to conform to the

increased height of the girder, which is given with the same lattice-bars B by making them more nearly vertical, they being connected with the elements A at the middle of the latter as well as at the ends thereof.

In place of using posts in two parts, posts of one length only could be employed, that length being made sufficient for the highest girders in which they are to be used, and intermediate holes being provided for the reception of the joining-pins when they are used in girders of less height, the excess being allowed in the latter case to project beyond or above the girder.

Cross-girders.—The cross-girders H of the truss, with vertical posts in the principal girders, are as represented in Fig. 4, and their connection with the parts of the principal girders is as shown in detail in Figs. 9, 10, 11, and 9^{bis}, 10^{bis}, 11^{bis}. These cross-girders have double walls of open-work, they being formed by posts 5 and diagonals 6 between an upper (7) and a lower chord (8). The chords are each composed of two angle-bars placed at the proper distance to embrace exactly the space occupied by the width of the vertical posts D of the principal girder. (See Fig. 9.) The two members of the upper chord are secured outside the cut-away plates F on the sides of the vertical posts D by a single bolt, C', directly in the axis of the post D, which bolt passes through the last diagonal 6 of the cross-girder, where it laps upon the web of the upper chord, 7. The stress transmitted by the cross-girders is thus applied mathematically in the axis of each principal girder. The angle-bars of the lower chord, 8, of the cross-girder are bolted directly to the heads of the pins C, which heads are with that object much the same width as the posts D. This double attachment of the cross-girders to the principal girder assures the vertical position of the latter by the movement of resistance which it presents.

In the case of principal girders without vertical posts, Figs. 14, 15, and 16, the cross-girders terminate in a fork, 9, Fig. 15, which embraces both the chord and the lattice-bars, and is secured thereto by the pins C in the same manner that the lower end of the vertical post of the former type is secured. Two stay-pieces, K, prevent the overturning of the cross-girder, which otherwise might revolve on the pins C. The vertical position of the principal girders in this type is secured by the lateral inclined braces M, Figs. 14 and 15.

Longitudinal stringers underlying the rails.—Each stringer is constituted according to the resistance which it should have by one or two lines of the elements A, Figs. 1, 6, 7, 6^{bis}, 7^{bis}, 15, 17, and 18, identical with those of the chords. They are connected with the cross-girders by bolts c'' through the holes provided in the elements for use as parts of the chords. The cross-girders have each a post, 5, under the axis of the rails for establishing the connection.

Figs. 18 and 19 show the construction when the stringers are composed of a single line of elements, and Figs. 15 and 17 the same with a double line.

Since the cross-girders have double walls and are of open work, the posts 5, on which the stringers are placed, have a width equal to the space between the two walls, which width is sufficient to permit the union of the elements of the stringers by pins or bolts c'' of the same diameter as those which connect together the elements of the chords.

For the spacing shown between the cross-girders, a single line of elements, A, suffices for each stringer. In this case, as represented in Figs. 18 and 19, the post 5 of the cross-girders which supports the stringer is composed of two [ ] or channel-irons between which the I-iron constituting the stringer passes and to which it is united by a pin, c'', as before described. For greater security this stringer rests on brackets formed by angle-iron riveted to the flanges of the channel-iron composing the post.

Horizontal diagonals.—The horizontal diagonal braces Q are such as represented in Fig. 5, and their connection with the cross-girders is indicated in Figs. 10, 11, 10^{bis}, 11^{bis}, and 15, 16. These braces are composed of [ ] or channel-iron terminated by eyes, which permit them to be united to the cross-girders by a single pin, L, at each end.

Means of setting up the truss.—As already seen, there is at each point where the chord elements are connected with each other and with the lattice-bars and the posts—that is to say, at each joint—a large number of pieces secured by the same pin, which pin must necessarily have a large diameter. It would be difficult on the one hand to bring and to maintain all these pieces perfectly in place, so that the hole in each exactly coincides with those in the other pieces, and on the other hand to introduce this large pin by the ordinary means, the friction which it exerts on the interior surface of the holes tending to separate the pieces by pushing them before the pin. The means devised to surmount these two difficulties consist of the following: First. In order to center the pieces a series of small holes are drilled in each piece (namely, the jaws of the chord elements and the eye-plates of the lattice-bars and vertical posts) around the eye which receives the coupling-pin C, and by thrusting a needle of proper size through these small holes the exact position of the different pieces may successively be assured, and consequently the registry of the large hole or eye. Second. In order to insert the coupling-pins into the pieces brought into position, as just explained, a small apparatus, termed a "bolt-drawer," is employed. Such apparatus is shown in Fig. 20, at the commencement of the operation of drawing or inserting a pin, and in Fig. 21 at the end of the operation. It is composed of a screw, *a*, terminating at one end in a hollow enlargement, *b*, threaded inter-

nally, so as to engage the reduced and threaded end of the pin C, and at the other end in a squared portion designed to receive a key, *h*, and also of a hollow block, *d*, and a nut, *f*, the latter engaging the screw *a*, bearing against the block *d*, being revolved, when desired, by the wrench *e*. To introduce a pin, C, it is inserted until its motion is arrested by the rubbing friction, or it may be held simply at the entrance of the orifice through which it is to pass. Then the enlargement *b* is secured by means of the key *h* onto the reduced and threaded end of the pin C. Care would of course be taken that the nut *f*, wrench *e*, and block *d* should be drawn back so far that the screw may reach the end of the pin. When the end of the pin is engaged, the nut *f* is advanced by turning it with the wrench *e* until it forces the block *d* against the outermost of the pieces to be connected, whereupon the continued rotation of the nut draws out the screw *a* and advances the pin C until it has been drawn entirely through. The hollow of the block *d* receives the enlargement *b* and the threaded end of the pin C. During the introduction of the pin the chord elements and lattice-bars do not tend to separate, but are rather clamped by the resistance of the pin C and the counter-pressure on the block *d*, and consequently the inconvenience of mounting in the ordinary way is no longer to be feared.

Although the arrangements described relate to girders with crossed lattice-bars or diagonals, the improvements are applicable also to girders or trusses in which the lattice is formed by diagonals in one direction and vertical posts.

Where iron is spoken of in this specification it is intended in a general sense, and not excluding the use of steel or other suitable metal from the invention.

I claim as my invention or discovery—

1. A trussed girder of variable height comprising, in combination, with diagonals adapted to be more or less inclined, so as to vary the height, a chord or chords provided with holes for the connection of the diagonals and with other spaced holes, so that said diagonals can be connected therewith at different inclinations, substantially as described.

2. A chord or stringer composed of one or more lines of similar-flanged elements, each provided at the ends with forked jaws differently spaced at the two ends and connected together with the jaws intermeshed, substantially as described.

3. In a trussed girder, and in combination with the lattice bars or diagonals, the chord or chords composed of separate sections or elements, and provided with holes in the ends for coupling-pins for connecting the ends of the chord elements and the ends of the diagonals, and provided with other spaced holes additional to those required for the connections aforesaid, whereby the height of the girder can be varied by inclining the diagonals more or less and connecting them with the chord elements by means of such additional holes, substantially as described.

4. A trussed girder of variable height having vertical posts provided with extension-pieces for increasing the length by addition to the main portion thereof, substantially as described.

5. A trussed girder of variable height having vertical posts formed of two channel-irons symmetrically arranged with reference to the vertical axis of the girder and connected with the chords by the coupling-pins which unite together the elements of the said chords, said posts being of variable length between the chords, substantially as described.

6. In a trussed metallic bridge and in combination, the principal girder, skeleton cross-girders connected with the principal girders by a single horizontal pin at each end and stayed to prevent turning on said pins, substantially as described.

7. The skeleton cross girders with double walls, in combination with the vertical posts of the principal girders embraced by the ends of said walls and secured thereto by a single pin at each end, and the coupling-pins in the chords of the said principal girders, the lower part of the said cross-girders being connected with the heads of the last-mentioned coupling-pins, substantially as described.

8. In combination with the cross-girders, the stringers composed of elements united to each other and to the said cross-girders by a pin at each joint, substantially as described.

9. In a truss or bridge, the combination, with the cross-girders and the lattice or skeleton web of the principal girders, of the upper and lower chords and the stringers, each composed of one or more lines of elements the same for all, joined together, substantially as described.

10. The combination of chord and lattice elements, the cross-girders, the elements of the stringers, and the coupling-pins, the said chord elements having intermediate holes to receive said pins when necessary to vary the height of the principal girders, and the elements of the lattice being adjustable, substantially as described.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

MARTIN LÉONARD EDMOND DUVAL.

Witnesses:
GIRAL,
J. B. BOURNE.