(Model.) 3 Sheets—Sheet 1.

C. E. EMERY.

CONNECTED BRIDGE GIRDER.

No. 279,927. Patented June 26, 1883.

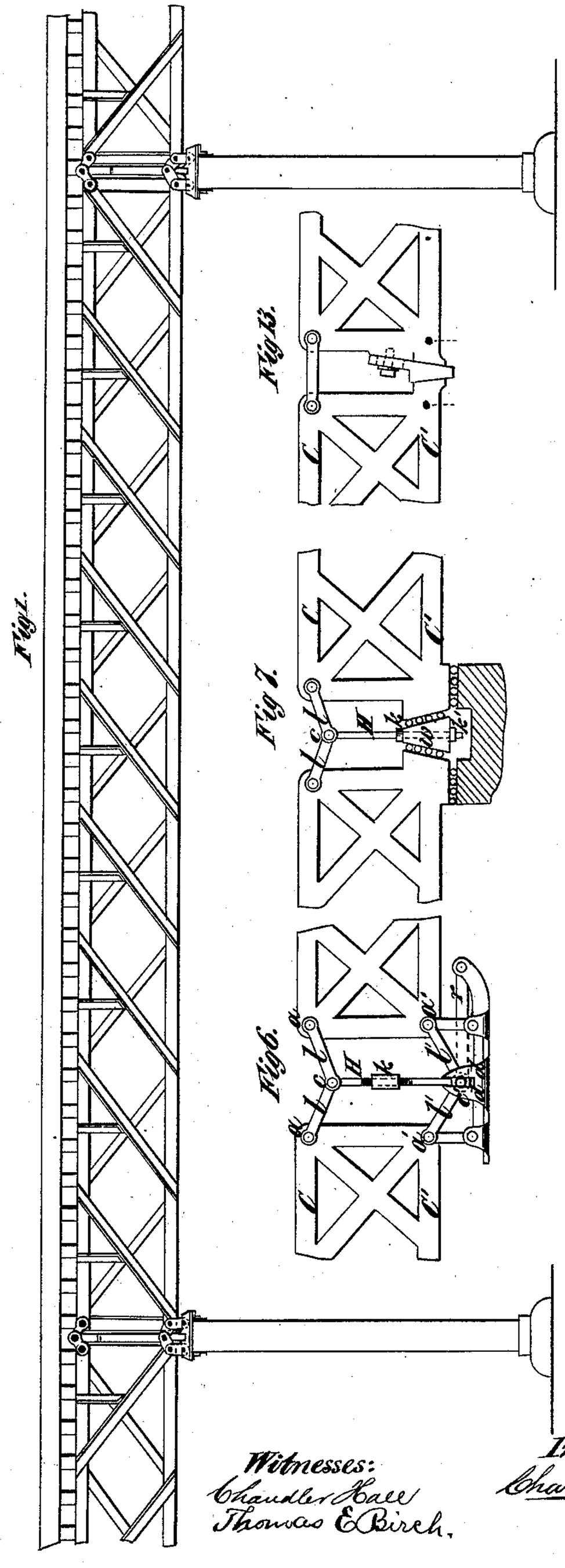

Fig. 1.

Fig. 3.

Fig. 4.

Fig. 5.

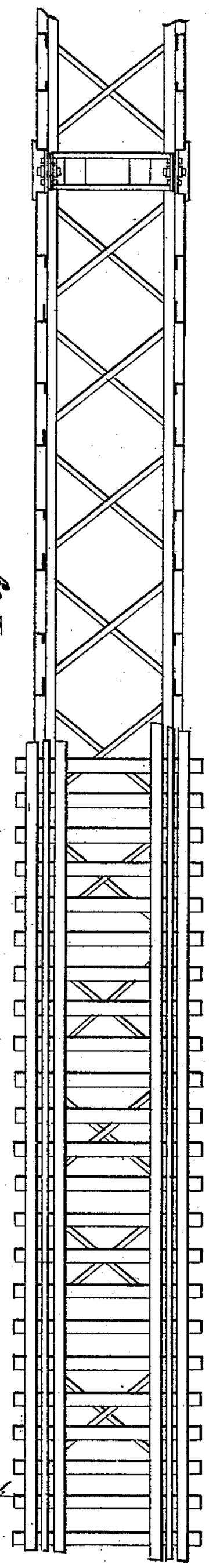

Fig. 2.

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Chandler Hall
Thomas E. Birch.

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(Model.) 3 Sheets—Sheet 2.

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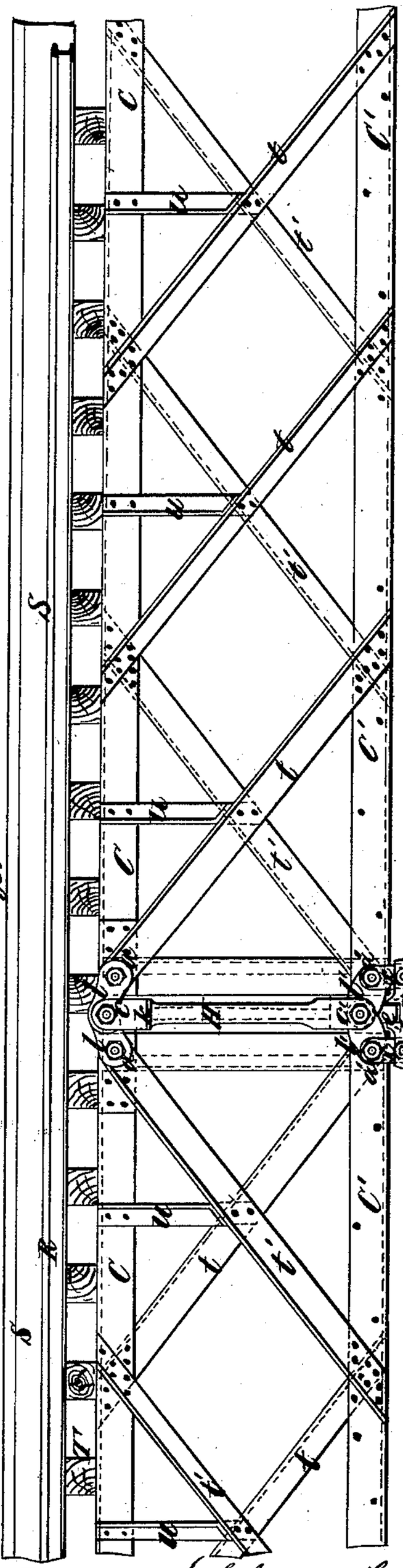


Fig. 3.

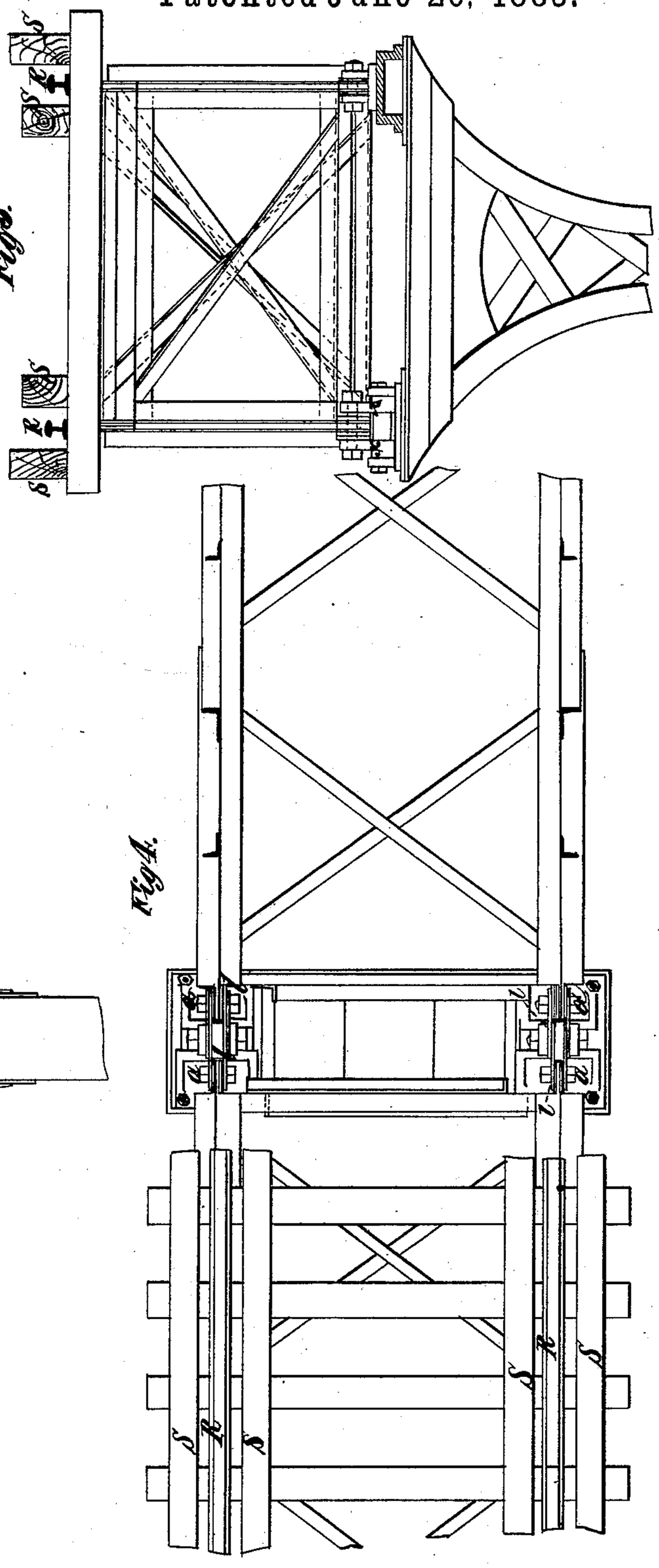


Fig. 4.

Witnesses: { Chandlee & Hall. Thomas E. Birch.

Inventor. Chas. E. Emery

(Model.) 3 Sheets—Sheet 3.

C. E. EMERY.

CONNECTED BRIDGE GIRDER.

No. 279,927. Patented June 26, 1883.

Fig. 9.

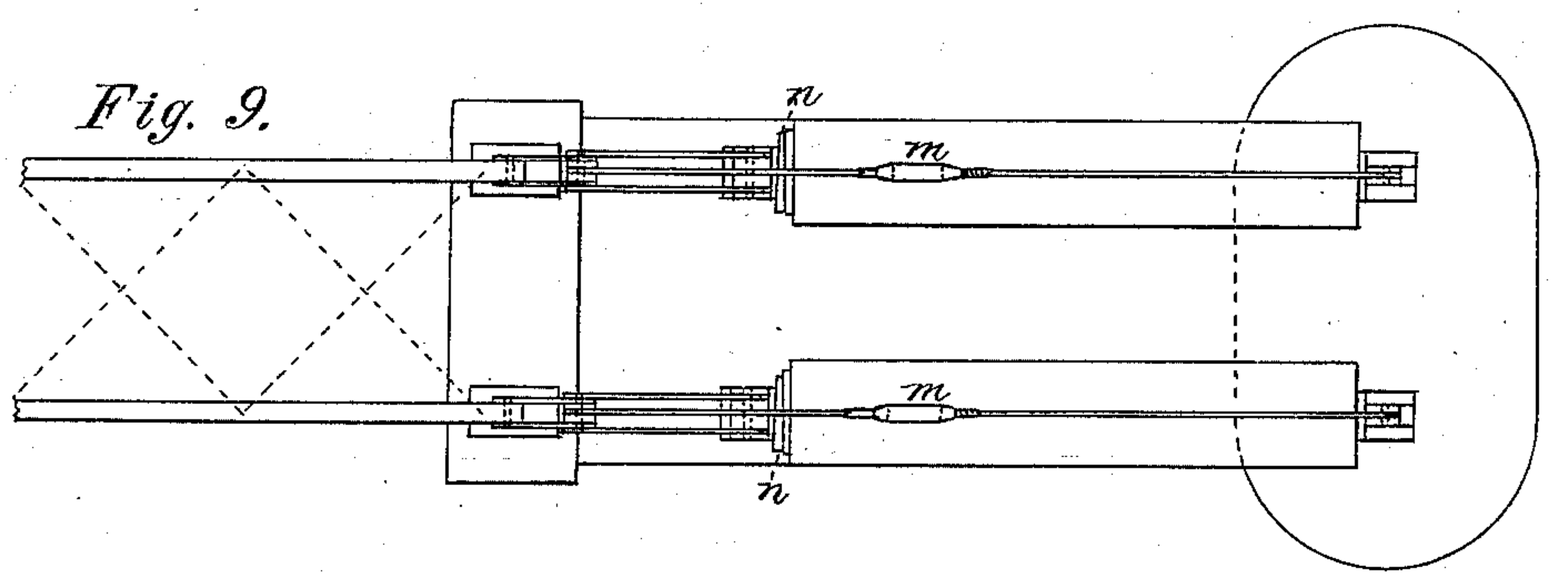


Fig. 8.

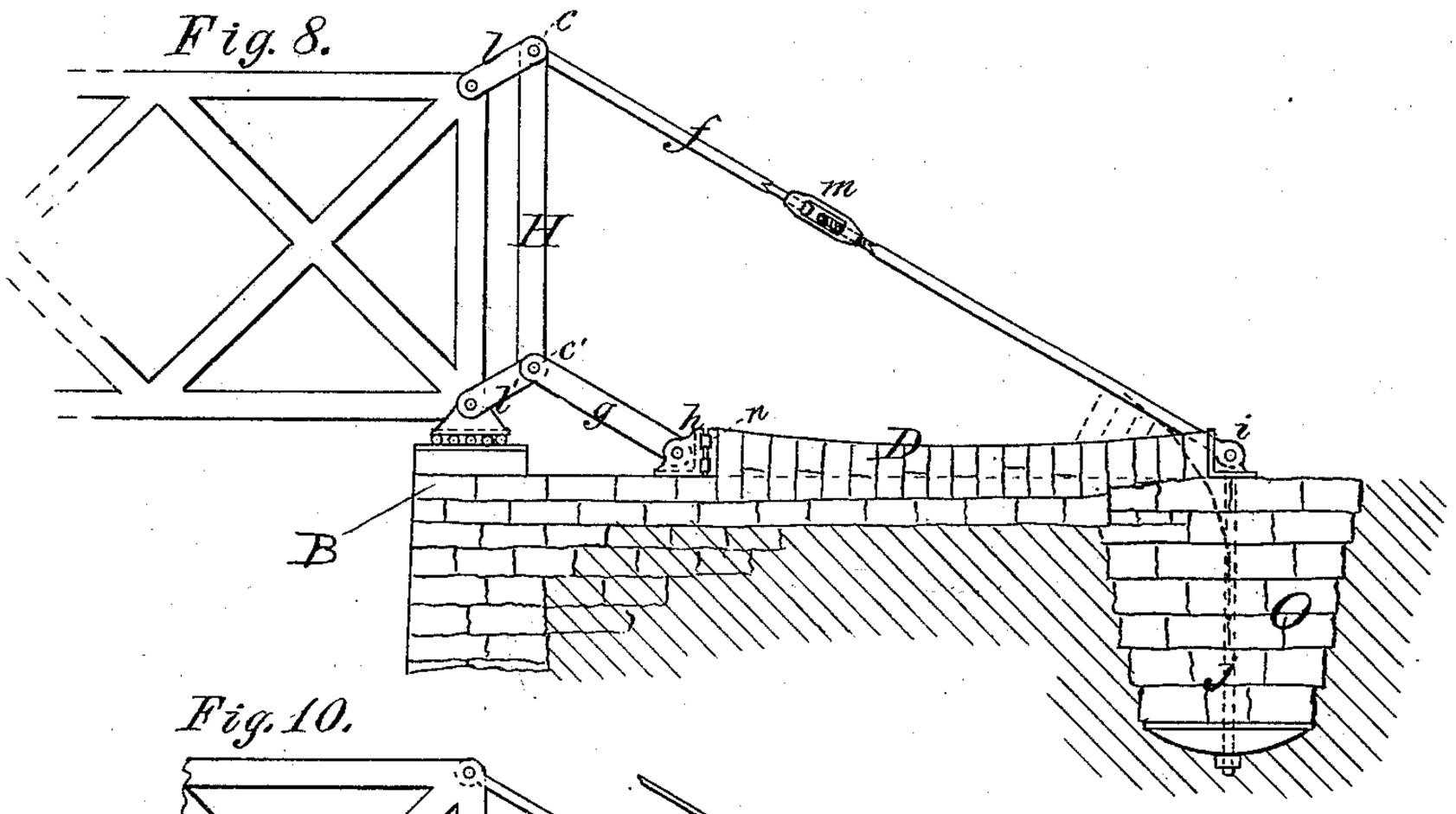


Fig. 10.

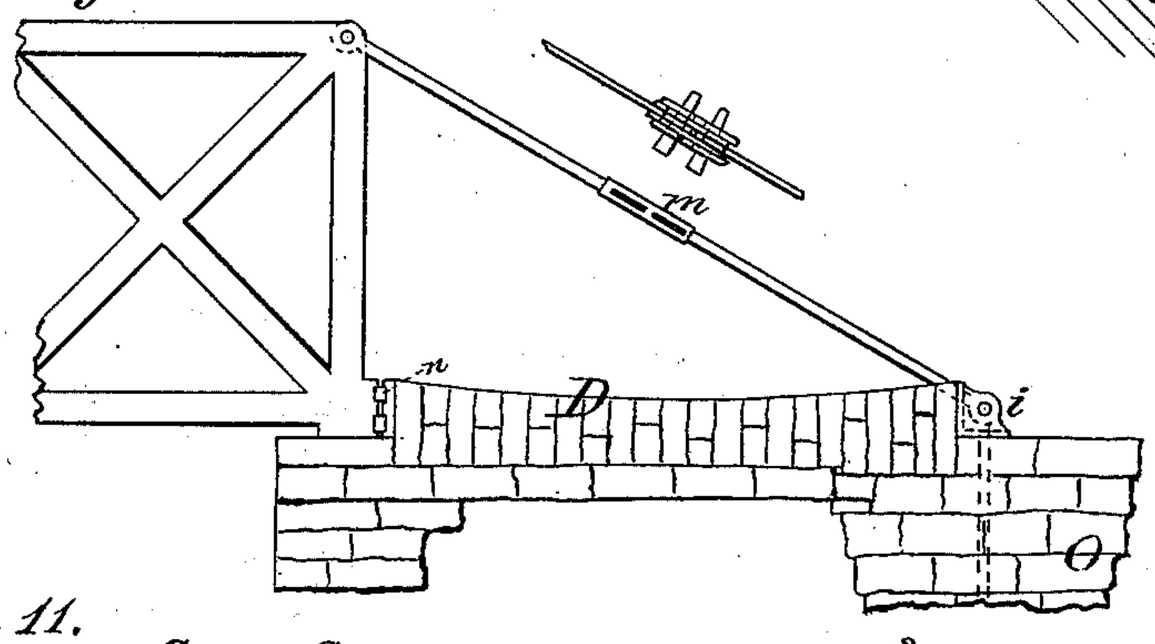


Fig. 11.

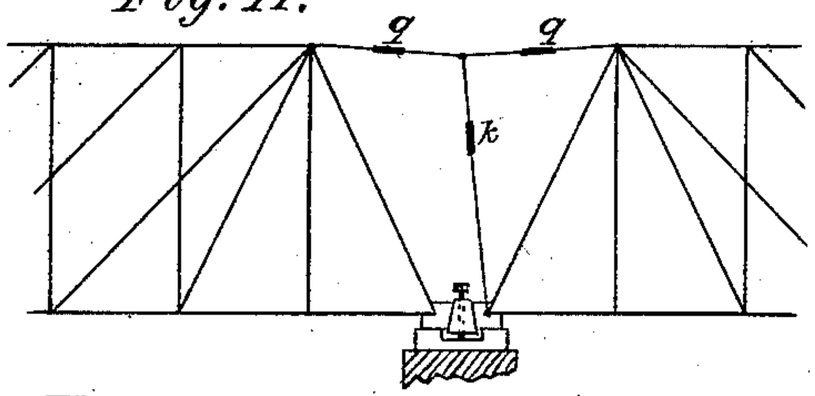
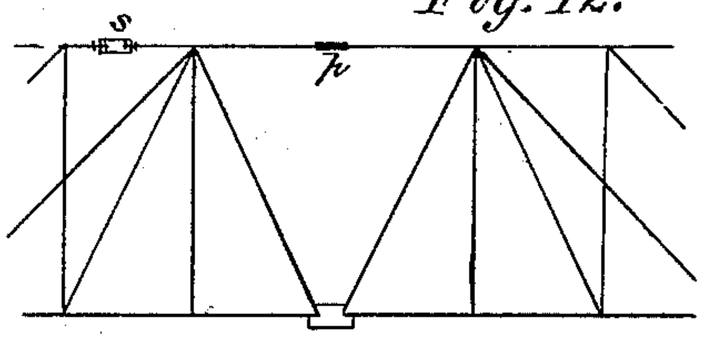


Fig. 12.



Witnesses,

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T. D. Keane

Inventor,

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UNITED STATES PATENT OFFICE.

CHARLES E. EMERY, OF BROOKLYN, NEW YORK.

CONNECTED BRIDGE-GIRDER.

SPECIFICATION forming part of Letters Patent No. 279,927, dated June 26, 1883.

Application filed April 29, 1879. Renewed December 15, 1882. (Model.)

To all whom it may concern:

Be it known that I, CHARLES E. EMERY, of Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Connected Bridge-Girders; and I do hereby declare that the following is a full, clear, and exact description of the same, reference being had to the accompanying drawings, making part of this specification.

The object of the invention is to overcome certain difficulties that have been urged against that form of bridges known as "continuous girders," or those in which several spans are secured together over the supports, so that the bending moments are resisted by the metal in the chords both at the ends and centers of the spans.

The invention relates to an improved form of joint designed to connect contiguous spans of a bridge to permit free expansion without inteference with the transfer of the moments; also, to the anchorages and other devices designed to resist a portion of the bending moments at the extreme ends of a girder; also, to devices for adjusting the relation of the positive and negative moments at the ends and centers of the spans, respectively; also, to an improved device for securing the ends of bridges to the supports, and a combination relating to the web and floor systems of connected girders, all of which features may necessarily be employed together in constructing a continuous girder of a number of spans.

In the drawings, Figure 1 represents a side view of a span of a deck-bridge, comprising two double-truss riveted girders, also portions of adjacent spans, all connected on my system over the supports. Fig. 2 is a plan view of the same. Fig. 3 is an enlarged side view of a portion of the girders near a support, showing the details of the connecting expansion-joint. Fig. 4 is an enlarged plan view, and Fig. 5 an ealarged end view, for a similar purpose. Figs. 6 and 7 are side views showing modifications of the expansion-joint. Fig. 8 is a side view, and Fig. 9 a plan view, showing the method of applying the expansion-joint at one of the abutments of a continuous girder. Fig. 10 shows a modification adapted for an abutment to secure an end moment without provisions for expansion. Figs. 11, 12, and 13 are side views of the ends of girders connected over supports, showing modifications for adjusting the end moments by varying relative lengths of upper and lower chords.

The same letters in all the figures refer to corresponding parts.

Over such of the supports of a continuous girder as it is desirable to permit changes in the length of the chords, on account of variations in the temperature, the upper and lower chords, C and C′, at ends of adjacent spans, are connected together by links *l l l′ l′*, as shown in Figs. 3, 4, and 5. The links are arranged in pairs, jointed together centrally, with their outer ends connected to the ends of the chords, of adjacent spans. The central joint of each pair of links for both chords of a girder is deflected from the direct line of the chords either up or down, to resemble a toggle-joint, and the central joints, *c*, of the top links, *l l*, are connected to the central joints, *c′*, of the bottom links, *l′ l′*, by equalizing-connections H H, which, in Figs. 3, 4, and 5, are struts, the links *l l l′ l′* being deflected upward. The ends of chords may rest directly or through rollers on the supports in the ordinary way; or the ends of adjacent spans may connect to the support through rocking links *x x*, pivoted to the girder and support, to permit longitudinal movement with but little friction. The links *x* are particularly applicable when it is possible that a lifting force will be exerted on the support at any time.

The operation of this form of joint is as follows: A load on a continuous or connected girder causes a positive moment over the support—that is, it tends to produce tension in the top chord and compression in the bottom chord near the contiguous ends of the spans—and through the connections over the support. In Fig. 3 the tension on top chords at ends of contiguous spans tends to separate the pins *a a* and to bring the links *l l* into the same line, which causes a downward pressure through central pins *c* on the strut H. On the other hand the compression in the bottom chord of same girder tends to carry together the pins *a′ a′* and to deflect the toggles or links *l′ l′* upward farther from a right line, thus causing an upward pressure through central pins *c′* on the strut H. Thus the downward pressure from upper toggles is balanced by the up-

ward pressure from the lower toggles, and the system is always in equilibrium, whatever angle the toggles make with the horizontal. When all the toggles are of equal length, and the heights between pin-holes in trusses and in strut are also equal, the toggles on either side of the center are parallel in all practicable positions, and the forces in tension on top chords equal those in compression on the bottom. It will be seen that if, when toggles are diverted from a right line, both chords of the spans on either side expand and contract under changes of temperature, the effect will be simply to change the angle of the toggles slightly without interfering with the transfer of the moments—that is, whatever the angle be within practicable limits, the strain on a chord on one side of the support will be transmitted through to and equalize its strain with the opposite chord on the other side of the support. The joint system is in effect a parallel motion, which permits the opposite ends of the connected girders to move to and from each other in practically parallel lines, and prevents the ends of said girders from changing their angle in relation to each other, except to a slight extent, due to changes in the lengths of the several parts of the joint. If the change of length of the spans on either side of the support be the same, the equalizing-strut H will remain in the same vertical plane; hence in many cases it may be attached to the support in a longitudinal direction, if free to move vertically. This is accomplished in Fig. 3 by carrying the strut H down below the pin c', and causing the extension e to enter a slot between jaws d d, formed in the bed-plate attached to support. The longitudinal resistance of the support itself is thus brought into play to equalize the variations in length of spans and prevent it from accumulating at any one point when there are a large number of spans connected. If the links l l l' l' be deflected below the line of the chords, as shown in Fig. 6, instead of raised above the same, as in Fig. 3, the results are precisely the same; but evidently the equalizing-connection H becomes a tie instead of a strut. The longitudinal position of the tie may be fixed by attaching to the pins c at top or pin c' at bottom links r, Fig. 6, run horizontally, or nearly so, to the support, or a fixed object; or, as shown in Fig. 6, the lower pin, c', may engage with a vertical slot, or the jaws d d in the bed-plate, for a similar purpose.

The toggles at the bottom may be replaced by a wedge, w, Fig. 7, having slopes corresponding to normals to the upper toggles, in the average position, said wedge being connected by a member, H, with the center c of the upper toggles. The inclined faces of the wedge may abut directly, or through friction-rollers, against the lower ends of the girders, and the ends of the latter be supported on links, or carried on rollers, as shown.

In constructing connected girders it will frequently be necessary to provide for expansion at the final abutment. A method of doing this is shown in Fig. 8. The extreme end of the bridge is supported on the abutment B, so that it is free to move longitudinally, and the end of each girder connected through toggles l and l' with an equalizing-strut, H, as in Fig. 3. The upper junction, c, also connects through a diagonal, f, and vertical j with an anchorage, O. The change of direction when necessary, may be made at once through a joint-box, i, or by a series of links in the masonry, (represented by the dotted lines,) as is common in suspension-bridge anchorages. The joint c' at bottom of strut H connects through another toggle, g, and a pin-joint with a joint-box, h. Between the joint-boxes h and i for each girder are placed suitable struts, D, which may consist of iron or other columns, or of masonry with straight surfaces, or in the form of an invert, as shown, to obtain increased stability by directing the tendency to cripple in the direction of the foundation, where it can be resisted. The operation of this combination is practically the same as those previously described. The connections f and g being of different lengths, a perfect parallel motion is not formed; but within the small limits of movement necessary the influence on the result is insignificant. The anchorage O, struts D, and abutment B, should be connected together by suitable masonry and foundations. In some cases the connections f and g may be horizontal, as when the bridge terminates against a cliff. The deflection of the toggles may also be reversed in certain cases, as in Fig. 6. It is only necessary that f and g should be practically parallel at average position.

Fig 10 shows the arrangement for a fixed end of a connected girder. In this case the diagonal f connects directly to the top chord of bridge, and the lower chord abuts directly, through suitable connections, against the strut D and joint-box i. The moment over a support resulting from connecting two girders in the same line is rarely the best to secure the greatest economy of material. Generally it is better to make the top connections shorter than the bottom ones, so that the bridge, when supporting its own weight, will have a slight camber upward after erection, though originally built straight. The proper adjustment of the moments will depend somewhat upon the modulus of elasticity of the material of which the girder is composed. It is proposed to test this influence by direct measurement of the elongations of members, or for each girder that will support its own weight before connecting, by fixing points in a line on the girder when it is laid flat, and noting the deflection of the central points when the girder is placed upright but not connected; then to connect contiguous ends of spans and regulate the deflection or camber, as the case may be, and end moments from the deflection as previously ascertained. To permit adjusting the end moments, not only for the above purpose, but to compensate for any irregularities in height

of supports, adjusting devices are provided in some part of the connections over each support. In the form shown in Fig. 3 the equalizing-strut H is made in two parts, one having a tenon entering the other, and between the shoulders at *k* washers are introduced, which may be varied in thickness, so as slightly to vary the comparative angles of the top and bottom toggles, and thus practically lengthen one chord and shorten the other. While, as has been explained, the upper and lower links each side of the center should be parallel for perfect action, a slight variation will make no practical difference. In general, the less length required for the top connections, compared with those at the bottom, will be approximately arranged, either in the position of the end pin-holes, *a a a' a'*, or by making the top toggles, *l l*, shorter than the bottom ones, *l' l'*, so that toggles on the same side of the center will be very nearly parallel when end moments are adjusted as desired. The lengths of *l l'* or H may, however, be regulated to vary the strain on chords, when desired. The lengths of the toggles in all cases should be such that the variation in angle, due to change of temperature, will be small. The washer system at *k*, Fig. 3, will only be practicable when the centers of the girders can be temporarily blocked up to relieve the end moments and permit disconnecting to insert the washers, or giving room to put in or remove sectional washers. In other cases the connection of the two parts of the strut H should be by means of a cross-key or screw-threads, to permit adjustment at any time. In Figs. 6 and 7, where H is a tie, its length may be varied by a turn-buckle, *k*, or some other combination of screw-threads.

For the abutment arrangement shown in Figs. 8 and 9, the end moment is adjusted by a turn-buckle, *m*, in the diagonal *f*, and by wedges *n*, placed horizontally or vertically behind the joint-box *h*. It will not be necessary to put an expansion-joint, like one of those shown in Figs. 3, 6, and 7, at every support. The ends of the girders may be fastened to certain supports—alternate ones, for instance—or to two adjoining supports, forcing the latter to spring sufficiently to allow expansion of one span, when the expansion-joints would be placed only over supports intervening between these systems. It is desirable, however, to have a method of adjusting the end moments over supports where joints are omitted. This can be done by a modification of the joint itself—for instance, by fastening the ends of the girders to the supports. In Figs. 3, 6, and 7 the joint is no longer an expansion-joint; but the end moments may still be regulated by the washers or turn-buckles *k*, as before. The arrangement in Fig. 7 is particularly well adapted for this purpose, the friction-rollers being omitted; but by securing the wedge to its inclined abutment, after adjustment, the lower rollers may remain, and thus all the expansion from a fixed point at one side be transferred to another point on the other side. A modification of this is shown in Fig. 11, in which the lower wedge is adjusted by a screw run through it and abutting on the bed-plate, while the top toggles, *l l*, are longer and deflected less than in the regular joints, the central point being held down by an adjustable rod, H, secured at the bottom to any fixed point. Evidently the rod may be run through the wedge *b*, secured to bed-plate, and the wedge adjusted independently by a nut on the rod under the wedge. Generally it will be sufficient to adjust the length of one chord of a girder, which may be done by using straight riveted or pin connections for the top chords, as in Fig. 13, and using a wedge or equivalent at bottom; or the toggles and center rod may be used at top and no wedge at bottom; or, in either chord, screw-threads may be applied direct to shorten or lengthen the chords or the connections between them. In Fig. 12 a turn-buckle, *p*, is shown in connections of upper chord. In Fig. 11 turn-buckles *q q* are shown in the toggles, and in Fig. 12 the upper chord is shown made with screw ends connecting in a box, *s*. The distribution of the end and central moments may be varied by adjustment at any point in the length of the chords, but is preferably done in the mechanism for connecting the spans. The result of using connected girders is to materially reduce the chord-sections at the centers of the spans without necessarily replacing an equivalent amount of material at the ends. In girders where the cross-beams are not carried on the chords, the web system may be of any well-known kind; but when the cross-beams carrying the floor of an ordinary bridge or the rails of a railroad-bridge are laid upon or supported directly from either chord the reduction in section is too great to withstand both the transverse and longitudinal strains, and such chord needs to be supported at more frequent intervals than is customary.

Figs. 1 to 5 show a common method of supporting the track of elevated railroads. Cross-ties T T, resting directly upon the upper chord, support the rails R R, and are connected by longitudinal stringers S S. To obtain the requisite transverse strength of upper chord, I use a double system of diagonals, *t t t' t'*, &c., in each girder, and from the intersection of the diagonals bending toward the two ends I secure verticals *u u u u*, which attach, also, to the upper chord, and thus reduce the distance between the points it is supported by the web members. The result would be the same if the girder were inverted and cross-ties bolted up to the lower chord, which arrangement may be seen by inverting Fig. 1 or 3, though the rails would be put inside the structure, which would become a "through-bridge." Additional verticals, similar to *u u*, are old in bridges with long panels, being used to support an intermediate panel-point, but are believed to be new in combination with floor beams or ties directly carrying the load and bearing directly on the chord between its points of support.

It is not necessary that the expansion of the

iron rails of a railroad-track be provided for at the same points as the expansion-joints are located. By permitting the cross-ties to slide slightly on their longitudinal supports, and connecting such ties by longitudinal wooden stringers, the girders will expand independently of the track.

I claim as my invention and desire to secure by Letters Patent—

1. The combination of the end of a span of a connected or continuous girder with another span, or an anchorage, to support an end moment by means of connected toggle-joints or equivalents, for the purposes specified.

2. The combination of the contiguous ends of chords forming parts of a continuous or connected girder, by means of a parallel motion, to transfer the moments while permitting expansion.

3. In combination with an abutment or anchorage for a continuous or connected girder, a strut, in the form of an invert, to utilize the foundation and earth in maintaining stability under the strain required to balance the horizontal thrust of the lower chord, by means of the contrary horizontal thrust necessary in anchoring the upper chord.

4. In combination with the contiguous ends of chords forming part of a continuous or connected girder, and parallel-motion connections of such cords, screws, wedges, or equivalent adjusting devices adapted for the regulation of the end moments.

5. In combination with a continuous or connected girder of two or more spans, toggles, screws, or keys, as a means of adjustment to vary the lengths of the chords at or near the supports, and regulate the angle at which the spans meet, as desired, to secure economy or any particular distribution of the moments.

6. In a toggle-joint connection for connected or continuous girders, jaws *d d*, or equivalent means, combined with the center of the toggles, to secure the same to the support in a longitudinal direction.

7. The combination of the end of a bridge with its support, by means of vibrating links *x x*, substantially as specified.

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