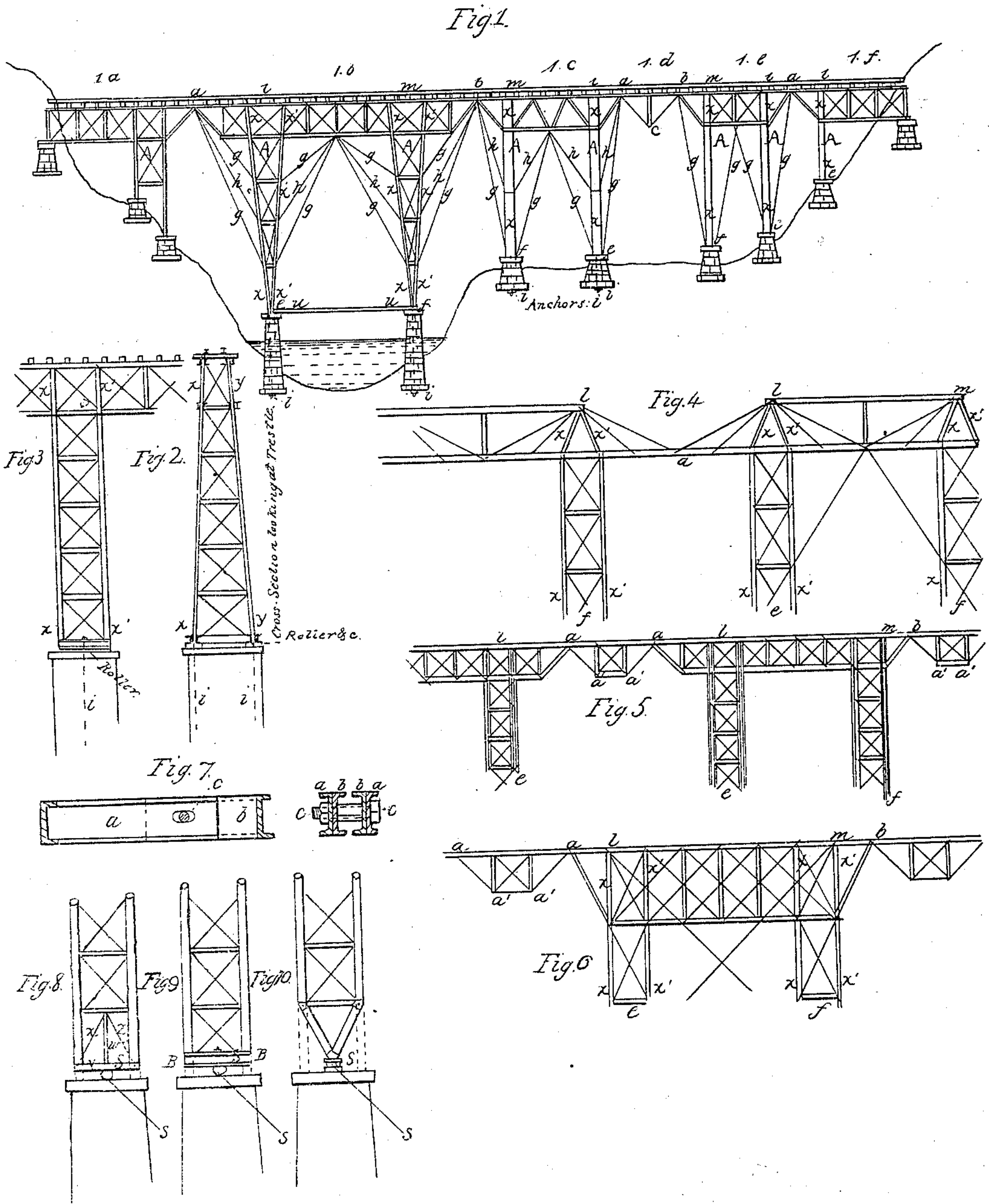
C. Bender.

Viaduct.

No. 108317 Patented Oct. 18. 1870




Witnesses:

William C. Sawyer

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# UNITED STATES PATENT OFFICE.

CHARLES BENDER, OF PHŒNIXVILLE, PENNSYLVANIA.

## IMPROVEMENT IN VIADUCTS.

Specification forming part of Letters Patent No. **108,317**, dated October 18, 1870.

*To all whom it may concern:*

Be it known that I, CHARLES BENDER, of the borough of Phœnixville, Chester county, in the State of Pennsylvania, have invented a new and Improved Viaduct; and I do hereby declare that the following is a full and exact description of the same, reference being had to the accompanying drawing, and to the letters of reference marked thereon.

Viaducts, trestles, and pier bridges hitherto designed or built consist of independent substructures, stable in themselves, and of independent bridges, connected or not connected, resting on the substructure. The stability of the single or combined piers of such structures rests in the piers themselves, and the superstructure, at the most, is only used to do the service of a strut. Stiffness of such structures is obtained by various methods of longitudinal and lateral bracing by stays, diagonals, &c.

My system of viaducts differs from these by combining the piers or trestles with the spans themselves, so as to use the stiffness against flexure of the truss as the element of stability likewise as the frame of a common table keeps in position the table-legs, and thus the whole table. Piers and trusses make one system, whereby one part is stiffened and strengthened by the other, so that any force whatever acting on my system of viaducts will be resisted by the truss, as well as by the piers or legs.

My viaducts, besides this novelty, are arranged for expansion and contraction, in case of change of temperature, providing rollers or sliding arrangements, or their equivalents, underneath the trestles or piers directly on the foundation. Thus my bridges resemble tables with rollers underneath their legs. By these arrangements I believe that I am able to build viaducts cheaper and more perfect than any one in existence.

My viaducts are made of iron or steel, or wood and iron combined.

In Figures 1, 4, 5, 6 of the annexed drawing, *a b e f* represent spans of my viaducts. Such a span as *a b e f* is a unit, and has an obvious resemblance with a common table. The piers or trestles A represent the legs, and the arrangement *a b* the table-frame. Such a span as *a b e f* may be called a "table-span."

My viaduct may consist of a number of such table-spans, or there may be independent spans *a b c*, Fig. 1, *d* or *a a a′ a′*, Figs. 5 and 6, inserted between two table-spans. By this system of stiffening the trusses by the piers, and the piers by the trusses, a great stability is obtained in connection with great economy, while this system also admits greater spans, with less material than is necessary for other kinds of viaducts.

The trusses of my viaducts consist of upper and lower chords with suitable vertical and horizontal systems of ties and braces between them. The chords may be parallel, straight, or curved. They also can intersect each other. The spans may be deck or through spans, according to locality.

A great variety of general arrangements and of detailed constructions may be applied, some of which are shown in the figures.

The trusses may stop near *l* and *m*, or they may have projections *a l m b*. (See Figs. 1, 5, 6.) These projections, if made, are for the purpose of shortening the independent spans *a a a′ a′* between two table-spans, and for the purpose of obtaining points wherefrom to stiffen the piers by staying or bracing members *g h*, Fig. 1. These members have to connect suitable points of the truss with suitable points of the table-legs or piers, and their effect is to give additional strength to the truss by exerting the legs, or to give more strength to the legs by exerting the resistance of the truss against flexure. Usually they are applied only when there is no objection against occupying the clear space between piers and underneath the truss. The connection of the piers, legs, or posts A with the trusses can be done in many ways by a great variety of details.

The calculation of strains will show that there may be tensional and compressive forces in horizontal and vertical directions, which have a tendency to separate the legs and frames or piers and trusses and the connection between piers or trestles; and trusses must be made accordingly by pins, bolts, or rivets, by shoulders, or any mechanical equivalent preventing separation of trusses and piers. The connection can be made directly with the chords, or it can be done indirectly by connecting the piers with the ties or braces, or with ties and braces between the chords, or with the chords and a system of bracing between the chords of the trusses. However the connection may be done, one thing is essential—namely, that it be made in such a manner that the stiffness of the trusses against flexure is brought into action when a force is tending to disturb the stability.

The Figs. Nos. $1^a$, $1^b$, Nos. 2, 3, 4, 6, show that each complete pier or leg A of a table-span is connected with two or more points of each truss of the frame of the table, and likewise the Figs. Nos. $1^c$, $1^e$, $1^f$ show that each isolated pier, shaft, or column *x x* is connected with the truss *a b* in more than one point. This is essential and a distinguishing feature of my bridge, when compared with other trestle-works or viaducts, because the connection must be made in such a manner that the stiffness of the trusses against flexure, either vertically or horizontally, is brought into action when a force is tending to disturb the stability.

The trestles or piers A can be made in various manners. In Fig. $6^b$ they consist of iron or steel shafts or columns diverging toward the truss. In Figs. 3, 4, 5 these shafts are shown parallel in section. They also could diverge toward the foundation, or could be made in any other suitable shape. The shafts or columns $x\ x\ x'\ x'$ may be connected in one point, S, (see Figs. 8, 9, 10,) so as to rest on the foundation in this point.

In Fig. 9 the connection is made by beams B or their equivalents; in Fig. 10 it is done by stiff bracings; in Fig. 8, by the reversed truss Z V W Z.

Other details may be devised to answer the same purpose, which is to prepare only two lines, (represented by the points *e* and *f* of the side elevation, Fig. 1, or by the points S, Figs. 8, 9, 10,) on which the bridge is resting. By this arrangement I remove uncertainty about the values of pressures in the shafts or columns constituting the legs or piers, I can distribute the pressures at option, and I simplify calculation and construction.

My arrangement for expansion or contraction of a viaduct-span is made as follows: Suppose there are two or more trestles or piers, and a bridge resting thereon, and the whole system be made a unit, either by application of the principle of my table-bridges, or by a system of struts and ties between the trestles or piers. I put this whole system or unit on rollers laid on the foundation, or I render only one trestle or pier immovable and make the rest movable.

Rollers can be replaced by rockers or a sliding arrangement, or any equivalent thereof.

By this arrangement I do away with obnoxious additional strains arising from change of temperature. The effect of the arrangement will be that the feet of the trestles (or of one trestle, if but one should be made movable) have a longitudinal movement, changing the point where they rest on the foundation in the same measure as the superstructure is expanding or contracting. I obtain a parallel longitudinal motion of the piers or trestles, altering the distance of one trestle or pier from another.

For my table-bridges I apply struts *u*, extending from one pier to the other, (see Fig. $1^b$,) for the purpose of distributing the action of any horizontal force over the legs of the bridge, which especially I find desirable when only one side of the table-bridge is movable, so as to allow for expansion and contraction.

Fig. 2 shows a section through bridge and pier A, showing a manner of connecting the corresponding legs of both sides of bridge.

In some cases it may not be necessary to make such connections. In some cases it may also not be necessary to apply more than one upright rib, shaft, or column, *x x* or $x'\ x'$. (See Fig. 3, side elevation.)

Figs. $1^c$, $1^e$, $1^f$, for instance, show but single posts A in side view.

Again, there may be three or more legs, *x x y y*, (see Fig. 2,) in one trestle, if found to be desirable.

The legs, or shafts, or columns, &c., of my table-bridges may be used to resist pressure, as well as tension, and therefore it may be necessary to connect the parts of a leg, &c., by bolts, pins, rivets, or other means, or even to run tension-rods along the shafts or columns $x\ x\ y\ y\ x'\ x'\ y'\ y'$, either in or out side.

In Figs. 1 and 4 it has been shown how one table-span may be connected with the other in points *a* and *b*; also, an independent bridge or beam, $a\ a\ a'\ a'$, Figs. 5 and 6, and *a b c*, Fig. $1^d$, may rest on the projections of two table-trestle bridges, or it may rest directly on the legs of table-bridges without projections. These connections between two trusses or beams have to prevent vertical and lateral motion of any one of the adjoining bridge ends. In the longitudinal direction of the bridge this connection allows for expansion and contraction caused by change of temperature.

Fig. 7 shows such a connection where a pin, C, holds together both truss ends, preventing vertical and lateral motion, but allowing longitudinal by oblong pin-holes. Many other mechanical equivalents may be devised.

From the action of wind or from the loads, forces may arise acting to lift up one end of a table-trestle span, which forces will be neutralized by vertical anchors *i i* in the legs, or piers, or trestles.

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

1. A truss-bridge in which the pier is rigidly connected to the truss at two or more points, as and for the purpose set forth.

2. The ties or braces *g g* or *h h*, arranged and operating as set forth.

3. In the described bridge, the piers $x\ x\ x'\ x'$, when constructed to act either under tension or compression, whether anchored to the foundation or not, as set forth.

4. In the described bridge, the bearings S S S, applied to piers composed of two or more columns or shafts.

5. Underneath the piers of the described bridge, friction-rollers, or their equivalents, applied as and for the purpose set forth.

6. The intermediate truss *a a a′ a′*, Fig. 5, connecting two table-spans, in the manner set forth.

7. In combination with the table-spans, the struts *u*, extending from movable to immovable legs, as set forth.

Phœnixville, May 28, 1870.

CHARLES BENDER.

Witnesses:

Fr. Schmemann,

Wm. J. Bailey.