No. 701,034. Patented May 27, 1902.

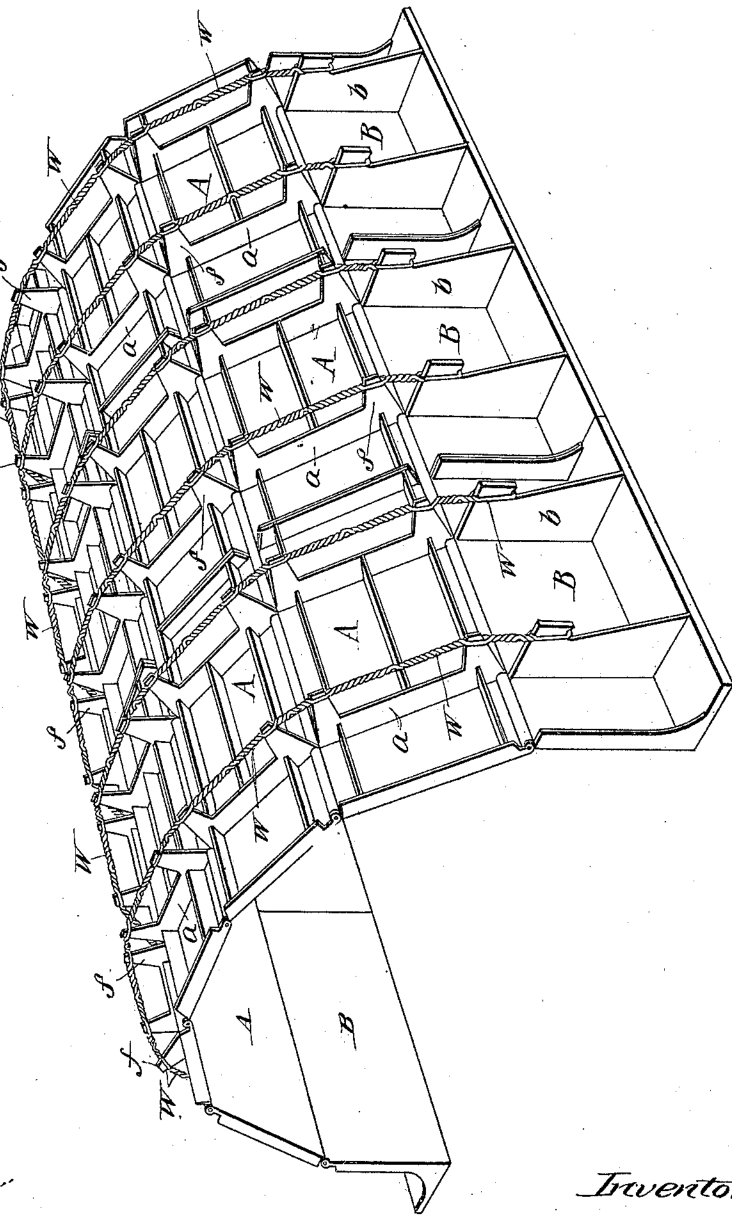
R. GRAY.

METAL ARCH.

(Application filed Jan. 2, 1902.)

(No Model.) 3 Sheets—Sheet 1.

Fig. 1



Witnesses:

John Gray

James Gray

Inventor:

Richard Gray

No. 701,034. Patented May 27, 1902.

R. GRAY.

METAL ARCH.

(Application filed Jan. 2, 1902.)

(No Model.) 3 Sheets—Sheet 2.

Fig. 2.

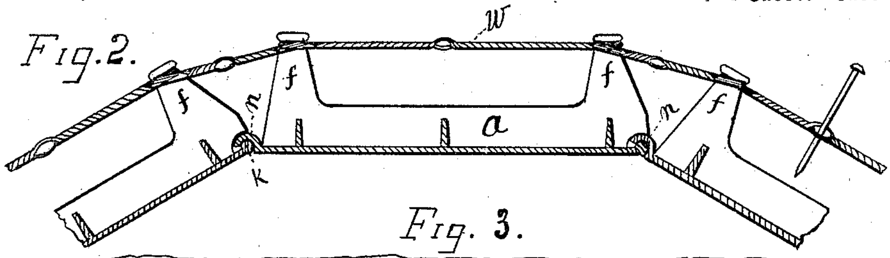


Fig. 3.

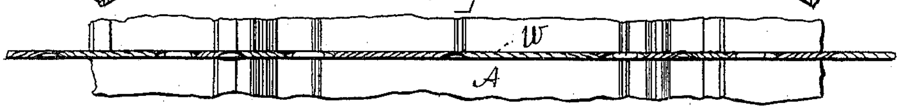


Fig 4

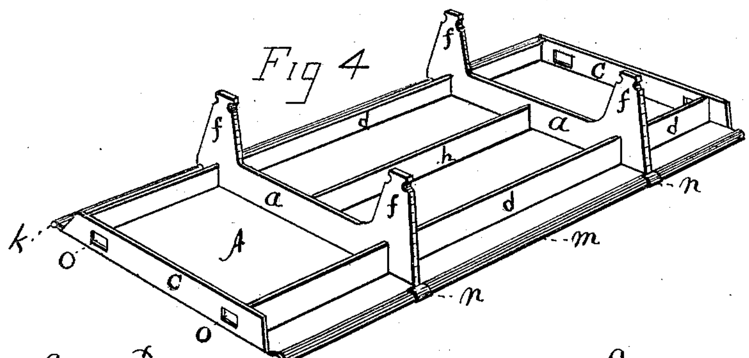


Fig. 5.

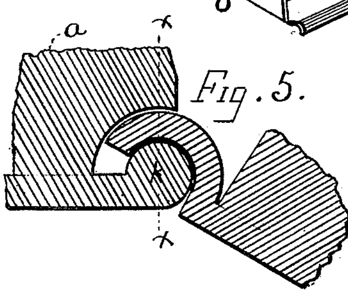


Fig 6

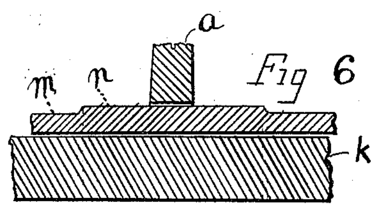


Fig 8

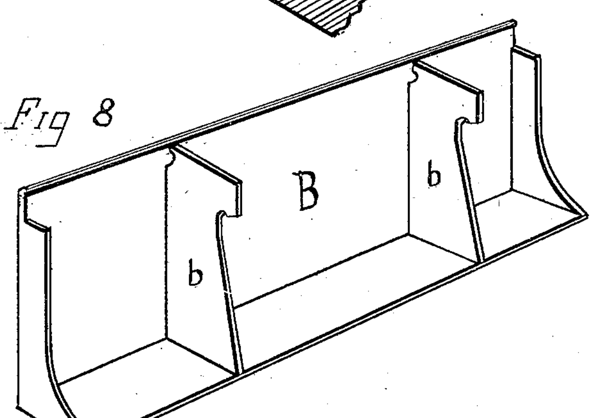
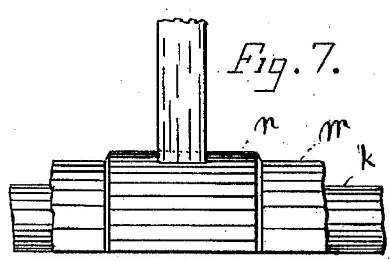


Fig. 7.



Witnesses

James Gray.

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No. 701,034. Patented May 27, 1902.

R. GRAY.

METAL ARCH.

(Application filed Jan. 2, 1902.)

(No Model.) 3 Sheets—Sheet 3.

Fig 9.

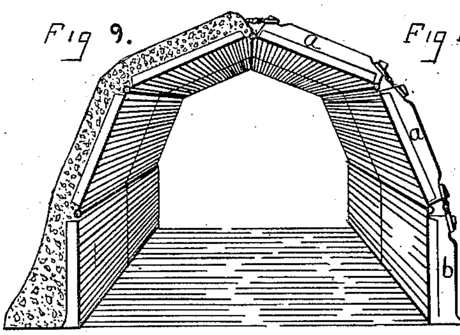


Fig 10.

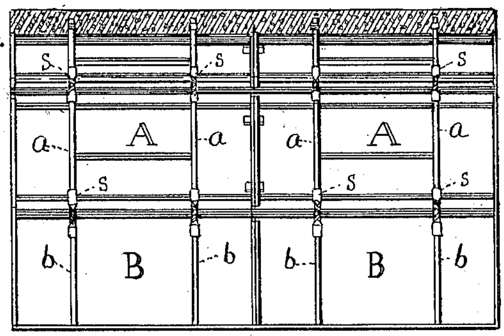


Fig 11.

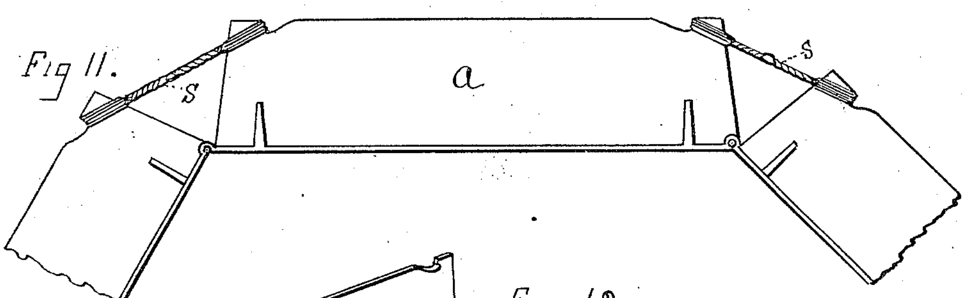


Fig 12.

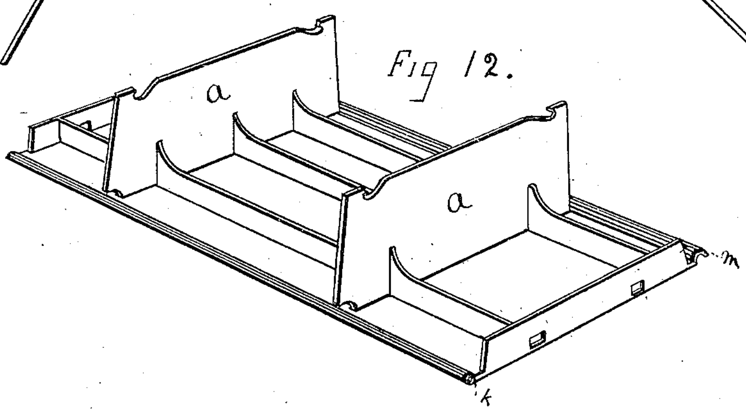
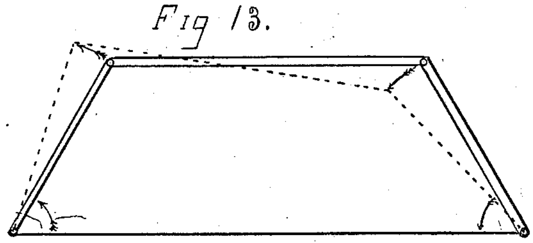


Fig 13.



Witnesses
James Gray
John Gray

Inventor
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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

RICHARD GRAY, OF BLOOMINGTON, ILLINOIS.

METAL ARCH.

SPECIFICATION forming part of Letters Patent No. 701,034, dated May 27, 1902.

Application filed January 2, 1902. Serial No. 88,248. (No model.)

To all whom it may concern:

Be it known that I, RICHARD GRAY, a citizen of the United States, residing at Bloomington, in the county of McLean and State of Illinois, have invented a new and useful Improvement in Metal Arches, of which the following is a specification.

My invention relates to metal arches having adjustably-connected plates or voussoirs.

It particularly relates to the construction shown and described in Letters Patent of the United States No. 587,392, granted to me August 3, 1897.

The object of my invention is to increase the strength, reduce the cost, and simplify the construction of the metal arch.

To this end my invention consists of reducing the number of pieces and a better distribution of materials to meet the varying stresses in different parts of the arch.

In my before-mentioned invention it is contemplated to use cast-iron exclusively, whereas in this invention I employ bands of wrought-iron or steel.

That my invention may be more clearly understood the following well-known facts and principles are mentioned.

The least number of straight pieces of which it is possible to construct an arch is three, and the least number of joints is four. (See Figure 13 in the drawings.) This is regarded as the primary arch. Arches comprising a greater number of pieces may be treated as extensions of the simple arch involving the same principles. In the case of the primary or simple arch an eccentric load tends to a change of shape, as indicated by dotted lines in Fig. 13, producing bending moments of opposite kinds at different joints. It is plain that the kind of moment at any joint depends upon the location of the load with respect to the joint, and that therefore a moving load may produce both positive and negative moments at all the joints; also, that the turning or rotation at all the joints must be simultaneous, and hence if ties or other devices are used to prevent turning the rotative force is opposed by the combined resistance of all the ties. The strength and rigidity of the arch will then be greater when all the joints are designed to resist rotation in both directions. In the masonry arch the rotative force is neutralized by fixing the depth of the voussoirs, so that the "line of resistance" does not traverse outside the body of the arch. Now it is well known that in the masonry arch if the line of resistance passes outside the body of the arch failure results by rotation and that the determination of the amplitude of the traverse of the line of resistance for moving loads is very difficult. It is evidently better, then, to construct the arch so that the joints will resist rotation.

An arch-bridge, especially beneath a railroad-track, is subject to shocks and vibrations which any brittle material is ill adapted to withstand, and no piece composing a bridge should be liable to be shaken loose from its fastenings.

With reference to the foregoing facts this invention has been wrought out, which I will now describe.

In the drawings, Fig. 1 is a perspective view of the metal work of my improved arch. Fig. 2, partly in elevation and partly in section, shows two joints and the connections. Fig. 3 is a plan or downward projection from Fig. 2. Fig. 4 is a perspective view of an arch-plate. Fig. 5 is a transverse vertical section through the hinge at the joint. Fig. 6 is a longitudinal vertical section through the hinge on the dotted line through Fig. 5. Fig. 7 is a front elevation of the hinge. Fig. 8 is a perspective view of the foundation-piece. Fig. 9 is an elevation of the end of an arch, showing the intrados in perspective. Fig. 10 is a side elevation of the same. Fig. 11 is an elevation of two joints and their connections. Fig. 12 is a modified arch-plate in perspective. Fig. 13 has been explained.

In the several figures, A A, &c., are the voussoirs of which the arch is composed.

B B, &c., are the foundation-pieces.

a a, &c., are transverse flanges upon plate A, having projections *f f*, &c., or notches, as shown in Fig. 12.

b b, &c., are transverse flanges upon piece B.

c c, &c., are small flanges at the ends, *d d* &c., small flanges near the edges, and *h* a small rib central, upon plate A. The plate A has upon one edge a bead *k*, and upon the other edge a curvature *m*, adapted to engage and cover the bead k of an adjoining plate. The cover m has an enlargement n upon its upper surface opposite one end of the flange a. (See Fig. 4.) The other end of flange a has a circular opening above the bead k. (See Fig. 12.) When two plates are put together, this opening admits the passage of the cover m loosely and the enlargement n snugly. The combination of the bead k and the undercut end of the flange a with the cover m and the enlargement n constitute a hinged connection between the plates. The projections $f f$, &c., are notched in both edges to receive the bands.

W W, &c., are flexible bands, which engage the projections $f f$, &c.

O O, &c., are small mortises or holes of any desired form through flanges c c, placed opposite, so as to register when the plates are in proper position end to end. Bolts, pins, or keys are placed in the holes O O, &c., to hold the abutting plates evenly.

The flanges b b of piece B are notched upon their outer edges to receive the wire bands, acting as anchors for these bands. The foundation-piece B upon one side of the arch has upon its upper edge the bead k and an opening beneath the end of flange b, the same as one edge of plate A, and upon the other side of the arch the foundation-piece has the cover m and enlargement n, the same as upon the other edge of plate A, so that the arch-plates form the same kind of hinge connection with the base-pieces as they do with each other upon both sides of the arch. Plate B also has a base-flange which rests upon the foundation. The plate B being cast integrally, the anchor-flange b is firmly attached to the body of the plate and to the base-flange. The bands W W, &c., are preferably composed of small steel wire, the number of strands being regulated by the amount of stress.

I prefer to erect the arch as follows: A wooden center is constructed for a single arch-ring of any desired dimensions. I then connect the plates together, adjusting them to the curve of the support. I then apply the wire bands, which I prefer to weave upon the projections as follows: The end of the wire is fastened to a projection, preferably to the anchor-flange b. It is passed to the next projection above, wound once around this projection in the notches, thence to the next projection and wound once around in the notches, and so on over the arch to the opposite anchor-flange, through the notch, thence returning, passing the wire around each projection in succession, and continuing over the arch in alternate direction until the band is given the desired number of strands. If the wire is continuously wound in the same direction, there will be no crossing between the projections, which is preferable. It is plain, however, that the weaving may be such as to vary the number of strands in different parts of the band to meet the requirements of different stresses in different parts of the arch. I maintain a moderate tension in the wire during the winding. After the band is woven it is twisted at each interval between the projections by means of a lever inserted within the band, (see Fig. 2,) whereby any desired tension is obtained. This twisting also effectually prevents the slipping of the projections within the bands. I prefer to remove the levers; but, if desired, they can be placed so as to prevent untwisting and allowed to remain. Succeeding rings are erected on either side of the first ring and joined together by the end connections before mentioned.

The construction shown in Figs. 9 to 12, inclusive, is in all respects the same as above described, excepting the flanges a, which are notched in the upper edges instead of being cut away so as to leave the projections $f f$, &c., and the short bands s s, &c., in these notches instead of the continuous bands W W, &c., over the entire arch. It is obvious that the bands W W, &c., and the ties s s, &c., can be made of flexible rods instead of wire. After the metal arch is erected I apply a covering of concrete over the entire arch, as shown upon the left side of Fig. 9.

Attention is now called to the following: The bands are applied with equal facility to the projections or flanges whatever may be the inclination of the plates to each other, (see Fig. 11,) thereby affording the convenience without the complication and extra material of adjustable couplings.

The bands are not liable to be broken or loosened by vibrations or shocks, are exceedingly simple and strong, and so elastic as to easily meet the requirements of temperature strains in the arch. The tension due to negative moments is resisted by the bands or ties, while the compression is resisted by the concrete. The hinged joint resists both tension and compression, whence the combination fulfils the conditions of greatest strength before mentioned.

I claim as new and useful as follows:

1. An arch made up of metallic plates adjustably connected with each other and bound together with flexible metallic bands.

2. An arch made up of metallic plates, adjustably connected at their inner faces, and bound together with twisted metallic bands at or near their outer faces.

3. The hinge connection between the plates of a metal arch at their edges comprising the bead k; the undercut end of flange a; and the cover m with the enlargement n upon its upper surface; substantially as described.

4. A metal plate, adapted to join other metal plates in an arch, so as to form an adjustable connection with them, and having transverse flanges with projections or notches adapted to receive and retain flexible bands.

5. In an arch made up of metallic plates,

having transverse flanges; a twisted metallic tie between the ends of said flanges, for the purpose specified.

6. A band, comprising two or more strands of flexible metal applied to the voussoirs of a metal arch, and means for twisting said strands together.

7. As a part of a metal arch a foundation-piece, having anchors attached thereto adapted to receive and retain the ends of flexible metallic bands, in combination with flexible metallic bands.

In witness whereof I have hereunto set my hand in the presence of two witnesses.

RICHARD GRAY.

Witnesses:

JAMES GRAY,
JOHN GRAY.