

D. B. LUTEN.

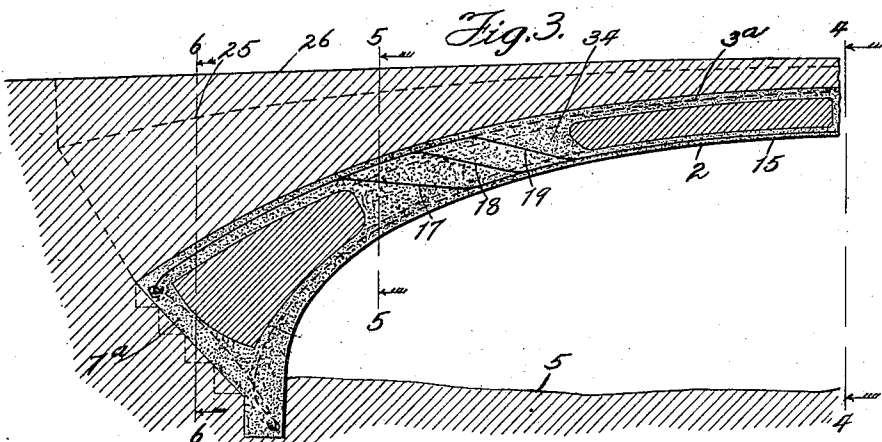
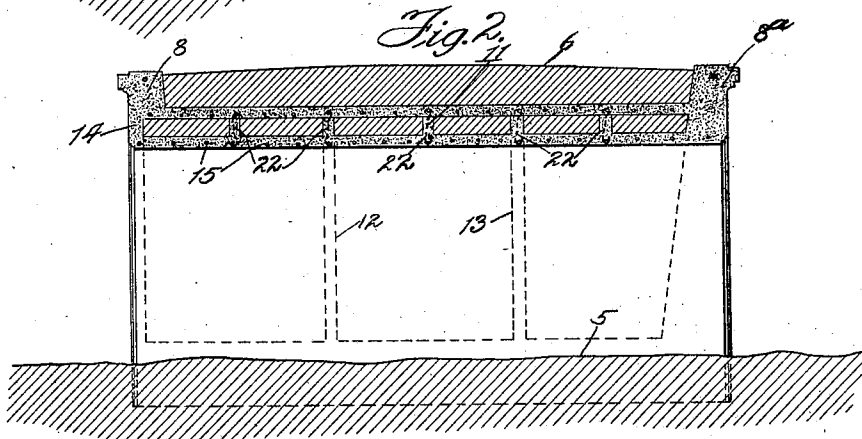
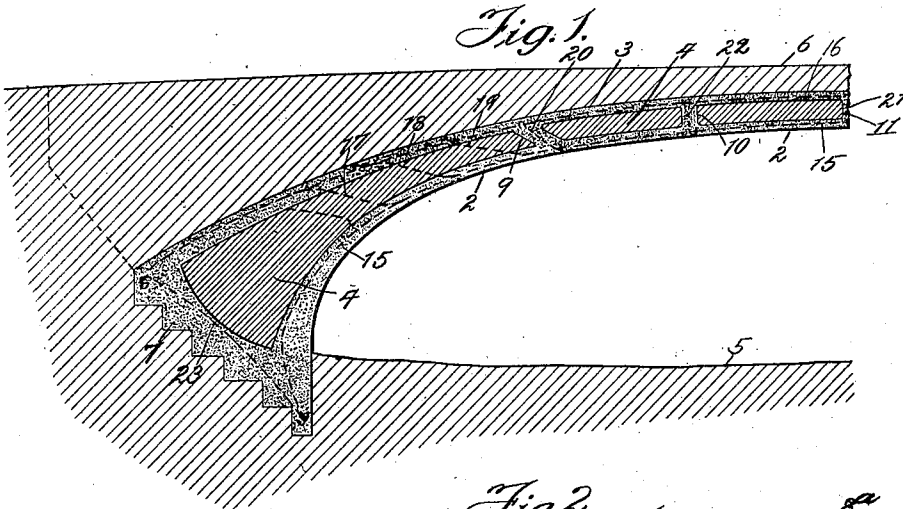
ARCH.

APPLICATION FILED APR. 24, 1905.

1,060,917.

Patented May 6, 1913.

2 SHEETS—SHEET 1.



Witnesses:

W. Perry Hahn

Inventor:

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3 SHEETS—SHEET 2.

Fig. 4.

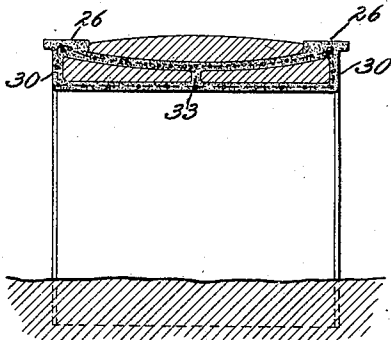


Fig. 5.

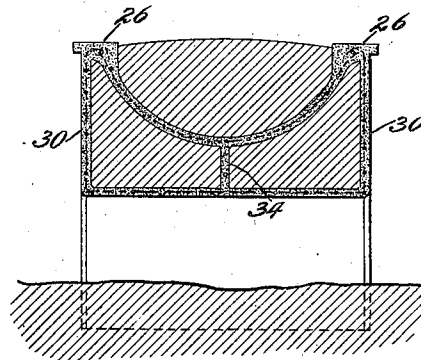


Fig. 6.

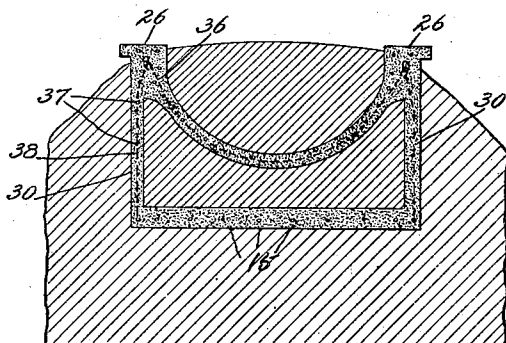


Fig. 7.

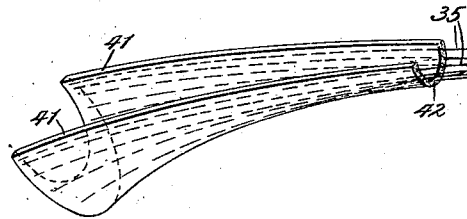


Fig. 9.

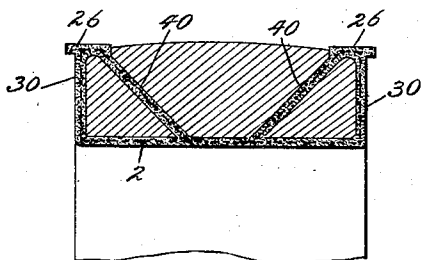
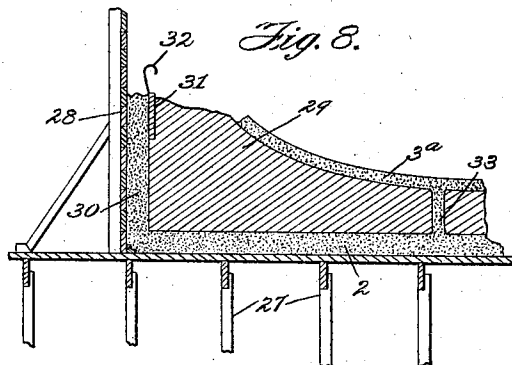


Fig. 8.



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UNITED STATES PATENT OFFICE.

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ARCH.

1,060,917.

Specification of Letters Patent.

Patented May 6, 1913.

Application filed April 24, 1905. Serial No. 257,165.

To all whom it may concern:

Be it known that I, DANIEL B. LUTEN, a citizen of the United States, residing at Indianapolis, in the county of Marion and State of Indiana, have invented a new and useful Improvement in Arches, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawing, forming a part of this specification.

This invention relates to improvements in concrete arches, the object being to secure greater strength for the same amount of material or the saving of material for the same strength, and the cheapening of the method of constructing such arches. Arches of this class have heretofore been constructed with solid ribs or drums, that is, the rib or drum of the arch is solid from face to face, which results in an inefficient portion near the central axis of the structure and a waste of material so far as this part is concerned. The present invention has to do with the saving of this central inefficient section of the drum and is accomplished by providing double drums, that is, an extradosal and an intradosal drum, which are placed at the proper distance apart, thus dispensing with the said central portion, concentrating the material at maximum distances from the central axis, giving greater radius of gyration, greater resistance to bending moments, and making a structure which is at once light and strong and economical to erect. The two drums are preferably placed at such a distance apart that the line of thrust of the structure as a whole is kept within the middle third, thereby preventing tension in either drum and the necessity for reinforcement by the usual means, such as tension rods or the like placed throughout the portions in tension. However, such reinforcement may be employed in any way desired, that is with the drums separately or as a combined structure as hereinafter described. The two drums may be joined by struts or connecting ribs in any desired manner. As a part of the present invention, a convenient mode of constructing such arches has been devised, to wit: The inner drum is first constructed upon light forms or centers which are of sufficient strength to support said light drums only, and the latter is then covered with a layer of earth or other suitable filling corresponding to the centrally disposed section of the arch which is securely tamped and

rounded and serves as a form or center for the outer drum. Thus the first center or form is comparatively cheap and inexpensive to erect, while no additional centering or form other than the earth is required for the second drum, since the first drum supports the weight of the earth filling in addition to the said second drum. The invention therefore, results in a cheaper method or process of construction than with former types of arches, and in addition a saving in material and a better design.

The present invention further contemplates the provision of an arch having a non-cylindrical, warped or non-developable extrados, and still further, the provision of a double drum arch provided with a non-cylindrical, warped or non-developable extradosal drum. The latter may be readily built by building the lower drum in the usual manner upon a light centering, and providing the same with comparatively thin spandrel walls, then covering the inner drum with earth and molding the same to the form of the desired surface for the outer drum between the spandrel walls and then laying the extradosal drum upon said earth mold. The lower drum readily carries its own weight with the earth filling, and the outer drum may be relied upon to carry the remainder of the loading.

Further features and advantages will appear from the detailed description and claims in connection with the drawing.

Referring to the accompanying drawing, Figure 1 is a longitudinal section of a cylindrical arch embodying the improvements; Fig. 2 is a transverse section through the center of the arch of Fig. 1. Fig. 3 is a longitudinal sectional view through the center of an arch having a warped extradosal drum; Fig. 4 is a transverse sectional view of the same on the line 4—4, of Fig. 3; Fig. 5 is a similar view on the line 5—5, of Fig. 3; Fig. 6 is a similar view on the line 6—6, of Fig. 3; Fig. 7 is a perspective view of the extradosal drum and showing the preferred arrangement of reinforcing rods therein; Fig. 8 is a transverse sectional view of the arch of Fig. 3, showing the method of construction, and Fig. 9 is a transverse section of a modified form of arch in which the extradosal drum is conical.

In these Figs. 1 and 2, 2 designates the inner drum, 3 the outer drum, and 4 the space between the two drums. The bed of the

stream is indicated at 5 and the earth filling or roadway at 6. An abutment 7 upwardly inclined away from the extrados and having its outer face stepped joins the two drums 2 and 3 to form a support for the end of the structure. The preferred form of spandrel wall 8 is indicated in section at the left in Fig. 2, and between the drums 3 and 4 the spandrel wall is comparatively thin as shown at 14. This portion of the spandrel wall may be built up with the wooden forms only upon the exterior or outer face, while the earth filling between the drums may serve as a form for the inner face. If desired a facing plank or board may be placed between the dirt and the inner face of this portion of the spandrel wall, and be raised as the wall is built up. This method of construction being indicated in Fig. 8. At the opposite side of the arch the old form of spandrel is shown, which consists of a heavy retaining wall throughout built with forms at both front and back. The inner drum is shown as of substantially elliptical section, but obviously may be of any desired form, while the outer drum section follows more nearly the arc of a circle but likewise may be of the particular form desired. Intermediate connecting ribs or struts 9, 10 and 11 may be provided at any point between the drums and likewise vertical connecting ribs 12 and 13 may be located between the two drums and may extend from one end of the arch to the other as shown in Fig. 2. The struts or members 9 and 10 may be substantially perpendicular to the inner drum as in the case of the rib 10 or may be at an angle thereto like 9 to resist the shear. They may extend continuously through the space between the drums transversely or longitudinally to divide said space into compartments thereby confining the earth or central filling to these compartments, or they may extend continuously through only the shearing regions of the arch, and then only longitudinally. The latter type of rib is indicated in Fig. 3 in connection with the other form of arch. In erecting an arch thus constructed, a light form or center of the usual or any desired type is provided for the inner drum and need be of only sufficient strength to sustain said drum. Upon this center the inner drum is formed of concrete as shown at 2. A filling of earth is then placed upon said drum to fill the space 4 and is securely tamped and rounded to receive the outer drum 3 of concrete which serves as the outer member of the arch rib. The connecting parts 9, 10, and 11, are formed of concrete in the earth filling as the filling progresses. The earth may remain permanently between the two drums. The abutment is, of course, laid prior to the laying of the concrete for the outer drum. A lighter material than earth, or a stiffer ma-

terial such as weak concrete may be used to fill the annular space 4. The light centers serve to support the inner drum which in turn supports the filling and the outer drum. The concrete is thus concentrated at maximum distances from the central axis, giving greater radius of gyration and greater resistance to bending moments. The inefficient material near the center line is made of cheap filling instead of expensive concrete. A stronger arch with the same amount of concrete results or a cheaper arch with the same strength. If the arch is designed so that the thrust is kept within the middle third, there will be no tension in the drums and consequently no necessity for reinforcement. As this arrangement eliminates this inefficient portion near the central axis the two drums can be readily placed so far apart as to keep this line of thrust within the proper limits. In case such design is not resorted to, and particularly if it be desired for purposes of greater security to reinforce the structure with tension rods disposed in accordance with the so-called "Luten system", or in any other way, the same may be readily done. I have indicated in these same figures, reinforcement rods 15 in the inner drum disposed low at the crown and high at the haunches to resist tension in the corresponding regions and similar tension rods or members 16 located in like manner in the upper member or drum. Some of the tension rods may cross from one drum to the other as indicated at 17, 18 and 19 through the vertical ribs 12 and 13 or through the filling to thus reinforce the structure as a whole, such rods being low at the crown and high at the haunches with respect to the whole structure the same as in the case of the rods 15 and 16 which are confined to their respective drums. In addition, rods 20, 21 and 22 may be placed in the ribs 9, 10 and 11 respectively to bond the two drums together. The abutment 7, which is shown as comparatively light is reinforced by tension members 23 extending therethrough and into the ends of the inner and outer drums, and are there hooked around the other rods passing through the two drums. These tension members 23 are disposed near the inner or upper face of the abutment 7 to resist the tension throughout this region. In the remaining figures the inner drum 2 is cylindrical as in the case of the former figures, but the outer drum is shown in the form of a warped surface similar to a shoe-horn, as indicated in Fig. 7. This outer drum 3, is separated from the inner drum throughout the central portion by only a short distance, while the outer edges as indicated by dotted line 25, in Fig. 3, is considerably separated. The upper edge of the spandrel, or roadway, is shown by the full line 26. The outer ends of the drums are connected

by the footing or abutment 7^a, which may be stepped the same as in Fig. 1, or straight as shown in the full lines. The preferred method of constructing this type of arch is indicated in Fig. 8, the lower drum 2 having been first built in the usual manner upon a suitable light centering 27. A form 28 is erected for the outer face of the connecting spandrel; concrete is then deposited against these forms, and earth deposited at the back of the concrete. A facing board 31, may be used between the concrete and earth as they are filled in, said board being kept at a uniform distance of three or four inches from the face forms and being raised by loops 32, or in any other way as the work progresses. This obviates the necessity of forms for the back of the walls and at the same time provides a mold for the outer drum. These drums may be connected by ribs or struts such as strut 33, shown at the center, and vertical ribs 34 may be provided extending longitudinally between the drums through the shearing regions. By reference to Figs. 4 to 6 inclusive, the connection of the edges of the upper drum with the thin spandrel walls may be seen. The upper portions 26, of the spandrels are of the usual width. This outer drum acts to prevent the spandrel walls at the sides from overturning, and at the same time serves as an arch to carry the load to the abutments. An arch of this character is preferably reinforced, one method of accomplishing this being indicated in the drawings. The longitudinal tension rods pass longitudinally through the extradosal drum, and at the haunches are closely grouped near the flanges, while at the crown they are more closely grouped near the center and preferably pass diagonally across the roadway; that is, starting from one flange they pass under the crown and across to the diagonally opposite flange. Thus as is shown in Fig. 7, the rods 35 pass nearer the edges 41, at the haunches, and nearer the center 42 at the crown. Transverse rods 36 are passed through the outer drum to join the two spandrels and to help carry the earth filling above the outer drum as in a cradle. The spandrel walls are also reinforced by longitudinal rods 37, and vertical rods 38, while the lower drum is reinforced by the tension rods 15, as in the case of the form of arch shown in Figs. 1 and 2, similarly tension rods 17, 18 and 19 may be employed passing through from one drum to the other and preferably crossing at various longitudinal points from one drum to the other through the continuous ribs 34. It is obvious that this extradosal member may be varied in form and may be twisted, warped or of any non-developable or non-cylindrical form. As shown in Fig. 9, it may consist of conical surfaces 40, extending between the

central part of the inner drum 2 and the upper ends of the spandrels 30. However, this form would not be as strong as the warped form, but would be stronger than a cylindrical outer drum, and to this extent would embody certain features and advantages of my invention. The longitudinal and transverse reinforcement are shown here also. An arch thus constructed possesses the advantages of extreme lightness of arch rib, and of spandrels, and a saving of forms for the back of spandrels and provides a bracing of spandrels against earth pressures. Thus while the invention has been described specifically with reference to particular details of construction, it is to be understood that it is not so limited, but on the contrary may be embodied in various forms without departing from the scope or principle of the same.

The reinforcement may as stated be arranged as shown in Figs. 1 or 3, on any plan desired, and may consist of any section desired, such as rods, chains, cables, sheets, etc., and the rods from one drum may exist in short lengths extending into the space between drums and there hooked to other rods embedded in the upper drum and extending far enough beyond in the latter to afford secure anchorage. If desired, the earth filling may be replaced by forms erected on the lower drums and the drums may be made non-continuous, that is, of separate ribs side by side, like the upper and lower flanges of a steel arch. The earth roadway filling also may be replaced by skeleton superstructure. If desired, the earth filling between drums may be withdrawn after completion of the structure, a convenient method of accomplishing this being to provide suitable openings preferably near the springings in the inner drum and near the crown in the outer drum so that water could be introduced through the latter to wash the earth out through the former openings. If the earth filling is to remain, a few openings in the upper drum may be provided to afford opportunity for the said filling to expand upwardly in freezing thereby relieving pressure on the drums.

Having thus described the invention what I claim and desire to secure by Letters Patent is:

1. An arch having two members of concrete, one curved transversely of the arch axis, the other longitudinally thereof.
2. An arch having an inner surface concave transverse to the axis of the arch and an outer surface concave longitudinally of the said axis.
3. An arch comprising two continuous drums of concrete, one curved transversely of the arch axis, the other curved longitudinally and transversely of the said axis.
4. An arch comprising two continuous

drums of concrete, one curved transversely of the arch axis, the other curved longitudinally and transversely of the said axis, and each of said drums reinforced with embedded members transverse to the reinforcement of the other drum.

In witness whereof, I have hereunto sub-

scribed my name in the presence of two witnesses.

DANIEL B. LUTEN.

Witnesses:

J. C. STUCKENBERG,
WM. DERRY.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."