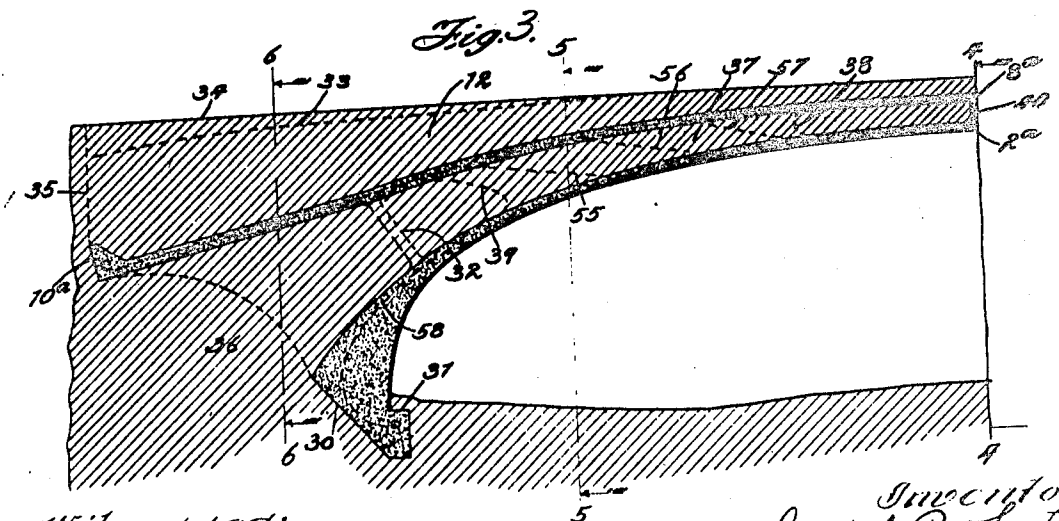
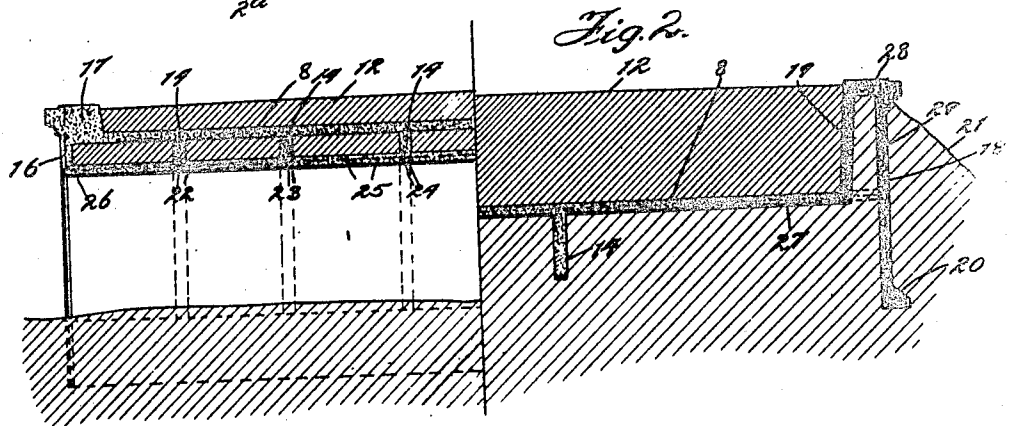
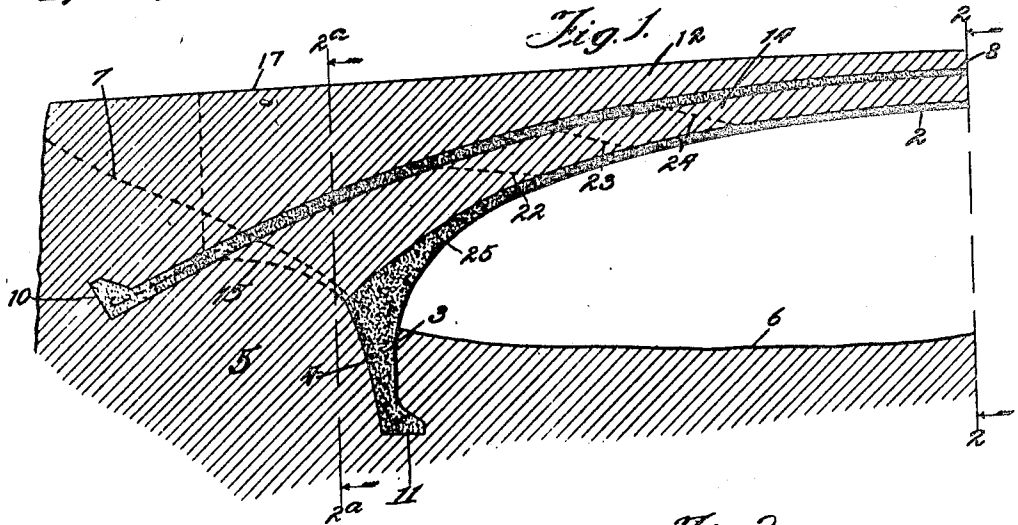


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 ARCH.
 APPLICATION FILED APR. 24, 1905.

Patented May 6, 1913.

2 SHEETS—SHEET 1.

1,060,918.



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 2 SHEETS—SHEET 2.

Fig. 4.

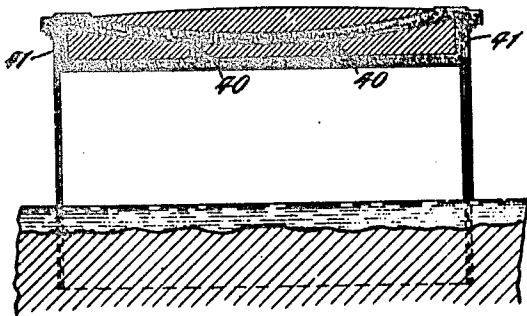


Fig. 5.

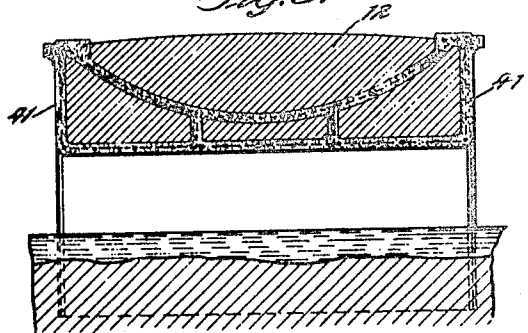


Fig. 6.

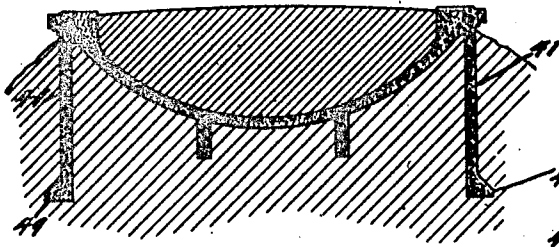


Fig. 7.

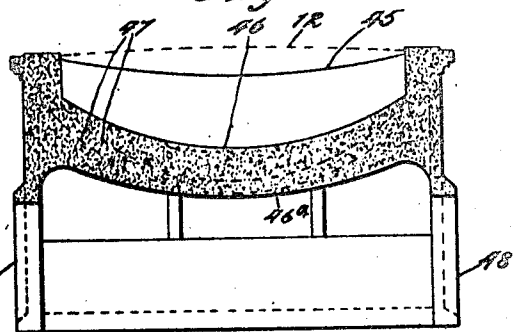


Fig. 8.

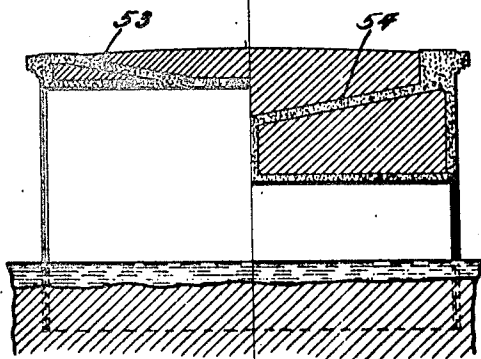
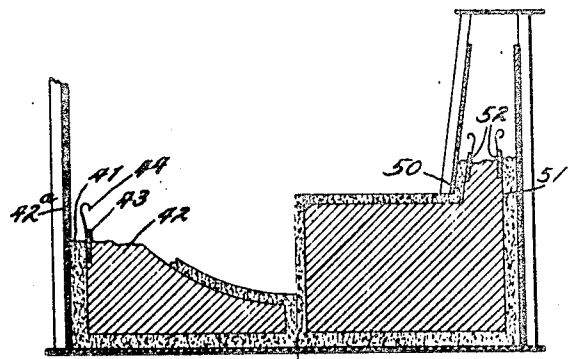


Fig. 9.



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UNITED STATES PATENT OFFICE.

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ARCH.

1,030,918.

Specification of Letters Patent.

Patented May 6, 1913.

Application filed April 24, 1905. Serial No. 257,166.

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.

In an application filed by me of even date herewith, Serial No. 257,165, I have shown and described an arch structure, consisting of double drums separated by an annular space or chamber whereby an economy of material and labor is secured.

The present invention also relates to such double drum arch structures and consists among other things in improvements whereby the bearing surfaces for the ends of the arch may be increased and extended well back from the bank of the stream without excessive material, whereby the earth pressures set up by the thrust of each drum are successfully resisted, and whereby a pleasing appearance is given to the structure as a whole.

Other features and advantages will appear from the detailed description and claims.

In carrying out the invention, an inner rib or drum is erected having preferably for its abutment support at each end an extended member bearing against the solid embankment and with an extension downward to afford support and to prevent the stream from undermining. This drum may be elliptical to give a pleasing appearance to the end of the structure. The solid embankment is then excavated far enough back to secure a good bearing for the ends of the upper rib or drum, the earth from this excavation being filled over the inner drum to provide a form for the upper or outer drum, thus economizing labor and room in handling the material excavated. The outer drum is then laid on the said filling covering the inner drum. These drums and extensions thereof may be joined in various ways by ribs, ties, struts, or any other members embedded in the earth filling or "stuffing," as it may be termed. The ends of the drums are preferably provided with expanded footings. By this arrangement, the thrust of the inner drum is resisted by the solid embankment against which it has a

large bearing surface, and also supports the vertical loading. The thrust of the outer drum is resisted by the footing in the solid embankment undisturbed by the excavation for the inner drum, and may be carried well back from the bank of the stream without excessive material. The outer drum prevents the earth from yielding under pressure of the inner drum thrust, while the outer drum transmits the vertical loading into pressures on the earth embankment back of the inner drum, thereby inducing pressures which resist the thrust of the inner drum. This type of structure possesses the advantages of requiring only a light centering or form for the inner drum, which in turn serves as a support and, together with the filling, as a center or form for the outer drum, and results in the saving of the inefficient material at the center of the arch rib. While the inner drum is preferably cylindrical, the outer may be of any form desired, as cylindrical, warped, conical, or any non-developable or non-cylindrical form.

Referring to the accompanying drawing, Figure 1 is a longitudinal sectional view of a double drum arch taken on the center line of Fig. 2. Fig. 2 is a transverse sectional view taken, at the left, through the center of this arch on the line 2-2 of Fig. 1, and, at the right, on the line 2'-2' of this figure. Fig. 3, is a longitudinal sectional view taken through the center of a similar double arch having a warped outer drum; Fig. 4, is a transverse sectional view on the line 4-4, of Fig. 3; Fig. 5, is a similar view on the line 5-5, of said Fig. 3; Fig. 6, is also a transverse sectional view on the line 6-6, of Fig. 3; Fig. 7, is a rear end view of the arch uncovered; Fig. 8, is a transverse sectional view of a modified form of arch in which the extrados are two cones, and Fig. 9, is a sectional view showing the method of constructing the warped drum and filled spandrel.

In the construction of this type of arch, a light inner drum 2 of concrete is erected upon a suitable center or form of the usual or desired kind, the ends of the drums terminating in the vertical members 3 forming abutments and bearing at their outer faces 4 against the solid embankment 5, the said outer faces being preferably formed as shown to afford a suitable bearing against the said embankment. This inner drum may be of elliptical form to furnish a pleas-

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ing appearance to the structure, and the vertical members 3 are extended downwardly beneath the bed 6 of the stream to prevent the latter from undermining. The line of the original embankment is indicated by the dotted line 7. This inner drum 2 is cylindrical in form. The outer drum 8, which is also cylindrical in these Figs. 1 and 2, is comparatively light and is provided with extended ends reaching well back into the solid embankment so that a good bearing for the same is provided far enough beyond the inner drum to prevent the same from being affected by the presence of or the excavation for the inner drum and its abutment or member 3. The earth taken from this excavation for this outer drum may be filled in over the inner drum to provide a form for the said outer drum, thus readily disposing of the same, such material being tamped and rounded to place it in condition to serve as such form. The ends of these extensions of the outer drum are provided with expanded footings 10 to provide good bearing surfaces. Likewise the lower ends of the abutments 3 may have expanded footings 11 for the same purpose. The roadway 12 over the outer drum is suitably filled in, and the two drums are preferably joined by intermediate vertical webs 14 extending throughout the length of the structure, the rear end of the same being indicated in Fig. 1 by the dotted line 15.

The edges of the drums may be connected by light spandrel walls 16, as indicated at the left in Fig. 2, said walls being built up with the usual facing or form upon the outer side and with the earth filling at the back in place of the usual wooden form. This method of construction is explained more fully hereinafter in connection with description of Fig. 9. The portion of the spandrel 17, above the outer drum may be made of the usual thickness to form a solid and strong retaining wall, the usual wooden forms being used on each face, and sufficient room being provided between them for the men to work in building the same. At the right in said Fig. 2, a hollow or earth filled spandrel wall is shown, the outer wall 18 corresponding to the portion 16 at the opposite end of the arch and serving to connect the two drums, and being extended above the outer drum to form the face wall of the said spandrel. An inner wall 19 for said portion above the outer drum is erected and the space between these portions is preferably filled with earth which may form the back for the concrete as the said walls are built up. A suitable footing 20 may be provided for the end of the spandrel wall. In Fig. 2, at the right the slope of the earth is indicated by the line 21. Any other material than the material excavated may obviously be employed be-

tween the drums, but such excavated material forms the cheapest and most readily applied form or center for the outer drum. With this arrangement it will be observed that the thrust of the inner drum is resisted by the solid embankment against which it has great bearing surface, and the thrust of the outer drum is resisted by the solid footing in the embankment undisturbed by the excavation for the inner drum, and such footings for the outer drum may be back far enough from the bank of the stream to afford a good bearing without employing excessive material. This outer drum prevents the earth from yielding under the pressure of the inner drum and transmits the vertical loading into pressures on the earth embankment back of the inner drum. A form of arch is thus provided without excessive expense for material, and one which obtains its support from the embankment, thus dispensing with either heavy masonry abutments or an excessive amount of material in the arch itself.

If the structure thus described is designed with the proper proportioning of the annular space between the drums and the thickness of the drums, reinforcement will be unnecessary. However, it may be desired to reinforce such an arch, and my invention contemplates the addition of such reinforcements if the same be desired. I have indicated in the drawing one method of reinforcement which consists in placing tension rods throughout the structure and passing continuously from side to side of the arch rib through the regions of tension. Thus these two drums are reinforced by tension members preferably in the form of rods arranged in any desired manner, the rods 22, 23 and 24 being embedded in the inner drum at the crown and in the outer drum at the haunches and crossing the chamber between the drums at about the shearing section or regions of minimum bending moment and preferably through the ribs 14. Additional tension rods 25 are located in the lower drum, centrally at the crown and high at the haunches and thence passing down adjacent to the outer face of the portion 4 of said drum. These rods are preferably bent or hooked at their ends to afford secure anchorage in the concrete. In Fig. 2, I have indicated tension rods 26 passing transversely through the lower drum and thence vertically in the spandrel walls 16 and 17 where they may be suitably hooked to other rods passing longitudinally through the said spandrel wall. At the right of said Fig. 2 other transverse rods 27 are shown passing through the outer drum 8, thence through the wall 19 of the spandrel to where they may be hooked around longitudinal rods; and other rods 28 pass over the top of the spandrel and down through the wall 18.

These rods may be arranged in any desired manner. The two drums may be joined together by struts at various points or by connecting members extending longitudinally or transversely throughout the structure and which may serve to divide the chamber between the drums into various compartments.

In Figs. 3 to 7 inclusive, an arch having an upper warped drum provided with extended footings is illustrated. The lower drum 2^a is substantially the same as in Fig. 1, but the ends are formed somewhat differently and are beveled as at 30 to provide a good bearing surface against the embankment while the extended footing forms the projection 31 which may serve as a support for the forms or centering. The outer drum 8^a, resembles a shoe-horn in form, and as indicated in Fig. 3, is extended beyond the end of the lower drum to find an independent footing in the embankment. The extreme end of this drum is provided with an enlarged or extended footing, 10^a, as in the case of the structure of Figs. 1 and 2. While this outer drum may take any form desired, I have shown the outer end slightly turned up so that the thrust tends to buckle it downwardly; and to resist this tendency a strut 32 is provided between this portion of the outer drum and the inner drum by means of which the thrust is transmitted to some extent to the inner drum. This strut may be continuous across the arch or consist of a plurality of single struts. In Fig. 3, the upper edge of the warped drum is indicated by the line 33, 34 indicating the upper edge of the spandrel. The dotted line 35 indicates the end of the spandrel wall, and the curved dotted line between the ends of the two drums indicates the end of the spandrel and also the ends of any intermediate ribs extending throughout the structure between the two drums. A plurality of vertical intersecting ribs 37 are provided which may extend continuously from end to end of the arch, but preferably extend only between the dotted lines 38 and 39, or through the shearing section of the arch. A single strut 40 is indicated in Fig. 3, or it may extend continuously across the arch. These struts and ribs may be arranged in any desired manner and may extend continuously or openly across the arch. After the outer drum is completed, the filling for the roadway 12, is supplied and is borne by the outer drum with the assistance of the inner drum. The side retaining walls 41 extend between the edges of the two drums and are constructed as indicated in Fig. 9. As is indicated in this figure the filling 42 and the retaining wall 41 are built up at the same time, a suitable form 42^a being provided for the front of the wall 41, while the earth filling 42 furnishes the form for the back face.

A facing board 43 maintained at the desired distance from the front facing 42, is raised gradually by the loops 44 between which board and the facing the concrete is first thrown. The earth filling is then rounded off after being tamped to provide a mold for the material for the upper drum, which is then placed thereon and suitably tamped. Obviously a fill of any granular material that can be readily molded to the desired form is to be preferred. By granular fill I mean a filling of sand, gravel, cinders, earth or similar granular material or which supplies equivalent passive resistances. By this means a light retaining wall may be provided since it is unnecessary to furnish room between the board 43 and the facing 42 for men to work as is the case with the usual retaining or spandrel wall. The outer edge of the upper drum sustains said wall since they are connected together. The upper edge of the retaining wall is thickened as is indicated in Figs. 4 to 7. In Fig. 7 the upper dotted line indicates the roadway while the curve at the crown is shown by the full line 45. The line 46 indicates the upper edge of the expanded footing of the outer drum, while the lower edge 46^a of said drum indicates that it is also extended downwardly, the latter feature not being indicated in Fig. 3; the dotted lines 47 in this figure show the curve of the outer drum at said footing. The outer edge of the end of the spandrel may be provided with footings 48 and 49.

As is indicated at the right in Fig. 9, a filled spandrel may be provided for the side of the arch, by building the inner and outer walls 50 and 51, the latter extending from the inner drum to the top of the spandrel while the former reaches from the outer drum to the railing or upper edge of the spandrel. Facing boards 52 are employed to guide the concrete and gage the depth of the wall while the earth filling and concrete are filled in and tamped at the same time.

In Fig. 8 a modification of the outer arch is shown which in this instance consists of the conical layers of concrete 53 and 54, the section at the left being taken at the crown, and that at the right at the haunches. Other curves and forms may be given to the outer drum; in fact, any non-cylindrical form would embody more or less the principles and advantages of my invention. Tension members in the form of rods or other well known forms may be supplied, those shown at 55, 56 and 57 crossing from the upper drum at the haunches to the lower drum at the crown, and crossing at different longitudinal points preferably through the ribs at the shearing region. Other rods, such as 58, may be disposed in the lower drum either low at the crown or as shown,

and high at the haunches, and then curving around near the face 30 of the end of the arch and being hooked to provide secure anchorage. Transverse rods are indicated 5 in the various sectional views and may pass not only through the two drums, but also through the spandrel walls and the vertical ribs or struts 40. In fact such reinforcement may be utilized in any way desired.

10 It is apparent that an arch of this character is much stronger than one with cylindrical drums only, and in view of the earth filling as a mold may be readily and economically constructed. Other methods of 15 constructing the upper drum may obviously be employed, as for instance, by erecting timber scaffolding upon the lower drum, and the earth if used as a form may be later withdrawn in any desired manner, as by 20 leaving suitable apertures in the drums so that water could be introduced to wash out the earth. Likewise the earth filling for the roadway may obviously be replaced by suitable superstructure so far as the broad 25 features of the invention are concerned. So far as some features of the invention are concerned, also, the drums or either of them may be non-continuous, that is, they may consist of separate ribs side by side similar 30 to the upper and lower flanges of a steel arch.

Other and various modifications and changes may be made and still come within the broad scope and principle of the invention. 35

Having thus described my invention, what I claim is:

1. An arch comprising an inner drum

supported on footings and an outer drum with ends extended back of the footings of 40 the inner drum and separated from them by the material of the embankment,

2. A concrete arch comprising an intradosal and an extradosal drum, supported at each end upon footings and separated by a 45 filling of granular material extending between and separating the corresponding footings of both drums.

3. An arch having an inner drum and outer drum, the ends of the outer drum being 50 extended beyond the inner drum and having an independent footing, substantially as described.

4. An arch comprising a plurality of gradually diverging drums embracing a 55 granular mass projecting between the ends of the drums, whereby the thrust of the arch is transmitted through said drums to the granular mass.

5. An arch comprising diverging compression members of hardened plastic embracing a granular mass extending between 60 the ends of the diverging members and forming part of the supporting foundations for the arch, whereby the thrust of the arch 65 is transmitted through the said members to the granular mass and thus to the supporting granular foundations.

In witness whereof, I have hereunto subscribed my name in the presence of two 70 witnesses.

DANIEL B. LUTEN.

Witnesses:

J. C. STUCKENBERG,
WM. DERRY.