R. A. CUMMINGS.

REINFORCED ARCH, BRIDGE, OR VIADUCT.

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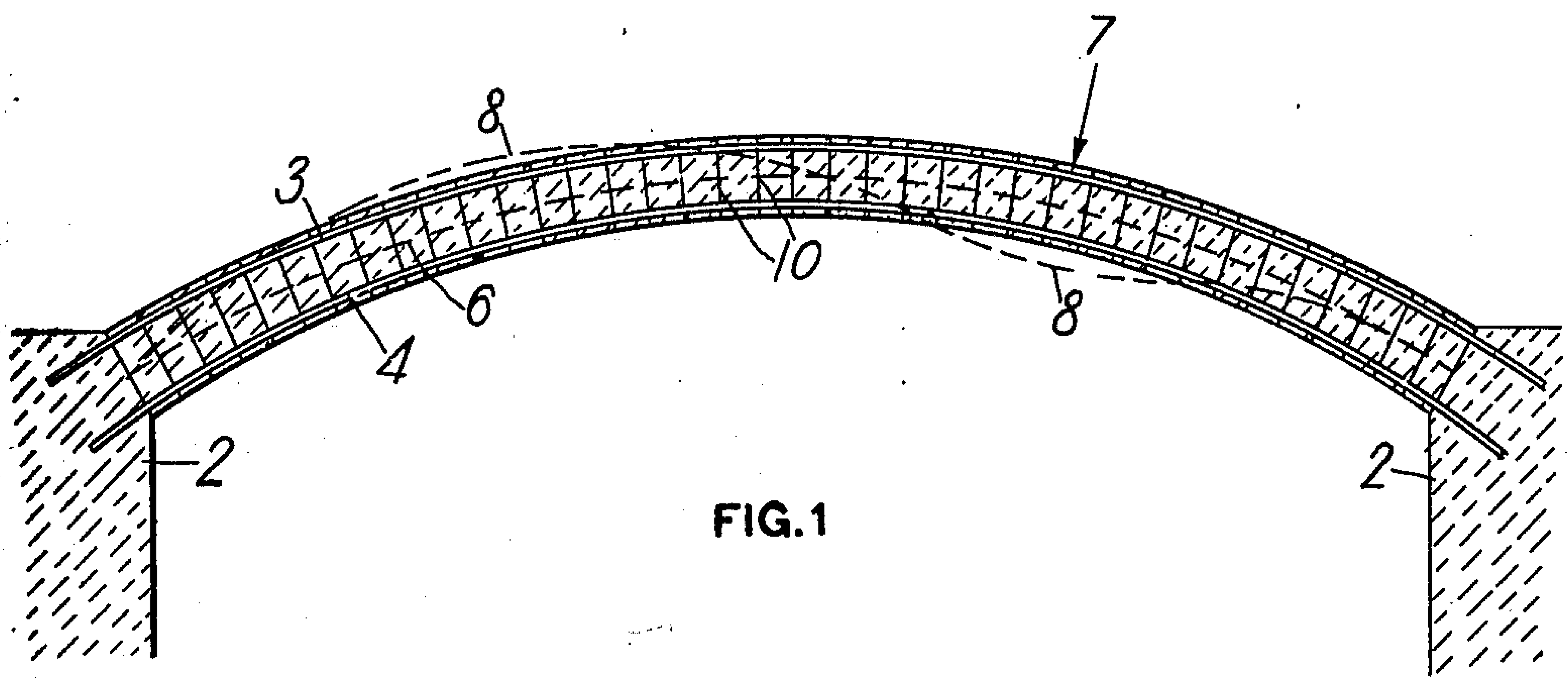


FIG. 1

FIG. 3

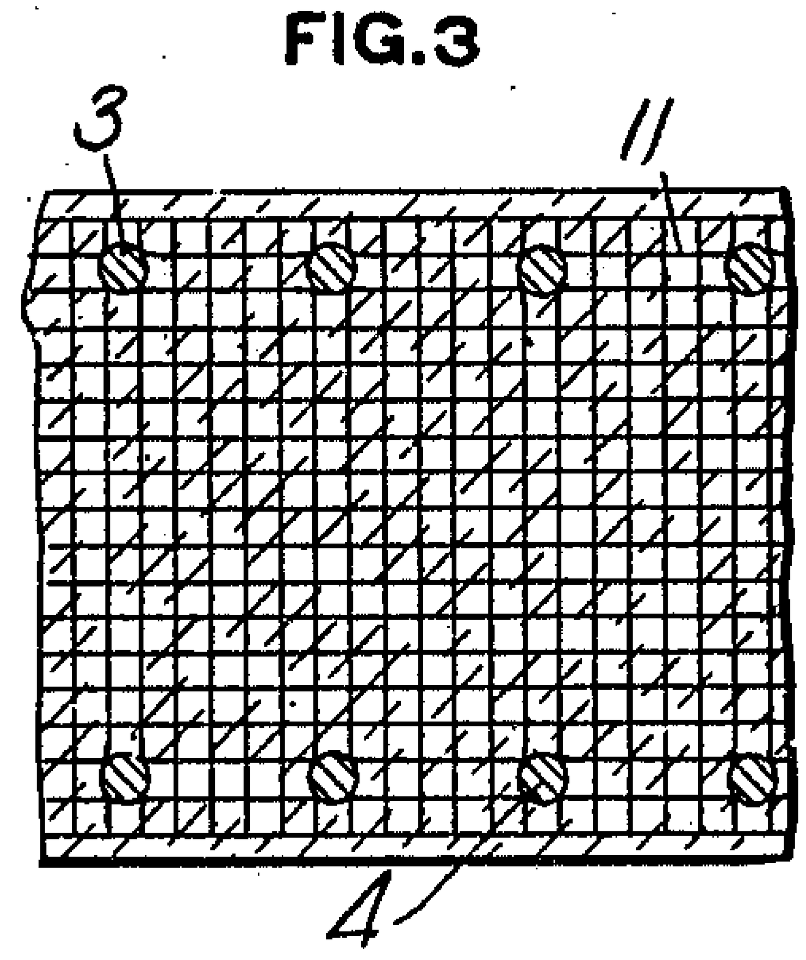


FIG. 2

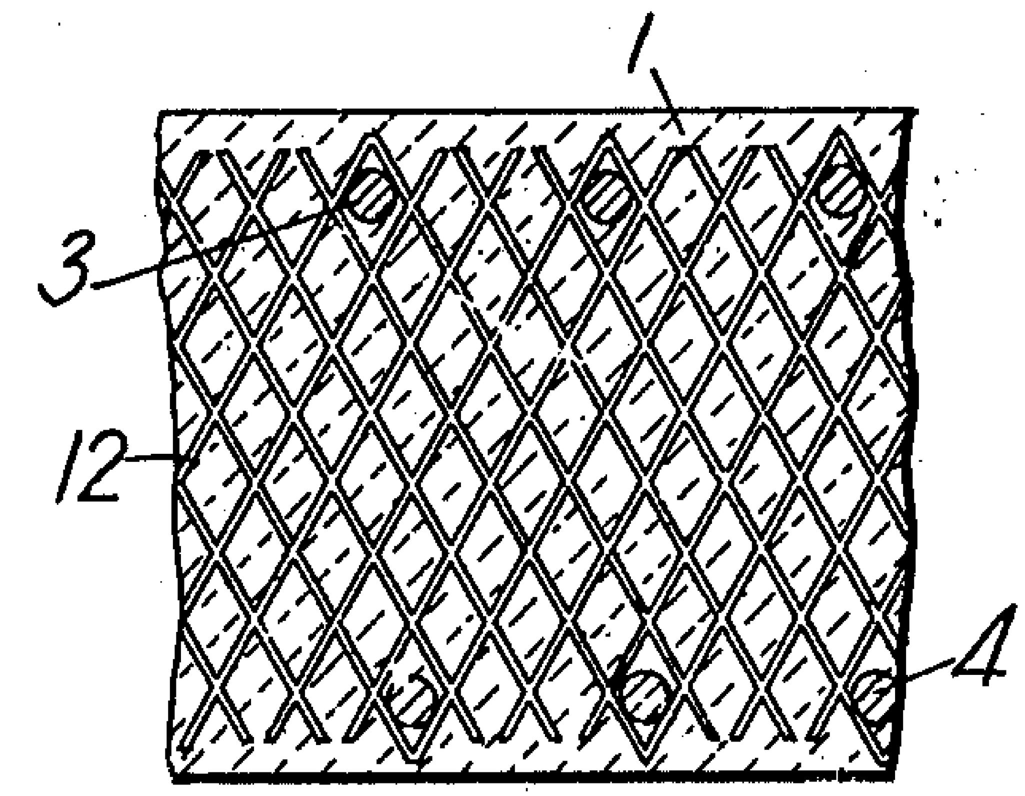
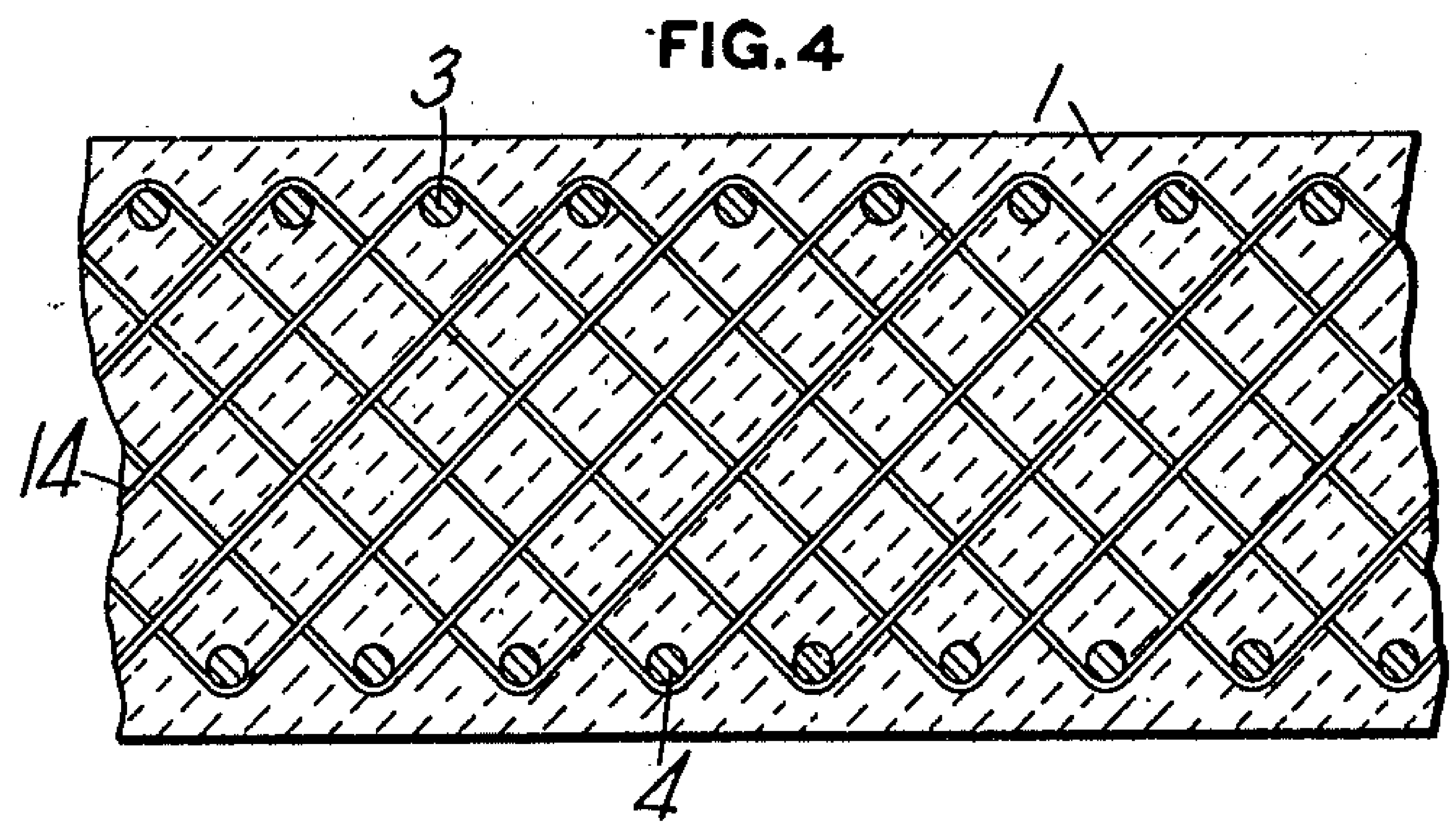


FIG. 4



WITNESSES

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ROBERT A. CUMMINGS, OF BEAVER, PENNSYLVANIA.

REINFORCED ARCH, BRIDGE, OR VIADUCT.

978,361. Specification of Letters Patent. **Patented Dec. 13, 1910.**

Application filed June 11, 1909. Serial No. 501,629.

To all whom it may concern:

Be it known that I, ROBERT A. CUMMINGS, a resident of Beaver, in the county of Beaver and State of Pennsylvania, have invented a new and useful Improvement in Reinforced Arches, Bridges, or Viaducts, of which the following is a specification.

This invention relates to reinforced concrete or similar arches or girders, such as for bridges, viaducts or for supporting the floors of buildings or other structures.

The object of the invention is to provide a system of reinforcement for such structures whereby the unit strength of the concrete is very greatly increased and failure of the structure under eccentric or unequal loads is largely avoided.

The invention comprises the construction and arrangement hereinafter described and claimed.

In the accompanying drawing Figure 1 is a longitudinal vertical section through an arch or arched girder having my invention applied thereto; and Figs. 2, 3 and 4 are transverse sections illustrating different characters of transverse reinforcements.

In the drawings the arch is shown at 1 springing from the abutments 2. This arch is provided with suitable longitudinal reinforcements arranged as is usual near the upper and lower surfaces of the arch, the drawings showing the upper reinforcements 3 and lower reinforcements 4. These may be formed of metal bars of any size or cross-sectional shape and may be applied as has heretofore been the custom. The equilibrium curve of an arch under uniform or central load is substantially midway between the top and bottom faces of the arch, and is indicated by the dotted line 6. Under an eccentric load such for instance, as a load applied at the point 7, the equilibrium curve is indicated by the dotted line 8, portions of said curve being entirely outside of the arch, that is, above and below the same, or at least outside the middle of the arch. Consequently the longitudinal reinforcement bars are in compression in parts thereof and in tension in other parts thereof and the arch with such load is out of equilibrium and cannot effectively resist the load. To overcome this as far as possible I provide reinforcements which greatly increase the unit strength of the concrete and also assist in taking care of the shearing stresses. I have discovered that by embedding in the concrete metal reinforcements extending transversely of the arch and substantially normal to the neutral equilibrium curve and extending substantially from the upper to the lower surface of the arch and spaced fairly close together, the unit strength of the concrete is much greater than that without such transverse reinforcement, although at first thought it might appear that the transverse reinforcements arranged substantially vertical or normal to the curve would have little effect on the strength of the arch. This increased strength is due to the fact that the first appearance of fracture due to compression in the arch under destructive load is the spalling off of the concrete from the top and bottom surfaces in the case of soffit arches, or the side faces in the case of rib arches, so reducing the cross-sectional area or thickness of the arch at that point. Under load the longitudinal curved reinforcing bars also tend to straighten so that the lower longitudinal bars have a tendency to break away or pull through the concrete on the lower face of the arch.

I have discovered that when transverse reinforcements are placed in the cement the spalling off is confined to the space between adjacent transverse reinforcements, and that the depth of such spalled off portions is proportional to the width thereof, so that it becomes evident that if the transverse reinforcements are placed fairly close together no great amount of spalling off can take place and therefore the arch will not fail as readily as without such transverse reinforcements. If these reinforcements are made to tie the top and bottom reinforcements together they also resist the tendency of the bottom bars to break or pull through the lower face of the arch. Accordingly I place in the arch a series of transverse reinforcements 10 which extend from side to side in the arch and substantially from the top to the bottom surfaces thereof and substantially normal to the neutral equilibrium curve. These reinforcements will be placed fairly close together. No fixed rule can be adopted but in all cases the spaces between such transverse reinforcing members is less than the thickness of the arch.

The reinforcements may be of any character, either rods arranged in two crossing series, or rectangular mesh 11, as shown in Fig. 3, or diamond shaped mesh 12, such as expanded metal, as shown in Fig. 2, or any other suitable mesh, or an arrangement of zigzag or interlaced bars, rods, strips or bands of any character, as shown at 14 in Fig. 4, or perforated sheet metal, such as metal lathing. In all cases, however, the transverse reinforcements must comprise a substantial portion of the cross-sectional area of the arch or girder, and all parts of such reinforcement must lie in substantially a single plane substantially normal to the neutral equilibrium curve, and must be the equivalent of an open sheet or open mesh. Such transverse reinforcements will preferably be so constructed or shaped as to be effectively anchored in the concrete, and preferably are connected to the top and bottom reinforcing bars, by which the latter bars are tied together and rigidly held in their proper relative positions and prevented from being displaced when under stress.

The concrete is filled around the longitudinal and transverse reinforcements so as to entirely embed the latter. While the longitudinal reinforcing bars 3 and 4 may serve in tension or compression and also resist shearing stresses, under eccentric loads and deformation of the arch secondary stresses are induced and their efficiency is therefore limited. When the equilibrium curve falls outside the middle third of the arch ring, the transverse reinforcements by greatly increasing the unit strength of the concrete and preventing spalling off as above stated, give the necessary added strength to the arch in compression under such loads. In fact for certain arches the longitudinal reinforcements may be entirely dispensed with. The transverse reinforcements extend substantially radial to the curve of the arch, and hence intersect or stand diagonal to the lines of vertical shearing stresses, and are therefore adapted to assist in resisting such shearing stresses. The same principle can, of course, be applied to girders, which in effect are merely straight arches.

What I claim is:

1. A reinforced concrete arch or girder comprising a series of closely arranged metal reinforcement members arranged transversely of the arch or girder, the parts of each member lying substantially in a single plane substantially normal to the neutral equilibrium curve of the arch or girder and extending from top to bottom and side to side thereof and the metal thereof comprising a substantial portion of the cross-sectional area of the arch or girder, whereby said reinforcement members resist vertical tension stresses throughout the width of the arch or girder, and cementitious material embedding and enveloping said reinforcement members.

2. A reinforced concrete arch or girder comprising a series of reinforcement members consisting of open metal sheets or mesh and arranged transversely of the arch or girder and all parts of each member lying substantially in a single plane substantially normal to the neutral equilibrium curve of the arch or girder and extending from top to bottom and side to side thereof and comprising a substantial portion of the cross-sectional area thereof, whereby said reinforcement members resist vertical tension stresses throughout the width of the arch or girder, and cementitious material embedding and enveloping said reinforcement members.

3. A reinforced concrete arch or girder comprising longitudinal reinforcement members, and a series of reinforcement members arranged transversely of the arch or girder and all parts of each lying substantially in a single plane substantially normal to the neutral equilibrium curve thereof and extending from top to bottom and side to side thereof and comprising a substantial portion of the cross-sectional area thereof, whereby said reinforcement members resist vertical tension stresses throughout the width of the arch or girder, and cementitious material embedding and enveloping said longitudinal and transverse reinforcement members.

4. A reinforced concrete arch or girder comprising longitudinal reinforcement bars arranged near the upper and lower surfaces thereof, a series of open metal sheet or mesh members arranged close together and all parts of each lying in substantially a single plane substantially normal to the neutral equilibrium curve of the arch or girder and extending from top to bottom and side to side thereof and comprising a substantial portion of the cross-sectional area thereof, whereby said reinforcement members resist vertical tension stresses throughout the width of the arch or girder, and cementitious material enveloping and embedding said longitudinal and transverse reinforcement members.

5. A reinforced concrete arch or girder comprising a series of metal reinforcement members arranged transversely of the arch and all parts of each lying in substantially a single plane substantially normal to the neutral equilibrium curve of the arch or girder and extending from side to side and top to bottom thereof and comprising a substantial portion of the cross-sectional area thereof, the spaces between adjacent transverse members being less than the thickness of the arch or girder, whereby said reinforcement members resist vertical tension stresses throughout the width of the arch or girder, and cementitious material embedding and enveloping said reinforcement members.

6. A reinforced concrete arch or girder comprising longitudinal reinforcing bars arranged near the upper and lower surfaces

thereof and a series of metal mesh members arranged transversely of the arch or girder and each lying in substantially a single plane substantially normal to the neutral equilibrium curve of the arch or girder and extending from side to side and top to bottom thereof, whereby said reinforcement members resist vertical tension stresses throughout the width of the arch or girder, and cementitious material enveloping and embedding said longitudinal reinforcement members.

In testimony whereof, I have hereunto set my hand.

ROBERT A. CUMMINGS.

Witnesses:
JOHN S. CORT,
F. W. WINTER.