

Sept. 6, 1932.

J. M. CROM

1,876,205

MONOLITHIC CONSTRUCTION

Filed Dec. 31, 1930

Fig. 2.

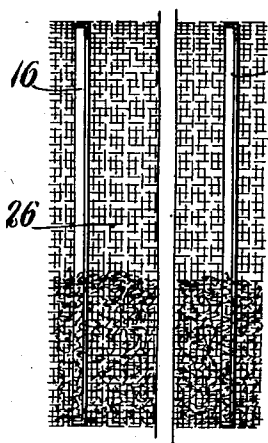


Fig. 1.

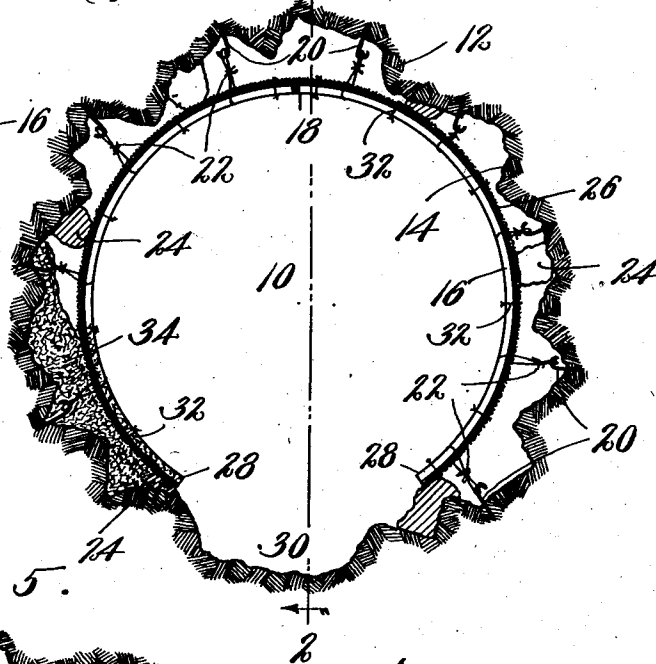


Fig. 5.

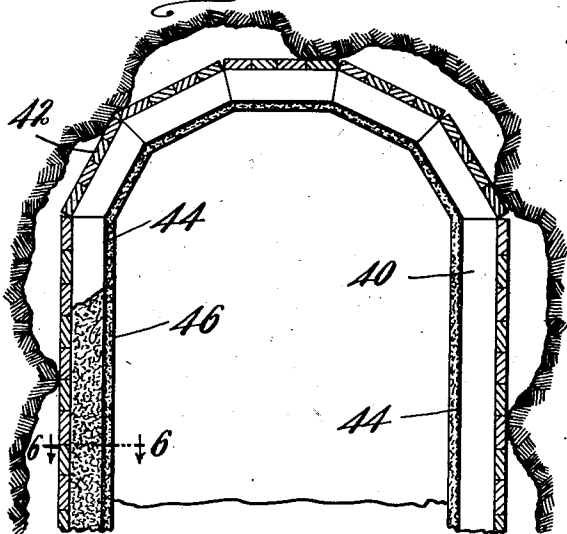


Fig. 3.

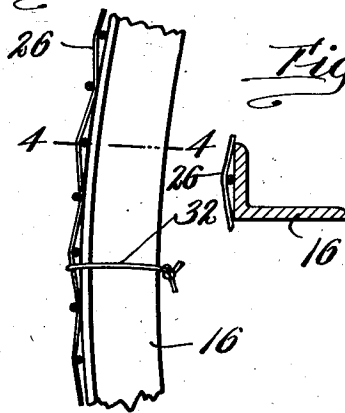
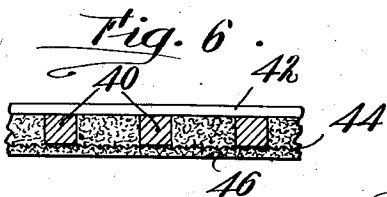


Fig. 4.



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UNITED STATES PATENT OFFICE

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MONOLITHIC CONSTRUCTION

Application filed December 31, 1930. Serial No. 505,743.

This invention relates to monolithic construction and more particularly to a type thereof commonly known as gunite. In ordinary concrete construction, the holding forms or frames are so arranged that the concrete can be poured thereinto from above but many building operations are not adapted to forms of this nature and cannot well be carried out in this manner. My invention herein deals with these operations and more particularly with a new method of making monolithic construction by the use of cementitious mixtures whereby the forms need not be left open at the top but may entirely enclose the cavity or space to be filled. In accordance with my method, I construct the form or forms of foraminous material, as sheets of wire mesh, and then shoot the cementitious mixture preferably through the form into the space to be filled, the foramina in the forms being sufficiently small so that the form supports the body of cementitious material. The production of such an improved method of forming cementitious construction comprises the primary object of my invention.

While, as will be understood, my invention is adaptable to a broad application of uses, it is very particularly adapted to the performing of certain construction operations which do not well permit the pouring of ordinary concrete into the open forms heretofore commonly employed. As examples of such operations, I may particularly mention the lining of shafts or tunnels which have been drilled through earth or rock formations. In proceeding with operations of this nature, I anchor supporting frames or bars to and properly spaced from the wall of the shaft or tunnel and cover the same with wire mesh or other foraminous material to provide a holding form for the cementitious mixture which is to fill the cavity between the wall and form. I then proceed to fill the cavity by shooting the filling material preferably through the form and against the wall, the foramina in the form and the nature of the material being such that the foraminous wall of the form supports the cement material while setting, all of which is hereinafter more specifically described. In like manner my invention is adaptable to the repairing or relining of old tunnels which have previously been lined with wood construction or the like. In such case, however, the old lining is well adapted to serve the purpose of a form-supporting frame and the mesh or other foraminous form may be attached directly thereto. A further object of my invention comprises the production of an improved method of monolithic lining for purposes of this nature.

In the accompanying drawing I have illustrated certain specific applications of my invention but it will be understood that the invention can be otherwise embodied and that the drawing is not to be construed as defining or limiting the scope of the invention, the claims appended hereto being relied upon for that purpose.

Referring to the figures of the drawing, Fig. 1 is a cross sectional view through a tunnel and illustrating the application of my invention to the lining thereof; Fig. 2 is a sectional view taken on line 2—2 of Fig. 1; Fig. 3 is an enlarged fragmentary view of one of the form-supporting bars; Fig. 4 is a cross sectional view thereof taken on line 4—4 of Fig. 3; Fig. 5 is a cross sectional view through a timber-lined tunnel and illustrating the application of my invention to a relining thereof with monolithic construction; and Fig. 6 is a fragmentary sectional view taken on line 6—6 of Fig. 5.

In Figs. 1 to 4 of the accompanying drawing I have illustrated the application of my invention to the lining of a horizontal tunnel 10 bored through rock formation 12, it being obvious, however, that the invention is in like manner applicable to the lining of a like vertical shaft. The first step necessary to this operation, in accordance with my invention, is to provide a suitable form for holding the gunite or like cementitious mixture in place against the wall 14. For this purpose, I provide a form-supporting frame on and spaced from the wall a distance substantially equal to the desired depth of the

lining, this frame as illustrated comprising a plurality of reinforcing bars or metal angles 16 relatively spaced along the wall. These bars will necessarily be shaped to the general contour of the wall and in the circular tunnel illustrated they will be curved to circular shape. For convenience in handling and installation, each bar may be in two or more pieces, the bar illustrated being in two pieces pivoted together at 18.

The bars 16 must be located with some accuracy relative to the wall and must be immovably supported in this position on the wall but the manner of thus mounting the bars or frame will vary in accordance with varying conditions. In the method illustrated, each bar is tied to a plurality of bolts 20 anchored therearound in the wall, wire ties 22 being conveniently used for this purpose, and suitable braces 24 may be provided between the wall and bars for cooperating with the ties to hold the bars properly spaced from the wall. While a combination of ties and braces may ordinarily be most desirable, it is clear that either ties or braces may serve the function, particularly where each bar is substantially rigid or in one piece. Since the function of these bars is to support the form 26, the bars will be spaced from the wall a distance about equal to the thickness of the desired lining. The ends 28 of the bars at the bottom or invert 30 of the tunnel are relatively spaced apart to permit the passage of workmen therebetween along the tunnel.

The reinforcing frame or bars 16 being properly mounted, the next step comprises the attachment of the form 26 thereto. This form is of a foraminous nature and, as best illustrated in Fig. 2, is most conveniently of wire mesh. This mesh is preferably attached to the rear or outer side of the frame but may in some cases be secured to the front side, if desired. Any convenient method of attachment may be used but I have found that sheets of mesh of sufficient width to span the space between adjacent bars are very suitable. These sheets are put in place and the edges thereof secured to the bars and to the adjacent edges of the adjacent sheets in any convenient manner, as by the use of ties 32. It will be understood that the bars 16 are spaced a distance to provide suitable supports and the mesh is tightly stretched therebetween. When this operation is completed, the mesh provides a foraminous form around the tunnel, except at the bottom or invert 30 thereof.

The cementitious mixture which I use to provide the lining is of a nature commonly termed gunite and is applied with pressure force by means of a cement gun. The mixture ordinarily comprises two to eight parts of sand and one part of cement, along with about eleven per cent in volume of water, although it will be understood that my in-

vention is in no manner dependent upon these proportions. The gun equipment usually includes the use of two separate hoses, one for the water and the other for the sand and cement mixture. These two hoses come together at the nozzle of the gun equipment wherefrom the mixture, along with the water, is shot by compressed air at a pressure of thirty-five to fifty pounds per square inch.

It is a well known fact that during the application of the cementitious mixture by means of the cement gun a certain amount of sand more or less coated with cement rebounds from the surface shot at and is usually referred to as the "rebound". If the rebound collects it hardens in a mass of very inferior strength and texture and such collected masses if later covered by dense gunite form what are termed sand pockets which impair the strength of the structure being formed. By my improved method and means the rebound is allowed to escape and the probability of sand pocket formation is reduced to a minimum.

In applying the lining mixture, the nozzle is so directed as to shoot the mixture preferably through the mesh 26 and against the wall 14, beginning at the bottom of the form and working upwardly as indicated in Fig. 1. By thus building up the lining while maintaining a relatively steeply inclined face, the rebound does not lodge to any extent on the surface already formed but passes out through the wire mesh and falls to the bottom where it does no harm. The wire mesh of course permits free escape of the air used in shooting the mixture and provides an ample form for supporting the finished portion of dense gunite while hardening. The mesh used preferably has openings of one to two-inch size or larger.

It is well known that gunite while being shot over any substantial areas is not self sustaining when the gunite is more than about one and one half to two inches in thickness, except of course on top of horizontal or nearly horizontal surfaces. Tunnel linings as shown herein are substantially thicker than that and by the term "relatively thick" as used herein I mean a thickness of gunite which would not be self sustaining while being shot. The relatively steep angle at which the shot face of the cementitious mixture is maintained may of course vary and, generally speaking, the steeper the angle the greater will be the opportunity for escape of the rebound, but an angle as low as about 20° will in most cases permit sufficient escape to produce satisfactory results. The cohesive consistency of gunite as compared to the soft flowing consistency of concrete or mortar may be judged from the fact that whereas the best concrete has a volume of twenty-five per cent water, gunite mixture has a water volume of about eleven per cent.

When the entire form cavity has been filled with the mixture 34, the same is allowed to set until it becomes sufficiently hard to remain in place by itself. The bars 16 are then removed and a finish coating shot or otherwise placed on and over the mesh, the bottom 30 of the tunnel thereafter being filled in any convenient manner. The gunite lining thus provided is exceedingly strong both within itself and because of the arched arrangement thereof, it being understood that gunite is several times stronger than the best concrete of like proportions and it furthermore being understood that in accordance with my invention the material may be applied so rapidly as to form a solid one-piece lining throughout.

In Figs. 5 and 6 of the drawing I have illustrated a further application of my invention. Fig. 5 illustrates a diagrammatic cross section through an ordinary timber-supported tunnel, such as is commonly used in railroads, mining and the like. The wood lining comprises heavy timbers 40 having lagging 42 nailed to their outer surfaces. These timbers, and more particularly the lagging, becomes weakened by rot, whereupon rocks frequently fall therethrough and onto the rails which extend through the tunnel. Thus these old tunnels require a constant vigil and constant and expensive repairing to prevent this danger. By the use of my invention, I am able to conveniently and cheaply provide a permanent lining which will positively eliminate this danger and the necessity for this constant repairing service.

In repairing the tunnel illustrated, I nail or otherwise secure to the outer faces of the timbers 40 a foraminous form 44, illustrated as wire mesh. I then shoot the above-defined cementitious mixture through this mesh to provide a monolithic construction between the timbers 40, as will be understood, the outer face of the mesh being covered over to a substantial depth as illustrated at 46. If a greater depth is desired on and over the outer faces of the timbers, I may mount the mesh on and in somewhat spaced relation from the outer faces thereof.

It is believed that the construction, use and advantages of my invention will be clear from the above description and the accompanying drawing showing certain applications of the invention.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A method of forming a relatively thick lining in a substantially imperforate tunnel bore which comprises making a retaining form wall of foraminous material spaced from the imperforate tunnel bore a distance substantially equal to the thickness of the lining desired, and then shooting a cementitious mixture into the space between the

tunnel bore and foraminous material to fill the space therebetween and maintaining the shot face of the cementitious mixture at a relatively steep angle to permit the rebound to pass outwardly through the foraminous material.

2. A method of forming a relatively thick cementitious structure which comprises providing a retaining form for the cementitious material, at least a portion of which form is of foraminous construction, shooting a cementitious material into the form to fill the space therein, and maintaining the shot face of the construction while being shot at a relatively steep angle to permit the rebound to pass out through the foraminous portion of the form.

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