April 6, 1943. J. M. CROM 2,315,895

CONCRETE CONSTRUCTION

Filed Sept. 11, 1941 2 Sheets-Sheet 1

Fig. 1.

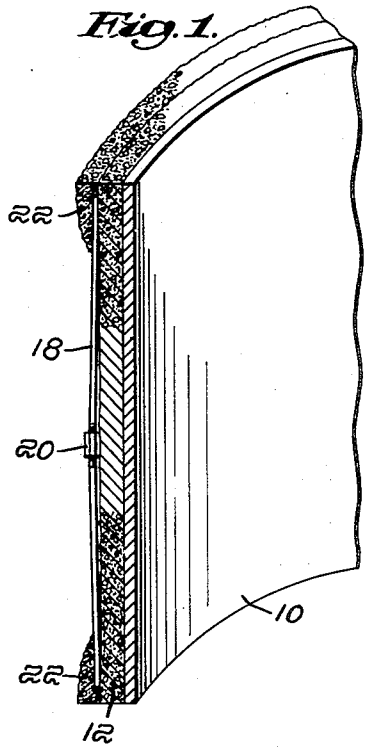


Fig. 2.

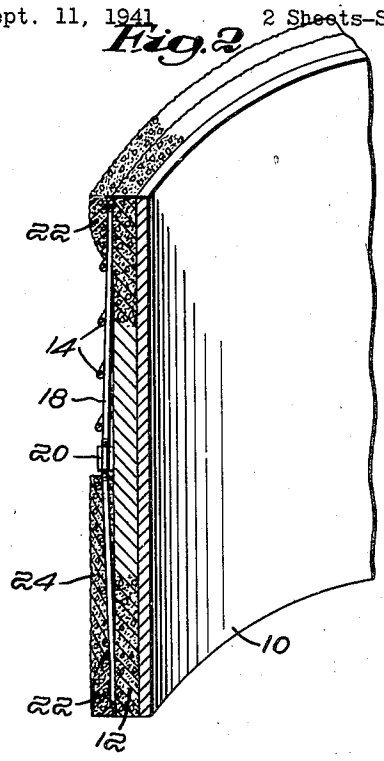
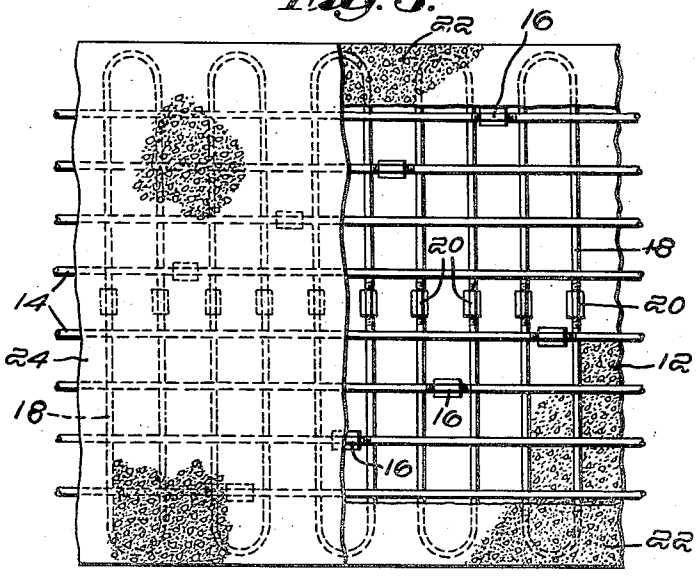


Fig. 3.



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Filed Sept. 11, 1941 2 Sheets-Sheet 2

Fig. 4.

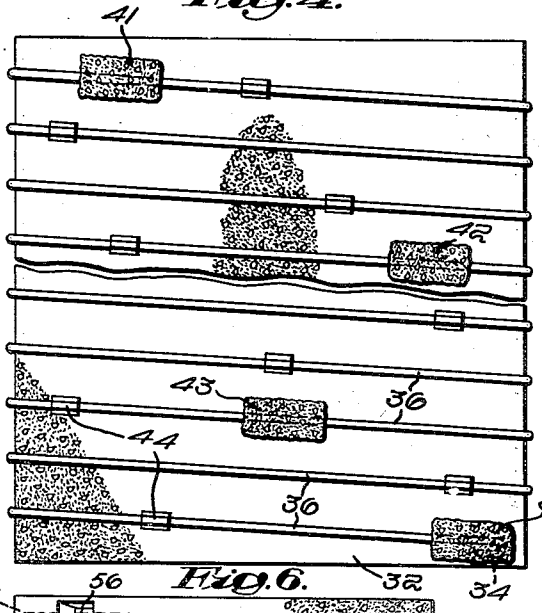


Fig. 5.

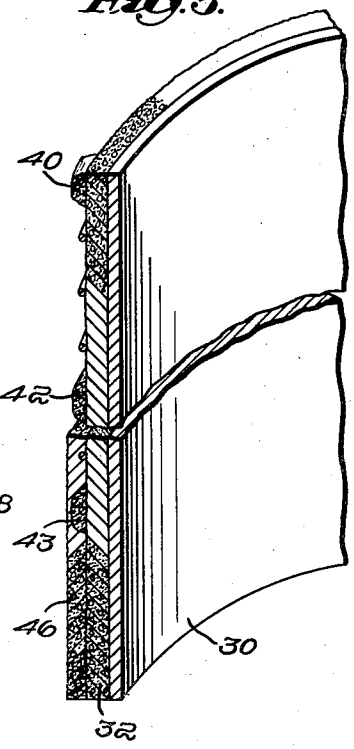


Fig. 6.

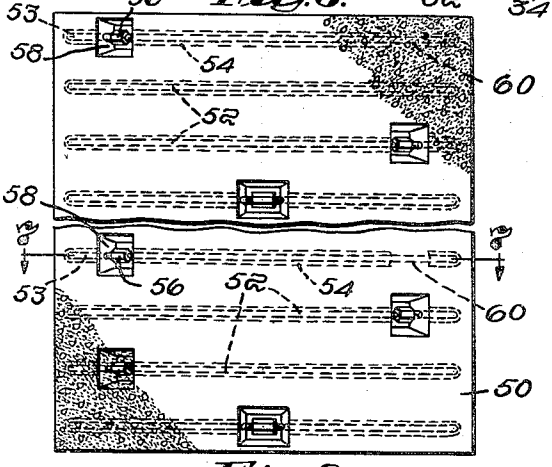


Fig. 7.

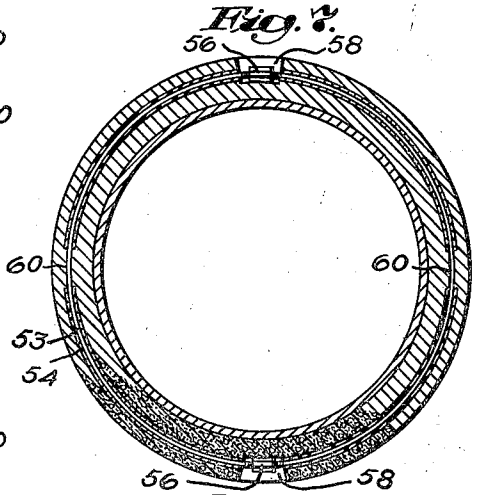
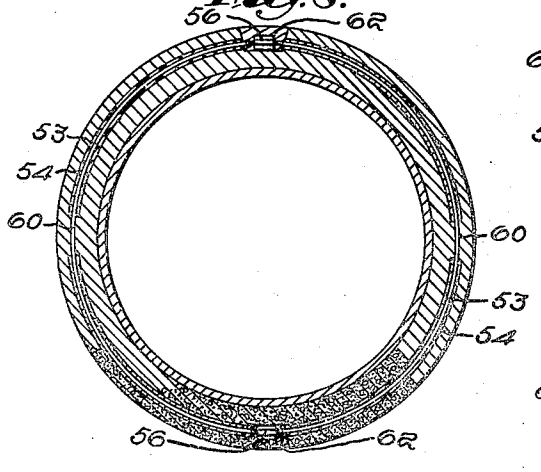


Fig. 8.



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Patented Apr. 6, 1943

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UNITED STATES PATENT OFFICE

2,315,895

CONCRETE CONSTRUCTION

John M. Crom, Jackson Heights, N. Y.

Application September 11, 1941, Serial No. 410,417

12 Claims. (Cl. 72—13)

This invention relates to concrete construction of the nature disclosed in my copending application Ser. No. 361,404 filed October 16, 1940. The invention relates more particularly to concrete construction held under a predetermined compression by steel reinforcement therein serving to hold the concrete from expanding to the point where tension occurs, since concrete will crack when under tension unless the tension is extremely small while it will not crack when kept in compression unless the compression is extremely large. Concrete is capable of withstanding without cracking relatively large compression stresses but it will crack under relatively small tensile stresses. Steel will withstand relatively large tensile stresses. In this invention steel reinforcement has been combined with concrete to keep the steel always in tension and to keep the concrete always in compression, in accordance with a "preloading" system whereby the steel has been stressed or tightened after setting and shrinking of the concrete. Sufficient tensile stress is applied to the steel so that the concrete remains in compression even after the concrete has entirely shrunk from setting and after the full working load has been applied to the structure. The primary object of my invention resides in certain improvements in concrete construction of this nature.

Concrete construction, such as tanks, flumes, pipes, conduits, etc., is largely used for storing and transferring liquids and one object of the above described construction has been to limit or prevent any cracking in the concrete so as to avoid leakage. My invention herein contemplates the accomplishment of these objects in greater degree and with greater security by the employment of improved methods effecting additional bonding of the reinforcement to sectional portions of the concrete structure whereby to maintain the compression thereof and preclude the loss of compression in each of such portions independently of the possible failure in other portions, more particularly during the formation of the structure. The permanent effect of the additional binding to the reinforcement serves to prevent the free sliding of the concrete along the reinforcing rods whereby more evenly to distribute any cracking of the concrete into minute cracks too small to permit leakage.

My invention is applicable to the formation and reinforcement of plane or curved surfaces and one important feature thereof relates to a novel and convenient anchoring of the reinforcement to the concrete construction by "spotting" viz. the application of cementitious material in position to cement the reinforcement to the concrete structure, the cementitious material preferably and most conveniently being applied by shooting it by means of compressed air. This feature of the invention not only provides for the convenient and economical anchoring of the reinforcement to the concrete, preparatory to tensioning the same, but furthermore permits such anchoring of the reinforcement to the structure that the reinforcement can be tensioned in sections and thereby eliminate the possibility of loss of compression throughout the entire structure should a portion of the reinforcement fail or break during tensioning thereof. The production of this novel feature, all as hereinafter more fully described, comprises another object of the invention.

These and other features of the invention will be best understood and appreciated from the following description of preferred embodiments thereof selected for purposes of illustration and shown in the accompanying drawings in which:

Fig. 1 is a fragmentary view of a cylindrical structure embodying my invention,

Fig. 2 is a like view of a further development thereof,

Fig. 3 is a fragmentary outside elevation of Fig. 2,

Fig. 4 is an elevation of a cylindrical structure embodying another form of my invention,

Fig. 5 is a fragmentary view thereof,

Fig. 6 is an elevation of a cylindrical structure showing a further application of my invention,

Fig. 7 is a plan section thereof,

Fig. 8 is a plan section of a further development of Fig. 7.

In Figs. 1–3 of the drawings I have illustrated the construction of a cylindrical tank or like structure in accordance with my invention. In constructing the tank, a cylindrical form 10 of wood or steel of the desired dimensions is first erected and the cylindrical concrete structure 12 is formed by shooting or pouring cementitious composition onto the outer face of the form. As illustrated, the resulting structure is thereafter reinforced in two dimensions by rods extending both longitudinally and circumferentially thereof, the rods being tensioned in a manner placing the structure under compression in said two directions. The rods 14 extend circumferentially around the structure and the ends are connected by turnbuckles 16 by which the rods are tensioned. These rods are the same as defined in my copending application and do not comprise per se

a part of the present invention. The invention resides in the application of the rods 18 to the structure as will now be described.

The rods or reinforcement 18 can be of any configuration desired. In the drawings I have illustrated this reinforcement as being in U-shaped sections having their adjacent ends threaded and connected by turnbuckles 20. The function of the turnbuckles is to place the rods under tension and the structure 12 under a corresponding compression. In order to perform this function, the U ends of the rods must be securely anchored to the structure and an important feature of my invention resides in the novel method herein disclosed for serving this anchoring function. The rod sections are placed against the outer face of the structure 12 with their U-ends located adjacent to its ends in the positions illustrated and cementitious material 22 is applied thereto and in bonding engagement therewith and with the structure 12, the material 22 being conveniently in the form of an annulus and preferably being applied or shot into place by compressed air. When the material has hardened it serves to anchor the rod sections firmly to the structure 12.

The tank is completed by tightening the turnbuckles 20 to a degree placing the structure under the desired compression longitudinally. The circumferential rods 14 are then applied together with their turnbuckles 16 and the latter are tightened to a degree placing the structure under the desired radial compression. When all turnbuckles have been tightened, a substantial layer 24 of cementitious material is applied to the outer face of the set and compressed concrete and to the rods in a manner and to a depth completely covering the same and bonding all into a unit. While this step as well as the application of the concrete to the form 10 is most conveniently and preferably performed by the shooting of cementitious material onto the structure, it will be understood that the broad aspects of the invention are by no means limited thereto.

In Figs. 4 and 5 I have illustrated the application of my invention to a tank or the like reinforced and held under compression by a spiral rod or like reinforcement. The structure 32 is built against the form 30 in the manner above described. One end 34 of the reinforcing rod 36 to be applied is then placed against the structure adjacent to the bottom thereof and cementitious composition 38 is shot thereonto, this "spotting" serving when dry to anchor the end 34 to the structure. The rod is then wrapped spirally about the tank and its top end is likewise spotted to the tank at 40. Other spottings are then applied to the intermediate portion of the rod as at 41, 42 and 43 in a manner also anchoring the rod to the structure at these points.

Turnbuckles 44 are provided in the rod between adjacent spottings. When the spotting cement has hardened, the turnbuckles are tightened to place the rod under the desired tension and the tank structure under a corresponding compression. It will be noted that in accordance with my invention each section of the rod between adjacent spottings is tensioned independently of the other sections. Should a turnbuckle or rod break or fail in the tensioning operation, only that particular section of the tank and rod will be effected and can be easily remedied. It will be apparent that, but for the intermediate spottings 41, 42 and 43, any failure of a turnbuckle or rod would effect the entire rod and tank and the labor and other cost entailed in remedying this situation and recompressing the tank would be quite substantial.

When all the turnbuckles have been tightened, a substantial layer 46 of cementitious material is applied to the outer face of the set and compressed concrete and to the rods in a manner and to a depth completely covering the same and bonding all into a unit.

In Figs. 6–8, I have illustrated a further application of my invention to a tank or like structure held under compression by annular bands or rods. The structure 50 is constructed in like manner as above described except that the bands 52 and 53 are originally incorporated within the structure 50 and are wholly or partially coated with asphalt 54 or equivalent material to prevent bonding thereto, somewhat like that illustrated in Patents Nos. 1,684,663 and 1,818,254. Each annulus of reinforcement includes one or more turnbuckles 56 and while all the reinforcing rods can be constructed and treated after the fashion illustrated at 53 it is also possible to construct a major portion of the rods after the fashion illustrated at 52 wherein the entire rods are coated to prevent bonding, this latter being the same as shown in Patent No. 1,818,254. I have illustrated the rods 53 as disposed at spaced locations along the tank structure and between a predetermined number of the rods 52.

Each annulus of reinforcement 53 preferably though not necessarily comprises a plurality of rod sections connected by turnbuckles. The rod sections are coated except at the turnbuckles and at intermediate portions 60. The structure is also cored at 58 to render the turnbuckles accessible. When the structure is formed, it bonds directly to the uncoated rod portions at 60. These portions 60, as well as the spottings illustrated in Fig. 4, are of a length to provide a firm anchor, ordinarily eight to ten feet being thus bonded.

When the structure has substantially hardened, the turnbuckles are tightened to a degree placing the rods under the desired tension and the structure under a corresponding compression. The cored openings 58 are then filled with cementitious material 62 in a manner bonding the turnbuckles to the structure. The corings 58 and bondings 60 are preferably staggered, as illustrated in Fig. 7, for the purpose of distributing the bonded portions of the rods around the structure.

When the tank is filled with water or other liquid the outward pressure thereof will be taken by the reinforcement, all of which is under tension holding the tank in compression. In other words, the tank is preloaded with a compression sufficient to prevent tension coming into the concrete even with the full liquid load in the tank. Under normal conditions and as long as the rods remain sufficiently tensioned, the concrete wall cannot expand into a condition of tension or crack under load. However, plastic flow and shrinkage are sometimes greater than anticipated and in such cases a certain amount of tension may come into the concrete. Concrete is substantially inelastic and it is well known that when expansion takes place the break comes at the weakest point or points. It is therefore quite apparent that, except for the bonding of the rods at 60 and 62, the structure 50 would be free to slide along the rods with the result that substantial expansion would cause one or more relatively large cracks to develop and permit substantial leakage. The bonding at 60 and 62 however

divides the rods into sections and precludes the formation of large cracks, instead the otherwise large cracks are distributed along the rods as numerous minute cracks too small to permit leakage, this action being made in effect continuous around the tank by the staggering of the bonding locations, as illustrated in Fig. 7. As stated above, all the reinforcement can be treated like the rods 53 to serve this function but ordinarily a portion of the rods properly distributed and thus treated will serve to perform the desired function quite efficiently.

Having thus described my invention what I claim as new and desire to secure by Letters Patent of the United States is:

1. A method of constructing and reinforcing concrete structures under compression, which consists in forming a monolithic concrete structure, applying reinforcement to one face thereof embodying a steel rod incorporating a turnbuckle therein for tightening the reinforcement, bonding the rod to the concrete structure at said face and remote from and at opposite sides of the turnbuckle while leaving the turnbuckle and the rod portions between the turnbuckle and said remote bondings free from bonding engagement with the structure, tensioning the rod by rotating the turnbuckle to a position placing the structure under compression, and thereafter applying cementitious composition to the turnbuckle, rod portions and the concrete structure to bond them together.

2. A method of reinforcing concrete structures under compression, which consists in applying steel reinforcement to a face of the structure, applying cementitious composition to a portion of said reinforcement and said face in position bonding and anchoring said portion of the reinforcement to the structure, tensioning the reinforcement between said anchored portion thereof and another anchored portion spaced therefrom, and thereafter applying further cementitious composition in position covering the tensioned reinforcement and bonding it to the structure.

3. A method of reinforcing cementitious constructions under compression, which consists in applying reinforcement to a face of a cementitious structure, pneumatically shooting cementitious composition onto the reinforcement and said face at relatively spaced locations along the reinforcement and in a manner bonding the reinforcement to the structure at said locations, tensioning the reinforcement between said locations, and thereafter pneumatically shooting further cementitious composition in position covering the tensioned reinforcement and bonding it to the structure.

4. A method of reinforcing cylindrical cementitious structures under compression, which consists in applying reinforcement spirally to the outer face of a cylindrical cementitious structure, pneumatically shooting cementitious composition onto the reinforcement and said face at spaced locations along the reinforcement and in position anchoring the reinforcement to the structure at said locations, tensioning the reinforcement between said locations in a manner placing the structure under compression, and thereafter applying further cementitious composition in position covering the tensioned reinforcement and bonding it to the structure.

5. A method of reinforcing cylindrical cementitious structures under compression, which consists in anchoring one end of reinforcement to the outer face of a cylindrical cementitious structure by pneumatically shooting cementitious composition thereto in a manner bonding said end to the structure at said face, wrapping the reinforcement spirally around the structure at said face, anchoring portions of certain convolutions of the reinforcement to the structure by the pneumatic shooting of cementitious composition thereto, tensioning the reinforcement between the anchored portions thereof in a manner placing the structure under compression, and thereafter applying further cementitious composition in position covering the tensioned reinforcement and bonding it to the structure.

6. A method of constructing and reinforcing cylindrical concrete structures under compression, which consists in providing a form and a plurality of annular reinforcing rods thereabout each embodying a turnbuckle therein, coating certain of the rods with a material preventing bonding of the structure thereto but leaving a portion of each coated rod remote from the turnbuckle uncoated, forming a cylindrical monolithic structure over the rods and in bonding engagement with the uncoated portions of the rods but not bonded to the turnbuckles and coated portions, tightening the turnbuckles to place the structure under compression, and thereafter applying further cementitious composition to the turnbuckles to bond them to the concrete structure.

7. A method of constructing and reinforcing cylindrical concrete structures under compression, which consists in providing a form and a plurality of annular reinforcing rods thereabout, each rod annulus comprising a plurality of sections connected by turnbuckles, coating certain of the rods with a material preventing bonding of the structure thereto but leaving a portion of each coated rod section remote from the turnbuckles uncoated, forming a cylindrical monolithic structure over the rods and in bonding engagement with the uncoated portions of the rod but not bonded to the turnbuckles and coated portions, tightening the turnbuckles to place the structure under compression, and thereafter applying further cementitious composition to the turnbuckles to bond them to the concrete structure.

8. Concrete construction comprising a monolithic slab of concrete, reinforcement including a rod provided with a turnbuckle therein, a layer of cementitious composition on and anchoring the rod to an outer face of the slab at points remote from the turnbuckle, and a further layer of cementitious composition on and anchoring the turnbuckle and the rod portions located between said points and the turnbuckle to said outer face of the slab, the turnbuckle and rod portions between said points being under tension holding the slab in compression.

9. Concrete construction comprising a cylindrical monolith of concrete, reinforcement extending longitudinally of the monolith at the outer face thereof, cementitious composition applied to the reinforcement and to the outer face of the monolith adjacent to its ends and bonding the reinforcement to the monolith at said ends, and turnbuckles in the reinforcement intermediately of said ends, the portion of the reinforcement located between said ends being unbonded whereby it can be tensioned by the turnbuckles.

10. Concrete construction comprising a cylindrical monolith of concrete, reinforcement under tension therein and comprising a plurality of annular reinforcing rods extending around and

relatively spaced longitudinally of the monolith, each rod being bonded to the monolith at a plurality of relatively spaced locations therealong and free from such bonding engagement between said locations, and the bonded locations of certain rods being staggered with relation to the bonded locations of relatively adjacent rods.

11. Concrete construction comprising a cylindrical monolith of concrete, reinforcement under tension therein extending circumferentially therearound and including a steel rod or the like embodying a plurality of sections connected by turnbuckles, the monolith being bonded to the rod sections at points remote from and located between the turnbuckles, and means preventing bonding of the monolith to the rod sections at those portions located between said points and the turnbuckles.

12. Concrete construction comprising a cylindrical monolith of concrete, reinforcement extending spirally therearound and under tension holding the monolith in compression, spottings of cementitious material on and bonded to the reinforcement and the monolith at relatively spaced locations along the reinforcement, and a layer of non-compressed cementitious material on and bonded to the outer face of the compressed monolith and the reinforcement in a manner and to a depth completely covering the same and bonding all into a unit.

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