

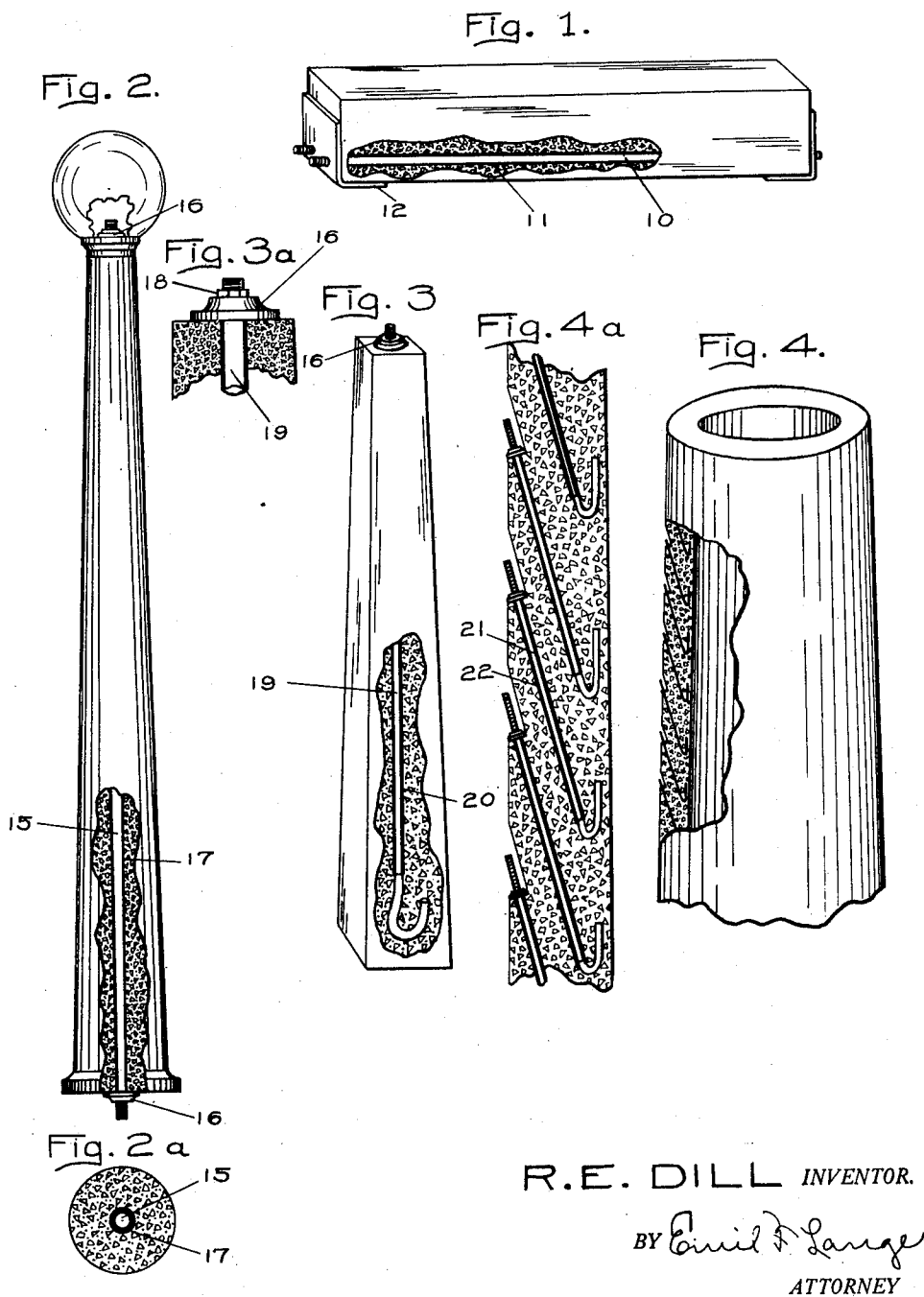
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R. E. DILL

MANUFACTURE OF REINFORCED CONCRETE

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R. E. DILL INVENTOR.

BY *Emil F. Lange*  
ATTORNEY

## UNITED STATES PATENT OFFICE.

RICHARD E. DILL, OF ALEXANDRIA, NEBRASKA.

## MANUFACTURE OF REENFORCED CONCRETE.

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This application is filed as a continuation in part of my prior application Serial Number 618,733, filed February 12, 1923, manufacture of reenforced concrete.

5 The present invention relates generally to the manufacture of reenforced concrete. Its object is to produce a manufacture of reenforced concrete that recognizes the difference in qualities of concrete and steel and combines the two materials in a scientific manner. Specifically, it is the object of my invention to provide a mobile relation between the concrete and the reenforcing material and to provide means for subjecting the reenforcing material to tension.

15 Having in view these objects and others which will be pointed out in the following description, I will now refer to the drawings, which are illustrative of the methods which I employ, and in which

20 Figure 1 is a view in perspective of a concrete beam with a portion broken away to disclose the reenforcing and showing the construction whereby the reenforcing may be tensioned.

25 Figure 2 is a view of a lamp post with centrally positioned reenforcing and means for tensioning the reenforcement.

30 Figure 2<sup>a</sup> is a transverse sectional view of the lamp post shown in Figure 2.

Figure 3 is a perspective view of a post or pillar with the lower end of the reenforce embedded and anchored in the concrete.

35 Figure 3<sup>a</sup> is a fragmentary sectional view of the upper portion of the post shown in Figure 3.

40 Figure 4 is a perspective view, partly in section, of the upper portion of a chimney, showing the manner in which the concrete walls are reenforced.

Figure 4<sup>a</sup> is an enlarged sectional view of a portion of the wall shown in Figure 4.

45 In Figure 1 is shown a beam with reenforcing bars or rods at 10, the bars 10 being coated at 11 throughout their effective length with asphalt or similar material. The screw threaded projecting ends of the bars 10 pass through suitable apertures in the L-shaped washers 12, and tension on the rods 10 may be applied by means of nuts engaging the screw threaded ends of the rods and bearing against the washers 12.

In the lamp post shown in Figure 2 the re-

enforce consists of a pipe 15 which may serve as a conduit for the electric light wires. It is screw-threaded at both extremities and is provided with washers 16 over the projecting extremities. The pipe 15 is surrounded by the layer 17 which prevents a bond between the reenforce and the concrete. Tension is applied to the reenforce by means of nuts 18, one of which is shown in Figure 3<sup>a</sup>. The pipe 15 may, of course, serve as a passageway for gas or for any other purpose, or the pipe may be replaced by a rod. So far as the present application of the invention is concerned the part 15 is primarily a reenforce and any other function is secondary.

55 In Figure 3 is shown a concrete post in which a rod 19 is positioned lengthwise and imbedded in the concrete, the rod being coated throughout a portion of its length at 20. In this instance the lower portion of the rod is entirely within the concrete and it is therefore, provided with a hook-shaped end in order to effectively anchor it in the concrete. As shown in Figure 3 the coating 20 is not applied to the hook-shaped end but only to the reenforcing portion of the rod 19. The projecting extremity of the rod is screw-threaded and is surrounded by a washer 16 so that tension may be applied by means of the nut 18. The form shown in Figures 4 and 4<sup>a</sup> is similar to that shown in Figure 3, it being merely an extension of the same principle to chimneys and similar structures. The reenforcing rods 21 are necessarily inclined, with the hook ends adjacent the inner or outer wall of the concrete structure. The coating is applied throughout the effective length of the rod 21 at 22, but it is not applied to the hook.

60 It is a scientific fact well known to all concrete engineers, that the modulus of elasticity of steel is approximately 30,000,000 while that of concrete is about 3,000,000, or approximately one-tenth that of steel. The strength of steel in tension is approximately 30,000 pounds per square inch, while that of concrete is only about 300 pounds. In other words, concrete will stretch about  $\frac{1}{10,000}$  of its length before cracking, and steel will stretch about  $\frac{1}{1,000}$  of its length before reaching its yield point. So that if a concrete post,

or beam, or pile, or floor, or any structure of concrete and steel that is called upon to resist a tensile strain, is stretched  $\frac{1}{10,000}$  of its length the concrete will crack. If it is stretched  $\frac{1}{1,000}$  of its length the concrete will crack in ten different places, or if in a lesser number of places the cracks will be relatively wider. The cracks will form in advance of the full loading of the steel. It is thus apparent that reinforced concrete as ordinarily made, is a product that is not expected to remain homogeneous under strain. It is a makeshift product. My invention overcomes the difficulties due to the fact that steel at rest and concrete at rest have such different capacities for elongation before rupture. My invention permits the manufacture of a product of concrete and steel that does not allow the concrete to break until the load reaches or exceeds the tensile strength of the steel.

However, before specifically describing my invention I desire to call attention to the fact that the means set forth in my afore mentioned application, that of stretching the steel and keeping it stretched during the setting process, as nearly to its elastic limit as is practicable, will not produce the desired result for the following reasons:

(1) Concrete, during the setting process, shrinks. The degree of shrinkage is variable. In general the richer the concrete in cement the greater the shrinkage.

(2) Concrete, after the set is apparently completed, will shrink with loss of moisture.

(3) Concrete will shrink under compression at the same rate that it will expand under tension.

Therefore, when the steel is held under tension and the plastic concrete is poured about it, what happens is this: As the concrete is initially setting it shrinks or attempts to shrink, or in other words, it is in tension. If later it dries out it will shrink some more and increase its tension, so that the product of concrete and steel will lose part or all of the tension placed in the steel and may, in addition, develop such tensional strains on the concrete as to cause the concrete to crack. In the very exceptional case where the mixture is very thin and the concrete is left moist so that it does not shrink, the tension of the steel allowed to come on the concrete will compress it so that part of its tension is lost and the product is not perfect even in that case. In reinforced concrete, as ordinarily manufactured, no tension is placed in the steel during the manufacture, and the tension developed by the concrete almost always results in compression of the steel, relieved in part by numerous cracks in the concrete. It is to be remembered that this relief is in part only. The sections of concrete between

the cracks is not at rest but is in tension and being in tension holds the steel in compression. Each section is in a state of unstable equilibrium.

My invention consists in the use of relatively smooth rods, such as the plain round reinforcing bars of commerce, dipped or coated with a substance such as liquid asphalt that will prevent the bond of the steel to the concrete together with, subsequently to the setting and shrinking of the concrete, the extension of the steel bars as near their limit of tensile strength as is deemed advisable.

While liquid asphalt is mentioned as being admirably suited to the purpose described, many other substances or compounds may be substituted or a combination of two or more substances may be used. I have invented the use of any substance or combination of elements that will—first, prevent the bonding of the steel to the concrete and—second, subsequently to the setting of the concrete, furnish sufficient elasticity or flow or slipperiness to permit the extension of the steel without materially harming either the steel or the concrete in which it is imbedded. I have invented the use of a substance, or combination of substances that will permit of such easy flow that the concrete in shrinking as it sets or dries will shrink along the line of the reinforcing without outside aid. The use of heat as a factor in increasing mobility or other physical or chemical means to secure the same result is expressly included as a part of my invention.

It is obvious that this slipperiness or ability to permit flow, may be furnished in a number of ways. The substance used might bond itself to both the steel and the concrete and furnish the flow in its own molecular body. Or it might bond itself to the steel and not to the concrete, but slip on the concrete as a base. Or, two substances might be used that bond to the steel and to the concrete respectively, but not to each other, or similar results may be obtained by any of numerous other methods.

Further as a subsidiary part of the main invention, and in continuance of the scientific attitude in the construction of reinforced concrete, I have invented the plan of building such structures as floors of buildings, floors of bridges, concrete road ways and other types of structures now usually built as one unit, in many sections of relatively long length, as compared to the depth and width, together with the use of coated or dipped lengthwise reinforcing. The use of the plastic coating on the reinforcing will permit shrinking of the concrete in a lengthwise direction during or after setting. The narrow width and short depth will permit of shrinkage in these two dimensions. Each section is then a concrete product free from cracks. After the steel is placed in correct

tension, the section is ready to be put in place and go into immediate service. To compensate for the lack of bond between the sections in the floor or roadway, and where a bond is desirable, I use either of these two methods: A wet grout of very rich concrete, or of neat cement can be placed between the adjacent sections and a concrete bond thus set up. In cases where the bond is very essential I use the following method: In the construction of the sections I leave holes so placed that when the sections are put in place the holes in each section form one or more continuous holes. Through these holes I place reinforcing bars, and place them in tension. This bonds all the units together into one integral structure as far as working loads are concerned. It is obvious that the two methods may be used in combination.

As has been explained, the use of my invention permits the construction of reinforced concrete products in which the concrete is not in pieces, nor in tension in whole or in part, as is the case with reinforced concrete as usually constructed, but is free from tension or is in compression and the steel in tension as is usually the desirable relation or where both elements are at rest. Further, the use of my invention permits the production of crackless concrete in the cylindrical form for use as cisterns or pressure pipes. It is becoming generally known that a dense concrete mixture that is free from cracks is impervious to a moderate pressure of either water or air. It is obvious that the use of my invention in the production of such products is very important.

The full value in saving a beam, a post, or similar structure, from failure by the use of my invention has not been fully explained.

By the use of my invention the full strength of the steel is brought into play by a very slight distortion of the structure. If the steel is very highly tensioned, its full strength can be brought into action in support of the structure, without forming any cracks. But, in reinforced concrete, as ordinarily constructed, a comparatively very high degree of distortion must be accomplished before the tensional strength of the steel is developed. But, when the distortion is great, the areas of concrete in contact with each other, which form the bases on which the tension of the steel works as a fulcrum are very small so that the structure fails through the crumbling of this too narrow base and as it crumbles continually decreases the distance of the fulcrum from the load, and thus continually increases the strain per square inch of base.

A further advantage in the use of my invention consists in the utilization of hard steel, or steel of high elastic limit and high ultimate

strength. It is the present practice to use mild steel because since the modulus of elasticity of mild, semi-hard, and hard steel is practically the same there is no advantage within working limits in the use of hard steel. The distortion of a reinforced concrete structure sufficient to develop the full strength of mild steel, is sufficient to completely ruin the concrete. With the use of my invention, the required tensional strength can be obtained much more cheaply by the substitution of hard steel, since the strength that can be obtained by the substitution of hard steel for soft steel, increases much more rapidly than the increase in cost.

While the use of threads on the rod, and nuts and washers, will commonly be the easiest way to produce tension with rods, I do not claim that method, nor limit myself to any specific method of producing tension.

It will also be obvious that my invention is applicable to related products, Lumnite cement as well as Portland cement, and iron or other reinforcing material as well as steel.

While I have found liquid asphalt a very satisfactory plastic non-setting substance and claim its use specifically, I do not limit myself to its use alone, but claim any substance that will do the required work as described.

Having thus described my invention in terms which will be readily understood by those skilled in the art to which it pertains, what I claim to be new and desire to secure by Letters Patent of the United States is:

1. The method of reinforcing concrete which consists in forming a body of green concrete with the reenforce embedded therein, in permitting the body of concrete to set, in preventing the bonding of the reenforce to the concrete during the setting of the concrete, and finally in subjecting said reenforce to tension.

2. The method of reinforcing concrete which consists in coating the reenforce with a substance which will prevent the bonding of the concrete and the reenforce, in then forming a body of green concrete with the reenforce embedded therein, in permitting said body of concrete to set, and finally in subjecting the reenforce to tension against the resistance of the body of concrete.

3. The method of reinforcing concrete which consists in coating a reenforce with asphalt, in then applying said coated reenforce to a concrete body, and finally in tensioning said reenforce, the arrangement being such that the reenforce is out of bonding relation with the concrete.

In testimony whereof I have affixed my signature.

RICHARD E. DILL.