Dec. 7, 1954 J. M. CROM ET AL 2,696,040

METHOD AND APPARATUS FOR PRESTRESSING

Filed Sept. 15, 1950 6 Sheets-Sheet 1

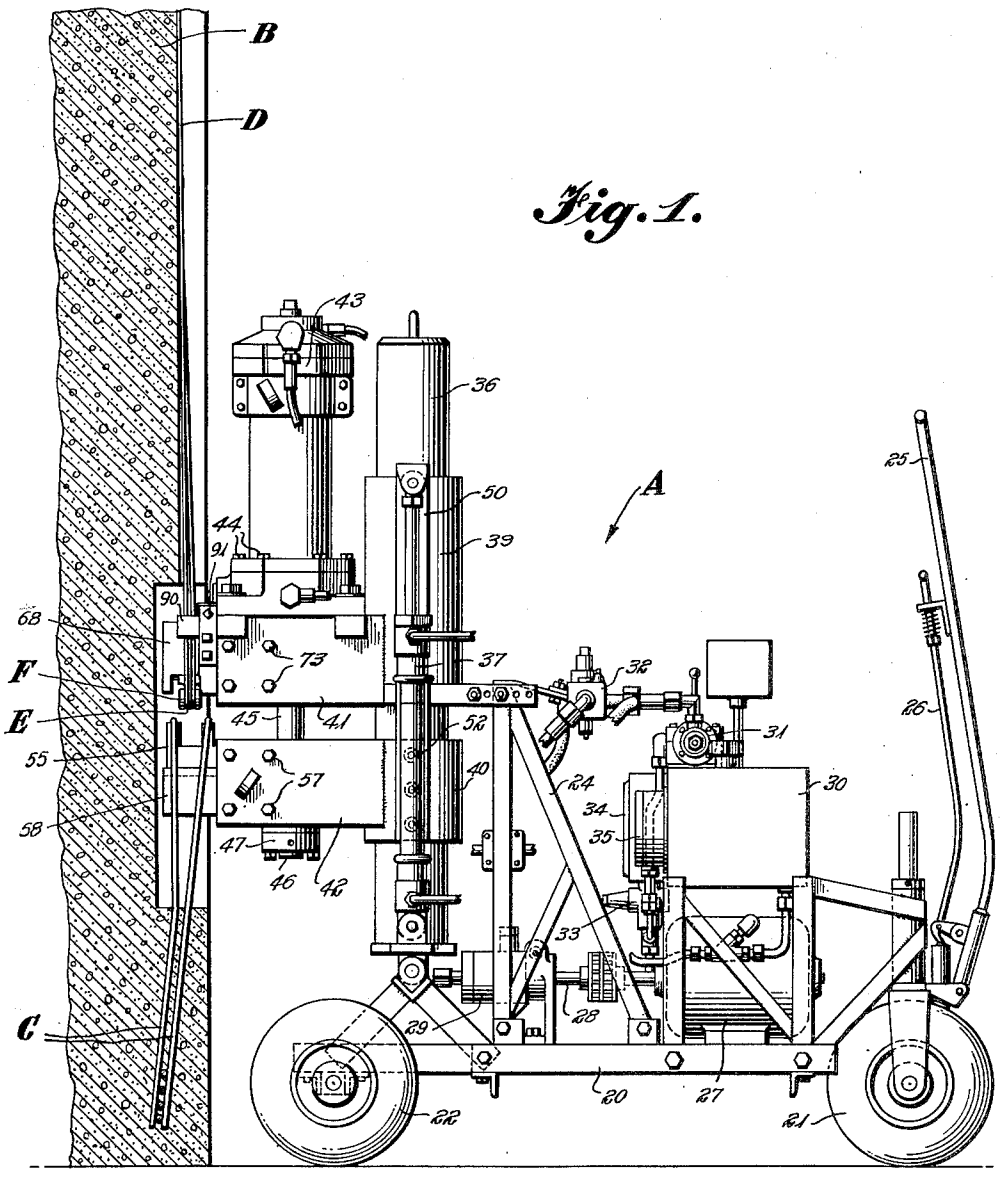


Fig. 1.

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METHOD AND APPARATUS FOR PRESTRESSING

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Fig. 2.

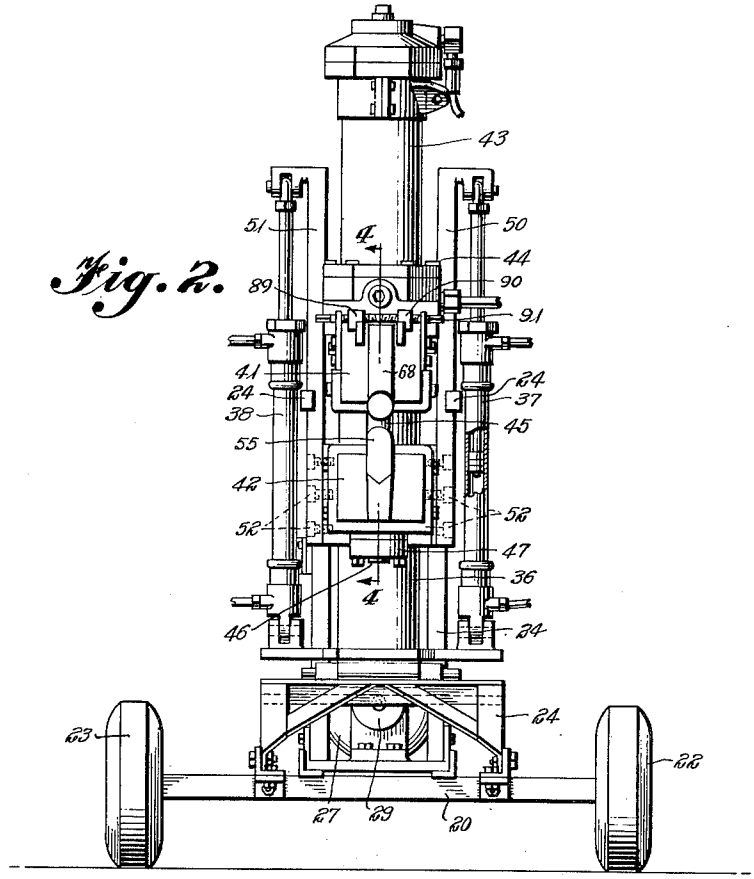
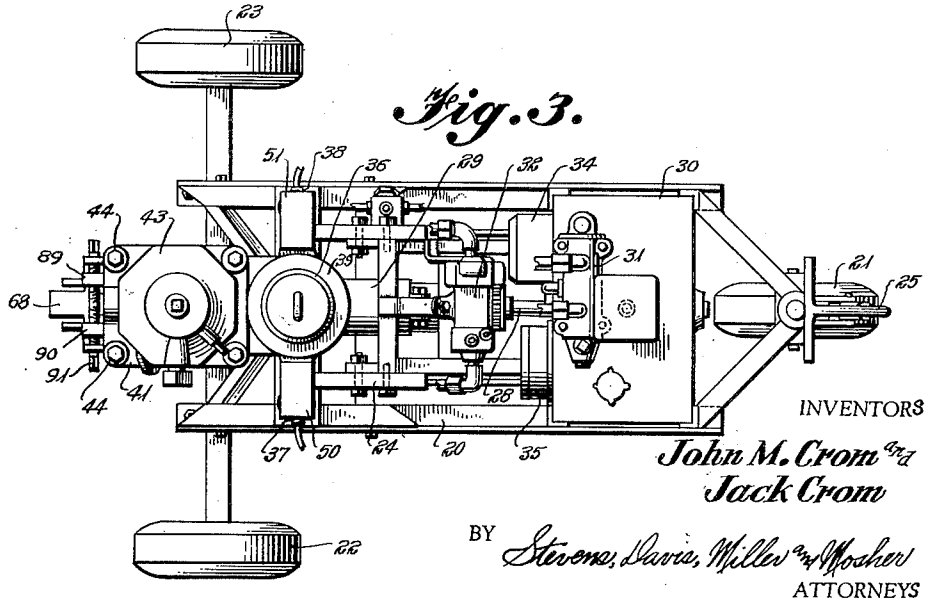


Fig. 3.



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METHOD AND APPARATUS FOR PRESTRESSING

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Fig. 4.

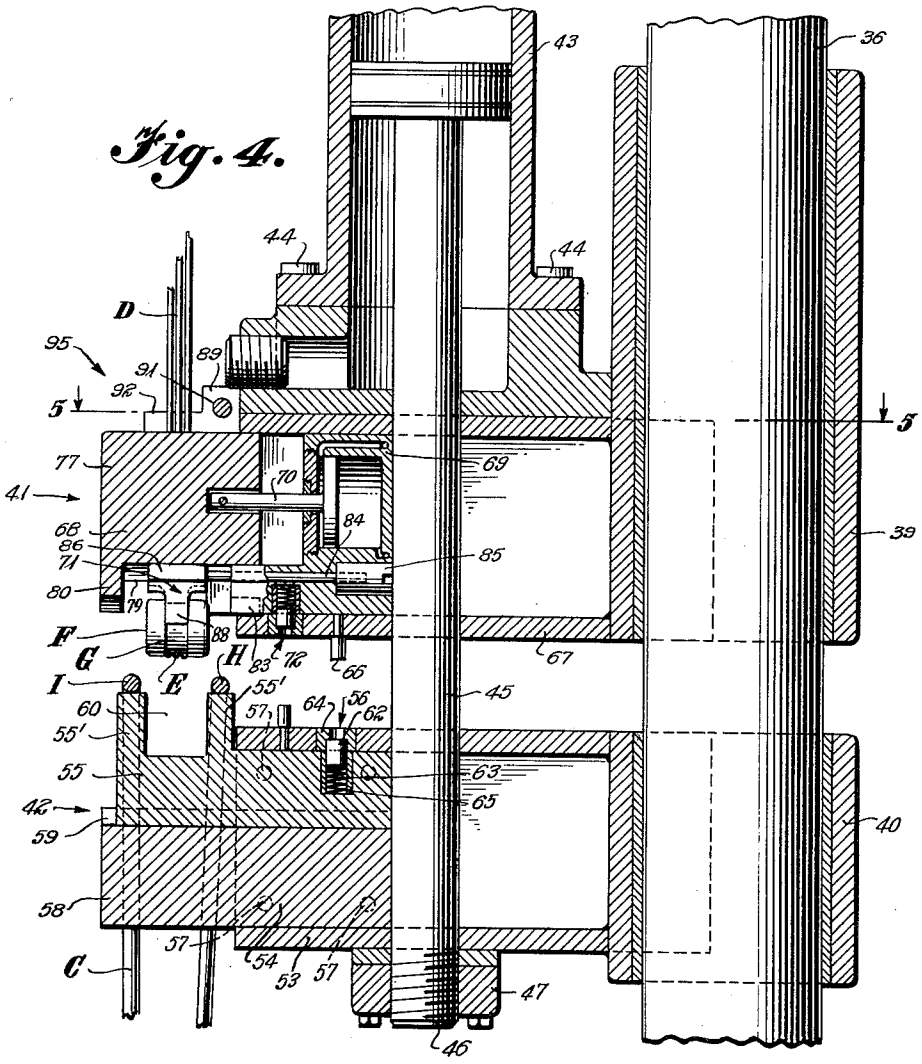
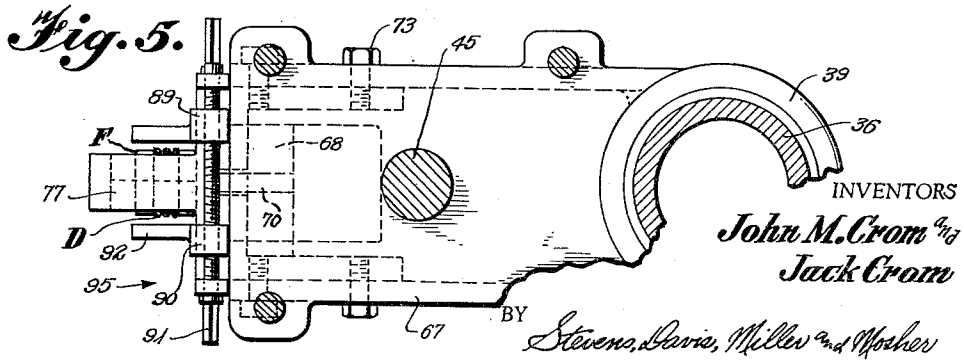


Fig. 5.



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METHOD AND APPARATUS FOR PRESTRESSING

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Fig. 6.

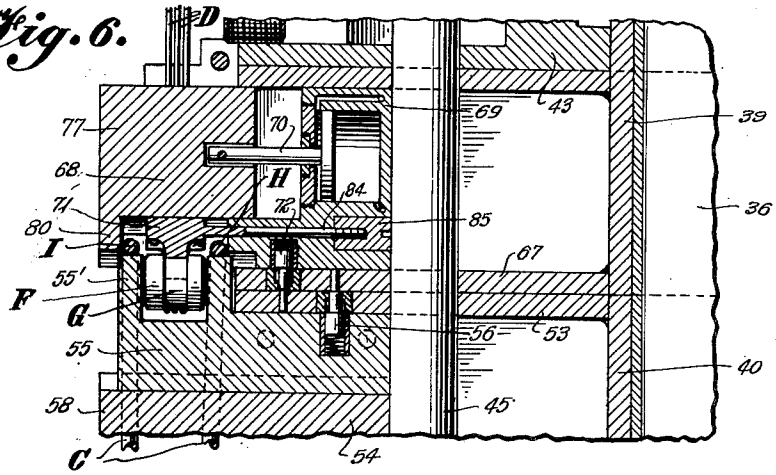


Fig. 7.

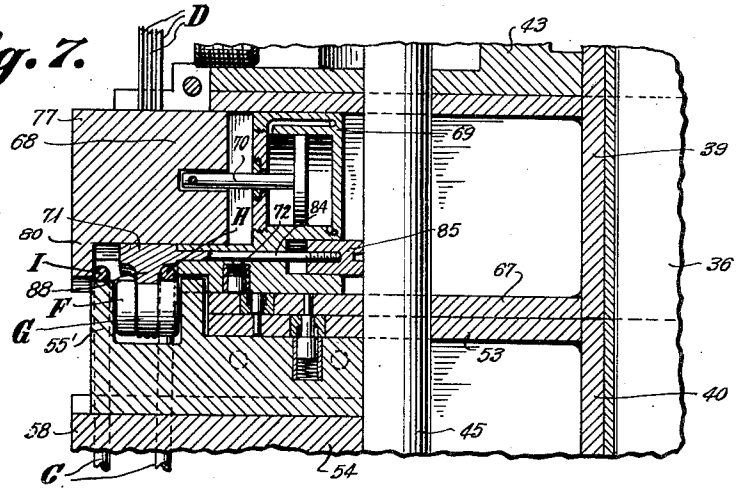
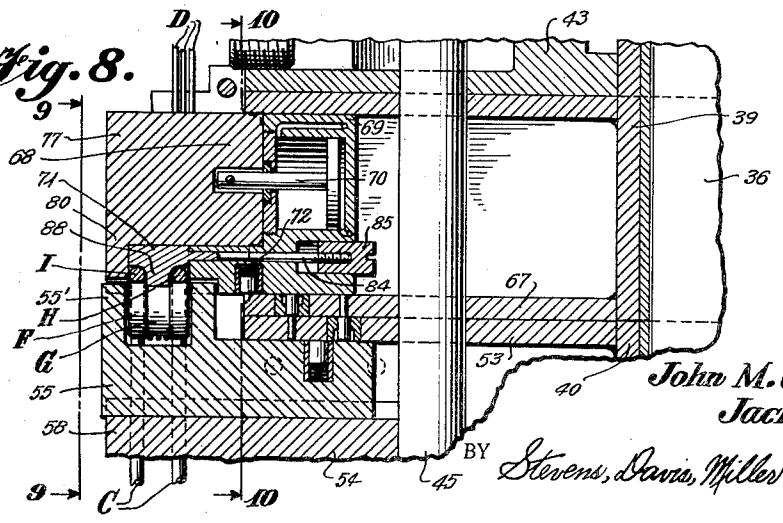


Fig. 8.



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Fig. 9.

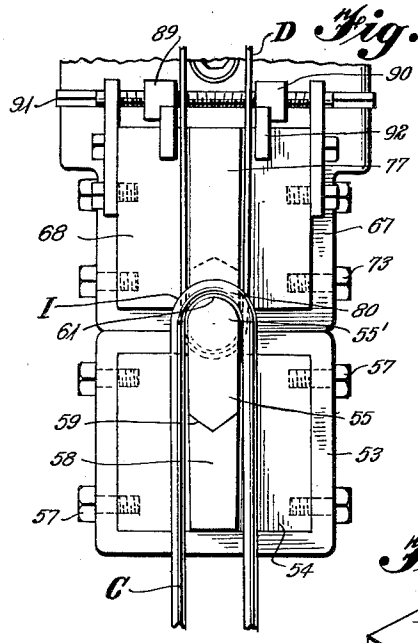


Fig. 10.

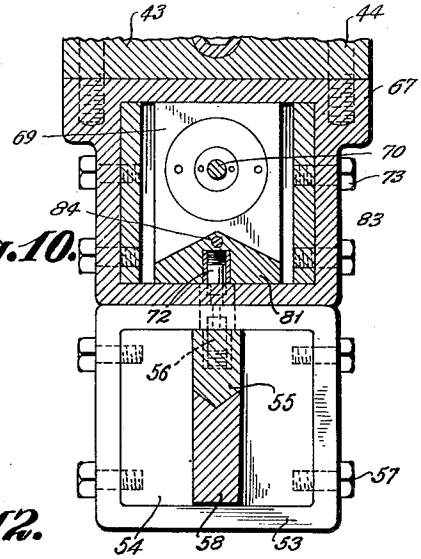


Fig. 12.

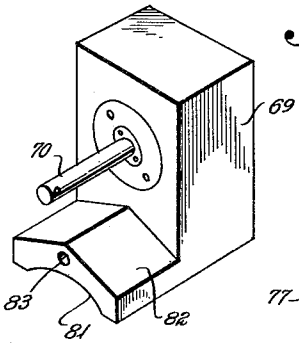


Fig. 13.

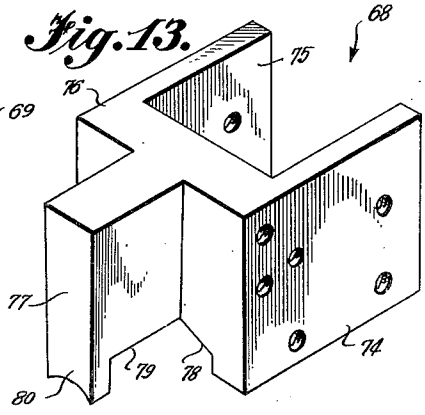


Fig. 11.

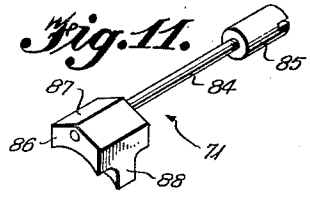
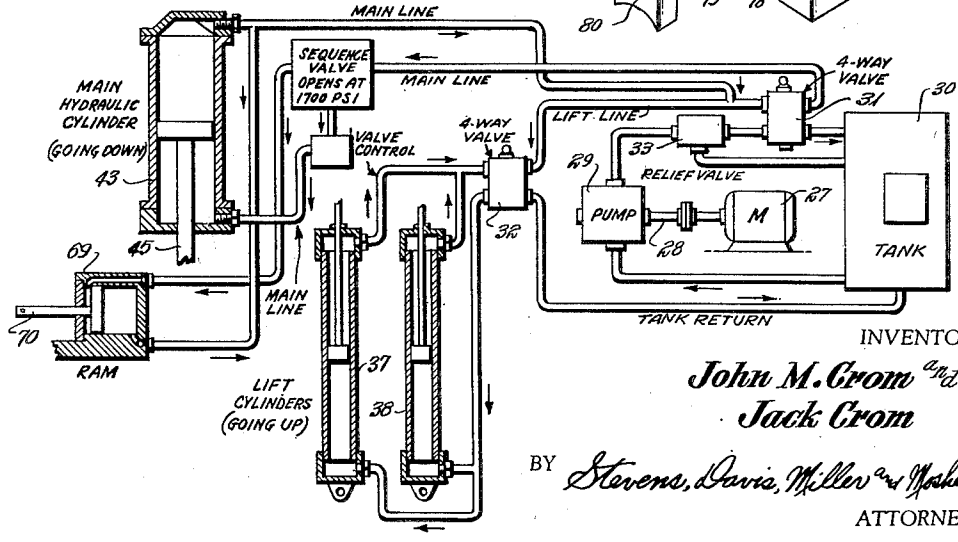


Fig. 14.



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Fig. 15.

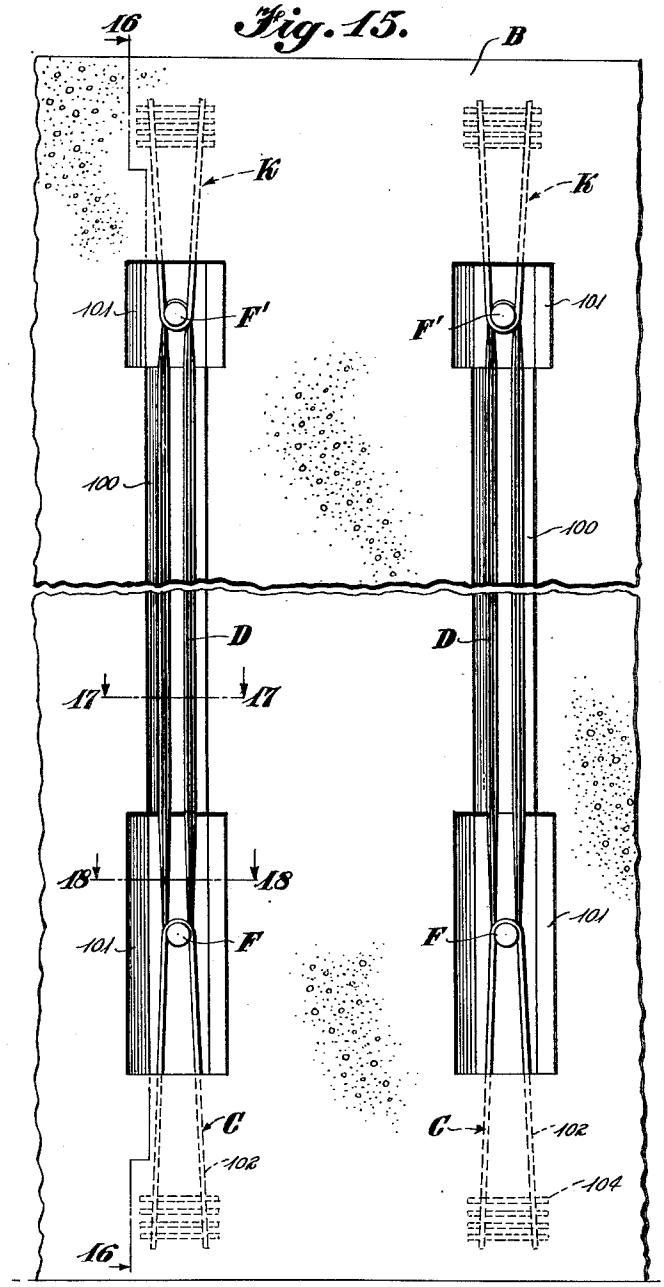


Fig. 16.

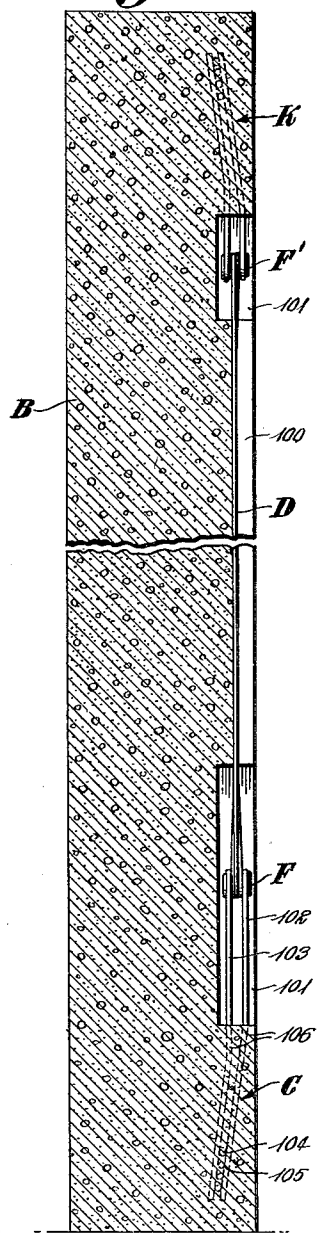


Fig. 17.

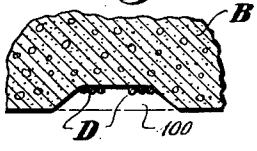
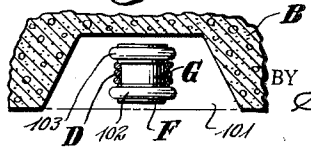


Fig. 18.



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METHOD AND APPARATUS FOR PRESTRESSING

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Application September 15, 1950, Serial No. 185,082

6 Claims. (Cl. 29—452)

This invention relates to a method for prestressing a concrete wall structure and a machine for effecting the prestressing thereof.

Heretofore in the art of prestressing much difficulty has been encountered in the fabrication of concrete structures which are adaptable to being prestressed in situ. Previous methods which have been advanced to solve this problem have not been fully successful for various reasons. One of these is the inability to produce anchor elements which could be sufficiently embedded in the concrete to withstand the strain of tensioned elements and be of such a nature that an efficient method of operation could be developed using them. Another is the troublesome prospect of designing and building a machine which could properly accomplish the work desired and also possess the qualities of maneuverability and portability. Yet another reason is the selection of the prestressed wall structure per se. The situation in this instance is one of devising a prestressed wall structure which will lend itself readily to an efficient and economical method and result in a structure as free as possible from undersirable bending moments.

It is an object of this invention to provide a method of prestressing a concrete wall structure in situ which is more efficient and economical than has heretofore been available.

It is another object of this invention to provide a machine for prestressing concrete wall structures in situ that is maneuverable, portable, and well adapted to an efficient and economical method for effecting the desired prestressing.

Other objects and advantages of the present invention will become apparent from a study of the following specification when considered in conjunction with the drawings, in which:

Figure 1 is a side elevation showing the machine in position;

Figure 2 is a front elevation of the machine;

Figure 3 is a plan view of the machine;

Figure 4 is a vertical section of Figure 2 along line 4—4;

Figure 5 is a horizontal section of Figure 4, along line 5—5;

Figure 6 is a view similar to Figure 4;

Figure 7 is a view similar to Figure 4;

Figure 8 is a view similar to Figure 4;

Figure 9 is a front elevation of the jaw assemblies;

Figure 10 is a vertical section of Figure 8 along line 10—10;

Figure 11 is a perspective view of the traversing support;

Figure 12 is a perspective view of the ram with the piston rod;

Figure 13 is a perspective view of the upper jaw block;

Figure 14 is a schematic view of the hydraulic system;

Figure 15 is a front elevation of the prestressed concrete wall structure;

Figure 16 is a vertical section of Figure 15 along line 16—16;

Figure 17 is a horizontal section of Figure 15 along line 17—17; and

Figure 18 is a horizontal section of Figure 15 along line 18—18.

Referring to the drawings, Figure 1 shows generally the manner in which a concrete wall structure is prestressed. The wall B is prepared for the operation of the machine A by embedding an anchor C in its lower portion and positioning a series of looped wire elements D in its upper portion. These elements D are held by an anchor similar to anchor C. The wire elements D do not extend sufficiently to be secured to the anchor C. The prestressing machine A is moved into the position shown in Figure 1 and subsequently operates to bring the looped ends E of the wire elements D down to the anchor C by means of coupling pin F. This will tension the wire elements D as they are anchored at their other end and consequently the concrete wall structure will become prestressed. This is broadly the way in which the components of this invention perform. A more detailed discussion of the several parts now follows.

Figures 1, 2 and 3 show in detail the machine A which is utilized to effect the prestressing of the concrete wall structure. The machine is constructed upon a carriage 20 which is mounted upon wheels 21, 22 and 23 for greater maneuverability. The carriage 20 supports a frame 24 which assists in holding the main components of the machine securely and provides stability. Attached to the carriage 20 at the rear wheel 21 is a handle 25. Fastened therewith is a brake 26 to act upon the front wheel 21 to prevent movement of the machine when in position.

At the rear of carriage 20 an electric motor 27 is provided which drives through shaft 28 a pump 29. The pump 29 serves to transmit the fluid in the hydraulic system as shown in Figure 14. Supported above the motor 27 on frame 24 is the hydraulic fluid tank 30, valves 31, 32 and 33, an electrical switch box 34, and a pressure gauge 35. The function of these elements will be considered more fully in conjunction with the hydraulic system.

At the front of carriage 20 is mounted a main guide tube 36 and hydraulic lift cylinders 37 and 38. The main guide tube 36 has mounted thereon for vertical movement an upper guide bearing 39 and a lower guide bearing 40. Welded to each guide bearing respectively is an upper jaw assembly 41 and a lower jaw assembly 42. A main hydraulic cylinder 43 is attached to the upper jaw assembly by means of bolts 44. The piston rod 45 of the main hydraulic cylinder 43 extends through both jaw assemblies and is threaded at its end 46 to receive a nut 47 which connects the rod 45 to bottom of the lower jaw assembly 42. The piston rods 48 and 49 of the hydraulic lift cylinders 37 and 38 are connected by means of linkage 50 and 51 and bolts 52 to the sides of lower guide bearing 40.

The upper jaw assembly 41 and lower jaw assembly 42 can be explained in greater detail when reference is had to Figures 4 and 5. The lower jaw assembly 42 consists of lower jaw housing 53, lower jaw block 54, bottom anchor engaging slide piece 55, and bottom anchor engaging slide piece lock 56.

The lower jaw block 54 fits into the lower jaw housing 53 and is held securely by means of bolts 57 through the sides of the housing 53. At the end of the lower jaw block 54 there is a protruding nose 58 which can be inserted between the loops on bottom anchor C. Riding on nose 58 in a V-groove 59 machined in the lower jaw block 54 is the sliding piece 55. This sliding piece 55 is held against movement by lock 56 and is split at 60 to allow the coupling pin F to travel downward until its top elevation is level with the top of the raised portions 55' of slide piece 55. The top 61 of the split portion 60 of the slide piece 55 is curved to the inside radius of the loops of the bottom anchors C as well as to the coupling pin F. As a result the coupling pin F, when brought down into alignment, matches the portion of the slide piece 55 machined away to form the split 60.

The bottom anchor engaging slide piece lock 56 consists of a spring urged pin 62, a spring 63, and hardened bushings 64 and 65. The lock is made to cooperate with a pressed fit pin 66 mounted on the upper jaw assembly 41 to release slide piece 55 when the jaw assemblies are brought together. When this occurs the pressed fit pin 66 on the upper jaw assembly projects into the hole in the hardened bushings 64 and 65 of the lower jaw assembly 42 pushing pin 62 downward until the top

of pin 62 is level with the top of slide piece 55 which is then free to move.

The upper jaw assembly 41 consists of upper jar housing 67, upper jaw block 68, ram 69, piston 70, anchor pin traversing support 71, and ram lock 72.

The upper jaw block 68 fits into the upper jaw housing 67 and is held securely by means of bolts 73 through the sides of the housing 67. The upper jaw block 68, shown in perspective in Figure 13, consists of two leg members 74 and 75, a cross member 76, and a plate 77. The cross member 76 is provided on its under surface 78 with an inverted V-shape as in the under surface 79 of plate 77. A lug 80 projects from plate 77 and serves as a limit stop.

Ram 69 and piston 70, shown in perspective in Figure 12, fit within upper jaw block 68. The piston 70 protrudes into plate 77 of upper jaw block 68 and is secured thereto by suitable means against movement. The ram 69 has a forward projection 81 which has an upper surface 82 of complementary design to surfaces 78 and 79 of upper jaw block 68 to permit the ram to slide forward. The projection 81 is also provided with a bore 83.

The anchor pin traversing support 71 shown in perspective in Figure 11 consists of rod 84 which fits into bore 83 of ram 69. The rod 84 is screw threaded at its end to receive a nut 85. At its other end, the traversing support 71 is provided with a head 86 having its upper surface 87 of complementary design to surface 79 of jaw block 68 to permit the traversing support 71 to slide forward. Depending from head 86 is a lug 88 which is adapted to fit the contour of coupling pin F.

Mounted on the top of jaw block 68 is a vise assembly 95 for the purpose of holding the wire loops D in place until tension can be brought to bear on them. The assembly consists of a pair of jaws 89 and 90 which run in or out by means of a threaded screw 91 which has a left hand thread for one half its length and a right hand thread for its other half. The screw 91 is free to slide laterally to insure even bearing pressure on both of the jaws 89 and 90. These jaws ride on the flat portion of upper jaw block 68 and have a gripping portion 92 which hooks over the top of the jaw block 68 to bear against plate 77.

The ram lock 72 is of the same construction as the slide piece lock 56 and cooperates with pressed fit pin 93 mounted on the lower jaw assembly 42 to release ram 69 when the jaw assemblies are brought together.

The hydraulic circuit shown in Figure 14 consists of hydraulic fluid tank 30, pump 29 driven through shaft 28 by motor 27, main four-way valve 31, relief valve 33, lift four-way valve 32, sequence valve, valve control, lift cylinders 37 and 38, ram 69, and main hydraulic cylinder 43.

To operate the lift cylinders the flow of the fluid is as follows. Starting at tank 30 the fluid passes through pump 29, relief valve 33, main four-way valve 31 and into the lift line to the lift four-way valve at which point the direction of lift cylinders 37 and 38 is determined. Figure 14 illustrates the path the fluid takes to cause the pistons of the lift cylinders to move upwardly thereby raising the lower jaw assembly. To bring the lower jaw assembly downward the flow is reversed by the lift four-way valve. The fluid then passes through the tank return line to the tank 30. It is important to note that the lift line leading from the main four-way valve is interconnected with the upper portion of the main hydraulic cylinder 43. By this arrangement, whenever the lift cylinders are moved upwardly the main cylinder will also move upwardly, raising the upper jaw assembly.

The operation of the main cylinder 43 and the ram 69 is as follows. The fluid is introduced into the main line leading to the sequence valve from the main four-way valve. It then passes through a control valve which allows free flow in this direction and into the lower portion of main cylinder 43 to cause downward movement, thereby lowering the upper jaw assembly. The fluid returns to the tank 30 by means of main line leading from the upper portion of main cylinder 43.

As the main cylinder moves down, pressure is built up in the circuit. When this pressure reaches a predetermined value, the sequence valve operates to put the ram 69 in parallel with the main hydraulic cylinder 43.

As has been previously pointed out, one side of the main line is interconnected with the lift line and consequently the lift cylinders may be operated with the main cylinder particularly when it is desired to raise them both together as is normally the case. In this situation the fluid enters the main cylinder at its upper portion and leaves at its lower portion to pass through the flow control valve on its way back to the tank. The flow control valve which allows free flow in the other direction is provided with a check to build up the pressure to about a fourth of the pressure required to lower the upper jaw assembly. The lift cylinders operate on this low pressure. If there were no check or resistance in this direction, the fluid beneath the piston in the main cylinder would have a free path back to the tank and could escape, causing a loss of all pressure in the system.

The operation of the machine is shown in Figures 1, 4, 6, 7 and 8. The machine A is rolled toward the tank wall B in line with the bottom anchor C so that the protruding nose 58 of lower jaw block 54 will pass between the loops H and I of the anchor C. The anchor C is then brought to bear against the raised portions 55' of slide piece 55 by raising the lower jaw assembly 42 by means of lift cylinders 37 and 38 until the anchor loops H and I straddle split 60 of slide piece 55 and bear tightly against raised portions 55'.

With the bottom anchor C engaged with the lower jaw assembly 42, the next step is to engage the depending wire loops D with the upper jaw assembly 41. It is to be noted at this point that the upper jaw assembly 41 has been raised by the action of the lift cylinders 37 and 38 on the lower jaw assembly 42 due to the hydraulic lock in the main hydraulic cylinder 43. This feature is important since the machine has automatically adjusted itself for the next step. The coupling pin F is seated in the traversing support 71 by fitting lug 88 into groove G in the coupling pin F. The loops of the wires D hanging down along tank wall B are also set in groove G of coupling pin F. The wires D are held in place by means of the vise assembly 95. The upper jaw assembly 41 is then brought down toward the lower jaw assembly 42 by operation of the main hydraulic cylinder 43 until all the slack has been taken from the wire loops D. When this condition has occurred the vise is released. The machine is then in the position as shown in Figure 4.

The main hydraulic cylinder 43 is again brought into operation to continue the downward movement of the upper jaw assembly 41 toward the lower jaw assembly 42, tensioning the wires D, until the upper jaw housing 67 strikes the lower jaw housing 53. At this point the coupling pin F has aligned itself with the split 60 of the slide piece 55 of lower jaw assembly 42, the loops H and I of bottom anchor C have become flush with the top of coupling pin F, and locks 56 and 72 holding slide piece 55 and ram 69, respectively, have been released to allow these parts freedom to move outwardly. The jaw assemblies of the machine are now in the position shown in Figure 6.

It should be noted that the fluid lines of the main hydraulic cylinder 43 and the ram 69-piston 70 assembly are in parallel. Consequently, whenever pressure exists in one, it will also exist in the other. Therefore, the piston 70 is under hydraulic pressure, developed by the main hydraulic cylinder 43 as it took the load of tensioning wires D. The coupling of the bottom anchor C to the coupling pin F will now commence automatically in the following manner.

With the locks 56 and 72 disengaged, ram 69 moves forward activated by the hydraulic pressure on piston 70. As the ram moves, it engages the rear loop H of the bottom anchor C and pushes it onto coupling pin F. The position of the parts at this time is shown in Figure 7. The ram 69 has now reached the traversing support 71, which has, previous to this time, remained stationary.

Further movement of ram 69 causes the traversing support 71 to be carried forward. Inasmuch as the coupling pin F is interlocked with the traversing support 71 by means of groove G and depending lug 88 as well as with slide piece 55 by means of raised portions 55', slide piece 55, coupling pin F, and rear loop H of the anchor C will also be carried forward. The front loop I of the bottom anchor C, however, is restrained from movement by limit stop lug 80 on upper jaw block 68. Therefore, as the ram 69, the traversing support 71, slide piece 55, and coupling pin F advance forward, the front anchor loop I remains stationary. The coupling pin F finally comes to rest under the front loop I. When this point has been reached, full coupling of the bottom anchor C

with wire loops D has been obtained. The machine is now in the position shown in Figure 8. Both upper and lower jaw assemblies 41 and 42 are then released from coupling pin F and removed.

The completed wall structure and anchoring detail are shown in Figures 15, 16, 17 and 18. The wall structure consists of the prepared wall B, bottom anchor C, top anchor K, wire loops D, and coupling pins F and F'.

The prepared wall B is constructed for concrete tanks by pouring the wall to full thickness in one operation. The anchors C and K are put in position prior to the pouring so that they will be amply embedded. During this construction wooden forms or the like are used to prepare the shallow vertical slots 100 in which wire loops D are placed. Notches 101 to provide access to anchors C and K are simliarly fashioned. At the conclusion of the wire stressing operation the slots 100 and notches 101 are filled with gunite until the wall surface is even and smooth. The gunite covering protects the wire loops D and anchors C and K from weathering and corrosion. The term "gunite" is a name commonly applied to pneumatically projected concrete, the dry ingredients of which are mixed with water in a nozzle and projected by air pressure onto a surface to be covered. Insofar as we are aware, the term "gunite" is not a trade name.

In the case of gunite tanks, the wall B is built by shooting successive layers of gunite against a form wall, usually from the inside of the tank wall. The wall is built up to not quite full thickness. The anchors can be fixed to the wall forms initially to assure proper spacing, and distance apart from top to bottom. With the wall built up to not quite full thickness, the gunite is generally flush with the outer loop of the anchors. It is, therefore, necessary to remove a portion of the fresh gunite in the vicinity of the anchors in order that the proper clearance will be available for access of the stressing machine to operate upon the bottom anchor, and for the coupling pin to be placed in the upper anchor. After the wires have been placed and stressed, a final gunite coating is applied over the entire wall area building up the thickness of the wall to final amount desired. A tank with gunite walls, therefore, does not require vertical slots for the wire loops. However, there must be the usual clearance at the top and bottom anchors.

Bottom anchor C consists of two loops 102 and 103 formed from a suitable material such as high strength rod stock. The loops are flash welded to struts 104 as at 105 to provide space between the loops and bent at 106. Spacing and bending the loops provides resistance against the anchor pulling free from the concrete.

Top anchor K is of the same construction as bottom anchor C except that it is made shorter. The extra length in the bottom anchor is necessary to allow the lower jaw of the stressing machine to enter between the loops.

The coupling pins F and F' which are used to interlock the wire loops D with the anchors C and K consist of short cylindrical pieces. The pin F used for the bottom anchor C should be carefully finished as it is a working part of the stressing machine during its operation. In the center of the bottom pin F a groove G is formed. This groove G has a function in operation of the pin F in the stressing machine as has previously been explained. In addition the groove G also furnishes a seat for the retention of the wire loops D.

The wire loops D are formed in the following manner. The wire is first passed through a straightening device. Thereafter the wire is formed into three loops and the ends are spliced together. The loops are then placed in a suitable apparatus and stretched between two pins. This may be accomplished by means of a hydraulic jacking arrangement. The pins are of such a size as to give radii to the loop ends that will produce optimum results when the wire loops are stressed.

The wire loops D may then be used directly or they may be further prepared for shipment or storage by taping the loops together at several points to keep the loops intact and to prevent tangling.

While this invention has been illustrated with regard to a concrete tank wall it is nevertheless to be understood that it is also applicable to the construction of improved concrete structures such as floors, walls, beams, pilings, roads, etc.

In addition to concrete structures, the method of this invention is suitable and well adapted to producing stronger metallic structures such as beams and the like.

What have been described heretofore are specific embodiments of the present invention. Other and further embodiments, as well as various modifications obvious from this description to one skilled in the art, are within the contemplation and spirit of this invention.

What is claimed is:

1. A method of tensioning wire-like reinforcing material for concrete objects and the like that comprises positioning said reinforcing material with respect to the object to be reinforced so that it forms two aligned portions terminating near each other in loops, the opposite ends of said portions being anchored to the objects, one portion having at least two loops and the other portion having at least one loop, taking a spool capable of passing through all of said loops to lock said portions together, said portions being of such length and so fixed to the object to be reinforced that they will be under the desired tension when so locked, placing the spool in the loop of the portion having at least one loop, forcing the spool toward the portion having at least two loops, forcing the two loops around the opposite ends of the spool by pressure upon the inside of each of said loops and thereafter pressing said two loops together onto the ends of said spool so that the tension can be maintained by the spool.

2. A method of tensioning reinforcing material as defined in claim 1 in which the object to be reinforced is the wall of a concrete tank and in which the two portions of reinforcing are arranged in a generally vertical direction, and at least one of said portions of reinforcing material is fixed in position by being partially imbedded in the concrete tank wall.

3. A method of tensioning reinforcing material as defined in claim 1 in which the object to be reinforced is a concrete tank wall and the aligned portions of reinforcing material are arranged in a generally vertical direction with one of the portions of reinforcing material partially imbedded in the concrete of the tank wall to position it and with the other portion of reinforcing material fixed to an anchor that is partially imbedded in the tank wall so as to fix the position of that portion of the reinforcing material.

4. A method of tensioning reinforcing material as defined in claim 1 in which the object to be reinforced is concrete and in which one portion of the reinforcing material is connected to a third portion of reinforcing material by a spool in the same general manner as the first two portions of the reinforcing material are connected together.

5. Apparatus for tensioning wire-like reinforcing material in concrete objects and the like, which reinforcing material is formed and positioned with respect to the object to be reinforced so that it forms two aligned portions terminating near each other in loops, one portion having at least two loops and the other portion having at least one loop, and in which a spool is adapted to pass through all of said loops to lock said portions of reinforcing material together, said portions being of such length and so fixed to the object to be reinforced that they will be under the desired tension when so locked, said apparatus comprising a supporting carriage, a spool-holding member mounted on said carriage, a bifurcated loop-holding member arranged to hold the two loops of the portion of reinforcing having two loops, and to hold said loops in spaced-apart position, means connected to said spool-holding member and said loop-holding member for forcing said members together to position the spool held by the spool-holding member between the loops held by the loop-holding member, and means mounted on one of said holding members for forcing said loops together upon the ends of said spool after tension has been applied.

6. Apparatus as defined in claim 5 that includes hydraulically operated means to force the spool-holding member and the loop-holding member together so as to force the loops into positions opposite the ends of the spool, and also includes a hydraulically operated means mounted on one of said holding members and arranged to push the loops of reinforcing off of the bifurcated holding member and onto the spool.

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