

Sept. 12, 1967

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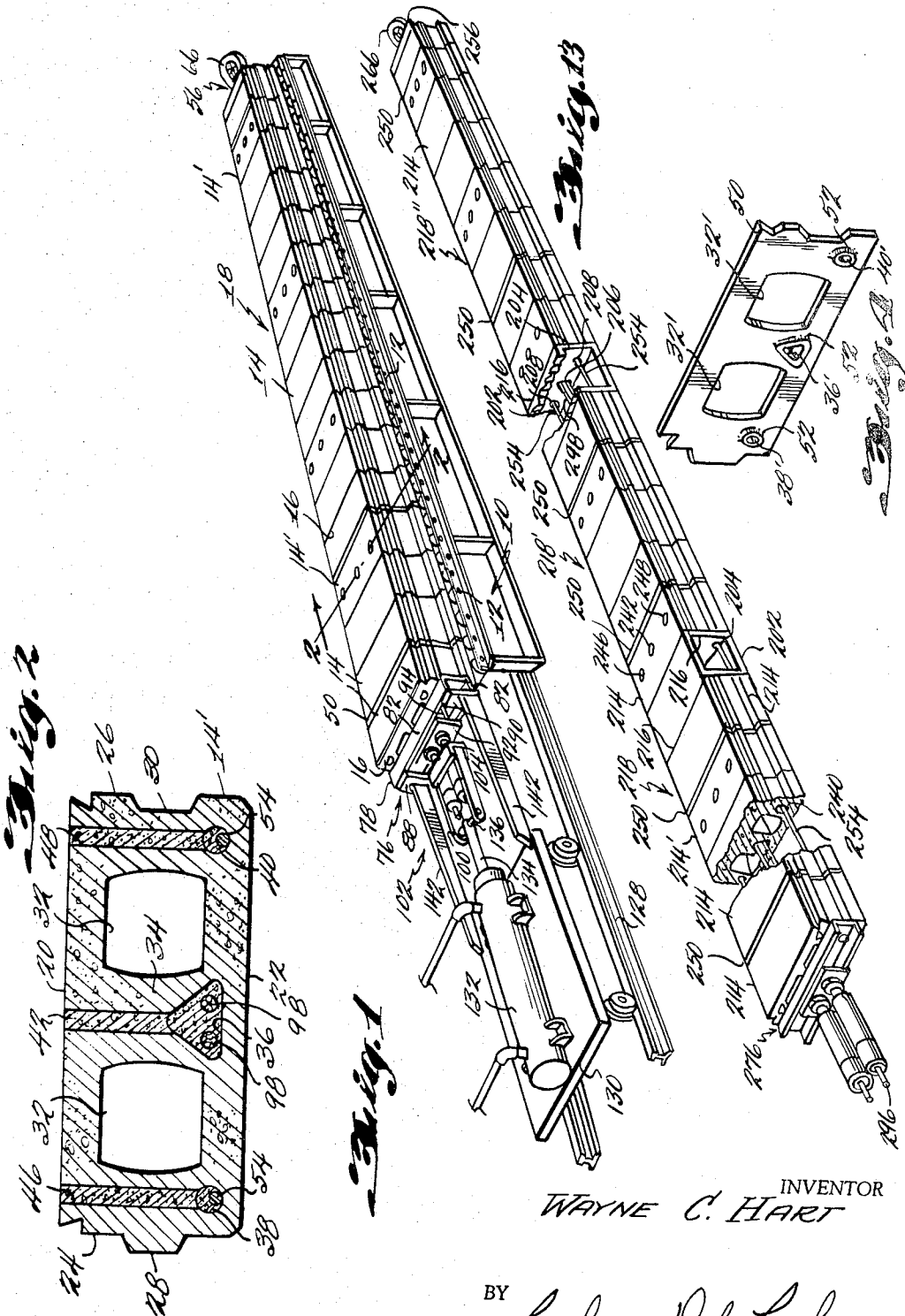
3,341,176

APPARATUS FOR IMPORTING TENSION TO A REINFORCING CABLE

OF U-SHAPED CONFIGURATION

Original Filed Jan. 22, 1964

5 Sheets-Sheet 1



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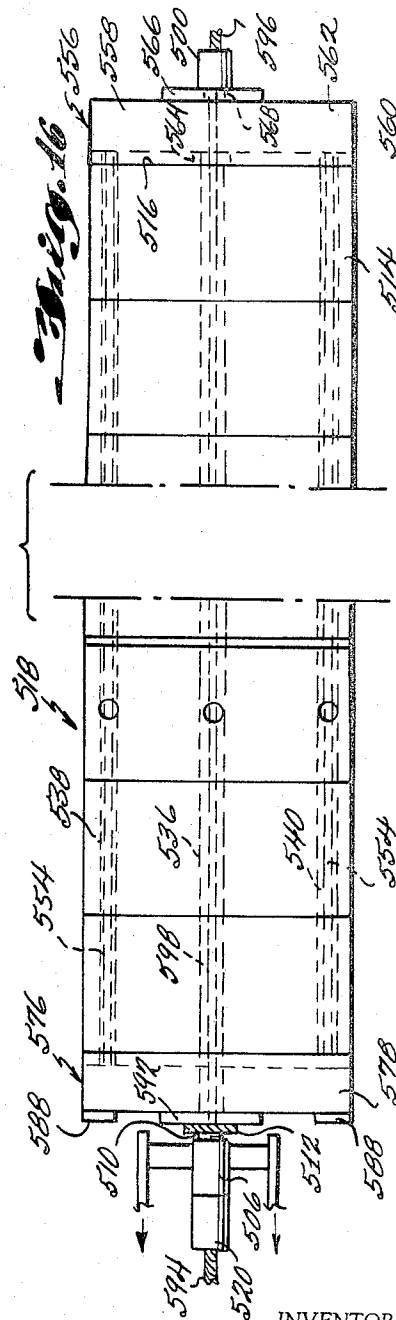
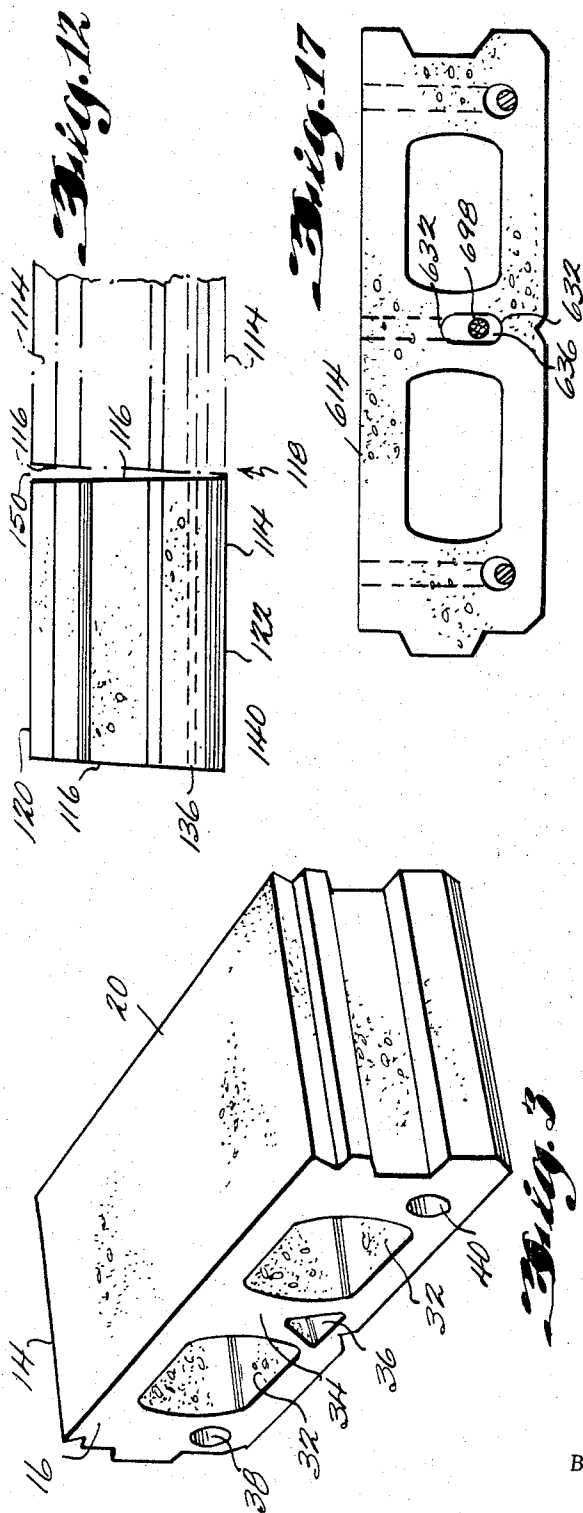
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5 Sheets-Sheet 2



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5 Sheets-Sheet 3

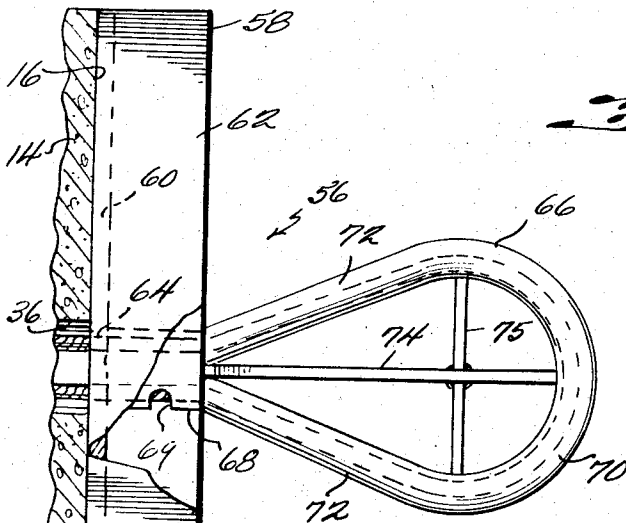


Fig. 5

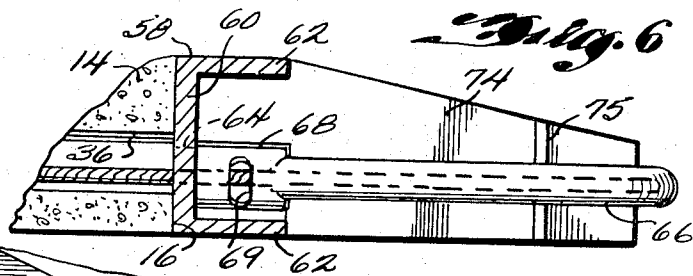


Fig. 6

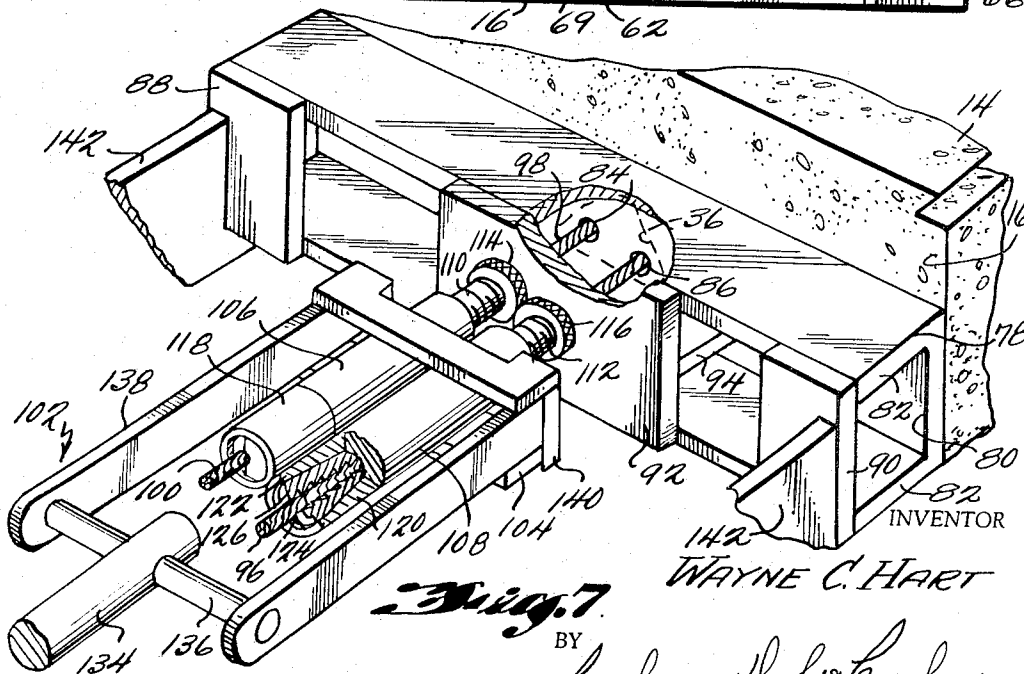


Fig. 7

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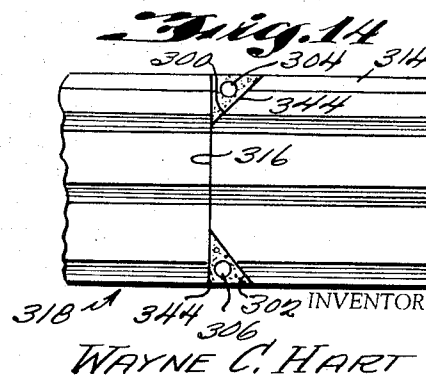
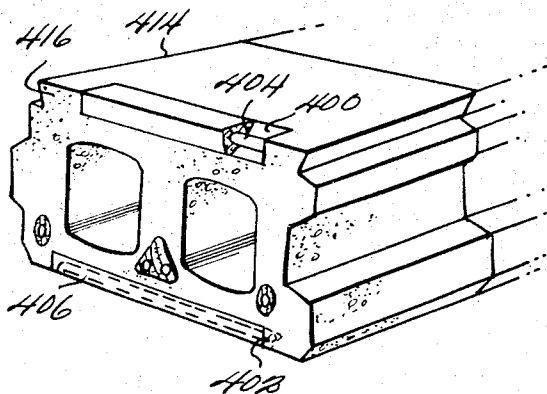
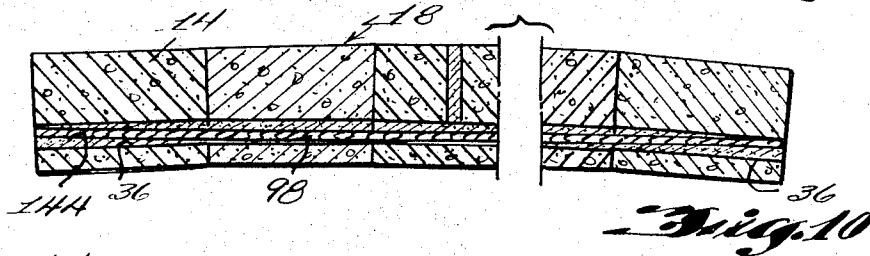
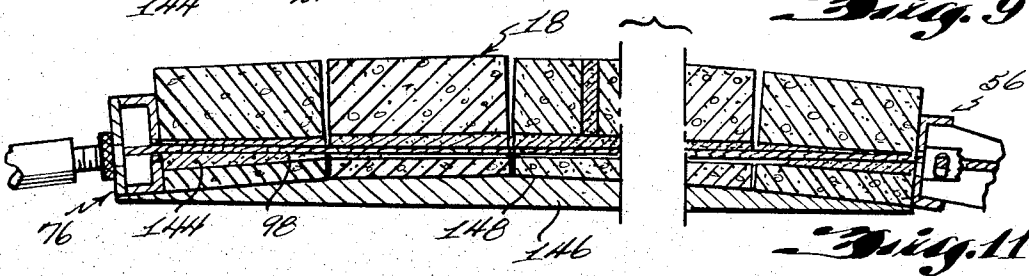
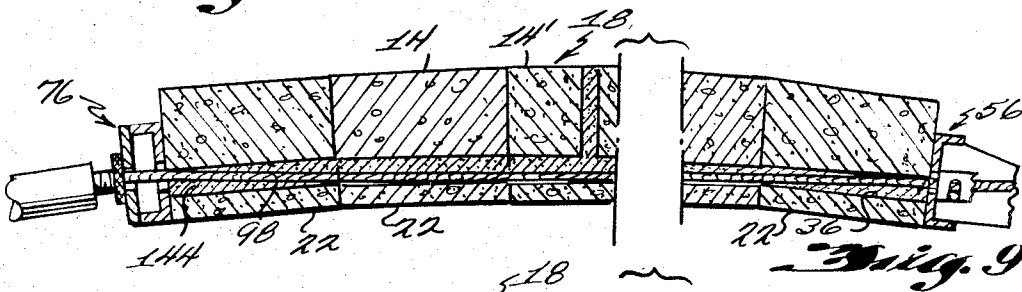
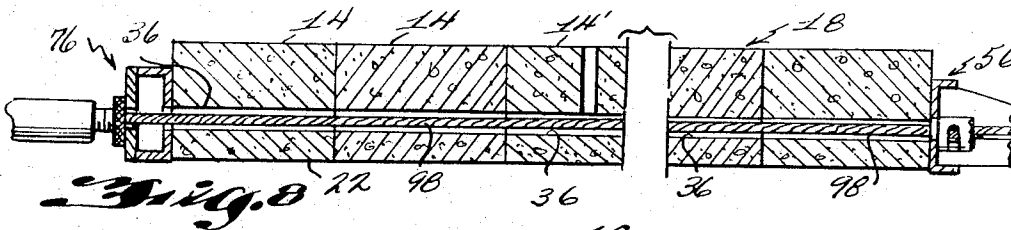
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5 Sheets-Sheet 4



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5 Sheets-Sheet 5

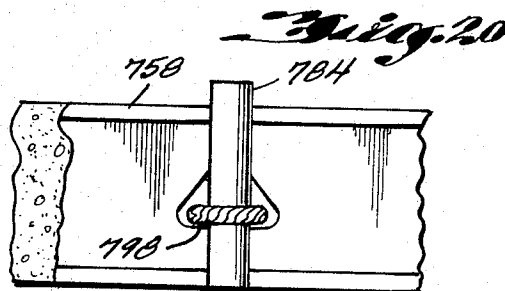
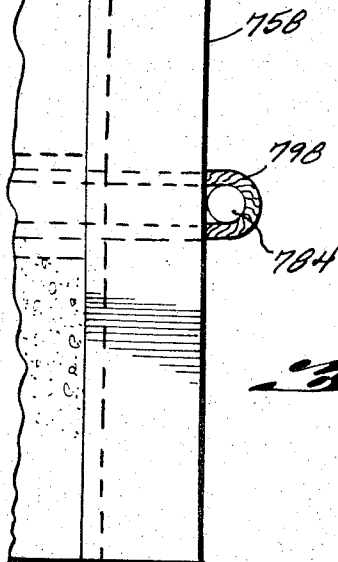
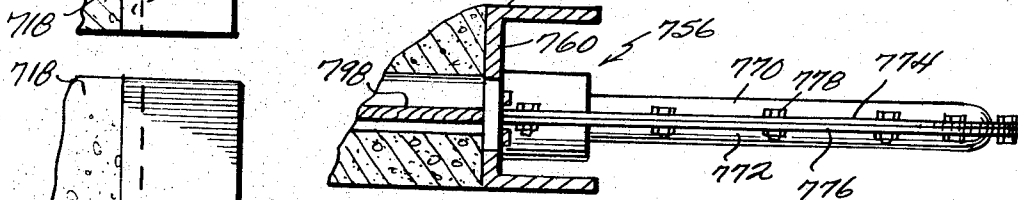
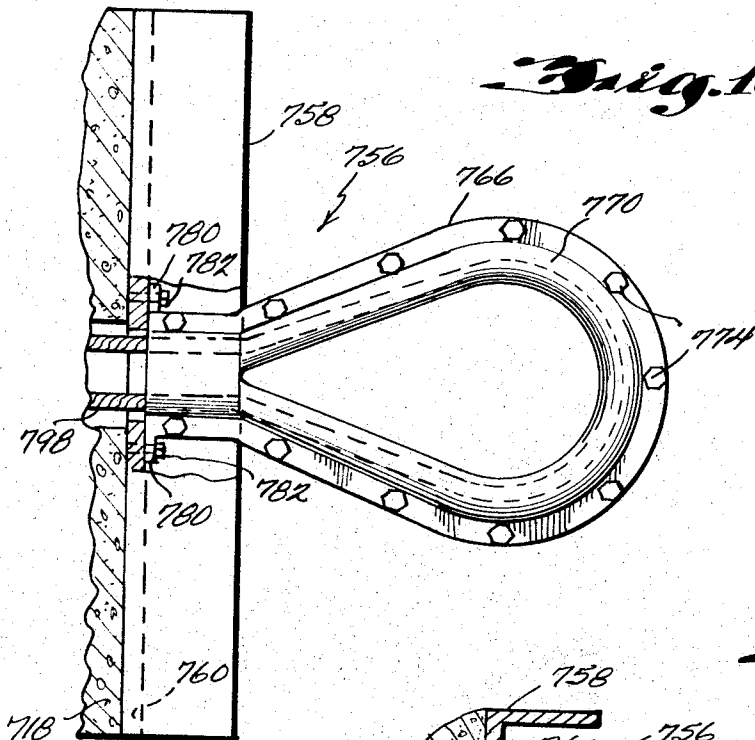


Fig. 21

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3,341,176

APPARATUS FOR IMPARTING TENSION TO A REINFORCING CABLE OF U-SHAPED CONFIGURATION

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Original application Jan. 22, 1964, Ser. No. 339,506, now Patent No. 3,283,457, dated Nov. 8, 1966. Divided and this application June 2, 1966, Ser. No. 567,026

1 Claim. (Cl. 254—29)

This is a division of application Ser. No. 339,506 filed Jan. 22, 1964, now Patent No. 3,283,457.

The present invention relates generally to prestressed concrete and, more particularly to a new and improved method and apparatus for forming prestressed concrete slabs or planks, as well as a new and improved prestressed concrete plank construction.

There is disclosed in the patent to Vander Heyden, No. 2,696,729, a method of forming concrete slabs wherein reinforcing rods are carried in aligned, opposed channels or passages in a plurality of concrete blocks. The blocks are placed under temporary compression by tensioning a clamping rod extending through aligned openings in the plurality of blocks and the channels containing the reinforcing rods are filled with grout along this stressed row of blocks, and the grout is allowed to set while the clamping rod is maintained under temporary tension. After the grout has set so as to bond the reinforcing rods to the blocks, the tension on the clamping rod is released and the clamping rod removed to thereby transfer the tension to the bonded reinforcing rods and complete the reinforced slab construction.

Likewise, means for introducing grout under pressure in these opposed longitudinal channels or passages from the ends of the row are taught in the patent to Carper No. 2,897,570. While such prior art method and means for forming concrete slabs have enjoyed varying degrees of success, such a teaching necessarily is tedious, expensive and time consuming, requiring excessive clamping rod handling and storage facilities.

Remembering that the degree or portion of the initial prestress of a concrete plank is lost due to plastic flow, creep stress and the like, the above described prior art provisions for forming a prestressed plank of preformed concrete blocks necessarily provide on a nominal degree of prestressing. When the only stress placed on the plank is by the tension elements, which is retained after the initial compression of the plank is relieved, the resulting degree of prestress is inherently relatively small.

In addition, because of the relatively low tensile strength of the mild steel bar or rod stock employed as reinforcing elements in the prior art, it was frequently necessary to employ numerous relatively expensive, relatively large diameter rods in order to obtain the desired amount or degree of prestress in the finished concrete plank. Moreover, the time consuming arrangement of such relatively expensive rods within the plank further increased the costs of manufacture.

Additionally, prior reinforced concrete plank constructions frequently have resulted in undesirable stress patterns and concentrations which caused splitting or cracking of the finished concrete plank.

Also, the rods in the row of blocks in this prior art are clamped at both ends of the row to impart tension thereto, resulting in additional time-consuming assembly requirements.

According to this invention, the shortcomings of the prior art are obviated by initially compressively stressing a preformed row of concrete blocks by imparting tension to one or more lengths of cable passed through the row

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of blocks. As will be more fully described hereinafter, the reaction force resulting from such tensioning of the cable will place the plank formed from these aligned blocks under the desired compressive stress. By virtue of this, a notably superior prestressed concrete plank is provided which does not rely on relaxing a compressed row of blocks as the sole means for imparting a prestress to the plank via tension rods.

This invention generally contemplates prestressed concrete planks formed from a plurality of specially constructed concrete blocks, each having centrally located apertures or holes which, when aligned, define a longitudinally extending cable receiving passage wherein one or more lengths of cable are passed through the passage from end to end of the block row and then tensioned so as to place the row of blocks under compression. Preferably, each of the concrete blocks is additionally provided with laterally spaced opposed holes which, when the blocks are aligned, define laterally spaced longitudinally extending opposed passages wherein reinforcing members such as steel rods are disposed. Thereafter the cable containing passage and the reinforcing member containing passages are filled with grout which is allowed to set while the cable is maintained under tension. Most desirably, certain spaced apart blocks along the row have transverse passages communicating with the longitudinal passages so as to receive grout under pressure along the length of the block row, from a suitable apparatus. To this end, a novel cable guide and tensioning arrangement are provided to temporarily stress the cable.

Accordingly, a principal object of the present invention is to provide a new and improved prestressed concrete plank construction.

An additional object of the present invention is to provide a new and improved method of making a prestressed concrete plank embodying my novel construction.

A further object of the present invention is to provide a new and improved apparatus for making a prestressed concrete plank embodying my novel construction.

A further object of the present invention is to provide an improved prestressed concrete plank construction having the desired degree of prestress without the necessity of employing relatively expensive and numerous relatively large diameter reinforcing rods.

A still further object of the present invention is to provide a new and improved method of making a prestressed concrete plank from a plurality of aligned concrete blocks which is relatively inexpensive and eliminates the need for employing separate clamping rods or the like to apply temporary initial compressive stress to the aligned blocks.

An additional object of the present invention is to provide a new and improved prestressed concrete plank construction comprising a plurality of aligned preformed concrete blocks having a transversely centered longitudinally extending passage wherein prestressed cable portions are positioned within the passage so as to provide the plank with enhanced load carrying capabilities.

Another object of the present invention is to provide a new and improved prestressed concrete plank construction comprising a plurality of aligned preformed concrete blocks having a transversely centered longitudinally extending passage wherein a prestressed cable is positioned within the passage in a generally parabolic or arcuate curve to provide the plank with enhanced load carrying capabilities.

A further object of the present invention is to provide a novel method of making a new and improved prestressed concrete plank construction comprising a plurality of aligned preformed concrete blocks having a transversely centered longitudinally extending passage wherein a prestressed cable is positioned within the passage in a gen-

erally parabolic or arcuate curve to provide the plank with enhanced load carrying capabilities.

Another object of the present invention is to provide a new and improved prestressed concrete plank construction which eliminates splitting or cracking of the plank resulting from undesirable stress concentrations.

A still further object of the present invention is to provide a new and improved concrete plank construction formed of individual preformed concrete blocks having a longitudinally extending passage carrying a tensioned cable and including means at each end of the plank to prevent the longitudinal cracking occasioned by localized compressive stress on the plank due to the tensioned cable.

Other objects and advantages of the invention will become apparent from the following description and accompanying drawings in which:

FIGURE 1 is a perspective view showing the prestressing of a concrete plank according to this invention;

FIGURE 2 is a sectional view taken along the line 2—2 of FIGURE 1;

FIGURE 3 is a perspective view of a concrete block employed in forming a prestressed concrete plank according to the present invention;

FIGURE 4 is a perspective view of a tie plate which is employed in the prestressed concrete plank shown in FIGURE 1;

FIGURE 5 is a plan view, partly in section, of the rear cable guide assembly employed in the prestressing of the concrete plank shown in FIGURE 1;

FIGURE 6 is a side view, partly in section, of the rear cable guide assembly shown in FIGURE 5;

FIGURE 7 is an enlarged perspective view of the front cable guide assembly and tensioning means employed in the prestressing of the concrete plank shown in FIGURE 1;

FIGURE 8 is a longitudinal sectional view of the concrete plank shown in FIGURE 1 prior to prestressing;

FIGURE 9 is a longitudinal sectional view of the concrete plank shown in FIGURE 1 after prestressing and grouting;

FIGURE 10 is a longitudinal sectional view of the prestressed concrete plank shown in FIGURE 9 after the grout has set and the front and rear cable guide assemblies have been removed;

FIGURE 11 is a longitudinal sectional view showing a modified form of the present invention;

FIGURE 12 is a side view showing another modified form of the present invention;

FIGURE 13 is a perspective view, partly in section, illustrating still another modified form of the present invention;

FIGURE 14 is a side view showing a further modified form of the present invention;

FIGURE 15 is a perspective view, partly in section, showing another modified form of the present invention;

FIGURE 16 is a plan view showing a still further modified form of the present invention;

FIGURE 17 is an end view of another modified form of the present invention;

FIGURE 18 is a plan view, partly in section, of a modified rear cable guide assembly employed in forming a prestressed concrete plank according to the present invention;

FIGURE 19 is a side view, partly in section, of the modification shown in FIGURE 18;

FIGURE 20 is an end view showing a modified means for anchoring the closed end of the cable during tensioning when the modification illustrated in FIGURES 18 and 19 is employed; and

FIGURE 21 is a plan view of the modification shown in FIGURE 20.

Referring now to FIGURE 1 of the drawings there is shown a stationary conveyor assembly 10 including a plurality of transversely extending, longitudinally spaced apart rotatably mounted rollers 12. A plurality of sub-

stantially identical preformed concrete blocks 14 are arranged with their end faces 16 abutting and in aligned relationship on the rollers 12 according to the length of the slab or plank 18 to be formed.

As best seen in FIGURES 2 and 3, each block 14, which is made of suitable cementitious material, is generally rectangular in shape and includes substantially flat and parallel upper and lower faces 20 and 22, respectively, substantially parallel end faces 16 and side faces 24 and 26 provided with suitable tongue and groove formations 28 and 30, respectively. Preferably, each block 14 is provided with two transversely spaced enlarged passages 32 extending through the block from one side face 16 to the other and separated by a transversely centered vertically extending web portion 34. The enlarged passages 32 not only reduce the weight of the finished plank, but also define longitudinally extending passages for receiving electric conduits, heating ducts and the like having obvious utility where the formed planks are to be used in floor construction. In addition, each block 14 will be seen to be provided, adjacent the lower face thereof, with a transversely centered aperture 36 and laterally located apertures 38 and 40 spaced transversely on either side of the central aperture 36. Each of the apertures 36, 38 and 40 extends through the block 14 from one side face to the other and is adapted to register with a corresponding aperture in adjacent blocks when arranged in plank forming alignment so as to define generally parallel, longitudinally extending passages. Preferably, the central aperture 36 is of a generally triangular configuration in cross section while the laterally located apertures 38 and 40 are of a substantially circular configuration in cross section, as best seen in FIGURES 2 and 3.

Certain spaced apart blocks 14' (FIGURES 1 and 2) have vertical passages 42, 46 and 48 extending from the upper face 20 of the block 14' and communicating with the apertures 36, 38 and 40, respectively, for reasons to be more fully described hereinafter.

If desired, tie plates 50 can be interposed between each endmost pair of blocks 14 in order to provide the finished plank with enhanced resistance to longitudinal cracking. The tie plates 50, which are preferably of sheet metal construction, have a pair of enlarged openings 32' and smaller openings 36', 38' and 40' corresponding to, and adapted to register with, the enlarged passages 32 and apertures 36, 38 and 40, respectively, in the adjacent blocks 14. The tie plates 50 may also be provided with raised boss portions 52 surrounding the openings 36', 38' and 40'.

After the blocks 14 are arranged in plank forming alignment, as shown in FIGURE 1, a rod member 54, having a length substantially corresponding to the length of the plank 18 to be formed, is positioned in each of the passages defined by the aligned laterally located apertures 38 and 40. Each rod member 54, which is preferably a steel reinforcing rod, is of a diameter substantially less than the diameter of the passage in which it is received in order to provide a grout receiving space.

As best seen in FIGURES 1, 5 and 6, a rear cable guide assembly 56 is positioned adjacent the outwardly facing end face 16 of the rear endmost block 14 at one end of the row of blocks. The rear cable guide assembly 56 generally includes a rear channel-shaped abutment member 58 having a substantially flat web portion 60 connecting the spaced flanges 62. The flat web portion 60 is provided with an aperture 64 adapted to register with the central aperture 36 in the rear endmost block 14 when the member 58 operatively abuts the outwardly facing end face 16 of the block. A tubular cable looping member 66, having the general form of a closed loop when viewed in plan, is mounted on the outwardly facing surface of the web portion 60 in alignment with the aperture 64 so as to be in operative cable receiving communication with the passage defined by the central apertures 36 in the blocks 14. The tubular cable looping member

66 includes a substantially straight, common tubular portion 68 extending perpendicularly outward of the web portion 60 and having a laterally disposed cable access aperture 69 and a tubular loop portion 70. The tubular loop portion 70, as best seen in FIGURE 5, includes two tubular branch portions 72 in communication with the bore of tubular portion 68 which, as they extend outwardly thereof, initially diverge and then arcuately converge to meet at their outermost extent and thereby form a closed tubular loop. The tubular cable looping member 66 will thus be seen to define a closed loop-like tubular passage in communication with the passage defined by the central apertures 36 in the blocks 14. Preferably, the cable looping member 66 is provided with strut members 74 and 75 to provide enhanced structural support, as will be readily appreciated.

If desired, the web portion 60 of the channel-shaped abutment member 58 may be provided with two additional apertures (not shown) transversely spaced so as to register with the laterally located apertures 38 and 40 in the block 14 to thereby permit introduction of the rod members 54 after operatively positioning cable guide assembly 56.

A front cable guide assembly 76 is positioned adjacent the outwardly facing end face 16 of the foremost block 14 of the row, preferably adjacent an end of the conveyor 10, as best illustrated in FIGURES 1 and 7. The front cable guide assembly 76 includes a channel-shaped front abutment member 78 having a substantially flat web portion 80 connecting the spaced flanges 82. The flat web portion 80 is provided with closely spaced apertures 84 and 86 adapted to register with the adjacent central aperture 36 in the foremost block 14 when the member 78 operatively abuts the outwardly facing end face 16 of the block. Alternatively, instead of the two spaced apertures 84 and 86, a single, somewhat larger aperture (not shown), adapted to register with the central aperture 36, may be provided in the web portion 80. A pair of transversely spaced vertically extending plates 88 and 90 abut the outwardly facing edges of the flanges 82 of the channel-shaped member 78. Preferably, the plates 88 and 90 are joined to the channel-shaped member 78 by welding or the like. Also abutting the outwardly facing edges of the flanges 82 of the channel-shaped member 78, intermediate the ends thereof, is a vertically extending plate member 92 having apertures (not shown) axially aligned with the apertures 84 and 86 in the web portion 80. Preferably the plate 92 is joined to the channel-shaped member by welding or the like. The plate 92 is preferably reinforced by a horizontally extending plate 94, as best seen in FIGURE 7.

With the front cable guide assembly 76, the blocks 14, the tie plates 50, and the rear cable guide assembly 56 positioned as shown and described, the leading end 96 of a cable 98, preferably steel, is passed through one of the apertures in the plate member 92 and the corresponding aligned aperture, such as 84, in the front abutment member 78, through the longitudinal passage defined by the central apertures 36 in the blocks 14, through the aperture 64 in the rear abutment member 38 and into the common tubular portion 68 of the tubular cable looping member 66. Continued longitudinal feeding of the cable 98 will cause the leading end 96 to pass into one of the tubular branch portions 72 where it will be guided in a generally U-shaped path to form a loop and enter the other tubular branch portion 72 and thence return through the common tubular portion 68, the aperture 64, and the passage defined by the central apertures 36 in the blocks 14 until the leading end 96 emerges from the other aperture 86 in the front abutment member 78 so that the opposed leading end 96 and trailing end 100 extend through and outwardly beyond the vertically extending plate 92 of the front cable guide assembly 76. Thus it will be seen that two lengths of cable will be disposed in the passage defined by the central apertures 36 in the blocks 14.

As best seen in FIGURES 1 and 7, there is provided a means 102 for tensioning the cable 98 by pulling the cable ends 96 and 100. To this end, a plate 104 has attached to its upper surface intermediate its ends, cylindrical, internally threaded sleeves 106 and 108, the sleeves being axially aligned with the apertures 84 and 86, respectively, in the front abutment member 78 so that the cable ends 100 and 96 may be operatively received so as to extend through the sleeves 106 and 108, respectively. Threadedly received in the respective sleeves 106 and 108 adjacent the vertical plate member 92, are externally threaded collars 110 and 112, having knurled heads 114 and 116, respectively, and longitudinal bores or passages adapted to freely receive the respective cable ends 96 and 100.

Next, vice members or cable clamps 118 and 120 are slid over the respective ends 100 and 96 of the cable 98, these clamps 118 and 120 being in abutting relationship with the outer ends of the respective sleeves 106 and 108, as best shown in FIGURE 7. The cable clamps 118 and 120 are of conventional construction, and each includes a tapered outer sleeve 122 and a gripping surface 124 carried by a cooperatively tapered collar 126 of split construction.

Extending from the front end of the row of blocks defining the plank 18 is a track 128, carrying a wheeled cart 130. Fixed to the cart 130 is a fluid cylinder 132 having a piston rod 134 extending therefrom toward the front end of the row of blocks. Pivotally connected to the free end of the piston rod 134, as by a removable pin 136, is a clamping assembly 138 having transversely spaced perpendicularly depending end members 140. By virtue of the pivotal connection of the clamping assembly 138 to the piston rod 134, the vertically extending end members 140 may conveniently be pivoted into and out of the space between the laterally extending inner edge of the plate 104 and the front cable guide assembly 76. The cart 130 also carries transversely spaced opposed longitudinally extending bars or struts 142 positioned for abutment at their ends with the outwardly facing surface of the front cable assembly 76, for reasons to be more fully apparent hereinafter.

With the elements assembled as described, the cart 130 is moved toward the front end of the row of blocks and the end members 140 of the clamping assembly 138 are pivoted downwardly into the space between the sleeve carrying plate 104 and the front cable guide assembly 76, as aforescribed. The fluid cylinder 132 is then actuated to move the piston rod 134 away from the row of blocks, so as to effect firm engagement of the end members 140 with the inner edge of the sleeve carrying plate 104 and thereafter exert tension on the cable 98 by pulling the cable ends 96 and 100 through the cooperation of the sleeves 106 and 108 and the cable clamps 118 and 120, the reaction force being transmitted to the row of blocks through the longitudinally extending struts 142 carried by the wheeled cart 130. This movement of the piston rod 134 inwardly of the fluid cylinder 132 causes the cable clamps 118 and 120 to firmly grip the cable ends; and, when a predetermined tension is imparted to the cable, which is preferably controlled automatically by a pressure responsive solenoid operated valve (not shown) operatively connected to the fluid-source (not shown), the collars 110 and 112 are unthreaded from their respective sleeves 118 and 120 until they abut the outwardly facing surface of the vertical plate member 92. Thus, the tension imparted to the cable 98 and the consequent compression imparted, as a reaction thereto, to the aligned row of blocks is maintained by engagement of the collars 110 and 112 with the plate member 92. The fluid cylinder 132 is then deactuated to permit disengagement of the end members 140 with the sleeve carrying plate 104 by upward pivotal movement of the clamping assembly 138.

The row of blocks forming the plank 18, which is now subjected to the desired predetermined degree of prestress,

may be moved along the rollers 12, as desired, away from the wheeled cart to permit the same to be employed for the prestressing of another row of blocks. With the row of blocks forming the plank 18 so stressed, grout 144 is introduced into the longitudinally extending rod member containing passages defined by the apertures 38 and 40 and the longitudinally extending stressed cable containing passage defined by the central apertures 36, through the vertical passages 42, 46 and 48 in the blocks 14' disposed along the length of the row of blocks. By introducing the grout 144 under pressure through the apertures 42, 46 and 48 in the blocks 14', the longitudinal passages are filled quite rapidly and efficiently. The grout 144 or other suitable bonding substance which is employed should be capable of providing a strong stress-transmitting bond between the stressed cable 98 and the concrete blocks 14.

After the longitudinally extending passages defined by the apertures 36, 38 and 40 have been filled with grout, the plank 18 composed of the compressively stressed blocks 14 is permitted to set a sufficient time to allow the grout to set thereby fixing the cable 98 under stress within its longitudinally extending passage as well as operatively securing the rod members 54 within their respective longitudinally extending passages. Thereafter, the front and rear cable guide assemblies 76 and 56, respectively, are removed as by burning or cutting the exposed portions of the cable 98 at the front cable guide assembly 76, between the vertical plate member 92 and the web portion 80 of the channel-shaped member 76, and at the rear cable guide assembly 56 through the cable access aperture 69 in the cable looping member 66. As will be apparent, the sleeves 106 and 108, collars 110 and 112 and cable clamps 118 and 120 may be reused after removal of the severed cable ends 96 and 100 therefrom.

The tendency of the compressed concrete blocks 14, in the finished prestressed plank 18, to expand after removal of the front and rear cable guide assemblies 76 and 56, respectively, is resisted entirely by the grouted tensioned cable 98 without any transfer of tension to the grouted rod members 54. Thus, the aforementioned limitations and disadvantages inherent in the prior art wherein the initial prestress applied during forming of a prestressed plank is transferred to bonded reinforcing rods are effectively and simply overcome. The laterally disposed longitudinally extending grouted rod members 54 not only resist any tendency of the blocks 14 to twist relative to one another about the longitudinally extending transversely centered axis defined by the tensioned cable 98, but also provide the formed plank 18 with enhanced load carrying capabilities, as will be more fully described hereinafter.

The tie plates 50, of course, are retained within the formed plank 18 by the grouted and stressed cable 98 and the grouted rod members 54. Thus, it has been found that prestressed concrete planks 18 formed of blocks 14 and prestressed grouted cable 98, as described, retain a notably superior resistance to longitudinal cracking by provision of the tie plates 50 disposed adjacent the opposed end regions of the formed plank 18 so as to distribute the local stresses throughout the cross sectional area of the plank 18.

Reference is now made to FIGURES 8 and 9 wherein there is shown the relative disposition of the cable 98 within the longitudinally extending passage defined by the central apertures 36 in the aligned blocks 14 and the disposition of the blocks 14 before and after, respectively, the aforescribed application of prestressing tension to the cable 98. In FIGURE 8, before the application of prestressing tension to the cable 98, the aligned blocks 14 will be seen to be disposed in a substantially straight condition with the cable 98 similarly disposed along the top surface of the longitudinally extending passage defined by the central apertures 36 in the blocks 14. As best seen

in FIGURE 9, application of the desired prestressing tension to the cable 98, which is disposed below the vertically centered longitudinal axis of the plank 18 adjacent the lower faces 22 of the blocks 14, will result in upward vertical displacement of centrally located blocks relative to the end blocks, thereby causing the plank 18 to assume a slight camber or arched configuration and thus dispose the cable 98 at the longitudinal central portion of the plank 18 adjacent the lower surface of the passage defined by the central apertures 36. At each end of the plank 18, the ends of the tensioned cable 98 will remain disposed adjacent the upper surface of the passage defined by the central apertures 36 since the tensioned cable 98 remains in a substantially straight condition. The passage defined by the central apertures 36, which will be seen to have assumed the form of a positive curve of arcuate or parabolic configuration, is then filled with grout 144, which is allowed to set, as aforementioned. Thus, the cable 98 will be fixed within the curved passage defined by the central apertures 36 so that the end portions thereof are adjacent the upper surface of the passage at the ends of the plank, while the central portions of the cable 98 are adjacent the lower central surface of the passage.

After the grout has set and the front and rear cable guide assemblies 76 and 56, respectively, have been removed, the plank 18 will be in the aforescribed arched condition, as best seen in FIGURE 10. Due to the fact that the cable 98 has become set within the grout 144, the central portion of the cable 98 will be seen to be maintained adjacent the central lower portion of the central passage while the cut ends are adjacent the upper surface of the passage at the ends of the plank 18.

Referring now to FIGURE 11 of the drawings, there is shown a modified form of the present invention wherein a support member 146 having an arcuate supporting surface 148 is employed to support the prestressed and grouted plank 18 in a predetermined arched condition while the grout 144 is setting. This modification, employing the support member 146, is particularly useful where the amount or degree of tension applied to the cable 98 to prestress the plank 18 may not in and of itself effect the desired amount of camber or arching of the plank 18 and thus effect the aforescribed desired disposition of the cable 98 during the setting of the grout 144. The arcuate supporting surface 148 will be seen to support the central portion of the plank 18 at a higher elevation than its ends so that the cable 98 at the longitudinal center of the plank 18 is closely adjacent the lower surface of the passage defined by the central apertures 36 while the cable ends are adjacent the upper surface of the passage at each end of the plank in a fashion substantially similar to the embodiment described by reference to FIGURE 9. After the grout 144 has set, the front and rear cable guide assemblies 76 and 56, respectively, are removed as aforementioned, and the supporting member 146 is removed from the underside of the plank 18. The formed prestressed plank 18 will then relax somewhat so as to assume the lesser camber or arched configuration which is imparted by the tensioned cable 98 alone, substantially similar to that aforescribed by reference to, and shown in, FIGURE 10. The tensioned cable will assume a slightly negative or upwardly concave curve with the cut ends of the cable adjacent the upper surface of the central passage and the central portion of the cable at the longitudinal center of the plank 18 closely adjacent the lower surface of the passage.

While the limited controlled arching or camber of a prestressed concrete plank as aforescribed is frequently desirable, it should also be noted that an excessive arching or camber can impair the functioning of the prestressed plank. Such undesirable excessive arching of the plank may occur during formation of the plank as a result of the initial compression of the blocks by the tensioned cable, or can occur with the passage of time through what is believed to be a creep phenomenon. The last-mentioned

cause of excessive arching which may be called "long-term arching" or "long-term camber," is believed to result from a slow but continuing shortening of the plank below its vertically centered, longitudinal axis due to the longitudinal compression of the plank imparted by the tensioned cable. Such "long-term arching" can ultimately impair the function of the prestressed concrete plank to such an extent that its removal and replacement will be necessary. In prestressed concrete planks constructed according to the teachings of the instant invention, such long-term arching has been effectively controlled, by virtue of the laterally spaced rod members disposed below the vertically centered longitudinal axis of the plank. It has been observed that a short time after the grout has set and the plank has been completed, the rod members, which are bonded to the plank by the grout, are under compression. It is believed that the rod members are thus effective to control and limit such "long-term arching" by resisting the tendency of the plank to shorten below its vertically centered longitudinal axis. Thus, it will be apparent that an effective, simple and inexpensive means of controlling "long-term arching" or "long-term camber" has been provided by employing the rod members 54, as aforescribed.

Reference is now made to FIGURE 12 of the drawings wherein there is shown a modified form of preformed concrete block 114 which can be employed in the present invention to form a prestressed plank 118. The block 114 differs from the block 14, just described, in that the upper face 120 is slightly shorter than the lower face 122 so that the end faces 116 are not parallel but taper or upwardly converge as shown, greatly exaggerated, in FIGURE 12. As was the case with the blocks 14, the blocks 114 are provided, adjacent the lower face 122 thereof, with a transversely centered aperture 136 and laterally located apertures 140 spaced transversely on either side of the central aperture 136, which are adapted to align with corresponding apertures in adjacent blocks so as to define longitudinally extending passages. When the blocks are arranged in plank forming alignment, a small upwardly opening wedge-shaped space 150 will be formed between the opposed end faces 116 of adjacent blocks 114. The use of blocks 114 having upwardly converging end faces 116 to form a prestressed plank 118, as aforescribed, will limit the amount of initial camber or arching of the plank which results from the tensioning of the cable and consequent compression of the aligned blocks. Thus, this modification utilizing blocks 114 having upwardly converging end faces 116 is particularly useful where prestressing would normally result in an excessive or undesired amount of camber or arching of the plank.

Reference is now made to FIGURE 13 of the drawings which illustrates another modified form of the present invention wherein a plurality of longitudinally aligned prestressed concrete planks 218, 218' and 218'' are simultaneously formed. The embodiment of the invention shown in FIGURE 13 differs from that aforescribed by particular reference to FIGURES 1-7, in that spacer members 202 are interposed between adjacent concrete blocks 214 at preselected positions along the row. Thus the disposition of the spacer members 202 relative to the front and rear cable guide assemblies 276 and 256, respectively, will determine the lengths of the planks 218, 218' and 218''. The spacer members 202 are preferably metal plates bent or otherwise formed into the shape of a rectangle having longitudinally spaced vertical end walls 204 adapted to engage the opposed end faces 216 of adjacent blocks 214. Each vertical end wall 204 of the spacer members 202 is provided with a transversely centered aperture 206 and two laterally located apertures 208 spaced transversely on either side of the central aperture 206. The central aperture 206 and laterally located apertures 208 are adapted to align with the corresponding apertures 236, 238 and 240, respectively, in the adjacent

blocks 14 when the spacer members 202 are operatively disposed along the row of aligned blocks.

Certain spaced apart blocks 214' have vertical passages 242, 246 and 248 communicating with the apertures 236, 238 and 240, respectively, to facilitate the introduction of grout under pressure into the planks 218, 218' and 218''. In addition, tie plates 250, substantially identical to the aforescribed tie plates 50, can be interposed between each endmost pair of blocks 214 in each of the planks 218, 218' and 218''.

The plurality of prestressed planks 218, 218' and 218'' are formed simply in a manner substantially similar to that described by reference to FIGURES 1-7. Thus, after the rod members 254 are positioned in the longitudinally extending lateral passages defined by the laterally located apertures 238 and 240 in the blocks 214, a cable 298 is passed through the aligned central apertures 236 of the entire row of blocks 214, which is segmented into planks 218, 218' and 218'' by the spacer members 202. As aforescribed, the looping member 266 of the rear cable guide assembly 256 will guide the leading end 296 of the cable 298 in a generally U-shaped path to form a loop whereby continued feeding of the cable 298 will return the leading end 296 through the cable receiving passage defined by the apertures 236 so that two lengths of cable will be disposed in each plank 218, 218' and 218''. Thereafter, prestressing tension is applied to the cable 298 to thereby place the blocks 214 forming the planks 218, 218' and 218'' under prestressing compression and the cable 298 and rods 254 are then grouted in place, all in a manner substantially identical to that aforescribed by reference to FIGURES 1-7.

After the grout has set, the row is broken into its individual planks 218, 218' and 218'' by burning or otherwise cutting the cable at its ends to remove the rear and front cable guide assemblies 256 and 276, respectively, as well as severing the exposed cable 248 and rod members 254 which are visibly accessible from the open sides of the spacer members 202. Thus, when the block row in FIGURE 13 is broken down, three slabs 218, 218' and 218'' are formed by a single stressing operation on the whole row. As will be appreciated, the length of the rows and the number of slabs formed is readily adjusted by the particular demand, and special equipment or the like is not required to change the slab lengths as well as the number of slabs formed by a single cable stressing step, as previously described.

Turning now to FIGURE 14, there is shown a modified arrangement for obviating the transmission of undesirable stress along the end regions of the prestressed plank which cause a longitudinal cracking of the plank along the central vertical plane thereof due to the greater stress at the ends, which longitudinally compress the concrete at these localized end regions. There is shown here an end block 314 of the plank 318, having bevelled upper and lower cut-out portions 300 and 302, respectively, adjacent its inner end face 316. Transversely extending reinforcing rods 304 and 306 are positioned within these beveled portions 300 and 302 respectively, and secured with grout 344. As the plank 318 is not subjected to these localized compression stresses during the grout setting stage due to the channel-shaped members of the front and rear cable guide assemblies, the grout can set while the grout introduced into the longitudinally extending passages is also setting. When the setting has been completed and the cable guide assemblies are removed, the undesirable local stress in the plank 318 is efficiently distributed throughout the surface thereof via the reinforcing rods 304 and 306 and their surrounding grout 344. Thus, the reinforcing rods 304 and 306 and grout perform an equivalent function to that of the tie plates 50. Accordingly, the modification is equally applicable to the various other modifications described herein, as the end blocks in each prestressed plank may be so formed.

In FIGURE 15, still another modification of the plank

construction is provided, wherein the outside end face 416 of the endmost blocks 414 have upper and lower transverse recesses 400 and 402 inwardly of the corners thereof, which carry reinforcing rods 404 and 406, respectively, in grout. By virtue of this arrangement, the tendency of the endmost blocks of the planks to crack longitudinally, as aforescribed, is obviated. The end blocks 414 may be conveniently formed prior to assembly of the plank or simultaneously with the formation thereof, as desired.

Also, depending on the degree of stress in the cable lengths, the block width configuration and so forth, the end blocks 314 (FIGURE 14) or 414 (FIGURE 15) may be formed with reinforcing at one end edge only, as necessary.

Referring now to FIGURE 16 of the drawings, there is shown another modified form of prestressed concrete plank 518 embodying the invention. The construction of the prestressed concrete plank 518 differs from that of the prestressed concrete plank 18, aforescribed, in that the longitudinally extending passage defined by the transversely centered apertures 536 is provided with only a single length of tensioned cable 598. Since only one length of cable 598 is disposed within the longitudinal passage defined by the central apertures 536, it is not necessary to employ my novel cable looping member 66, aforescribed. Thus, the cable 598 can be anchored at the rear end of the plank 518 by means of a conventional cable clamp 500 embodying substantially the same construction as the cable clamps 118 and 120, aforescribed. To this end, a modified rear cable guide assembly 556, similar to the aforescribed front cable guide assembly 76, is provided. The rear cable guide assembly 556 includes a rear channel-shaped abutment member 558 having a substantially flat web portion 560 connecting a pair of spaced flanges 562. The flat web portion 560 is provided with an aperture 564 adapted to register with the central cable containing aperture 536 in the rear endmost block 514 when the abutment member 558 operatively abuts the outwardly facing end face 516 thereof. Abutting the outwardly facing edges of the flanges 562 of the channel-shaped abutment member 558 is a vertically extending plate member 566 having an aperture 568 axially aligned with the aperture 564 in the web portion 560 of the abutment member. The front cable guide assembly 576 is of a construction substantially identical to that of the aforescribed front cable guide assembly 76, and includes an apertured channel-shaped abutment member 578, a pair of transversely spaced vertically extending plates 588 and a transversely centered, operatively aligned apertured plate 592 abutting the channel-shaped abutment member. The means for tensioning the cable is substantially similar to the means 102, aforescribed, and includes an internally threaded sleeve 506, an externally threaded collar 510 having a knurled head 512 and a cable clamp 520.

Prestressing of the plank 518 formed by the aligned row of blocks 514 is accomplished in a manner substantially similar to that aforescribed by reference to FIGURES 1-7, with the exception that only a single length of cable 598 is disposed within the blocks. Thus, after the rod members 554 are positioned in the longitudinally extending lateral passages defined by the laterally located apertures 538 and 540 in the blocks 514, and the front and rear cable guide assemblies 576 and 556, respectively, are operatively positioned at the ends of the plank 518, a single length of cable 598 is positioned within the longitudinally extending passage defined by the centrally located apertures 536 in the aligned blocks 514 with the opposed ends thereof, 594 and 596, extending outwardly beyond the vertically extending plates 592 and 566. With the cable clamp 500 operatively engaging the cable end 596 and the sleeve 506, collar 510 and clamp 520 operatively positioned on the other cable end 594, the plank 518 is subjected to the desired degree of prestress by tensioning the cable 598, as in the embodiment of the inven-

tion described by reference to FIGURES 1-7. The collar 510 is then unthreaded so as to abut the vertical plate member 592 and thereby maintain the cable 598 under the desired prestressing tension and the blocks 514 under compression during introduction and setting of the grout in the longitudinally extending rod and cable containing passages. As in the aforementioned embodiments, the front and rear cable guide assemblies 576 and 556, respectively, are removed by severing the exposed end portions of the cable 598.

Reference is now made to FIGURE 17 of the drawings wherein there is shown a further modified form of a preformed concrete block 614 which can be employed to form a prestressed concrete plank according to the invention. The block 614 differs from the block 14, aforescribed, in that the transversely centered aperture 636 adapted to receive the prestressing cable 698 has a vertically elongated generally rectangular configuration in cross section, the upper and lower edges 632 thereof preferably being curved or arcuate. This modified block construction 614 has particular utility where only a single length of cable 698 is disposed within the prestressed plank, as just described by reference to FIGURE 16.

Reference is now made to FIGURES 18, 19, 20 and 21 of the drawings, wherein there is shown a modified rear cable guide assembly 756 and a modified arrangement for anchoring or restraining the closed or looped end of the cable 798 during formation of the prestressed plank 718. The rear cable guide assembly 756 differs from the rear cable guide assembly 56, aforescribed, in that the tubular cable looping member 766 is adapted to be removed after forming the cable 798 into a loop and prior to tensioning of the cable. To this end, the tubular cable looping member 766 is of a separable or split construction and includes top and bottom sections 770 and 772 having mating flanges 774 and 776, respectively. The top and bottom sections 770 and 772 are held together in operative association by suitable removable fastener means such as bolts 778 which extend through the opposed mating flanges 774 and 776. The common tubular portion 768 is preferably provided with flanges 780, through which suitable fastener means, such as bolts 782, extend so as to removably secure the tubular cable looping member 766 to the web 760 of the rear channel-shaped abutment member 758. When assembled and operatively positioned adjacent the rear channel-shaped abutment member 758, the tubular cable looping member 766 will be seen to define a closed loop-like tubular passage in communication with the central cable receiving passage in the plank 718. After the cable 798 has been disposed within the central cable receiving passage in the plank 718 by being guided through the tubular cable looping member 766 in a generally U-shaped path to form a loop, in a manner substantially similar to that described by reference to FIGURES 1-7, the bolts 778 and 780 are removed to thereby permit disassembly and removal of the tubular cable looping member 766.

As best seen in FIGURES 20 and 21, after the tubular cable looping member 766 has been removed from operative association with the closed or looped end of the cable 798 and the rear channel-shaped abutment member 758, a bar member 784 is disposed within the now exposed, closed or looped end of the cable 798. Upon the application of prestressing tension to the cable 798, as aforescribed, the bar 784 will engage both the rear channel-shaped abutment member 758 and the closed end of the cable 798 so as to anchor or restrain the closed end of the cable to thereby permit tensioning of the same during the grouting operation. After the grout has set, the exposed, closed end of the cable 798 is severed, as by burning or cutting, so as to permit removal of the bar member 784 and the rear channel-shaped abutment member 758 from operative association with the plank 718.

It will thus be seen that the objects of this invention have been fully and effectively accomplished. It will be

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realized, however, that the foregoing specific embodiments have been shown and described only for the purpose of illustrating the principles of this invention and are subject to extensive change without departure from such principles. Therefore, this invention includes all modifications encompassed within the spirit and scope of the following claim.

What is claimed is:

An apparatus for imparting tension to a cable extending through a longitudinal passage in a plank formed by an aligned row of preformed concrete blocks, said cable being in the form of a generally U-shaped loop having an open end portion defined by the leading and trailing ends of the cable extending beyond one end of said passage and a closed end portion extending beyond the other end of said passage, said apparatus comprising in combination: a tubular member including an arcuate surface means to engage the closed end portion of the cable loop and restrain said closed end portion against longitudinal movement relative to said passage; gripping means for gripping the leading and trailing ends of said cable defining the open end portion of the loop at said one end of said passage; movable means positioned adjacent said one end of

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said passage; ram means connected to said movable means and mounted for longitudinal movement relative to said passage and said movable means, said ram means operatively engaging said gripping means; a reaction force transmitting means carried by said movable means operatively engaging the endmost block at said one end of said passage whereby movement of said ram means away from said one end of said passage when said ram means is in operative engagement with said gripping means will simultaneously impart tension to said cable and longitudinal compression to said plank through said reaction force transmitting means.

References Cited

UNITED STATES PATENTS

2,615,678	10/1952	Stent	52—223 X
2,637,895	5/1953	Blaton.	
2,949,705	8/1960	Carper	52—229 X
3,207,829	9/1965	Nieber et al.	254—29 X

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