March 6, 1962 R. M. YERBY ET AL 3,023,475

APPARATUS FOR PRODUCING PRESTRESSED STRUCTURAL UNITS

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FIG. 1.

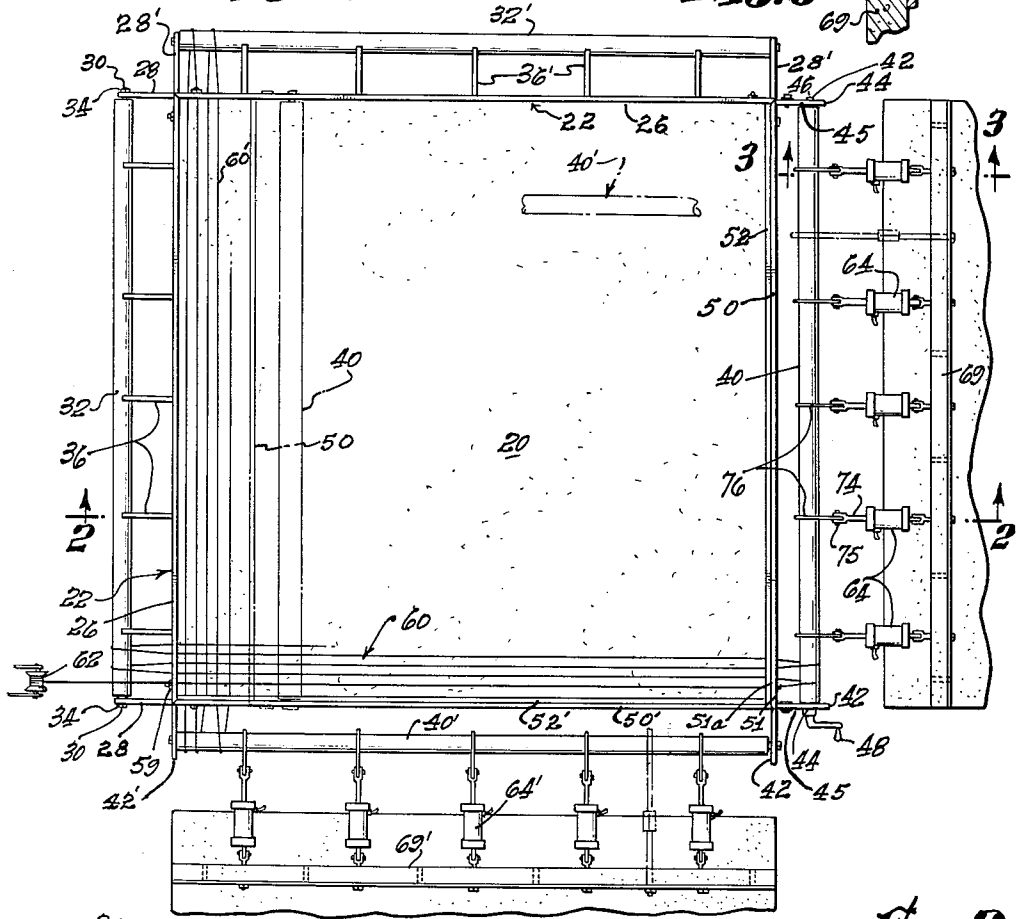


FIG. 3

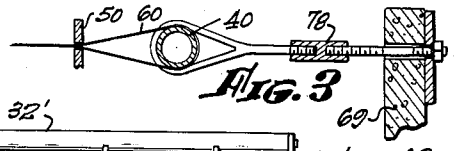


FIG. 2.

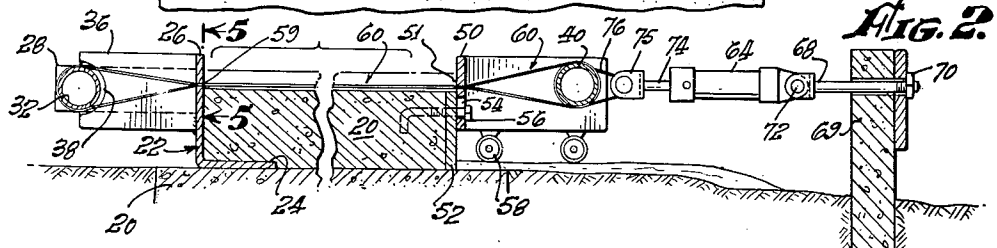
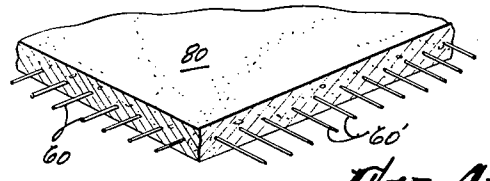


FIG. 4.



HENRY T. YERBY,
CARLOS F. YERBY,
ROBERT M. YERBY,
INVENTORS.

By. Bonniard O. Brown
ATTORNEY.

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FIG. 10.

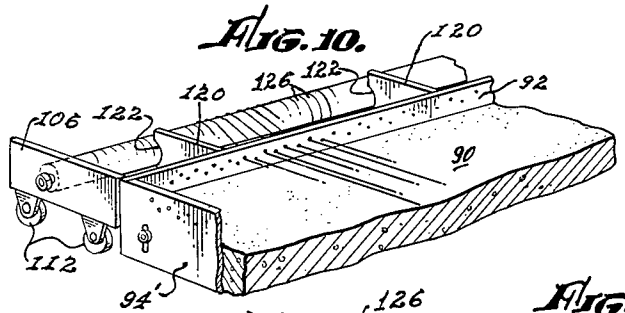


FIG. 5.

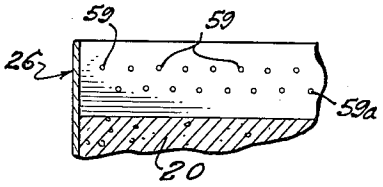


FIG. 6.

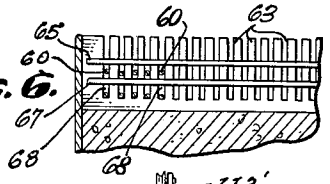


FIG. 11.

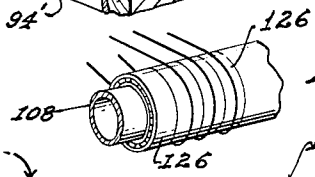


FIG. 9.

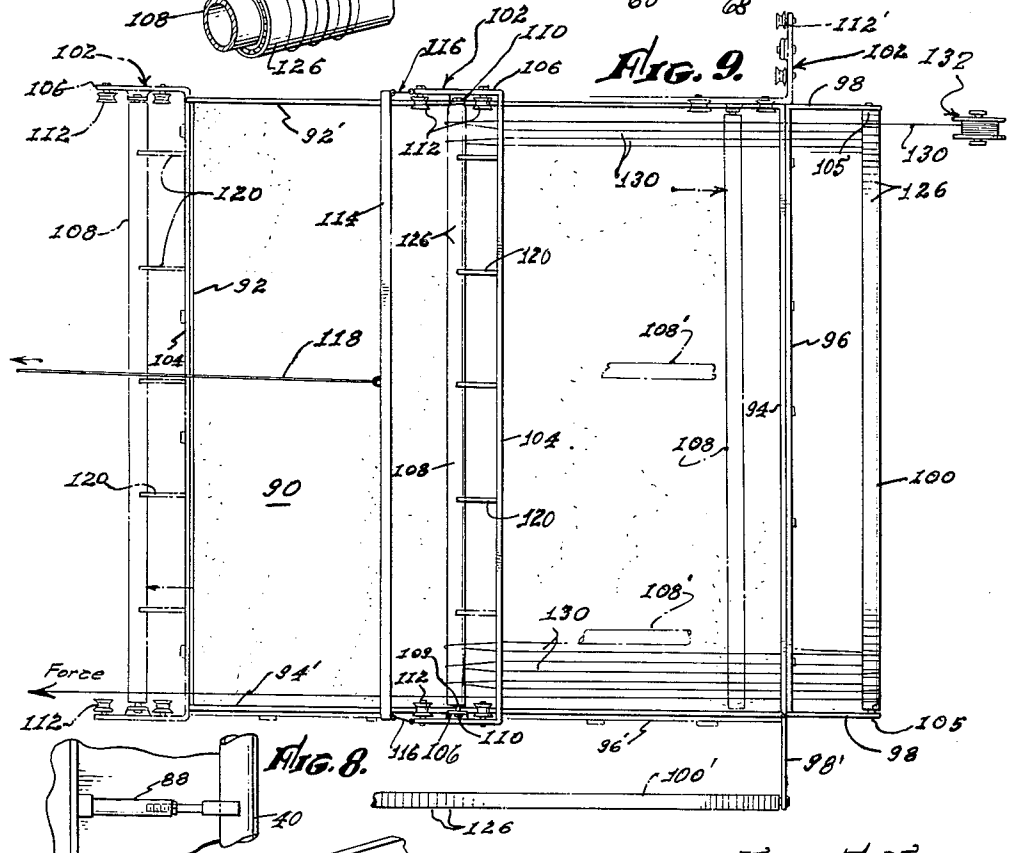
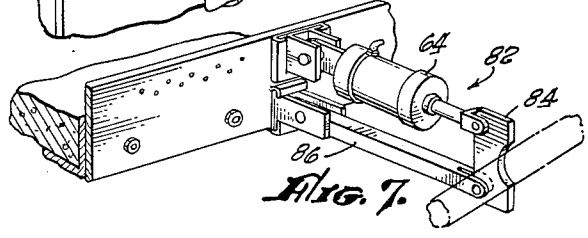


FIG. 8.

FIG. 7.



HENRY T. YERBY,
CARLOS F. YERBY,
ROBERT M. YERBY,
INVENTORS.

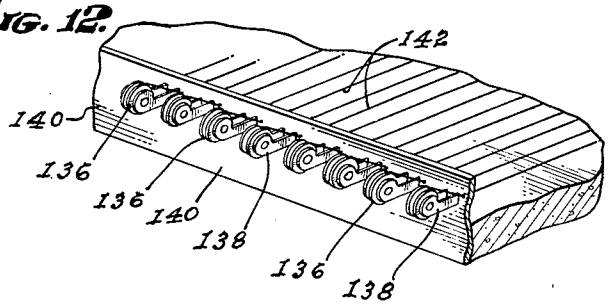
By Bernard S. Brown
ATTORNEY.

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FIG. 12.



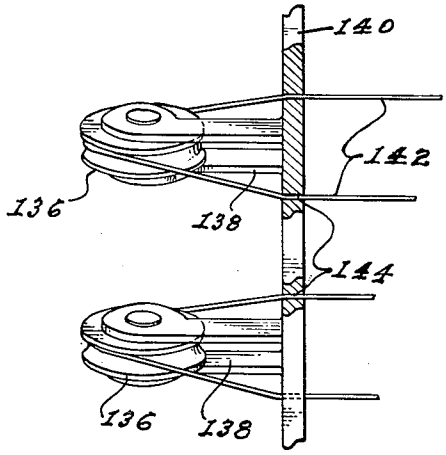
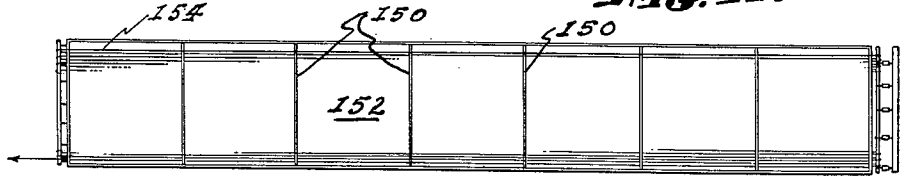


FIG. 13.

FIG. 14.



INVENTORS.
HENRY T. YERBY,
CARLOS H. YERBY,
ROBERT M. YERBY,

By Bonniard O. Brown
ATTORNEY.

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3,023,475

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3,023,475
APPARATUS FOR PRODUCING PRESTRESSED STRUCTURAL UNITS

Robert M. Yerby, Pomona, Calif. (726 Ridgefield Drive, Claremont, Calif.); Henry T. Yerby, 1430 Valley View, Pasadena, Calif.; and Carlos F. Yerby, 600 Wesley, Oakland, Calif.

Filed Apr. 2, 1957, Ser. No. 650,166
3 Claims. (Cl. 25—118)

This invention relates generally to the prestressing of structural units; more particularly, it relates to an apparatus for providing stressing elements within a mould in the production of prestressed units.

In producing prestressed structural units, it is general practice to place stressing elements, such as wires, under tension prior to the pouring of the structural material. The material, such as concrete, is permitted to harden about the stressing elements. Tension is maintained in the stressing elements until the material is hardened or set. A bond is created between the stressing elements and the hardened material. After the externally applied tension is removed, the elements remain in tension and hold the structural unit in compression. As is well known, such a unit is capable of withstanding greater tensile and bending loads than it could if it were not prestressed.

Heretofore, methods and devices for tensioning stressing elements have involved attaching individual lengths of an element to a part of an apparatus. Each individual element or wire is separately anchored, or two or more wires are attached to a member such as a header by means of retaining devices, such as grippers. Tension is conventionally applied to each wire individually or to a group of wires by applying tensioning force to the member to which the wires are attached.

Such devices and methods of the prior art have certain disadvantages. Considerable time and labor is required to mount each individual wire to an anchor member or to such a member as a header. The apparatus utilized usually requires a multiplicity of retaining devices or structural features to accommodate the individual wires. Conventional types of apparatus for use in production are usually complex and expensive. It is difficult, using devices and methods of the prior art, to insure that tension will be uniform among the stressing elements, because all are not tensioned simultaneously by the same force. Extra labor is required to insure uniform tension.

It is, therefore, a principal object of the present invention to provide an apparatus for tensioning stressing elements in producing prestressed units, which require a minimum of time and labor in operation.

It is an object of the present invention to provide novel apparatus for tensioning multiple lengths of stressing element simultaneously by a simple operation in producing prestressed units.

It is another object of this invention to provide an apparatus for tensioning stressing elements in producing prestressed units wherein confronting means for supporting and registering the elements may be brought into close proximity to facilitate the arrangement of the stressing elements.

It is another object of this invention to provide an apparatus for tensioning stressing elements in producing prestressed units wherein inexpensive components are utilized to maintain tension in stressing elements during hardening of the units.

It is a further object of the present invention to provide an improved apparatus for tensioning stressing elements in producing prestressed units.

The foregoing general objects are accomplished by a method involving the use of an apparatus which includes a pair of parallel support members located at opposite ends of a mould for a prestressed unit. A continuous elongated stressing element or wire is wound in spiral manner around both support members, each coil of the element encircling both members. The support members, in their preferred form, are adapted to rotatably receive the element or wire. The lengths of the element within the mould are maintained in predetermined alignment by means of registering members, located between the support members, which have apertures through which the element is threaded. To tension the continuous element, one of two methods may be used. Both ends of the element may be anchored and a force may be applied to one support member by hydraulic jacks in a direction away from the other support member. The other method is to anchor one end of the element or wire, then apply tensioning force to the other end. After the desired tension is supplied, adjustable braces may be used to replace the jacks to maintain tension during hardening of the prestressed unit.

Other objects and features of the present invention, as well as many advantages thereof, will become apparent to those skilled in the art from a consideration of the following description, the appended claims, and the accompanying drawings in which:

FIGURE 1 is a plan view of a preferred embodiment of the apparatus of the present invention;

FIGURE 2 is a cross-sectional view taken at line 2—2 of FIGURE 1;

FIGURE 3 is a partial cross-sectional view taken at line 3—3 of FIGURE 1 and showing a turnbuckle used with the present invention;

FIGURE 4 is a fragmentary perspective view of a prestressed concrete unit produced in accordance with the present invention;

FIGURE 5 is a fragmentary sectional view taken at line 5—5 of FIGURE 2;

FIGURE 6 is a fragmentary sectional view like that of FIGURE 5 and showing a modified form of register plate used with the present invention;

FIGURE 7 is a perspective view of a modified form of hydraulic jack used with the present invention;

FIGURE 8 is a fragmentary plan view of a portion of the embodiment shown in FIGURE 1, showing a modified form of turnbuckle used with the present invention;

FIGURE 9 is a plan view of a second preferred embodiment of the apparatus of the present invention;

FIGURE 10 is a perspective view of a portion of the apparatus shown in FIGURE 9;

FIGURE 11 is a fragmentary perspective view showing details of the bearing devices which may be used with this invention;

FIGURE 12 is a fragmentary perspective view showing a pulley arrangement which may be used with the present invention;

FIGURE 13 is a fragmentary plan view, partially in section, showing details of the pulleys shown in FIGURE 12; and

FIGURE 14 is a plan view of a modified form of apparatus of this invention.

Referring to the drawings, and particularly to FIGURES 1, 2, 3, 4, and 5, there is illustrated a preferred embodiment of the prestressing apparatus of the present

invention. This embodiment includes a concrete foundation 20, to which the remainder of the apparatus is attached and which supports the concrete or other material for forming a prestressed unit. Foundation 20 is shown as rectangular in configuration by way of example only, and not by way of limitation. This embodiment is adapted for producing prestressed units in the form of rectangular concrete slabs.

Angle plate 22, preferably constructed of steel or like material, is rigidly mounted with respect to foundation 20 by having its foot portion 24 disposed beneath foundation 20 in the manner shown in FIGURE 2. Upright portion 26 of angle plate 22 extends above level of foundation 20 and extends the length of the foundation, this upright portion being adapted to retain concrete while the concrete is setting. At the ends of plate 22 are attached bearing plates 28 having openings for rotatably receiving reduced threaded end portions 30 of rotatable support member 32. Nuts 34 are in threaded engagement with end portions 30, and in cooperation with slots in plate 28, provide means for adjusting the position of support member 32 in relation to bearing plates 28.

A plurality of braces 36, positioned between upright portion 26 of plate 22 and support member 32, and spaced apart along member 32, serve to maintain support member 32 in the position shown when it is under a load tending to distort it toward plate 22. Arcuate seats 38 in braces 36 conform to the shape of support member 32 and are adapted to receive support member 32 when the latter is subjected to the above mentioned load.

Rotatable support member 40, similar to support member 32, is located at the end of foundation 20 opposite support member 32 and has reduced end portions 42 journalled in openings 44 in bearing plates 46. Nut 48 is threaded on one end portion 44 and crank 48 is connected to the opposite end portion, so that roller 40 may be manually rotated when in use. Support member 40 is positioned at the same level as member 32 and the two support members are in parallel relation.

Both support members are preferably constructed of rugged steel tubing or other suitable material.

Bearing plates 44 are mounted on register plate 50, which is coextensive with support member 40 and is adapted to be detachably mounted to upright standard plate 52 by means of slots 54 (in plate 50) and bolt and nut unit 56, as shown.

From the foregoing description it will be understood that support member 40, bearing plates 46 and register plate 50 together constitute a structural unit which may be detached from standard plate 52 and transported to any desired location. Wheels 58 are attached to bearing plate 42 to provide for general convenience in handling this structural unit and to support the unit while it is being mounted to plate 52 or being detached therefrom.

Register plate 50 and upright portion 26 of angle plate 22 are each provided with a series of apertures 59 and 59*a*, shown in FIGURES 2 and 5, for receiving elongated stressing element 60. Each aperture is adapted to slidably receive element 60. The apertures of upright portion 26 and of register plate 50 are in registration for the purpose of properly arranging portions of element 60 between these plates.

FIGURE 6 shows a modified register plate wherein spaced vertical posts 63 are traversed by rods 65 and 67 to provide a series of register apertures 68 for the purpose previously described in connection with the apertures of register plate 50 and upright portion 26.

Stressing element 60 in the embodiment shown in FIGURE 1 is a high tension steel wire. Other types of metallic wire may be used, depending upon the particular application. Metal cable, plastic material, or glass are examples of other materials which might be used. The particular material and manner of construction of element 60 will obviously vary with the application and with the material forming the unit which is to be prestressed. For convenience of reference, stressing element 60 is hereinafter referred to as a wire. As shown in FIGURE 1, reel 62 for wire 60 may be provided at one end of support element 32, to supply increments of wire 60 upon demand.

Conventional hydraulic jacks 64 are provided for applying a load to support member 40 in a direction tending to separate member 40 from support member 32. Jacks 64 are anchored to upright concrete wall 66 by means of eye bolts 66 extending through apertures 69 and secured by nuts 70. The eye bolts are pivotally connected at joints 72 to jack 64. Piston rod 74 of each jack 64 is connected to a yoke 75, as shown. Cable 76 engages yoke 75 and passes around support member 40. FIGURE 7 shows a modified jack assembly 82 with which an anchoring wall is not required. The manner in which pad member 84, brace 86 and conventional jack 64 cooperate to exert a load on the support member (shown in phantom) is obvious. At the sides of foundation 20 other than the ends where plate 22 and 50 are located, plates 22′ and 50′ are provided, which join plates 22 and 50 to form a rectangular retaining wall extending above foundation 20, thereby providing a mould for concrete.

In FIGURE 1, plates 22′ and 50′ are respectively similar to angle plate 22 and register plate 50. Connected to upright portion 26′ of angle plate 22′ are bearing plates 28′ for rotatably mounting support member 32′. Braces 36′ are similar in structure and function to braces 36. Register plate 50′ is detachably mounted to plate 52′ and with plates 42′ and support member 40′, constitutes a transportable unit like the unit associated with support member 40. A series of jacks 64′ similar to jacks 64 and similarly anchored and connected for the application of force, are connected to support member 40′.

From the foregoing description it will be understood that a second pair of support members is provided, one at each side of foundation 20, and it will be understood that this second pair of support members and their cooperating parts serve the same purpose as support members 32 and 40, but operate at right angles thereto.

In the operation of the embodiment of the present invention shown in FIGURES 1 and 2, the movable unit which includes support member 40 is detached from standard plate 52 and is moved to a position in close proximity to upright portion 22 of angle plate 26. This position of support member 40 and register plate 50 is shown in phantom outline in FIGURE 1. A length of wire 60 is then unwound from reel 62 and inserted through an aperture 59 of upright register portion 26 of plate 22, as shown, then the wire is threaded through aperture 51 of plate 50 and is passed around roller 40. Wire 60 is next inserted through aperture 51*a* of plate 50, aperture 51*a* being next in horizontal line, and is then threaded through another aperture 59 in register portion 26, the latter aperture registering with aperture 51*a*. The wire is then wound around support member 32, back through a third aperture 59, then is passed through another aperture in register plate 50 in registration with the last mentioned aperture in upright portion 26. This procedure is repeated, spirally winding wire 60 around support members 32 and 40 while threading it through registering apertures in upright portion 26 of plate 22 and in registering plate 50, until the opposite ends of the support members are reached. At the end of the winding and threading process the end of wire 60 is anchored to support member 32 by tying or by any other convenient method. Crank 48 may be used to manually rotate support member 40 to reduce frictional drag between wire 60 and support member 40 during the winding process.

Rotatable support member 40 and register plate 50 are transported back to the position shown in FIGURE 2, where register plate 50 is reattached to standard plate 52

by means of bolt and nut unit 56. Sufficient force is applied in moving this structural unit that wire 60 is unwound from roller 62 during the movement and is pulled about rotatable members 32 and 40 throughout its spirally wound length, thereby lengthening the portions of wire 60 between register plate 50 and upright portion 26 of plate 22. The reel end of wire 60 is then severed and anchored to roller 32.

From the foregoing description, it will be understood that a continuous wire 60 is wound in spiral fashion around rotatable support members 32 and 40, each coil of the spiral winding extending through registering apertures in register plate 50 and upright portion 26 of angle plate 22. The lengths of wire 60 positioned within the mould space are held in predetermined spaced parallel alignment at uniform level above concrete foundation 20 by means of the registering apertures.

Nuts 34 are loosened, thus permitting support element 32 to move freely in relation to bearing plates 28 so that it can seat in arcuate seats 38 of braces 36.

Jacks 64 are then placed in operative engagement with support member 40 by placing cables 76 about member 40 and engaging nut 70 with eyebolt 68 to anchor the jacks to concrete anchoring wall 69, as shown in FIGURE 2. The jacks are hydraulically actuated from a single hydraulic source and exert forces on support member 32. After the jacks have operated sufficiently to apply initial tension to wire 60 to hold support element 32 against arcuate seats 38, their further actuation is delayed while register plate 50 is detached from standard plate 52 by disengaging the nut and bolt units 56. This permits the structural unit including support member 40 and register plate 50 to be moved outwardly somewhat by jacks 64 to stretch wire 60.

Jacks 64 are actuated until wire 60 is sufficiently elongated to effect the selected tension throughout its length. It is considered obvious that by this means tension is applied to each length of wire 60 disposed between register plate 50 and upright portion 26, thus effecting uniform tension in each of these lengths without the necessity of laborious individual tensioning of each length.

From the foregoing description, it will be understood that a continuous wire is spirally wound about both support members, and it will be understood that the hydraulic jacks serve to tension the wire throughout its length, thereby insuring that all portions of the wire between the support members are subjected to equal tension.

After the wire is thus tensioned, turnbuckles 78, one of which is shown in FIGURE 3 and in phantom outline in FIGURE 1, may be utilized in conventional manner to maintain the load applied to support member 40, thereby releasing jacks 64 for use elsewhere. Economy in the use of the hydraulic jacks is thus effected and any possible decrease in hydraulic pressure exerted by the jacks during the period necessary for the setting of the concrete in the mould, is substantially eliminated. In FIGURE 8 is shown a modified form 88 of turnbuckle. This type is for use in replacing the jack arrangement shown in FIGURE 7 during the period when the concrete is hardening.

Concrete is poured onto foundation 20 and is retained by the upper portions of upright portion 26 of angle plate 22, register plate 50, plate 22' and plate 50', these plates cooperating with foundation 20 to form a mould for the concrete slab which is to be cast and prestressed. After the concrete is hardened, each length of wire 60 may be severed externally of the registering apertures in plates 50 and 22 to permit the structural concrete slab 80 which has been formed to be stripped from the mould.

Although the externally applied tension is relieved, the lengths of wire 60 within structural unit 80 remain under tension because they are bonded to the concrete. Unit 80 is thus under compressive stress which, as is well known, greatly enhances its structural characteristics.

As hereinbefore described, the embodiment shown in FIGURE 1 includes a second set of support members 32' and 40', together with a second set of registering plates 22' and 50', these being like members 32, 40, 26 and 50 in construction and in operation. Being disposed at right angles to the latter support members and register plates, these additional parts serve to provide lengths of wire which extend across the mould perpendicular to wire 60 and serve to prestress the concrete slab unit 80 in the direction transverse to the direction in which it is prestressed by wire 60. Thus, the apparatus in FIGURE 1 may be used to prestress concrete in two perpendicular directions. Where the lengths of wire 60 arrayed in the mould are arranged at a certain level, the lengths of wire 60' may be arranged so that they are spaced above or below the portions of wire 60.

In FIGURE 4 is shown a prestressed concrete structural unit 80, such as may be produced by the apparatus shown in FIGURE 1, and which has been prestressed in two mutually perpendicular directions. Wire lengths 60' are at right angles to lengths 60 and are disposed at a different level in slab 80.

Referring to FIGURES 9, 10 and 11, there is shown a second embodiment of the present invention, this embodiment differing in certain respects from that shown in FIGURE 1. In this embodiment a detachable support member and register plate are mounted on a special carriage which is provided with means by which it may be pulled. A plurality of bearing devices is rotatably mounted on each of the support members to reduce frictional drag on the stressing wire as it is pulled around each support member. The use of hydraulic jacks is eliminated in this embodiment.

The basic construction of the apparatus shown in FIGURE 9 is similar to that of the apparatus shown in FIGURE 1. Positioned at the ends of concrete foundation 90 are upright standard plates 92 and 94 which are provided with apertures, as shown in FIGURE 10. Corresponding plates 92' and 94' are positioned on the two remaining sides of foundation 90. All four plates extend to the same height above foundation 90 and cooperate with foundation 90 to define a mould for concrete which is to be poured. Register plate 96 is attached to plate 94, and to it are attached bearing plates 98 in which support member 100 is rotatably mounted by means of openings 105. The construction is like that previously described in connection with support member 40, bearing plates 45 and register plate 50. Carriage 102 is attached to plate 92 by the attachment of register plate 104 to plate 92 by means of nuts and bolts, as described in connection with the embodiment shown in FIGURE 1. The carriage comprises, in addition to register plate 104, bearing plates 106 attached to plate 104, support member 108 (which has reduced end portions 104 rotatably mounted in journalled bearing plates 102 and secured therein by nuts 110), wheels 112 mounted on bearing plates 106, and pull-bar 114 which is attached to bearing plate 106 by cables 116. As shown in FIGURE 9, these parts together constitute a unitary carriage. Wheels 112 are adapted to function as trolley wheels for engaging the upper edges of plates 92' and 94' so that carriage 102 may easily be moved back and forth across foundation 90. Cable 118 is attached to pull-bar 114 so that force may be applied to the cable (in the direction indicated by the arrow) for pulling the carriage against a load. Braces 120, having arcuate seats 122, form parts of carriage 102, and are similar in construction and purpose to braces 32 previously described.

A number of roller bearings 126 are rotatably mounted on support members 100 and 114 in adjacent relation, as shown in FIGURE 11. Each bearing 126 is adapted to receive the stressing wire upon its periphery and serves to reduce friction between the moving wire and the support member.

The operation of the apparatus shown in FIGURE 9 is partially analogous to the operation of the apparatus shown in FIGURE 1 and previously described. Carriage **102** is detached from plate **92** and is moved across foundation **90** to a position where register plate **104** is in proximity to plate **94**, movement being facilitated by wheels **112** cooperating with plates **92'** and **94'**. A length of wire **130**, supplied from reel **132**, is wound about support members **108** and **110** and is threaded through registering apertures in register plates **104** and **96**, in substantially the same manner as has been previously described for the embodiment shown in FIGURE 1. Bearings **126** obviously reduce frictional drag between the support members and wire **130** and facilitate the winding operation. The end of wire **130** opposite spool **132** is then anchored to support member **108**. Next, carriage **102** is pulled across foundation **90** from the position in proximity to plate **94**, to the opposite end of foundation **90** by means of cable **118**, in the direction indicated by the arrow in FIGURE 9. Carriage **102** is then rigidly secured to plate **92** in the position shown in phantom outline in FIGURE 9. Nuts **110** are loosened from the ends of support member **108** so that it may seat in arcuate seats **122** of braces **120**. The end of wire **130** opposite spool **132** is detached from anchor member **108** and a force, indicated by the arrow in FIGURE 9, is applied to it by hydraulic means (not shown) to produce predetermined tension throughout wire **130**. This force is maintained during curing of the concrete slab.

As indicated in FIGURE 9, a second carriage **102'** and a second support member **100'**, with their associated parts, are mounted in opposing relation on the sides of foundation **90** not occupied by carriage **102** and support member **100**. These are obviously for the purpose of providing stressing wire in the mould in the direction perpendicular to the lengths of wire **130**, and the operation of these elements is substantially the same as that previously described for carriage **102**, support member **100** and their associated register plates.

Those skilled in the art will realize that a number of modifications may be made in the constructions shown without departing from the essential features of the present invention. As an example of such modification, FIGURES 12 and 13 show an arrangement of bearing devices in the form of pulleys which may be substituted for support member **100** (or support member **114**) and roller bearings **126**. Pulleys **136** are mounted by means of brackets **138** to register plate **140** at a sufficient distance from register plate **140** to permit metallic wire **142** to be passed through a registering aperture **144**, outward to a pulley **136**, around the pulley, then back to the register plate and through the next aperture **144** in line with the first aperture. As shown in FIGURE 13, each pulley is inclined at an angle from the vertical to reduce the bending and distortion of wire **142** in passing from one aperture, around the pulley and then back to a second aperture some distance from the first.

As a further example of such modification, FIGURE 14 shows a modified form of the present invention wherein a plurality of additional register plates **150** divide the mould into sections, thus permitting the production of several individual prestressed concrete structural units in one operation of the apparatus shown. Register plates **150** support the lengths of stressing wire **154** within the mould and their registering apertures maintain the proper arrangement of these lengths of wire.

Although specific embodiments of the present invention have been described and illustrated in detail, it is to be clearly understood that the same are by way of illustration and example only; it is to be understood that the invention is not limited thereto, as many variations will be apparent to those versed in the art and the invention is to be given its broadest possible interpretation within the terms of the following claims.

We claim:

1. Apparatus for providing stressing wire within a mould for producing prestressed structural units, comprising a frame defining a mould for said prestressed unit, first support means rotatably mounted at one end of said frame, a first register plate disposed inwardly of said first support member and parallel thereto, said first register plate having a plurality of apertures to accommodate said wire, a second register plate detachably mounted at the end of said frame opposite said first support member, said second plate confronting said first plate and having a plurality of apertures in registration with the apertures of said first plate, a second rotatably mounted support member substantially parallel to said second register plate, a continuous wire wound spirally around both said support members and extending through the apertures of the register plates to form a plurality of flattened coils having spaced aligned portions within said mould, said second support member being connected with the second register plate to form a unitary structure detachably mounted at the end of said frame opposite said first support member, said unitary structure being adapted to be moved to and retracted from a position in proximity to said first support member to facilitate winding of said wire around said support members, means for anchoring the ends of said wire, and hydraulically actuated means for applying predetermined tension to said wire.

2. Apparatus for tensioning stressing members within a mould for producing prestressed structural units, comprising a generally cylindrical first support member located at one end of said mould, a generally cylindrical second support member substantially parallel to said first support member, an elongated stressing element wound spirally around both said support members to form a plurality of flattened coils, each of said coils encircling both said support members and having a portion thereof disposed within said mould, carriage means attached to said second support member for advancing said second support member to a position in proximity to said first support member and retracting it therefrom, means for supplying incremental lengths of said stressing member on demand, whereby upon retraction of the second support member from said position the length of said stressing member wound around said support members is increased, means for detachably mounting said second support member at the end of said mould opposite said first member, means for anchoring the ends of said stressing member, and means for exerting predetermined force tending to urge said support members apart to apply tension to said stressing member.

3. Apparatus for producing pre-stressed concrete structural units comprising a frame defining a mould for said pre-stressed units, a first cylindrical support member mounted on one end of said frame, a second cylindrical support member in parallel relation with said first support member, a continuous wire wound spirally around said support members and forming a plurality of elongated coils, each of said coils encircling both said support members and having a portion therebetween disposed within said mould, carriage means attached to said second support member for advancing said second support member to a position in proximity to said first support member and retracting it therefrom, a first register plate mounted on said frame inwardly of said first support member and parallel thereto, said first register plate having a plurality of apertures to accommodate said wire, a second register plate mounted on said carriage confronting said first register plate and parallel thereto, said second register plate having a plurality of apertures in registration with the apertures of said first plate to insure spaced alignment of said portions of said wire disposed within said mould, means for supplying incremental lengths of said wire on demand, whereby upon retraction of the second support member from said position the length of said wire wound around said support members is increased, means for detachably mounting said second support member at the

end of said mould opposite said first member, and means for applying tension to said wire.

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