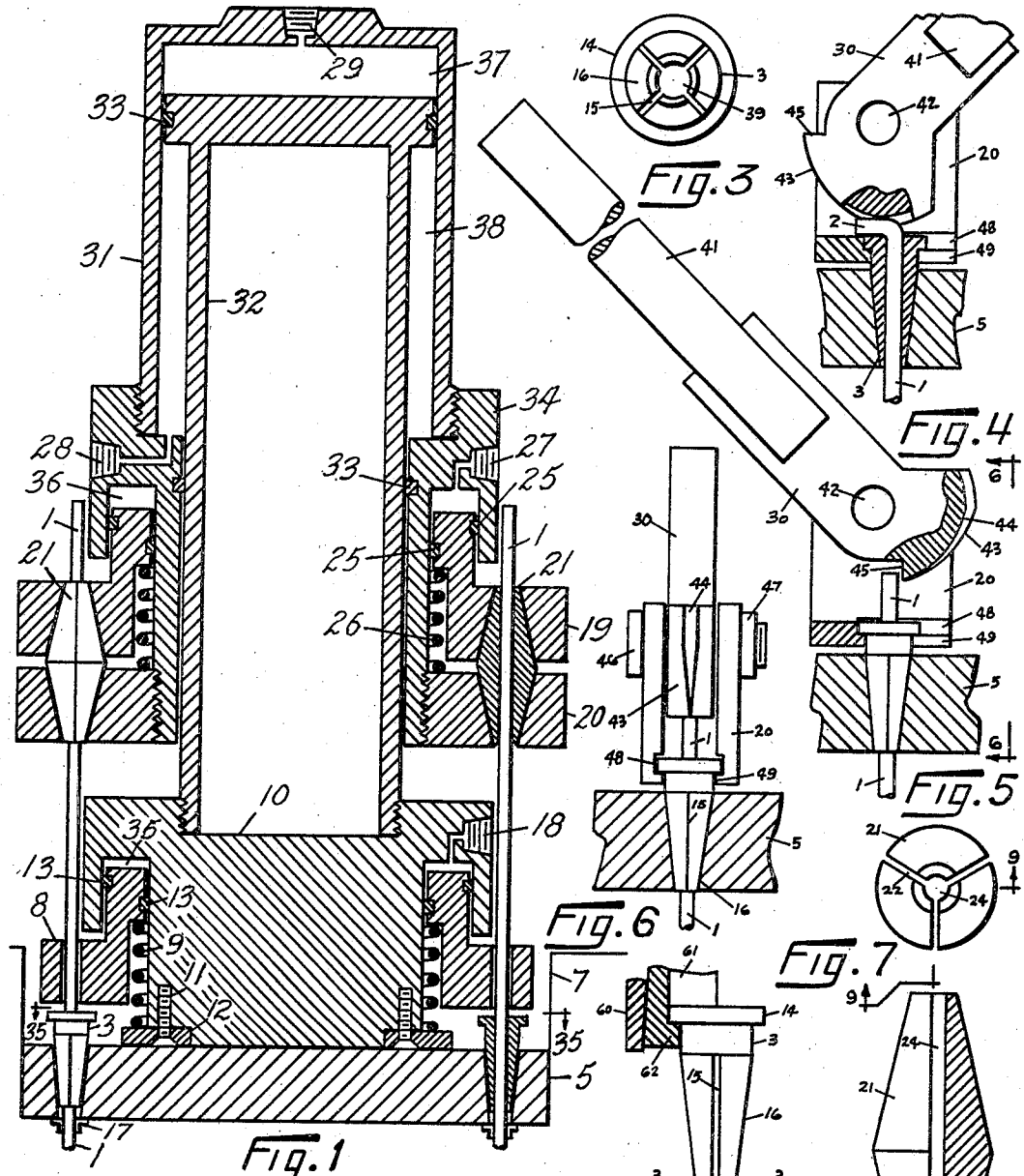
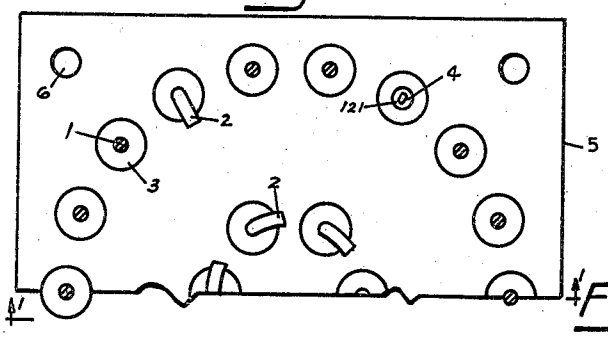
Jan. 27, 1970 B. B. PEWITT 3,491,431

METHOD AND DEVICES FOR POST-TENSIONING CONCRETE AND STRUCTURAL MATERIALS

Filed Aug. 25, 1967 4 Sheets-Sheet 1





INVENTOR.

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Jan. 27, 1970 B. B. PEWITT 3,491,431

METHOD AND DEVICES FOR POST-TENSIONING CONCRETE AND STRUCTURAL MATERIALS

Filed Aug. 25, 1967 4 Sheets-Sheet 2

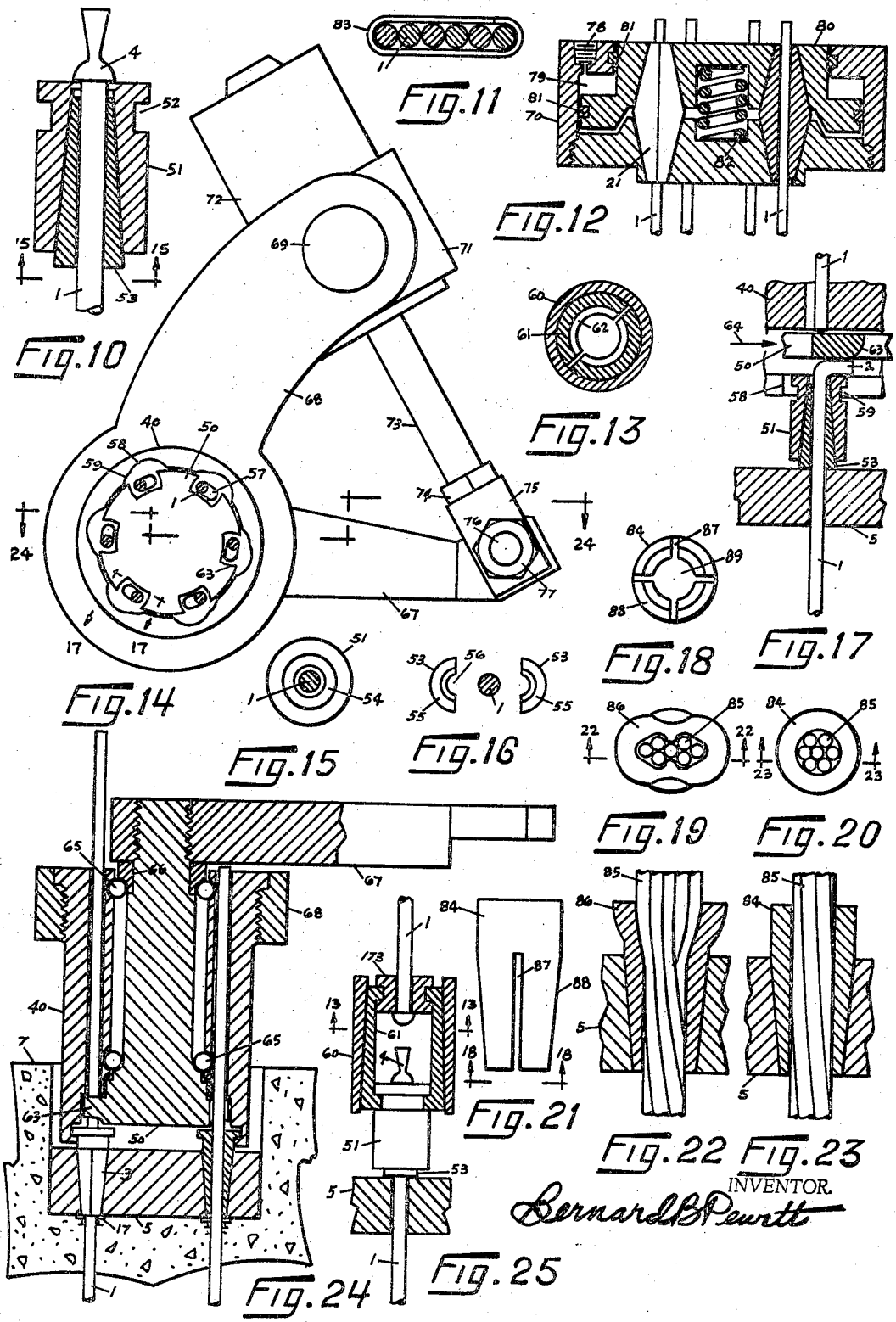


Fig. 10

Fig. 11

Fig. 12

Fig. 13

Fig. 14

Fig. 15

Fig. 16

Fig. 17

Fig. 18

Fig. 19

Fig. 20

Fig. 21

Fig. 22

Fig. 23

Fig. 24

Fig. 25

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METHOD AND DEVICES FOR POST-TENSIONING CONCRETE AND STRUCTURAL MATERIALS

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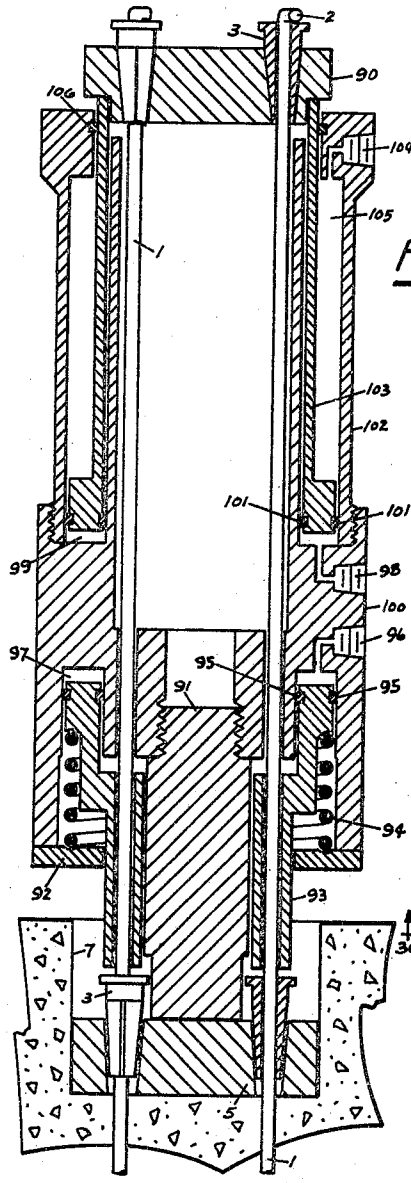


Fig. 26

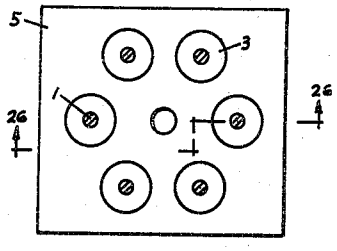


Fig. 27

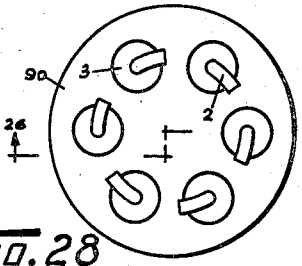


Fig. 28

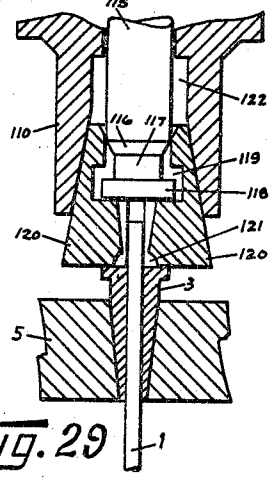


Fig. 29

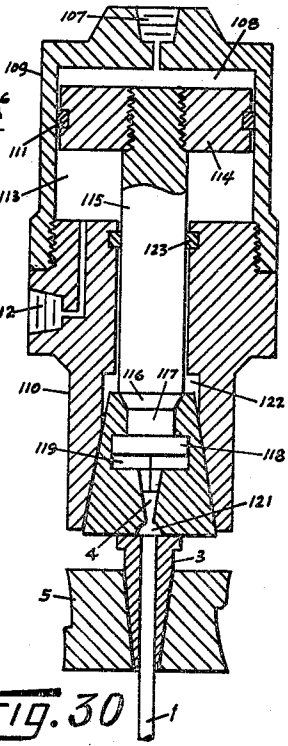


Fig. 30

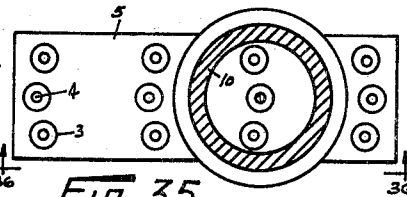


Fig. 35

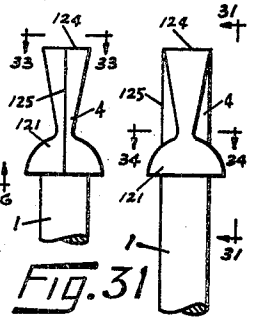


Fig. 31

Fig. 32

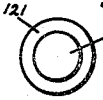


Fig. 33

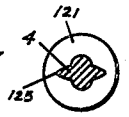


Fig. 34

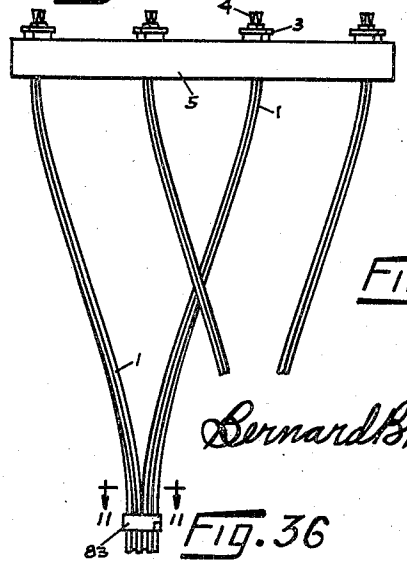


Fig. 36

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METHOD AND DEVICES FOR POST-TENSIONING CONCRETE AND STRUCTURAL MATERIALS

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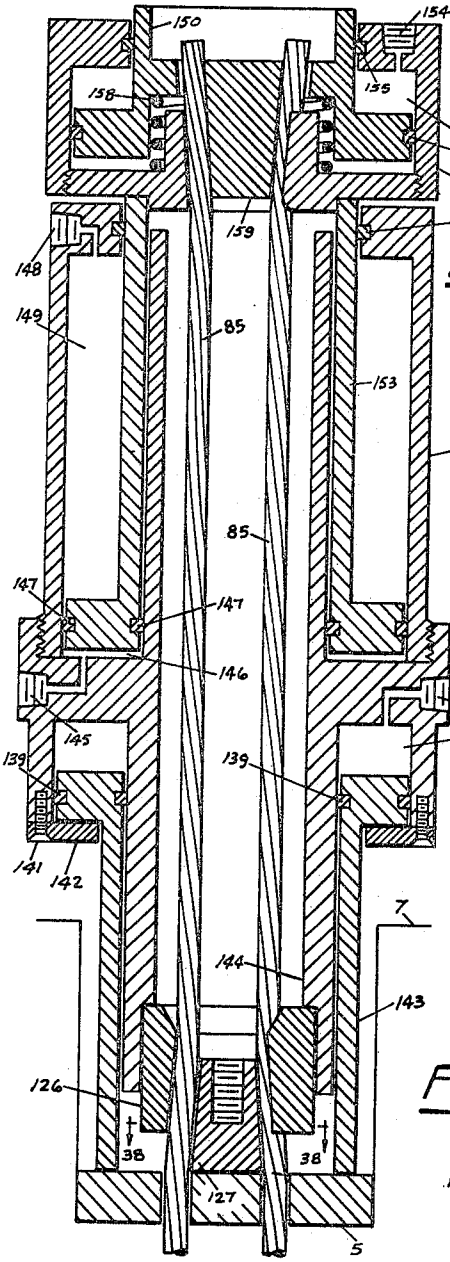


Fig 37

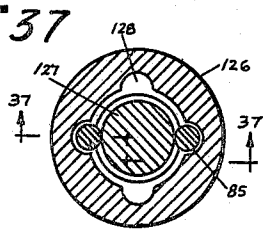


Fig 38

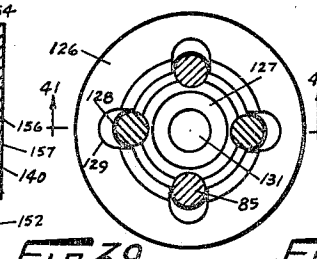


Fig 39

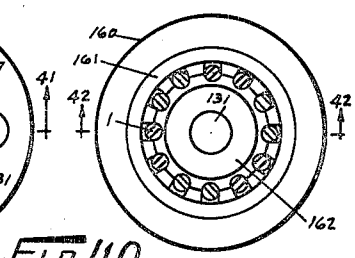


Fig 40

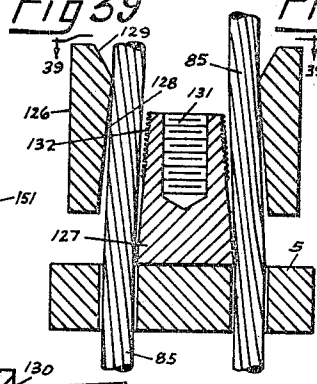


Fig 41

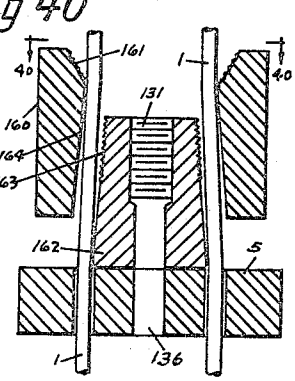


Fig 42

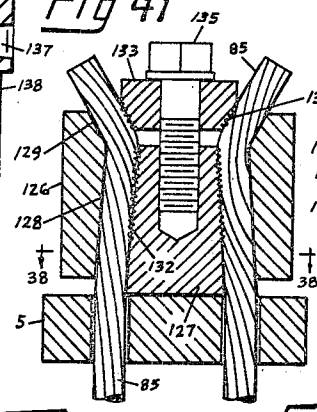


Fig 43

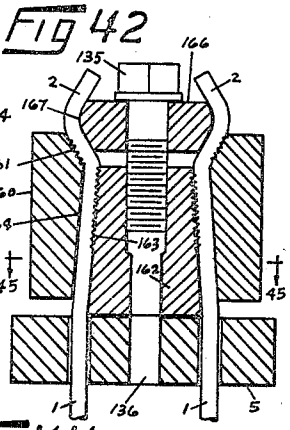


Fig 44

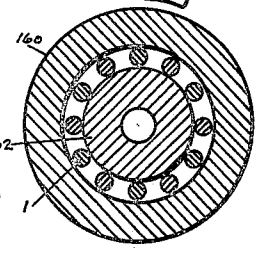


Fig 45

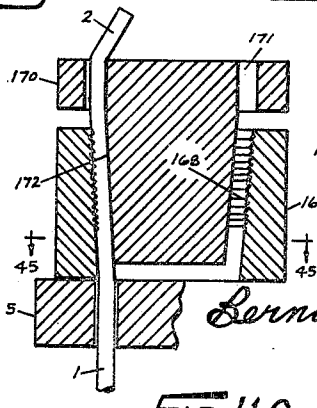


Fig 46

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United States Patent Office 3,491,431
Patented Jan. 27, 1970

3,491,431

METHOD AND DEVICES FOR POST-TENSIONING CONCRETE AND STRUCTURAL MATERIALS

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Filed Aug. 25, 1967, Ser. No. 667,621
Int. Cl. B21d *39/00;* B23p *21/00*
U.S. Cl. 29—452 15 Claims

ABSTRACT OF THE DISCLOSURE

A post-tensioning system through a concrete structure comprising high-strength steel wire or cable tendons stressed, elongated and anchored between opposing anchor blocks, and then deforming or upsetting the wire ends and clamping or swaging the cable ends, after stressing to positively maintain elongation of the tendons through the structure.

This invention relates to an improved method and devices for prestressing and post-tensioning concrete structures along a line and between fixed anchor blocks spaced apart and within or adjacent to said concrete structures. High strength steel wires or stranded cable tendons, treated along their length to prevent bonding with the concrete, are draped along a line between and through opposing anchor blocks, said drape being designed to satisfy positive and negative moment requirements, and, after placing and sufficient curing of the concrete, the tendons are stressed and elongated through the concrete and positively anchored through the anchor blocks, in a new and novel method that is described in this specification.

The known stressing systems may be classified into two groups: (1) positive end anchorage systems, and (2) friction gripping systems. The positive end anchorage systems are factory made to pre-determined lengths, require costly stressing heads as a component part of the tendon hardware, and must be stressed out-of-the-hole for elongation and shimmed against the anchor plates, or must be propped away from the structure to maintain elongation. This requires costly block-outs in the concrete that must be poured later to cover the exposed shims and stressing heads. The known friction-gripping systems overcome some of the above disadvantages but do not have positive end anchorage and must be grouted along their length to bond the tendons to the concrete after stressing and elongation.

The general object of my present invention is to avoid these said technical and economic disadvantages by using a friction-gripping method and devices for stressing and elongating the tendons through the fixed anchor plates, and then deforming or upsetting the wire ends, and clamping or swaging the cable ends, after stressing, to positively maintain said elongation. Thus, my system becomes a positive end anchorage system stretched and anchored between opposing anchor blocks without the use of external shims and hardware stressing ends as required in group 1 above.

The principal function of any anchorage of a post-tensioning tendon is to anchor the ends of the tendon in all circumstances. Under these conditions an unbonded tendon will elongate uniformly over its entire length in response to a severe overload such as that produced by an earthquake, whereas a grouted tendon, assuming that grouting results in bonding, will elongate only in the length over which bond is broken, and since this will occur at points of maximum moment, the prestressed building with bonded tendons is much more likely to

collapse under severe overloads, or earthquake conditions, than the prestressed building with unbonded tendons having positive end anchorage.

Post-tensioning tendons are normally stressed through the structure and anchored at 70% of the ultimate strength of the tendon, and this stress causes approximately 1% elongation of said tendon. The tendon may be elongated, however, up to about 6% before reaching the yield point of the material. It is normal to overstress up to about 80% of the ultimate strength to overcome friction, before anchoring at 70%, and the design stress is assumed to be 60% of the ultimate strength to allow for prestressing losses due to creep, fatigue and other factors. Quite often, the architect or engineer will specify partial or progressive stressing at some lower figure, say 50%, and then arrival at final stressing as outlined above.

Another object of this invention is to provide an on-the-job method of prestressing tilt-up wall panels of brick, concrete blocks or structural tile, whereby said brick, block or tile is grouted along the bearing surfaces and assembled together on a flat surface, such as the building floor slab, and between continuous channels or anchor members serving as top and bottom of the erected wall. Tendons of the required size are inserted through interstices in the structural material and through openings in the opposing anchor members, and the anchor members are then stressed together compressing and post-tensioning the brick, block or tile into an integral unit. Said unit is then tilted-up into vertical position and the base anchor is welded to steel anchor plates imbedded in the concrete slab. Each wall section is then joined together by welding the anchor plates at top and bottom to form a continuous structural wall designed to resist structural and wind loads without need for supporting columns and connecting beams. Details of erection are conventional and are not shown in the drawings, but the stressing details are shown and further described in this specification. Advantages of this system include the elimination of wall columns and connecting beams; the conversion of materials normally used to construct non-load bearing walls into structural load bearing panels; and the amount of labor and scaffolding is reduced versus conventional methods.

The stressing system disclosed herein is especially designed to meet the above requirements. The tendons are simple and consist of a plurality of parallel wires or stranded cables, which have been treated along their length for corrosion protection and to prevent bonding with the concrete. Said tendons are placed or inserted through the structure and through openings in opposing anchor plates with a slight excess of length extending therethrough for two-end stressing. For one-end stressing, the anchor end is imbedded within the structure in a conventional manner, and the stressing end is extended through the opposing anchor plate as above. The clamping hardware, disclosed in the drawings and further described in this specification, is placed in a manner to encircle the individual wire or cable components of the tendon, the stressing device is placed over the clamping hardware with means for simultaneous gripping the wires or cables comprising the tendon; said tendon is hydraulically elongated to the desired stress and the clamping hardware is hydraulically rammed to maintain said stress and elongation. The tendon elongation and clamping operation may be alternated successively to arrive at any desired stress or elongation. For example, a stressing ram with a relatively short elongation stroke may be used, by alternating the stroke and clamping action, to elongate a very long tendon through any required amount of elongation to reach the desired stress. After final

stressing of the tendon, the stressing ram is removed, the excess wire or cable is cut off and the wire or cable ends are anchored as disclosed herein to form a positive end anchorage after stressing.

The post-tensioning of flat slabs and thin wall sections requires a different anchorage approach from that used for heavy beams and girders in order to keep the anchorage stresses within safe limits. Most of the present tendon suppliers use a grease-and-wrap method of covering the tendon which leaves a void behind the anchor plate at the point of maximum stress. A very slight eccentricity in the placing of the tendon within the concrete section can and does cause a certain percentage of tendons to literally explode and fly out of the concrete at the anchored ends after stressing. To overcome this, my system uses a bond-breaking coating on each wire or cable and the individual wires or cables are spread apart at the anchorage to distribute the stresses over a larger area and eliminate the void caused by the aforesaid wrapping, and as shown in FIGS. 35 and 36. For beams and girders, or heavy sections where stirrups and spiraled reinforcing can be used to contain higher bearing pressures, a more compact arrangement of wires or cables is used to form the tendon as shown in FIGS. 38, 39, 40 and 45.

Several forms of apparatus for carrying out the method disclosed herein, are shown in the accompanying drawings in which:

FIG. 1 is a cross-sectional view of a stressing device, taken along line I—I of FIG. 2.

FIG. 2 is a half-plan layout of the anchor plate with wires and wedges shown therethrough.

FIG. 3 is a plan view of the partially split conical wedge, taken along line **3**—**3** of FIG. 8.

FIG. 4 is an elevation and partial section showing the wire anchorage tool inserted over the partially split conical wedge and with the wire in fully anchored position.

FIG. 5 is the same as FIG. 4, except that the wire anchorage tool is shown as first inserted over the wedge and before anchorage of the wire.

FIG. 6 is an elevation of the wire anchorage tool inserted over the partially split wedge and taken along line **6**—**6** of FIG. 5.

FIG. 7 is a plan view of the three-part double-conical collet wedge of the wire holding device of FIG. 1.

FIG. 8 is an elevation of the flanged and partially split conical wedge shown in plan in FIG. 3.

FIG. 9 is an elevation and partial section of the double-conical wire holding wedge shown in FIG. 1 and taken along the line **9**—**9** of FIG. 7.

FIG. 10 is a cross-sectional elevation of an alternative wire wedging device comprising a grooved and conically bored outer member retaining a split inner conical wedge with a wire shown therethrough and upset after stressing.

FIG. 11 is an elevation of a wire clamp with the tendon wires shown in section therethrough and taken along line **11**—**11** of FIG. 36.

FIG. 12 is a cross-sectional view of a wire clamping device to be used in lieu of part **90** in FIG. 26.

FIG. 13 is a plan-sectional view of a tendon-wire splicing device taken along line **13**—**13** of FIG. 25.

FIG. 14 is a plan, viewed from the underneath side, of a combination shearing and deforming tool, designed to lock onto the tendon wedge configuration shown in FIG. 27, to successively shear and deform the wires into the pattern shown in FIG. 28.

FIG. 15 is a plan view of the conically bored outer member shown in FIG. 10 and taken along line **15**—**15** thereof.

FIG. 16 is a plan view showing the split inner conical wedge of FIG. 10 viewed from the smaller end and showing the wire **1** in cross-section.

FIG. 17 is a cross-sectional view, along the line **17**—**17** of FIG. 14, showing the shearing and deforming tool in fully operated position with the wire sheared and deformed, after stressing.

FIG. 18 is a plan view, taken along the line **18**—**18** of FIG. 21, showing the partially split conical wedge designed for clamping stranded cable.

FIG. 19 is an upper plan view of the conical wedge of FIG. 18, after stressing the cable through said wedge and hydraulically swaging the wedge to rearrange the wire pattern for positive anchorage of the cable therein.

FIG. 20 is the view of FIG. 19 after stressing of the cable and before swaging of the wedge.

FIG. 21 is an elevation of the bored and conically turned split wedge shown in FIG. 18.

FIG. 22 is a longitudinal cross-section of the hydraulically swaged wedge and cable assembly shown and taken along line **22**—**22** of FIG. 19.

FIG. 23 is a longitudinal cross-section taken along line **23**—**23** of FIG. 20 and showing the wedge **84** rammed into the anchor plate **5** and retaining the cable **85** therethrough, with the cable end cut off ready for swaging.

FIG. 24 is a partial cross-section and elevation of the shearing and deforming tool, taken along line **24**—**24** of FIG. 14, and showing the tool in position over the wedge and anchor configuration of FIG. 27 and ready for the shearing and deforming action shown in FIG. 17.

FIG. 25 is a sectional elevation of a splicing device arranged to permit the attachment of a new wire to an already stressed and anchored wire, thus permitting prestressed continuity between old and new construction.

FIG. 26 is a cross-sectional view, along the line **26**—**26** of FIG. 27, of the stressing device arranged to stress the wires **1** through the wedges **3** of the anchor plate **5** shown in FIG. 27 and is intended to be used in conjunction with the stressing device shown in FIG. 1 for stressing the inner circle of wires **1** shown in FIG. 2.

FIG. 27 is a plan view showing the arrangement of wires and wedges within the anchor plate.

FIG. 28 is a plan view of the stressing block **90** shown in FIG. 26 and shows the wires sheared and deformed by the shearing and deforming tool disclosed in FIGS. 14, 17 and 24.

FIG. 29 is a partial cross-sectional view of the cold-forming button-heading tool, in open position, used to form an upset head on the wire for positive anchorage after stressing.

FIG. 30 is a longitudinal cross-section of the button-heading tool of FIG. 29 shown in closed position with the cold-formed head **121** shown flowed into the corresponding cavity of the split die **120**.

FIG. 31 is an elevation of the cold-formed upset head of the wire as formed by the tool shown in FIGS. 29 and 30 and is taken along line **31**—**31** of FIG. 32.

FIG. 32 is a right angled elevation of the headed wire shown in FIG. 31.

FIG. 33 is a plan view along line **33**—**33** of FIG. 31 showing the outline of the upset head **121** of the wire **1**.

FIG. 34 is a sectional plan view along the line **34**—**34** showing the metal flow from the restricted section **4** of the die **120** into the cavity **121** thus forming the corresponding head **121**.

FIG. 35 is a plan view of a tendon and anchor plate layout for flat slabs showing a stressing method by using the stressing device of FIG. 1 with a hollow base **10** and stressing and anchoring the wires from two locations of the stressing unit.

FIG. 36 is an elevation, taken along the line **36**—**36** of FIG. 35, showing the wires widely distributed over the anchor plate to reduce the concentration of stresses in thin slab and wall sections.

FIG. 37 is a longitudinal cross-section of a stressing device designed to stress and anchor both cable and wire units through the anchor plate and is taken along line **37**—**37** of FIG. 38.

FIG. 38 is a sectional plan view along line **38**—**38** of FIG. 37 showing the configuration of the clamping hard-

ware for stranded prestressing cables, and is taken along line **38—38** of FIG. 43, as well.

FIG. 39 is an upper plan view of the clamping hardware shown in FIG. 38 for stranded cables.

FIG. 40 is an upper plan view of the clamping hardware for parallel prestressing wires.

FIG. 41 is a cross-sectional view along the line **41—41** of FIG. 39 showing the outer ring **126** in open position with respect to the inner plug **127** for the purpose of stressing and elongaging the cable through the ring and plug assembly.

FIG. 42 is a cross-sectional view along line **42—42** of FIG. 40 showing the outer ring **160** in open position with respect to the inner plug **162** for the purpose of stressing the prestressing wires and elongating same through the ring and plug assembly.

FIG. 43 is the same as FIG. 41 except that the outer ring **126** has been rammed over the cables **85** and the inner plug **127**, and the cable clamp **133** is shown installed for positive anchorage of the cables.

FIG. 44 is the same as FIG. 42 except shown in rammed and closed position and with the wire clamp **166** in place.

FIG. 45 is a sectional plan view taken along line **45—45** of FIG. 44 and similar to line **45—45** of FIG. 46 and shows the relative position of the wires **1** in clamped position between the outer ring **160** and the inner plug **162** of FIG. 44 and the outer ring **169** and the inner plug **170** of FIG. 46.

FIG. 46 is a cross-sectional view of an intended variation of clamping hardware for prestressing wires wherein anchorage is improved by bending the wire ends, as shown.

Referring more in detail to the drawings:

FIG. 1 shows a longitudinal cross-sectional view of the stressing and anchoring device used to stress and elongate the wires **1** through the conical wedges **3** arranged in the peripheral ring of FIG. 2 and in the overlapping layout of FIG. 35, wherein: said device, having a solid base **10** as shown in FIG. 1 or a hollow base **10** as shown in FIG. 35, is centered within said peripheral ring of conical wedges **3** with the reinforcing wires **1** extending through openings in the spring-loaded hydraulic piston **8** and through the gripping wedges **21**. Hydraulic fluid is pumped through the opening **27** and into the cavity **36** causing the piston **19**, with seals **25**, to move down against the pressure of the spring **26** thus compressing the wedges **21** and securely gripping the wires **1**. With hydraulic pressure maintained through said opening **27** to retain grippage on said wires **1**, hydraulic fluid is now pumped through opening **29** and into the cavity **37** causing the outer cylinder **31** to move away from the inner piston **32**, with seals **33**, said inner piston **32** being attached to said base **10**, and causing elongation of the reinforcing wires **1** through the anchor plate **5** and the conical wedges **3**, encircling said wires **1**, until the calculated elongation of said wires **1** is achieved. While maintaining hydraulic pressure through openings **27** and **29**, hydraulic fluid is now pumped through the opening **18** and into the cavity **35** causing the piston **8**, with seals **13**, to move down against the pressure of the spring **9** and thus ramming the conical wedges **3** into the corresponding openings in the anchor plate **5**. The cross-sectional areas of the cavities **36**, **37** and **35** are balanced so that one hydraulic pump with appropriate valving can control the gripping of the reinforcing wires **1**, the elongation of said wires **1** and the ramming of said wedges **3** to maintain elongation of the wires **1** through the anchor plate **5**. After anchorage, hydraulic pressure is released at openings **27**, **29** and **18**, permitting the pressure from spring **26** to move the piston **19** upward thus releasing the gripping wedge **21** and freeing the wire **1**, and permitting the pressure from spring **9** to move the ramming piston back to the original position, thus the stressing device main body **10** may be lifted clear of the anchored wire assembly. The plate **12** is attached to the main body **10** with screws **11**, and serves as a stop for the piston **8** and retains the spring **9** within the assembly. Hydraulic fluid is now pumped through the opening **28** into the cavity **38**, with pressure retaining seals **33**, to move the outer cylinder down for the next stressing operation. It can be seen that by alternating the gripping, elongation and ramming operations, the wires **1** may be partially stressed and held, and the stressing operation may be repeated as many times as required to secure elongation of the wires **1** far in excess of the stroke of the outer cylinder **31**.

The peripheral ring of wedges shown in FIG. 2 is stressed and anchored as described above, and the inner ring of wedges is stressed and anchored with the stressing device shown in FIG. 26, which will be described later.

The anchoring wedge **3** of FIGS. 1 and 2 is disclosed in FIGS. 3 and 8 and consists of an upper flange **14**, a conically tapered outer and lower surface **16** with slits **15** to permit compression of the wedge **3** within the correspondingly bored opening in the anchor plate **5**, and a centrally bored opening through the wedge **3**.

The holding wedge **21** of FIG. 1 is disclosed in FIGS. 7 and 9 and consists of a three-part wedge conically tapered toward each end, with separating slits **22**, a hole **24** bored longitudinally therethrough and with an inner chamfer **23** for ease of inserting the wires **1**.

FIGS. 4, 5 and 6 disclose a wire anchorage tool consisting of a lower unit **20** that is counter-bored from the front side with a groove **48** and a lip **49**. Said groove **48** engages the flange **14** of the wedge **3** shown in FIG. 8 and the said lip **49** locks under said flange **14** and prevents upward movement of the said lower unit **20**. A rotatable upper unit **30** is inserted through the U-shaped upper part of the lower unit **20** and held in position with a bolt **46** and a nut **47** through the lower unit **20** and through the hole **42** of the upper unit **30**. The rotatable upper unit **30** has a hooked section **45** to engage the wire end **1**, a cammed outer surface **43** and a guide groove **44**. In operation, the tool, with handle **41**, is inserted over the flange **14** of the rammed wedge as shown in FIGS. 5 and 6, and the handle **41** is raised, causing the hook **45** to engage the pre-cut wire end **1**. Further elevation and rotation of the handle **41** and upper unit **30** causes the wire **1** to track within the guide groove **44** of the cammed surface **43** and results in right angle deformation of the wire end **1** and positive end anchorage of said wire **1**.

The conical wedge assembly **51** disclosed in FIGS. 10, 15 and 16 is intended to be used in lieu of the wedge **3** of FIG. 8 where post-tensioning is required through an existing structure with anchor members of insufficient thickness to develop the gripping stress required by wedge **3**, or where it is not practical, as certain field conditions, to conically bore the anchor member for the wedge **3**. The wedge assembly **51** is self-contained and requires only a drilled hole in the anchor member for insertion of the wire **1** therethrough. Said assembly **51** consists of a cylindrical outer section with a groove **52** located in the upper limits thereof and a conical bore **54** longitudinally therethrough. Split inner wedges **53** having a central bore **56** and a conically turned outer surface **55** complete the assembly. This wedge assembly **51** is designed for use with the stressing units disclosed in FIGS. 1 and 26 as well as the anchorage tool disclosed in FIGS. 4, 5 and 6, and also with the shearing and deforming tool later disclosed in FIGS. 14, 17 and 24.

The combination shearing and deforming tool disclosed in section in FIG. 24 and in lower plan view in FIG. 14 is designed to be inserted over a plurality of wires **1**, arranged in a pre-set pattern, after stressing and anchorage, whereby the wires **1** are simultaneously sheared to an even length of projection and progressively deformed in a circular pattern as shown in FIG. 28. Until being locked on the wedges **3** or **51**, the tool acts as a shear only, and the tool is inserted over the wire group and the shear is successively operated until the wires **1** do not extend

through the tool when in position over the wedges. In operation, the counterbores **58** of the outer unit **40** are fitted over the wedges **3** or **51** and the tool is rotated slightly thus engaging the lip **59** within the groove **52** of the wedge **51** or under the flange **14** of the wedges **3** thus locking the tool to the circular arrangement of the wedges and preventing further rotation of the outer unit **40**. Hydraulic fluid is then pumped into the cylinder **72** causing the shaft **73** to retract and thus causing the inner member **50** to partially rotate within the outer member **40**. Said rotation is shown in FIG. 17 whereby the cutting and deforming die **63** moves in direction **64** and shears and deforms the wire **1** into the configuration **2** for positive end anchorage. The flow of hydraulic fluid is reversed in the cylinder **72** causing the shaft **73** to extend and open the tool. Said tool is then rotated to release the lip **59** and is lifted off. The construction of this tool is unique due to the usage of hardened tool steel for both the outer unit **40** and the inner unit **50** whereby an efficient radial-thrust ball bearing assembly can be made within a very limited space. To assemble, the inner unit **50** is inserted within the outer unit **40** to a point where the reduced shaft section, for the inner bearing race **66**, coincides with the lower bearing race of the outer unit **40**, whereby a sufficient number of balls **65**, of a required size, are placed to fill said outer race. Said inner member is now pushed through the outer member **40** until angular contact is made with the lower row of hardened balls **65**. The upper row of hardened balls **65** is now installed, the inner bearing race **66** is fitted over the shaft and the lever arm **67** is screwed onto the threaded shaft comprising the upper end of the inner unit **50** thus retaining the units ball bearingly mounted one within the other. The stationary arm **68** is screwed onto the outer member **40** as shown. The hydraulic cylinder **72** is mounted on the stationary arm **68** in a conventional manner with a swivel bolt **69** and ring clamp **71**, and the shaft **73** is rotatably connected to the movable arm **67** by means of a threaded clevis **75** with lock nut **74**, and a bolt **76** with a nut **77**. The slotted holes **57** are arranged to permit sufficient movement of the center member **40** whereby the tool may be inserted over the wedges **3** or **51** and rotated slightly to lock the lip **59** to the wedges as outlined above.

The wire clamp **83** shown in FIGS. 11 and 36 is arranged as a convenient means to retain the wires **1** within a prescribed path through the concrete and to facilitate the handling of tendons during manufacture and prior to actual placing within the structure.

The hydraulic wire clamp **70** shown in cross-section in FIG. 12 is a new and novel method of simultaneously gripping the plurality of wires within the tendon and is intended to be used with the stressing device shown in FIG. 26 or with a commercially available through-hole stressing jack. In operation, the wires **1** are inserted through the wedges **21**, already disclosed in FIGS. 7 and 9 and described herein. Hydraulic fluid is pumped through the opening **78** into the cavity **79** causing the inner unit **80** to move down against the resisting pressure of the spring **82** thus compressing the wedges **21** and gripping the wires **1**. To release the wires **1**, hydraulic pressure is released and the spring **82** forces the inner unit **80**, with seals **81**, in an upward direction thus releasing the gripping action on the wedges **21** and the wires **1**.

The assembly view of FIG. 25 and the cross-sectional plan view of FIG. 13 discloses a method for continuity in prestressing forces from old to new construction whereby a stressing wire **1**, button-head anchored through a grooved washer **173**, is anchored to the existing wedge **51** by using a split inner sleeve **61** with internal flanges **62** fitted into the groove **52** of the wedge **51** and into the groove of the washer **173** with a tapered retaining sleeve **60** holding said split inner sleeve **61** in position. A similar method is used for gripping the alternate wedge **3**.

FIGS. 18 and 21 disclose a wedge **84** designed especially for stressing, gripping and anchoring seven-wire prestressing stranded cable. Said wedge **84** is made from annealed round bar stock with an inwardly tapered outer wall **88**, four slits **87** made by cross-sawing and extending part way upward from the smaller end, and with a longitudinal hole **89** bored therethrough for the passage of the stranded cable **85**. FIGS. 17 and 20 show the cable **85** through the wedge **84** and with said wedge rammed into the anchor plate **5** to hold the stress on the cable **85**. To secure positive end anchorage, after stressing, the exposed portion of the wedge **84** is hydraulically swaged into the configuration **86** thus causing a realignment of the wires comprising the cable **85** as shown in FIGS. 19 and 22, and thus forming a wedge within a wedge for positive end anchorage. The swaging tool is not specifically shown but is similar to the wire heading tool shown in FIGS. 29 and 30 with the cavity **121** of the die **120** arranged to the configuration **86** of the swaged wedge.

The aforesaid wire heading tool is arranged to cold-form a button-head or upset section adjacent to the end of the wire with said button-head bearing against the top of the wedge **3** or **51** thus forming a positive end anchorage of the wire **1**, after stressing. FIG. 29 is a partial cross-sectional view of the tool in open position and shows the forming die **120** in position over the end of the wire **1** and resting on the top of the wedge **3**. Said forming die **120** is longitudinally split into two halves and has a conically turned outer wall, an inner cavity **121** corresponding to the form of the cold-formed head **121** of the wire **1** as shown in FIGS. 31 and 32, and an upper and inner counterbored cavity **119**. The shaft **115** is shown in the fully extended position with the flanged end **118** within the bearing on the base of said cavity **119** thus holding the forming die halves **120** in the open position. FIG. 30 shows the wire heading tool in fully closed position wherein the shaft **115** and piston **114** is hydraulically retracted by pumping fluid through the opening **112** and into the cavity **113** with seals **111** and **123**. The forming die halves **120** move together against the wire **1** as the shaft **115** is retracted and the shaft flange **118** engages the upper end of the die cavity **119** thus forcing the die halves **120** between the conically bored lower section of the main body **110** on the outside and the reduced diameter **117** and chamfer **116** of the shaft **115** on the inside. The wire **1** is thus reduced in section at cavity **4** and forced to flow into cavity **121**, thus anchoring the wire **1** through the wedge **3**, after stressing and elongation therethrough. To open the die **120**, the above hydraulic pressure is released and hydraulic fluid is now pumped through the opening **107** and into the cavity **108**.

The normal method of upsetting a wire or rod end is well within the arts and consists of a gripping device to hold the wire or rod end exposed and progressing the exposed end into a die block with a concave cavity to form the desired button-head. However, the force required to form the button-head must exceed the ultimate strength of the material being formed, and since this force is longitudinally in line with the wire or rod, this method cannot be used to form an anchor head on a wire that is already stressed and anchored at 70% of the ultimate strength of the material without causing failure of the wire through the anchorage. For this reason it is necessary to use a force in the heading operation of the tool in FIGS. 29 and 30 that is perpendicular to the direction of the wire, and the anchorage of the heading tool must be on the free end of the wire, which is static or in a state of rest since the elongation stresses of the wire have been absorbed and equalized through the anchored wedge. Thus the upset head shown in FIGS. 31, 32, 33 and 34 is made with an upwardly tapered section **4** that is required as anchorage for the upsetting die **120** to prevent upward movement of the tool as the wire anchorage head **121** is formed by flowing the material into the cavity **121**. The parting line **125** of the die halves **120** is maintained as shown to permit the flow of material from the restricted

anchor cavity **4** into the enlarged cavity **121** thus forming the button-head adjacent to the wedge **3**.

FIG. 26 shows a longitudinal cross-section of a stressing and anchoring device arranged for simultaneous stressing of a plurality of wires **1** through the anchor plate **5** and anchoring wedges **3** in a pattern shown in plan in FIG. 27 and the inner ring of wedges of FIG. 2, wherein the stressing unit **100** is positioned over the wires **1** and said wires are anchored through the bearing block **90** and the wedges **3** by using the wire shearing and anchoring tool disclosed in FIGS. 14 and 24, or the wires **1** may be simultaneously gripped by using the hydraulic anchoring tool disclosed in FIG. 12. With the wires **1** anchored through the stressing unit **100** as above, hydraulic fluid is pumped through the opening **98** into the cavity **99** causing the piston **103**, with seals **101** and **106**, to progress upward causing simultaneous elongation of the wires **1** to the prescribed stress reading calculated on a hydraulic gauge connected into the hydraulic system. While holding the said elongation of the wires **1**, hydraulic fluid is pumped through the opening **96** into the cavity **97** causing the hydraulic piston **93**, with seals **95**, to move downward against the pressure of the return spring **94** and causing compression of the wedges **3** or **51** and consequent gripping of the wires **1** within the anchor plate assembly. Hydraulic pressure is now released at openings **96** and **98** and hydraulic fluid is pumped through the opening **104** into the cavity **105** to retract the piston **103**. The spring **94** automatically retracts the piston **93** when pressure is released at opening **96** permitting the hydraulic fluid to flow back to the reservoir. The wires **1** are cut loose from the stressing block **90** or released from the hydraulic gripper **70** of FIG. 12 and the stressing unit **100** is removed. Anchoring of the wires **1**, after stressing, may now proceed as already disclosed.

FIG. 27 shows the assembly of wires **1** through the wedges **3** and anchor block **5** for stressing and anchoring as outlined above.

FIG. 28 shows a plan layout of the stressing block **90** with the wires **1** and the ends **2** of said wires anchored with the tool disclosed in FIGS. 14, 17 and 24.

FIGS. 35 and 36 show an arrangement for distributing the anchor bearing stress in a relatively thin concrete slab section wherein the stressing and anchoring unit **10**, disclosed in FIG. 1, is used in an overlapping layout to stress the wires **1** in two successive operations. The American Concrete Institute Building Code requires that all wires in a tendon shall be simultaneously stressed, and this requirement is fully complied with by using two tendons, i.e., assembly of stressing wires, through a common anchor plate as shown in FIG. 36. The clamp **83** is used to contain each tendon in its prescribed track through the concrete.

FIG. 37 is a longitudinal cross-section of a stressing and anchoring device **130** arranged for stressing either wires **1** or stranded prestressing cables **85** through the anchor block **5** and through a plug **127** and cone **126** assembly wherein the stressing device **130** is positioned over the said plug and cone assembly with the wires or cables running therethrough and with the ends of said wires or cables securely clamped within the spring **158**, loaded plug **159** and cone assembly of the stressing block **140**, externally mounted on the stressing device **130**, wherein said stressing block grips the wires **1** or cables **85** by pumping hydraulic fluid under pressure through the opening **154** and into the cavity **156**, with seals **155** and **157**, causing the inner member **150** to move, against the opening pressure of the spring **158**, and clamp the wires **1** or cables **85** between the surfaces of the plug **159** and the cone forming the central opening through the main body of the stressing block **140**. After clamping, the wires or cables are stressed and elongated by pumping hydraulic fluid through the opening **145** into the cavity **146**, with seals **147**, causing the piston **153** to extend until the desired stress and elongation of the wires **1** or cables **85** is attained, while holding the lower piston **144** is fully extended position with hydraulic pressure through the opening **137** and into the cavity **138**, with seals **139**, and with said lower piston **144** being retained by plate **142** and screws **141**. While maintaining said elongation, hydraulic pressure is slowly released through opening **137** causing hydraulic fluid to flow from the cavity **138** back to the reservoir and permitting the inner barrel **144** to move downward and compress the outer cone **126** around the tapered inner plug **127**, thus anchoring the wires **1** or the cables **85** through the anchor plate **5** and within the plug **127** and the cone **126**. After anchoring is completed, hydraulic pressure is released at opening **145** and the piston **153** is retracted by pumping hydraulic fluid through the opening **148** and into the cavity **149**. The wire or cable ends are freed by releasing the hydraulic pressure at opening **154** of the clamping assembly **140**, and both units **140** and **130** are removed.

FIG. 38 is a cross-sectional plan view of the cone **126** and tapered plug **127** assembly, taken along line **38—38** of FIG. 37 and shows the longitudinal grooves **128** that conform to the half-configuration of the cables **85**.

FIG. 39 is a plan view from above showing the outer cone **126** with the inner tapered plug **127** therethrough, the angular grooves **129** that are a continuation of the grooves **128** shown in FIG. 38, and the tapped hole **131** centrally located in the plug **127**.

FIG. 41 is a longitudinal cross-section of the cone **126** and plug **127** shown during the stressing operation and before anchorage of the cables **85** and shows the clearance between the units permitting the cables **85** to be elongated through the anchor plate **5** and between the said plug and cone. The threaded or toothed section **132** of the plug is arranged for additional gripping action during the anchoring operation and is located so that the cables **85** may be pulled through the assembly, during stressing, without dragging over the surface of the toothed section **132**.

FIG. 43 shows the same view as FIG. 41 except that the assembly is shown in the final anchored position, with the teeth **132** gripping the cables **85** and the outer cone **126** rammed into position around the inner tapered cone **127**. The circular cable clamp **133** with the radial toothed section **134** is optional for use where an anchorage is required to develop 100% of the ultimate strength of the cable **85**, and said cable clamp **133** is bolted to the inner plug **127** with the cap screw **135**. The ACI Building Code requires that an anchorage shall develop 90% of the ultimate strength of the cables **85**, and, to remain competitive, it is intended to use anchorage with or without the circular cable clamp **133**.

FIG. 40 is an upper plan view and FIG. 42 is a cross-sectional view of an outer cone **160** and an inner tapered plug **162** arranged for stressing and elongating a plurality of wires **1** through the anchor plate **5** and through the said plug and cone assembly. Threaded sections **161** and **163** are arranged for additional gripping action on the wires **1**. The hole **136** through the anchor plate **5** and the plug **162** is intended for the pumping of grout into the tendon if a grouted condition should be required for any reason.

FIG. 44 is the same as FIG. 42 except that the cone **160** and plug **162** are shown in the anchored position around the wires **1**. The circular clamp **166** and the cap screw **135** are optional and may or may not be used depending upon the degree of anchorage required. Also the wire ends **2** may be bent outward or they may be bent inward as shown to secure positive end anchorage.

FIG. 46 is a variation of cone and plug assembly wherein the outer cone **169** bears on the anchor plate **5** and the inner plug **172** is arranged with an external flange **170** having a plurality of holes **171** bored therethrough for passage of the wires **1**. The outer cone is threaded along the inner surface at section **168** for additional gripping action on the wires **1** stressed therethrough and the wires **1** are

bent at their ends for positive end anchorage after stressing.

FIG. 45 is a cross-sectional plan view taken along the line 45—45 of FIG. 44 and is also similar for the section through FIG. 46 and taken along line 45—45, and shows the relationship of the wires 1 retained between the outer cone and the inner plug.

What I claim is:

1. A method of producing an anchorage for prestressed reinforcing wires for a concrete structure comprising inserting a plurality of reinforcing wires through conical openings provided in an anchor member and through conical wedges on the exterior face of said anchor member, utilizing a stressing means to elongate said reinforcing wires through the anchor member for a prescribed stress and length of elongation, utilizing a means to ram the conical wedges around the wires and into the conical openings in the anchor member thus holding the relative position of the reinforcing wires within the anchor member, and utilizing a further means to cut and deform the ends of said wires after stressing and elongation, thus forming a positive end anchorage.

2. A method of producing an anchorage for prestressed reinforcing wires for a concrete structure comprising inserting a plurality of reinforcing wires through openings provided in an anchor member and through assemblies comprising split conical wedges contained within the conically bored outer members, utilizing a stressing means to elongate the wires through the anchor assembly for a prescribed stress and length of elongation, utilizing a means to ram the said conically bored outer members around the said split conical wedges enclosing the wires, thus holding the relative position of the reinforcing wires to the anchor member, and utilizing a further means to upset the ends of said reinforcing wires after stressing and elongation.

3. A method of producing an anchorage for prestressed stranded wire cables for a concrete structure comprising inserting a plurality of stranded wire cables through conical openings provided in an anchor member and through conical wedges on the exterior side of said anchor member, utilizing a stressing means to elongate said cables through the anchor member for a prescribed elongation, a means to ram the conical wedges around the cables and into the conical openings in the anchor member, thus holding said cables, and utilizing a further means to swage the wedges, after stressing, thus forming a positive end anchorage.

4. A method of producing an anchorage for prestressed wire cables for a concrete structure comprising inserting a plurality of said cables through openings provided in an anchor member and through an assembly comprising utilizing an outer clamping ring having a conically bored and grooved inner surface and an inner plug member having a conically turned outer surface, utilizing a stressing means to elongate said cables through the anchor assembly, utilizing means to ram the said outer ring around the inner plug member, thus gripping the cables.

5. A method of producing an anchorage for prestressed reinforcing wires comprising inserting a plurality of reinforcing wires through openings provided in an anchor member and through an assembly comprising utilizing an outer ring having a conically bored inner surface and an inner plug member having a conically turned outer surface, utilizing a stressing means to elongate said wires through the said assembly, and utilizing a means to ram said outer ring around the inner plug member thus gripping the said reinforcing wires.

6. In the method of claim 4, utilizing a further means of securing positive end anchorage wherein a centrally bored cable clamp having a conically turned outer surface is attached to the aforesaid inner plug member, after stressing, and causing additional gripping force between the inner plug member and the conically bored and fluted outer ring.

7. In the method of claim 5, utilizing a further means of securing positive end anchorage wherein a centrally bored plug having a conically turned outer surface is attached end-to-end to the inner plug member of claim 5, thus forcing a change of direction into the free ends of the wires held between the gripping surfaces of the cone and plug assembly.

8. In the method of claim 7, utilizing a final means of anchorage whereby the free ends of the reinforcing wires are bent.

9. An anchoring device, for performing the cutting and deforming set forth in claim 1, comprising a stationary outer base arranged to slip over the free ends of a plurality of anchored wires, said base being counterbored to rotate and lock to wedges retaining said wires, an inner member mounted therethrough with the lower end comprising a die having a plurality of cutting and forming surfaces, a lever arm connecting the upper end of said inner member through a hydraulic cylinder to a lever arm connecting the stationary outer member, hydraulic means rotating the inner member through an arc and causing the wire ends progressively to shear and deform into a right angle bend, thus forming a positive end anchorage after stressing.

10. An anchoring device for producing said anchorage in claim 2, comprising a stationary outer base arranged to slip over the free ends of a plurality of anchored wires, said base being counterbored to rotate and lock into the grooves of a preset pattern of conically bored outer members, said outer members being rammed over split conical wedges encasing the reinforcing wires, an inner member mounted therethrough with the lower end consisting of a die having a plurality of cutting and forming surfaces, a lever arm connecting the upper end of said inner member through a hydraulic cylinder to a lever arm connecting the stationary outer member, hydraulic means rotating the inner member through an arc and progressively shearing and deforming the wire ends, thus forming a positive anchorage.

11. A stressing device, for producing the stressing in claim 4, comprising a hydraulic jack having a cylindrical main body with a central opening bored therethrough, said central opening being counterbored at the lower extremity thereof to hold the conically bored and grooved outer clamping ring of claim 4, a lower hollow piston slidably mounted around the main body and with hydraulic means to extend said piston for end bearing on the anchor plate, an upper hollow piston slidably mounted around the main body with a separate gripping device removably attached to the upper end of said hollow piston, said steel reinforcing units being guided through the central opening of said main body and gripped by said gripping device, the upper piston then being hydraulically progressed away from the anchor plate causing elongation of the reinforcing units, pressure then being relaxed on the lower piston causing movement of the main body toward the anchor plate and ramming the aforesaid clamping ring around the reinforcing units and the enclosed inner plug member thus gripping and holding said reinforcing wires, said upper piston now being retracted and the gripping device being relaxed for removal of the stressing device.

12. A gripping device, for producing the gripping in claim 11, comprising a stationary external unit having a base arranged for concentric mounting to the end of the upper piston of claim 11, said base having an inner wall with a conically bored and grooved inner surface, an outer wall extending upward from said base and an inwardly projecting upper wall with a vertically bored concentric opening therethrough, a slidably mounted inner unit comprising a spring-loaded hydraulic piston with a plurality of concentrically arranged holes bored vertically therethrough, and within said hole pattern a conically bored plug extending into the aforesaid bored and grooved opening of the external unit, steel reinforcing units being guided through the plurality of grooves and

corresponding holes, and hydraulic means compressing the inner and outer units together causing simultaneous gripping of the plurality of reinforcing units inserted therethrough.

13. A wire end anchoring tool, for producing the anchorage in claim 1 or 2, comprising a stationary outer member counterbored to fit and lock over an anchored wedge, a rotatable inner member with a handle attached thereto, a hooked section on said inner member to engage the wire end, a cammed outer surface on the inner member with a guide groove therein, whereby, as the inner member is rotated, the wire end is progressively formed into a bend adjacent to the top surface of the wedge encircling said wire end.

14. A wire holding device, for use in performing the method in claim 1, 2 or 5, comprising inserting a plurality of prestressing wires through double-ended conical wedges, said wedges being retained between two members with hydraulic means for compressing said wedges and clamping said wires running therethrough, and a spring-loaded means for releasing the clamping pressure and freeing said enclosed wires.

15. A stressing device, for use in performing the method in claim 1 or 2, comprising a hydraulic jack having a main body with a centrally located piston attached and a movable external cylinder, said external cylinder having a fixed flange at the base thereof and a movable flange and piston assembly, said fixed and movable flanges having a plurality of opposing conically bored holes with split conically formed wedges retained within said opposing holes, said plurality of reinforcing wires being inserted through openings in said wedges with the said main body resting on the anchor plate, said wires being gripped by hydraulically compressing said movable flange toward said fixed flange, the movable external cylinder then being moved hydraulically away from said anchor plate, thus stressing and elongating the reinforcing wires simultaneously, a spring loaded movable flange encircling the base of the main body being hydraulically moved toward the anchor plate thus compressing the anchoring wedges around the wires and within the conical retainers and retaining the relative position of the wires to the said anchor member, said hydraulic pressure being released causing the spring loaded movable flange to move away releasing the grip on the reinforcing wires for removal of said stressing device.

References Cited

UNITED STATES PATENTS

2,609,586	9/1952	Parry	264—138
2,728,978	1/1956	Birkenmaier et al.	29—452
2,804,674	9/1957	Long	264—228
3,081,976	3/1963	Carlson et al.	254—29

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