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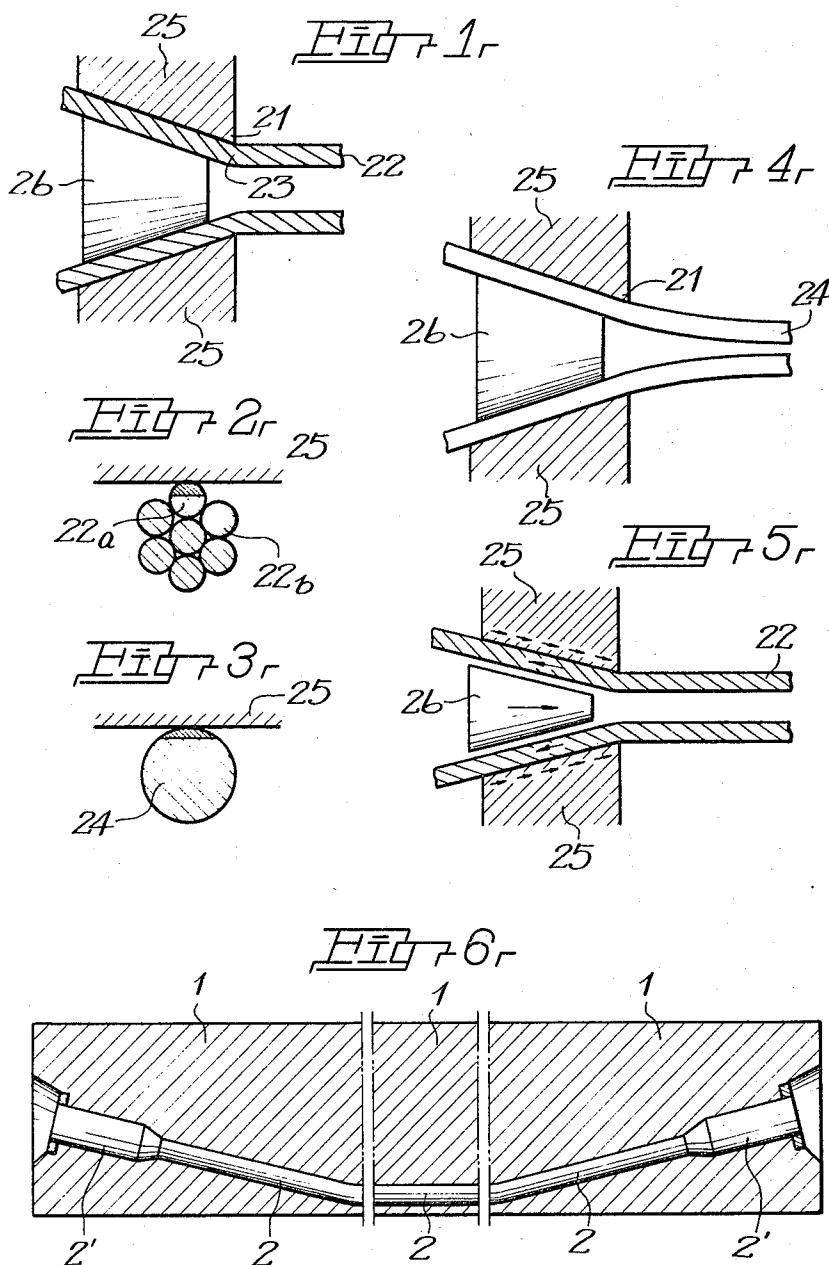
KIMIO YOSHIMURA

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END ANCHORAGE FOR PRESTRESSING STEEL STRANDS FOR USE  
IN PRESTRESSED CONCRETE STRUCTURES

Filed Feb. 15, 1966

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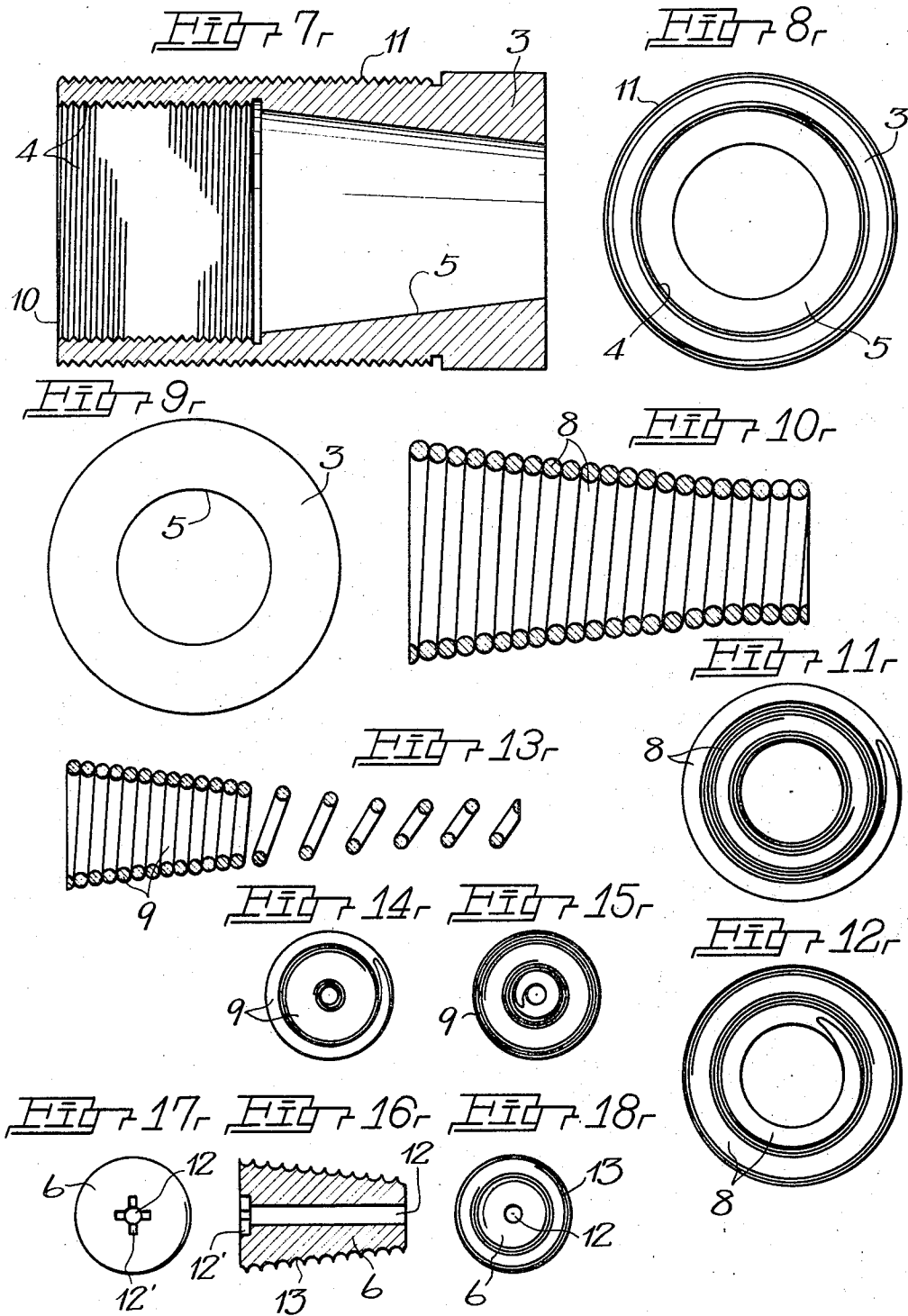
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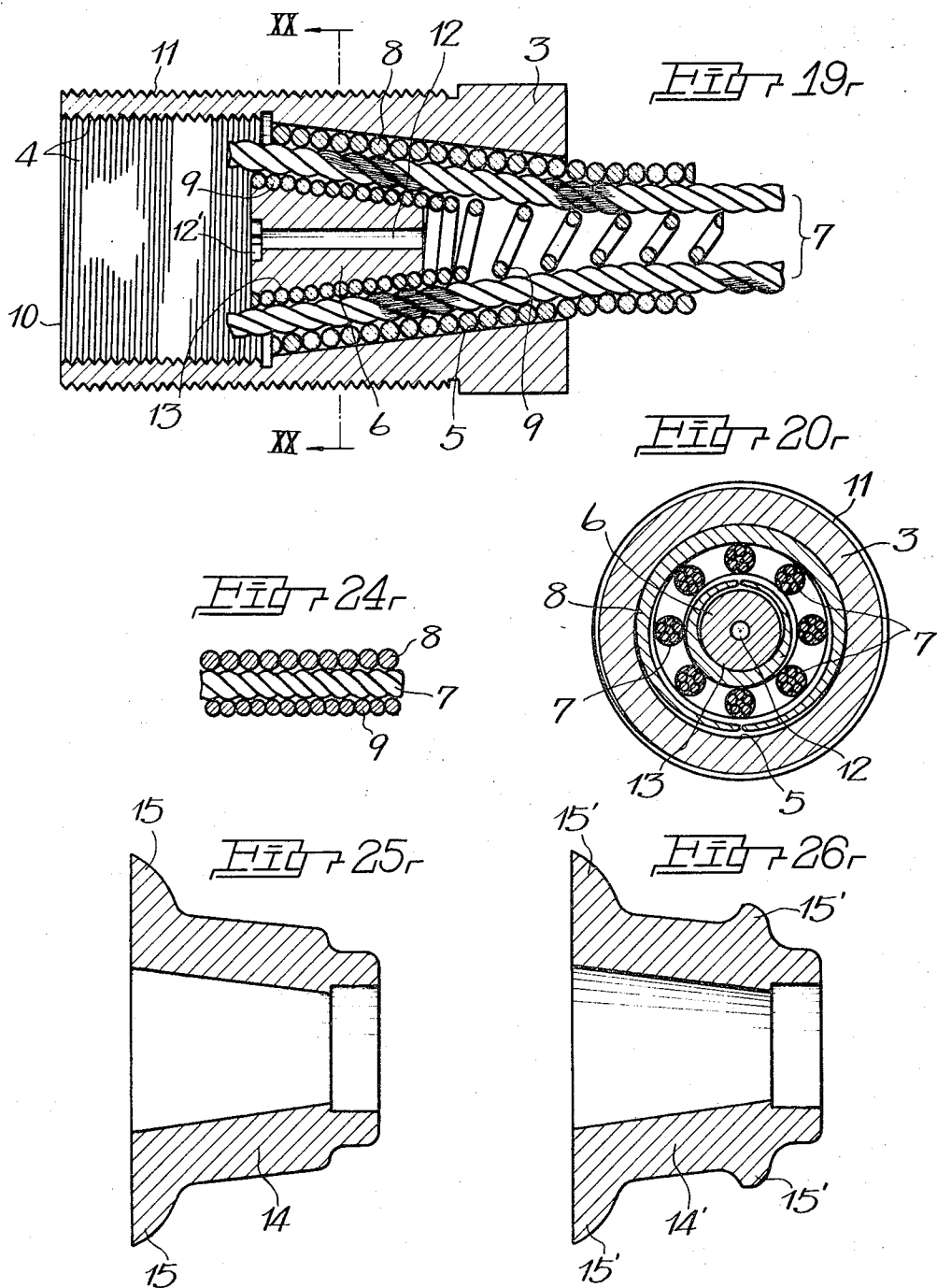


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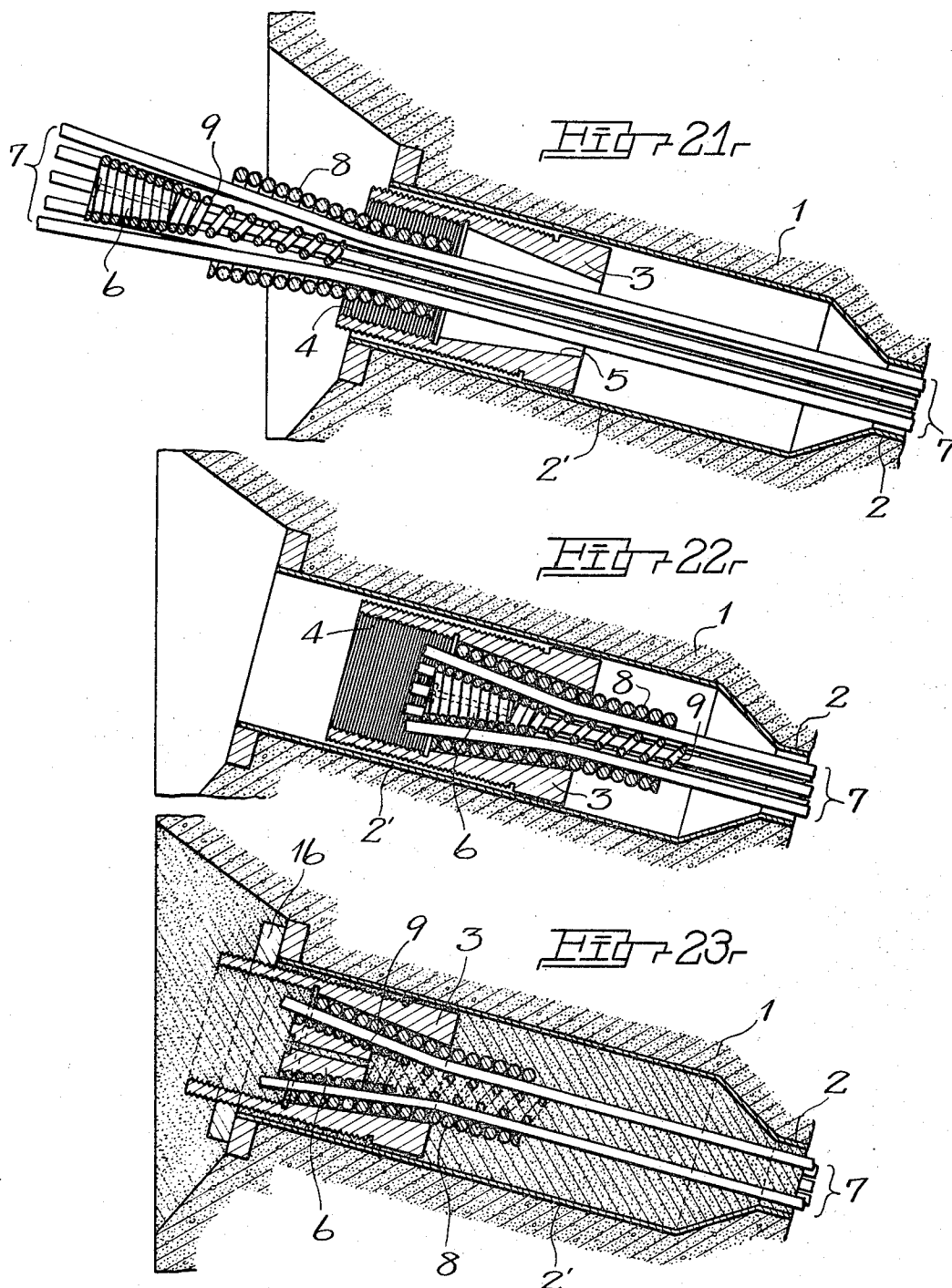
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## END ANCHORAGE FOR PRESTRESSING STEEL STRANDS FOR USE IN PRESTRESSED CONCRETE STRUCTURES

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7 Claims

### ABSTRACT OF THE DISCLOSURE

A device for prestressing and anchoring steel strands having a rigid support formed with a tapered, open-ended bore therethrough, tapered outer and inner helical coils and a conic wedge member.

The present invention relates to the prestressing of concrete constructions, and more particularly, to a novel and improved end anchorage means for prestressing a plurality of steel strand members to be embedded in the concrete structure.

In the past, many types of end anchorage means for prestressing steel members in a prestressed concrete structure have been known, but the anchorage means of prior art have been adapted only for a single rod or a plurality of steel wires as prestressing steel members in concrete.

A steel strand is defined as comprising a plurality of elongated steel filaments or elements which are plied and twisted together.

When the conventional and known end anchorage means are utilized for tensioning and anchoring a plurality of steel strands in prestressed concrete, there are produced in the steel elements local stresses which are concentrated only in parts of the steel filaments. This results in a premature breakage of each element in a successive manner to produce breakage of the whole assembly of steel strands. Accordingly, it has been difficult to provide an economical end anchorage for anchoring a plurality of steel strands in order to take full advantage of the inherent tensile strength of the steel strands.

An important object of the invention is to provide improved end anchorage means for steel strands for prestressed concrete.

The present invention overcomes the above disadvantages in connection with the anchorage means of the type described, and provides an improved anchorage for prestressing steel members, more particularly, steel strands formed from a plurality of steel filaments or elements. Thus the end anchorage means of this invention provides a means whereby the ends of strand members can be gripped and anchored in an economical manner without loss in their inherent strength and without any danger of breakage of the strands. Hence, by means of the end anchorage means of this invention the general use of steel strands in prestressed concrete is made possible and practicable.

While as described above, the anchorage means of this invention can be utilized to advantage when a group of strands is applied as prestressing members in concrete, the anchorage means of this invention can also be utilized for anchoring a group of steel wires as prestressing members in concrete. In either instance, the anchoring means of this invention obviates the occurrence of concentrated stress in steel strands and steel wires.

The principal object of the invention is to provide a novel anchorage means adapted particularly for a group

of strands when these strands are utilized as prestressing members in prestressed concrete.

In accordance with the invention, the end anchorage comprises a rigid support having a tapered, open-ended bore and correspondingly tapered separate inner and outer spring coils and wedge, said coils being of a material softer than said strands. In assembly, the outer coil is against the bore wall with the inner coil within the outer coil and the strands between the coils. The wedge is located within the inner coil and frictionally holds the assembly together. The provision of the spring coils results in highly advantageous structure, particularly in the distribution of the stresses upon the strands.

In the drawing:

FIGURES 1-5 are schematic views of known anchorage means commonly utilized in prestressing steel bars for use in concrete structures.

FIG. 6 is a longitudinal sectional view showing a prestressed concrete member containing a sheath for a plurality of steel strand members for use with the end anchorage means of this invention.

FIG. 7 is a longitudinal sectional view of a jacket pipe or pull head for use in the end anchorage means of this invention.

FIG. 8 is an end view of the left side of the jacket pipe of FIG. 7.

FIG. 9 is a similar end view of the right side of the jacket pipe of FIG. 7.

FIG. 10 is a longitudinal sectional view of helically wound coil made of a mild steel wire which forms an outer wedge member of female type for use in the end anchorage means of this invention.

FIG. 11 is an end view of the left side of coils of FIG. 10.

FIG. 12 is a similar end view of the right side of the coil of FIG. 10.

FIG. 13 is a longitudinal sectional view of a helically wound coil made of a mild steel wire which forms the inner male wedge member cooperating with a truncated cone in the end anchorage means of this invention.

FIG. 14 is an end view of the left side of the coils of FIG. 13.

FIG. 15 is a similar end view of the right side of FIG. 13.

FIG. 16 is a longitudinal sectional view of a wedge member of male type in accordance with this invention.

FIG. 17 is an end view of the left side of the male type wedge member of FIG. 16.

FIG. 18 is a similar end view of the right side of wedge member of FIG. 16.

FIG. 19 is a longitudinal sectional view of the end anchorage means of this invention completely assembled and containing a plurality of steel strand members.

FIG. 20 is a sectional view taken along the line XX-XX of FIG. 19 in the direction of the arrows.

FIGS. 21 through 23 are longitudinal sectional views showing successive stages of assembly of the end anchorage means of this invention.

FIG. 24 is a sectional view showing how the outer and inner helically wound coil contact the steel strands in accordance with this invention.

FIGS. 25 and 26 are sectional views of jacket pipes in accordance with other embodiments of this invention.

FIGS. 1-5 illustrate, somewhat diagrammatically, the problems encountered when prior art end anchorage means are used for strands.

FIG. 4 shows an anchorage member 25 having a frusto-conical bore, and shows the correspondingly shaped and oriented wedge 26. Conventional large diameter stress wires 24 are shown wedged between wedge 26 and the wall of the bore, the wires having first been pulled taut

by a jack or the like (not shown). Because of the stiffness of the wire 24, it curves gradually, rather than bending sharply, in the region of the terminal end 21 of the wedge. Also, as shown in FIG. 3, the ratio between sectional area of the wire 24 subjected to concentrated stress at the point 21 (darkened portion) to the entire area of the wire is relatively small. Accordingly, the wire resists effectively the stresses caused by the tension on the wire and the wedging action.

For a number of reasons, it is preferable to use as the prestressing agent in concrete the steel strand 22 shown in FIGS. 1, 2 and 5 and consisting of very thin, flexible wires twisted together to form the strand. Strand 22, as compared to wire 24, has greater tensile strength per unit area, greater flexibility and a stronger bond to either concrete or the end anchorage by reason of larger surface area. The strand can be transported more easily and can take up less volume.

However, when strand 22 is held by the conventional anchorage means of FIGS. 1, 2 and 5 a sharp bending point 23 is formed in the strand 22 at the end portion 21 of the wedge due to its inherent flexibility. Since a concentrated stress is produced at the bending point 23 of the strands, the steel strands tend to be broken successively.

As shown in FIG. 2, only one strand element 22a engages the bore wall at the bending point 23. As seen by a comparison of the darkened portions of FIGS. 2 and 3 (which illustrate the concentrated stresses), the proportion of sectional area subjected to the concentrated stress in contact with the wedge member is much greater for strand element 22a than for wire 24.

Therefore, when the pulling force is applied to the steel strand 22 approximately to the extent of destruction, an element 22a is first broken, then another element 22b which is then subjected to the load is broken, and in succession the load is transmitted to the remaining elements one after another until all of the elements are broken.

Accordingly, satisfactory results have not been obtained in connection with prestressing steel strands for use in prestressed concrete by utilizing the end anchorage means of prior art, although the steel strand itself has far better properties when utilized in prestressed concrete than steel wires.

The present invention overcomes the aforementioned disadvantages of the conventional anchorage means for prestressing a plurality of steel strands. The end anchorage means of this invention is utilized by first inserting it into a flared mouth or flared pipe section of a thin hollow cylindrical pipe which is embedded in concrete. The surface of the pipe can be either curved or straight as desired. The hollow pipe may have a flared mouth or flared pipe section at one of its ends or at both of its ends as in FIG. 6.

Briefly stated, the anchorage means of this invention is composed of a jacket pipe which can be secured within a flared end or flared pipe section which is embedded in concrete. The jacket pipe has a central frusto conical bore, having one of its ends open and communicating with the exterior of the concrete structure. Within the bore are contained inner and outer helical coils with the diameter of the outer helical coil being greater than the diameter of the inner helical coils and a wedge which is fixedly secured within the inner helical coils, and has interiorly converging tapered or frusto conical surfaces. The outer surface of the outer helical coil is arranged within the bore of the jacket pipe so that it contacts the converging walls of the jacket pipe along an interiorly converging frusto conical surface. Additionally, the inner surface of the outer helical coil is spaced from the outer surface of the inner helical coil to provide a space for gripping and securing the plurality of elongated steel members to be stressed. In this manner a plurality of elongated steel members, preferably a plurality of steel strands, can be fixedly secured and gripped between the inner surface of

the outer helical coil and the outer surface of the inner helical coil, and thereafter subjected to a tensile stress by any conventional means so that the strands are stressed without any danger of breakage, such as occurs through use of conventional end anchorage means.

The jacket pipe 3 is a hollow cylinder having a thick wall, as shown in FIGS. 7 through 9, one half of the inner wall thereof being provided with an internal thread 4 and the other half forming a hollow tapered or frusto conical surface which converges from center to end. Further, the inner thread 4 is adapted to be screwed to any conventional tensioning device such as a tensioning rod of a tension jack. An outer thread 11 is provided on the outer wall so as to carry a stop nut which secures the jacket pipe to the concrete during the tensioning step.

An outer helical coil 8 in the form of a funnel having an interiorly converging frusto-conical or tapered surface, as shown in FIGS. 10 through 12, is adapted to be fixed into the tapering bore portion 5 of the jacket pipe 3. The outer coil is adapted to be fixed in the jacket pipe 3 so that its surfaces taper in the same direction as bore 5 of jacket pipe 3. In this manner the inner circumference of the coil 8 is adapted to contact the outer surface of a group of prestressing steel members which are to be tensioned and anchored. It is preferred that the length of the coil 8 be somewhat longer than that of the taper portion of the bore 5 of the jacket pipe 3 so that the end of coil 8 protrudes out of the jacket pipe 3 after it is inserted therein.

The inner helical wound coil 9, illustrated in FIGS. 13 through 15, has a similar shape to that of coil 8. In the jacket pipe 3, coil 9 is wrapped about the outer surface of a male wedge 6, as shown in FIGS. 16 through 18. The wedge 6 is secured within the inner coil 9 so that the outer surface of the coil 9 can be pressed into the inner surface of the group of steel members described hereinafter. The diameter of the wire which forms the coil 9 is somewhat smaller than that of the wire which forms the coil 8. The surface portion of the male wedge member 6 is provided with a relatively rough thread or helical groove 13. The pitch of said helical groove 13 which provides the threaded peripheral surface of the wedge is less than the normal pitch of inner coil 9. This threaded surface of the male wedge member 6 which is in the form of a truncated cone allows the wedge to be screwed into the interior of the inner coil 9. A slot 12 is provided at the center of the male wedge member 6 through which cement grout can be poured. As shown in FIGS. 16 and 17, the slot 12 is provided with a groove 12' in the form of a cross, and the groove 12' is adapted to receive a driver or the like to screw the male wedge member into the inner helical coil 9.

The means of anchoring and tensioning a plurality of steel strands which is to be utilized as a prestressing member by the end anchorage of this invention is described hereinbelow in connection with FIGS. 19 through 23. In FIG. 6 a thin wall pipe 2 having a flared end at both ends is embedded in the concrete body 1 in either a straight or a curved manner as required, and then a plurality of steel strands 7 are inserted into the pipe 2. The ends of strands are pulled out of the flared end 2' of the pipe 2, and they are inserted into the jacket pipe 3 through the portion of the bore 3 having the smallest diameter as clearly shown in FIG. 21. Then the ends of steel strands 7 are arranged in such a manner that the strands 7 form a hollow cylinder which can be inserted in the interior of frusto-conical or tapered surface of the outer helical coil 8. Subsequently, another funnel-shaped inner helical coil 9 is inserted in the hollow of the cylinder formed by the strands and finally a male wedge member 6 is screwed into the interior of helical coil 9. In this manner the group of steel strands 7 is firmly gripped and protected between the outer and inner funnel-shaped coil 8, and 9 with the male wedge member 6 serving as the core thereof.

In this state, as shown in FIG. 22, the ends of strands 7 are made to protrude several centimeters beyond the

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surface of the male wedge member 6. The group of strands arranged and firmly held in the manner described above, is pulled into the tapered portion 5 of the bore of jacket pipe 3.

Further, the wire size of the inner coil 9 is smaller than that of the outer coil 8, and the contact area between strands is large, therefore the frictional force between strands and coil is stronger in the inside than in the outside. The group of strands, together with the male wedge member 6 are pressed or forced into the pipe jacket 3, by moving the group of strands 7 and the inner series of coils 9 and the wedge along the inner base of the outer series of coils 8. As a result of being pressed into the jacket pipe a double wedge action occurs between jacket pipe 3, the outer of coil 8, the strands 7 and the inner of coil 9 so that the group of strands 7 is all the more firmly pressed together in the jacket pipe.

Further, the steel strands are relatively hard because they are made of a high carbon steel while each of the helical coils is softer because they are made of a mild steel wire. A forced insertion of the male wedge member 6 in the jacket pipe 3 brings the inner coil 9 in close contact with the surface of the male wedge member 6 while, on the other hand, the coil 9 is deformed due to a firm grip with the strands, which results in a snug engagement with each other.

The above snug engagement is brought about when the steel strands are tangentially in contact with the coils 8 and 9 and the projecting portions of the strand surface are in contact with the periphery of each coil as shown in FIG. 24. During the step of pressing the assembly into the jacket pipe, each of the projecting portions of the surface of the strands is in contact with other so that a biting action occurs on the strands by the surface of the inner and outer coils 8 and 9.

As this bite increases the contact area between the coils 8 and 9 and the surface of the strands increases. Thus, the surface of the strands will be easily bitten by the coils but this bite will be less as resistance of the strands increases. Accordingly, with a very natural uniform engagement of steel strands with each of the helical coils, the force of the grip of the coils on the strands increases in proportion to the amount of tension applied to the strands. In this manner an exceedingly strong and firm grip on the strands by the helical coils 8 and 9 is developed as the assembly is pressed into the jacket pipe.

An entirely similar phenomenon to the above occurs during this step of pressing the assembly into the jacket pipe in coil 8 which contacts the group of strands 7. Besides, when the male wedge member 6 is forcibly inserted in position, it is done at an eccentric manner on a place of less resistance in response to the presence of resistance by the strands and the degree of bond between strands 7 and outer series of coils 8. The wedge 6 is inserted in position in a uniform manner so that each of the strands is held by an almost uniform clamping force. This wedge clamping force which is thus produced, is an essential feature of the end anchorage means of this invention.

After the above operation is carried out on the anchorage means in connection with both ends of strands, each of the inner threads 4 at both ends of the jacket pipe 3 is screwed to a tensioning means such as the tension rod of a jack and a strong tension is applied thereto.

The more the tension increases, the more the above-mentioned wedging action increases in proportion to tension, and, in turn, the more the gripping force increases, with the result that tension is completely transmitted to each of the strands until each of them elongates. In this case, the shortest strand begins to elongate at first. Since the series of coils 8 and 9 which grip the strands 7 are made of soft steel wire as described hereinbefore, they are also deformed by the strong bite of strands 7, as well as by the elongation of the strands. This deformation allows the spaces between convolutions of coils 8 and 9 to open to some extent, and consequently displace the

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gripping point. Accordingly, the operating length of strands elongates so that the tension on each strand due to the difference of length is, by its own accord, made uniform.

This phenomenon occurs since the inner and outer series of coils 8 and 9 grip the group of strands therebetween simultaneously. Therefore, they function most effectively, allowing each of the strands to bear an almost uniform tension. In this state, the inner and outer coils 8 and 9 holding the strands therebetween extend through the wedge constructing plane, and further, protrude several centimeters out of the end of jacket pipe 3 as clearly shown in FIGS. 19, 22 and 23. Hence, the pressing force produced by the wedge is applied not only to the coils which are adjacent the peripheral surface of the male wedge member 6, but also is applied to some extent to the entire surface of the series of coils 9. As a result, the group of strands 7 is subjected to a wedge action distributed all over the coil plane, though it is the strongest on the peripheral surface of the coil which surrounds the male wedge member, and it becomes weaker gradually as it is spaced from the male wedge member 6.

As described in the above, the group of strands 7 is gripped over a relatively wide area, therefore, a concentrated strain, such as shear, twist and bend resulting from the wedge force at the end of male wedge member 6 or at the end of jacket pipe 3 does not take place. This is another feature of the end anchorage means of this invention. Furthermore, by means of this invention the group of strands is not subjected to a local concentration of wedge force, because the group of strands is armored on both sides by one of the two series of coils 8 and 9. In this manner the strands can, by stressing, develop inherent tensile strength. Moreover, the straight tubular extension of the series of coils 8 and 9 out of the bore 3 serve as a guide or spacer to maintain each strand circumferential in the transverse direction and parallel in the longitudinal direction. Hence, by this construction, the group of strands is adapted to bear a uniform tension in a most effective manner.

In reference to the wire size or diameter of the funnel-spaced coil in contact with the strands, the size of the wires which form coil 9 are smaller than that of coil 8. This is so, since it is preferred that the frictional resistance between the inner coil and strand be greater than that of outer coil 8 and strand. This, in addition to providing an effective wedge action between jacket pipe and coil 8 by the forced insertion of the strands into the outer coil 8 when the male wedge member 6 is inserted therein, prevents the inner coil 9 from springing forth therefrom by the repulsion of wedge action.

When a predetermined amount of tension is applied, the outer face of the jacket pipe 3 is fixed by a stop nut 16 to secure the jacket pipe to the concrete body 1. In this manner the restoring force of strands is completely transmitted to the body 1 when prestressing tension is applied to the strands.

As fully described in the foregoing, the present invention has been explained in connection with the construction or assembly illustrated in FIGS. 7 through 9, but it is seen that a modified jacket pipe 14 integral with a flange 15 in place of the stop nut 16 at one end of strand can be embedded in the concrete body as shown in FIG. 25.

The jacket pipe integral with the flange can be made of low cost cast iron, since this jacket pipe need not have as great a strength as the jacket pipe having a stop nut.

Where it is feared that the strength of the jacket pipe is not sufficient for bearing the stressing pressure, it is preferred that a jacket pipe 14' having double flanges 15' and 15'. Further, it is preferred that the jacket pipe which contains either double or single flange be formed with a tapering outer wall, as shown in FIGS. 25 and 26. The outer wall is provided with a taper so that the pressure exerted by the concrete body can be borne by the entire tapered outer wall of the jacket pipe rather

than by just the flange alone. In this manner when a strong tension is applied on the steel strands, the support pressure can be transmitted to the concrete body via the jacket pipe so that the jacket pipe will be secured within the concrete body.

When the above flanged jacket pipe is used for tensioning one of the ends of the steel strands, it is usual to pull the jacket pipe having a stop nut together with the group of strands. However, it is also possible to apply tension from the direction of flanged jacket pipe if a jack is used which grips the steel strands directly. In addition, one is also able to tension the steel strands directly from either one or both directions after embedding the flanged jacket pipe at both ends of the concrete body.

While the advantages of the anchorage means of this invention have been described in details exclusively with respect to the use of steel strands as prestressing members these advantages are produced when other types of steel members are prestressed. Accordingly, it is understood that the anchorage means in accordance with the present invention could be employed for tensioning and anchoring a group of steel wires in a most effective manner.

The specific details given herein are merely illustrative and are not to be construed as imposing unnecessary and unwarranted limitations on the invention. Various modifications may be employed without departing from the spirit and scope of the invention as set forth in the claims.

What is claimed is:

1. End anchorage means for a plurality of elongated flexible steel members for use in prestressed concrete comprising as components a rigid support having a tapered, open-ended bore having a peripheral wall, correspondingly tapered separate inner and outer helical coils, and correspondingly tapered wedge, said components being correspondingly oriented with said outer coil against the wall of the bore, said inner coil within said outer coil, said members extending through said bore and distributed between said coils, and said wedge within said inner coil, said wedge further adapted to be forced into said inner coil to be retained frictionally therein and to retain said wedge, said coils and said members frictionally within said bore, said inner and outer coils being of a material softer than said steel members and deformable thereby during said forced assembly of said components to securely grip said steel members, whereby stress concentrations in said steel members are inhibited while uniform tensioning thereof is insured.

2. End anchorage means of claim 1 wherein the tapered inner and outer helical coils are greater in length than the corresponding tapered wall of said bore and extend through and beyond the end of said bore of smaller diameter.

3. End anchorage means according to claim 2, said coils being formed of helically wound turns of metal wire

stock, said wedge having a helical groove in its peripheral surface and extending between its ends, said wedge being adapted to be turnably threaded into said inner coil with the turns of said inner coil around said wedge being compressed and frictionally received within said groove, said wedge having means on its end of larger diameter adapted to be engaged in order to turn said wedge to screw it into said inner coil, said outer coil wire being of greater diameter than said inner coil wire.

4. End anchorage means of claim 1 wherein the diameter of the wire which forms the outer helical coil is greater than the diameter of the wire which forms the inner helical coil.

5. The end anchorage means of claim 1 wherein the elongated steel members are formed from steel strands.

6. End anchorage means according to claim 1, said coils being formed of helically wound turns of metal wire stock, said wedge having a helical groove in its peripheral surface and extending between its ends, said wedge being turnably threaded into said inner coil with the turns of said inner coil around said wedge being compressed and frictionally received within said groove, said wedge having means on its end of larger diameter adapted to be engaged in order to turn said wedge to screw it into said inner coil, said coils being of greater length than said wedge and also of greater length than said bore and extending through and beyond the bore end of smaller diameter, the outer coil wire being of greater diameter than the inner coil wire, said steel members each comprising strands of twisted thin wire, said strands biting into the wires of the coils at the points of frictional engagement thereof, and engaging said inner coil turns with greater frictional force than said outer coil turns.

7. End anchorage means of claim 1 wherein said assembled end anchorage means is longitudinally displaceable to tension said steel members while simultaneously increasing the grip of said end anchorage means on said steel members, said end anchorage means being adapted to be held in place after maximum displacement.

#### References Cited

##### UNITED STATES PATENTS

|           |        |         |          |
|-----------|--------|---------|----------|
| 1,461,466 | 7/1923 | Stout   | 24—122.6 |
| 2,677,956 | 5/1954 | Schorer | 52—230   |
| 2,751,660 | 6/1956 | Nakonz  | 52—230   |

##### FOREIGN PATENTS

|         |         |                |
|---------|---------|----------------|
| 70,297  | 4/1946  | Norway.        |
| 704,094 | 2/1954  | Great Britain. |
| 628,886 | 11/1961 | Italy.         |

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U.S. Cl. X.R.

024—126; 287—124; 052—230