Dec. 27, 1966 E. K. RICE 3,293,811

ANCHORAGE FOR CONCRETE STRESSING TENDONS

Filed June 1, 1965 3 Sheets-Sheet 1

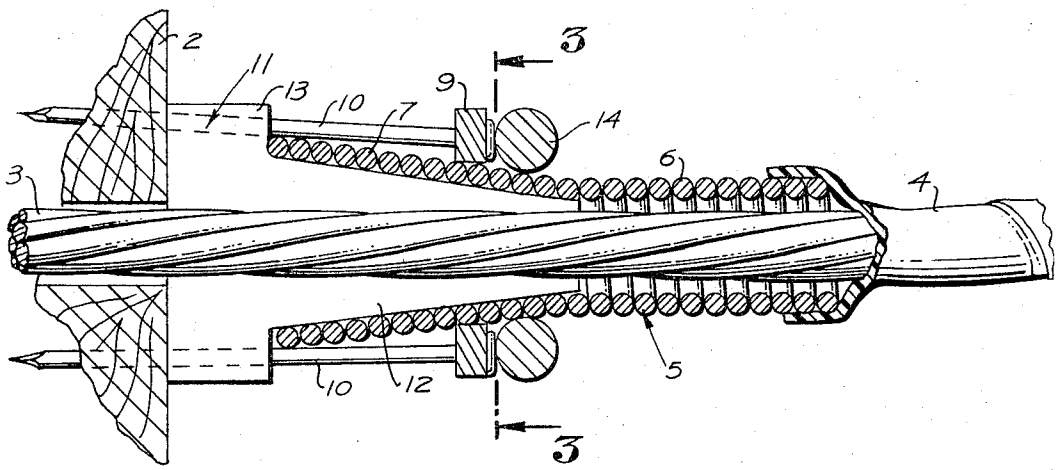


FIG. 1

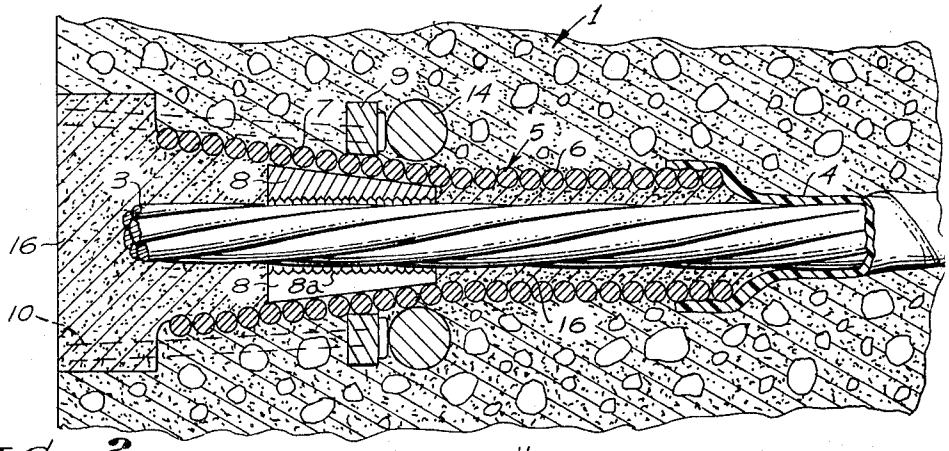


FIG. 2

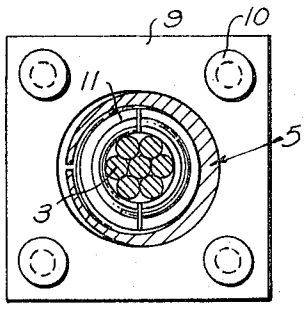


FIG. 3

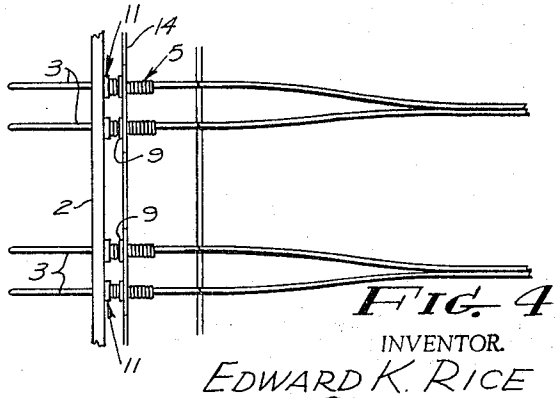


FIG. 4

INVENTOR.
EDWARD K. RICE
BY Lyon & Lyon
ATTORNEYS

Dec. 27, 1966 E. K. RICE 3,293,811

ANCHORAGE FOR CONCRETE STRESSING TENDONS

Filed June 1, 1965 3 Sheets-Sheet 2

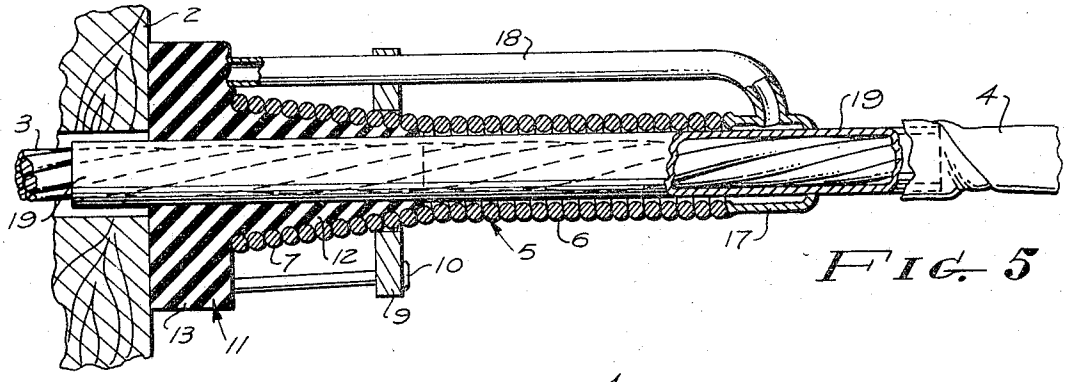


FIG. 5

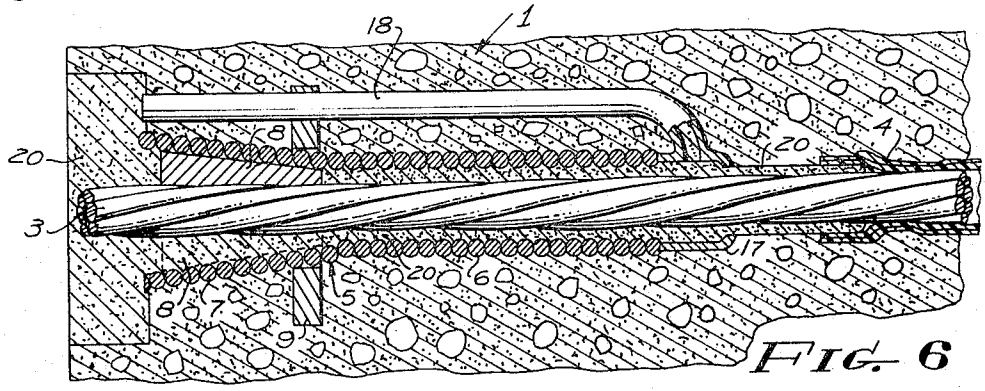


FIG. 6

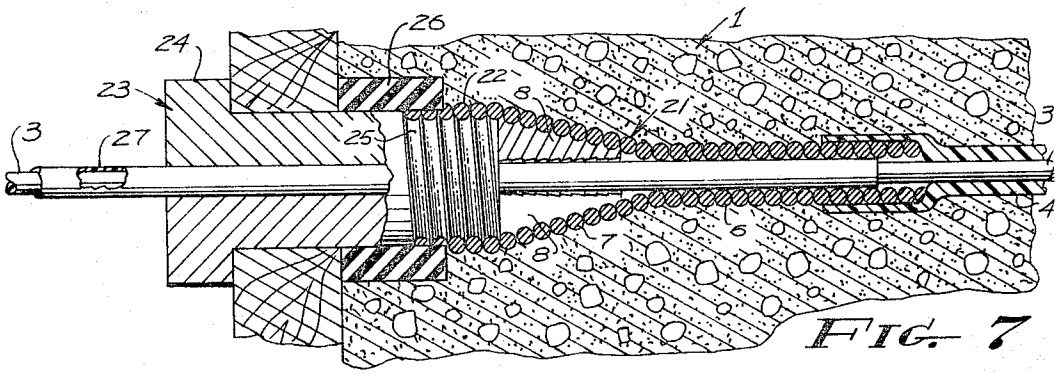


FIG. 7

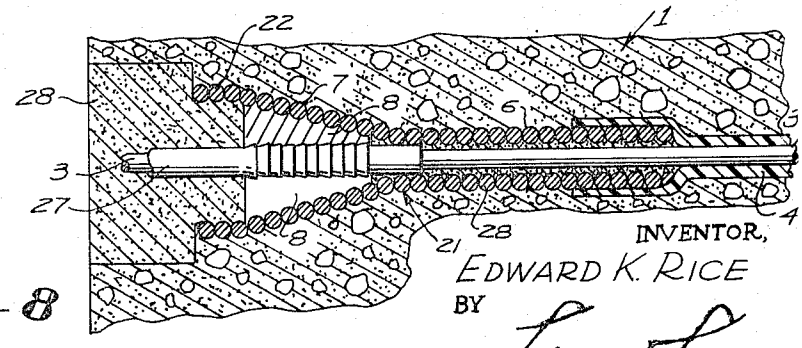


FIG. 8

INVENTOR,
EDWARD K. RICE
BY
Lyon & Lyon
ATTORNEYS

Dec. 27, 1966 E. K. RICE 3,293,811

ANCHORAGE FOR CONCRETE STRESSING TENDONS

Filed June 1, 1965 3 Sheets-Sheet 3

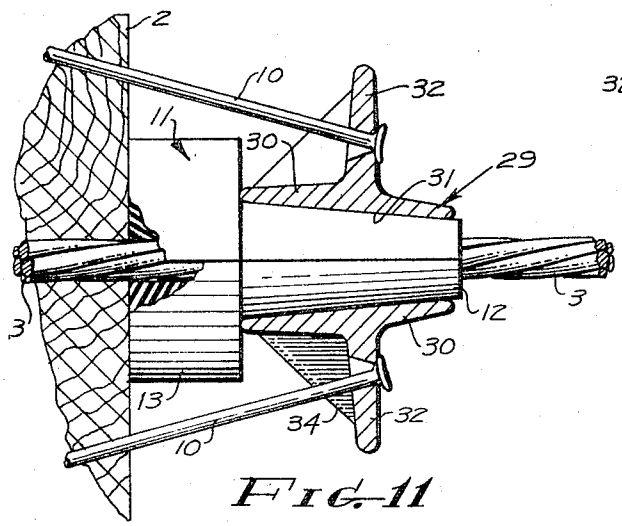


FIG. 11

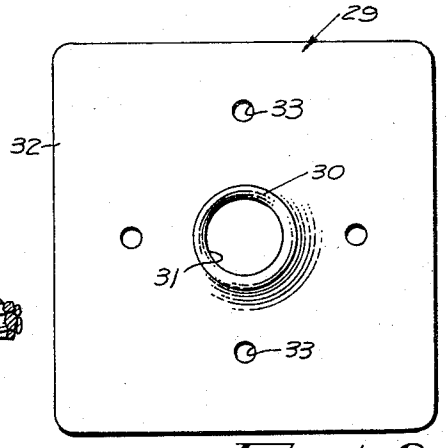


FIG. 9

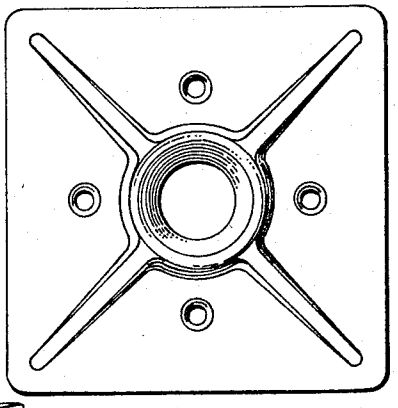


FIG. 10

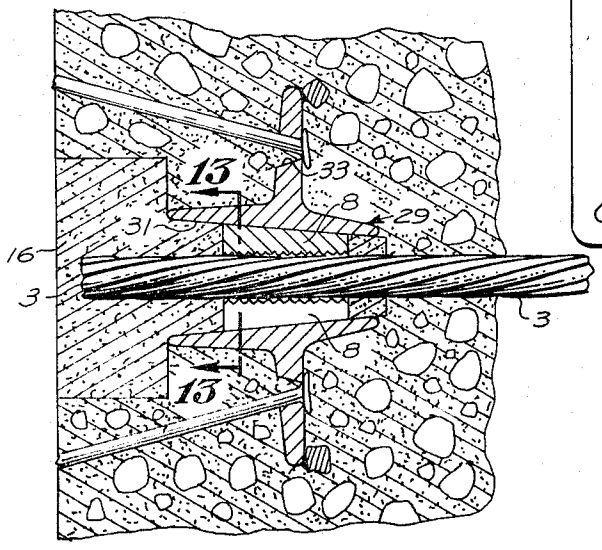


FIG. 12

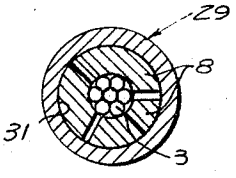


FIG. 13

INVENTOR.
EDWARD K. RICE
BY
Lyon & Lyon
ATTORNEYS

United States Patent Office 3,293,811 Patented Dec. 27, 1966

3,293,811

ANCHORAGE FOR CONCRETE STRESSING TENDONS

Edward K. Rice, 2077 Linda Flora,
Los Angeles, Calif. 90024

Filed June 1, 1965, Ser. No. 460,234
9 Claims. (Cl. 52—223)

This invention relates to anchorages for concrete stressing tendons, more particularly to devices for use in the tensioning of concrete beam tendons after the concrete has set, and is a continuation-in-part of my copending applications for Anchor Means for Concrete Prestressing Tendons, Serial No. 821,876, filed June 22, 1959, now abandoned; and Anchorage for Concrete Stressing Tendons, Serial No. 159,214, filed December 14, 1961, now abandoned.

Included in the objects of this invention are:

First, to provide an anchorage for concrete stressing tendons of the type which are cast in place in such a manner that they may be tensioned after the concrete has been set, the anchorage including a wedge and tendon-receiving conical bore, and an external, radially extending, constraining plate dipped in a plane passing through the midportion of the tendon wedges placed in the conical bore so that the radial forces produced by the interaction of the tendons and their wedges is not transmitted to the surrounding concrete; the constraining plate also serving to distribute the axial load of the tendon over a large area of the concrete.

Second, to provide an anchorage for concrete stressing tendons in which an embodiment thereof utilizes a single-piece wedge-receiving member and constraining plate.

Third, to provide an anchorage for concrete stressing tendons in which an embodiment thereof utilizes a wire coil as the wedge-receiving member.

Fourth, to provide an anchorage for concrete stressing tendons wherein an embodiment thereof utilizes a cylindrical member continuing axially from the wedge-receiving member, the cylindrical member having means for transmitting and distributing to the surrounding concrete the axial loads imposed by the tendon.

Fifth, to provide an anchorage of this type which includes further a rubber or elastomeric plug initially received in the wire coil, and held in bearing engagement with the concrete form when the anchorage is secured to the form, so as to provide a wedge and grout-receiving cavity, the plug forming an effective seal means to exclude concrete from the wedge-receiving member while the concrete is being poured.

Sixth, to provide an anchorage which utilizes a temporary sleeve surrounding the tendon and extending beyond the tendon to the wrapping or jacket which covers the major length of the tendon, so as to form, when the sleeve is withdrawn, an annular space between the tendon and anchorage into which a dense grout or other sealing and bonding agent may be forced.

Seventh, to provide an anchorage of this type which incorporates means for venting air and liquids during the grouting operation, thereby to ensure complete filling of any voids.

Eighth, to provide an anchorage for concrete stressing tendons utilizing serrated gripper elements wherein the steel tendon is coated in the region of the gripper elements of the anchor means with a bonded coating, thereby to minimize stress concentration at the points of contact of the gripper serrations.

Ninth, to provide an anchorage for concrete stressing tendons which may be arranged to permit bonded encasement of a selected length of the tendon inwardly of the gripping elements to improve the fatigue resistance of the anchorage.

With the above and other objects in view as may appear hereinafter, reference is directed to the accompanying drawings in which:

FIGURE 1 is a fragmentary, sectional view showing an end of a concrete beam and tendon and a portion of an end form, and showing anchorage in place before application of tension to the tendon;

FIGURE 2 is a similar fragmentary, sectional view, showing an end of the completed beam after the tendon has been subjected to tension and sealed in place;

FIGURE 3 is a transverse sectional view taken through 3—3 of FIGURE 1, showing particularly the hoop stress-resisting plate;

FIGUURE 4 is a diagrammatical plan view showing the manner in which stressing tendons may be arranged in a concrete beam or slab;

FIGURE 5 is a fragmentary, sectional view similar to FIGURE 1, showing a modified construction which includes means for forming a grout-receiving cavity between the tendon and anchorage and for venting air and liquid therefrom;

FIGURE 6 is a similar fragmentary, sectional view showing an end of the completed beam after the tendon has been subjected to tension and the grout-receiving space has been filled with grout;

FIGURE 7 is a fragmentary, sectional view showing an end of a concrete beam tendon and a portion of an end form, and illustrating a further modified form of the anchorage;

FIGURE 8 is a similar fragmentary, sectional view showing an end of the completed beam;

FIGURES 9 through 13 illustrate a further modified form of the anchorage particularly adapted for tendons of larger size, in which:

FIGURE 9 is an inner end view of the wedge-receiving member and constraining plate;

FIGURE 10 is an outer end view thereof;

FIGURE 11 is a longitudinal sectional view thereof showing a sealing plug in place and indicating a tendon and portion of a form fragmentarily;

FIGURE 12 is a longitudinal sectional view similar to FIGURE 11 showing anchorage after tensioning of the tendon; and

FIGURE 13 is a transverse sectional view taken through 13—13 of FIGURE 12 with the surrounding concrete omitted.

Prestressed concrete beams or slabs **1** are cast within suitable forms **2**, an end of which is indicated fragmentarily. Within the beam is one or more stressing tendons **3** which extend lengthwise of the beam **1** and protrude from the ends thereof. Each tendon may be a single wire or a multiple wire strand, or a more complex cable of essentially circular cross-section. If the concrete beam or slab **1** is stressed by a post-tensioning process, the tendons are placed in the form before pouring the concrete and are initially substantially tension free. The tendons are covered by a sleeve or wrapping **4** having a sufficiently low coefficient of friction to permit elongation of the tendons **3** after the concrete has set.

The concrete beam or slab **1** thus far described and the post-tensioning technique are conventional. In the exercise of the present invention, a special anchorage is provided at one or both ends of each tendon **3**.

With reference first to FIGURES 1 through 4, each anchorage includes a helically coiled wire structure **5** which in turn, includes a cylindrical sleeve member **6** surrounding the tendon **3** commencing at a predetermined depth from the end of the beam. The inner end of the sleeve member **6** may be covered by an extremity of the sleeve or wrapping **4**.

The outer end of the sleeve member **6** merges into or

is formed to a conical wedge-receiving member 7. The conical member 7 diverges outwardly towards the end of the beam 1. The conical member 7 forms an internal conical socket adapted to receive gripping wedges 8, which are complementary, to form a cone, the outer surface of which has a slope conforming to the slope of the conical socket. Internally, the wedges 8 have teeth 8*a*.

The conical member 7 of the coiled wire anchorage structure 5 is encircled by a hoop stress-resisting plate 9 forming a radially rigid constraining means which may be in the form of a square with a circular hole, the walls of which are adapted to engage the conical portion midway between its ends. The hoop stress-resisting plate 9 is cemented by a high strength adhesive, such as an epoxy resin, or is secured by brazing as indicated by 9*a*, or otherwise secured in place so as to remain fixed and resist axial loads, particularly in a direction toward the larger end of the conical member. The four corners of the plate 9 are apertured to receive nails 10 which are adapted to be driven into the form 2.

The anchorage structure 5 receives a segmental plug 11, which serves both as a seal and a mounting means. The plug is formed of rubber or other elastomer, and is split longitudinally, preferably in two complementary halves. The plug 11 includes a conical portion 12 which fits within the conical member 7 of the anchorage, and an enlarged cylindrical portion 13 which is interposed between the anchorage structure 5 and the form 2. The nails may be driven into the form around the plug 11 or the plug may be longitudinally perforated to receive the nails. The form is, of course, apertured so that the tendon may extend therethrough.

The plate 9 provides a convenient means for locating reinforcing bars 14 extending transversely to the tendon 3.

If the anchorage is used in the casting of concrete slabs, the tendons 3 may be arranged in pairs and diverge at their ends, as indicated by 15, into separate anchorages.

The anchorage is utilized as follows:

Prior to the pouring of a concrete beam or slab 1, the ends of a series of tendons 3 are extended through the anchorages and through the ends of the form 2. The individual anchorages are secured in place by nails driven through the plates 9. Suitable reinforcing bars 14 and other reinforcing bars are added, and the concrete is poured. After the concrete has set and developed the prerequisite strength, the form is removed, the segmental plugs 11 are extracted, and the gripping wedges 8 are inserted.

The tendons 3 are then placed under tension by use of conventional jacks and are held in tension by the gripping wedges 8. The tendons 3 are then cut so that their outer ends are within the cavities formed by the plugs 11, and these cavities are filled with grout. The wedges 8 form slots therebetween so that the grout 16 may pass between the wedges 8 and into the space between the sleeve portion 6 of the anchorage member 5 and the tendons 3, if this space has not previously been filled with the concrete. It should be noted that concrete may seep through the coils of the anchorage member 5 in the region beyond the segmental plugs 11.

It should be noted that the plate 9 defines a plane passing through the midportion of the wedges so that any radial expansion is so negligible as to insure that any slight tensional loads are well below the low tolerance that concrete has for such loads. Because of the central location of the plate 9, the taper or slope of the conical socket and wedges may be identical insuring uniform distribution of the gripping force throughout the length of the wedges.

In an absolute sense, through, the inner or smaller end of the wedges may undergo a slight radial expansion, but not enough to lose their gripping action. In fact, such slight expansion as may occur minimizes stress concentration.

The tendon is formed of hardened steel; however, the wedges are heat treated so as to be harder than the tendon. The teeth 8*a* are not so sharp as to nick the tendon but to impress therein.

Reference is now directed to FIGURES 5 and 6. The construction here illustrated incorporates a refinement which insures a space between the tendon 3 and the anchorage structure 5 which may later be filed with grout.

Added to the structure shown in FIGURES 1 through 4 is a tubular end fitting 17 which is suitably secured to the extended end of the sleeve portion 6. Attached to the end fitting 17 is a vent tube 18 which curves into parallel relation with the anchorage structure 5 and engages the enlarged portion of the segmental plug 11 which initially seals this end of the vent tube. In addition a sleeve 19 is initially fitted around the tendon 3 within the anchorage structure 5 and may extend beyond the anchorage structure. Its inner end may be initially covered with the wrapping 4 which normally encases the tendon 3.

The construction shown in FIGURES 5 and 6 is utilized in the manner of the first described structure.

After the concrete has set and the form 2 removed, the sleeve 19 is extracted along with the segmental plugs 11. The gripping wedges 8 are inserted, the tendon 3 is tensioned and secured by the gripping wedges, and a high strength, dense grout 20 or other sealing or bonding material is forced through the spaces between the wedge segments and into the annular space cast by the sleeve 19. The length of the sleeve and the resulting bonding connection between the grout 20 and the tendon 3 may be such as to develop the full strength of the tendom so as to supplement the action of the wedges 8 and provide an increased safety factor.

Reference is now directed to FIGURES 7 and 8. The construction here illustrated utilizes a modified anchorage structure 21 having an enlarged cylindrical member 22 continuing from the conical member 7.

A longitudinally split bolt 23 having a head 24 is inserted through an aperture provided in the form 2. The extended end of the bolt 23 is provided with screw threads 25 adapted to mate with the helically wound wire forming the cylindrical member 22 of the anchorage structure 21. Interposed between the anchorage structure 21 and the form 2, and surrounding the bolt 23, is a relatively thick-walled sleeve 26 formed of rubber or other elastomer.

With this construction the gripping wedges 8 are inserted before the concrete is poured, and the interior of the anchorage structure 21 is preferably filled with grease or other semisolid to exclude the entrance of cement and water and to allow axial movement of the tendon.

In the construction shown in FIGURES 7 and 8 the tendon is shown as a single strand member having a tenacious coating 27, for example, epoxy resins, have been found suitable for this purpose. The epoxy resin or similar coating is confined to the portion of the tendon which will be engaged by the wedges 8 and permits the use of sharper serrated teeth while serving to keep the serrated teeth from notching into the tendon and creating stress concentrations.

After the concrete has been poured and set, the form 2, bolt 23, and sleeve 26 are removed. The tendon is then tensioned and its end severed, so as to be within the cavity cast by the sleeve 26, and the cavity is filled with grout 28, as shown in FIGURE 8.

In each of the constructions illustrated, the anchorage member is formed of high strength spring steel, and therefore has high hoop strength.

Furthermore, in regard to the constructions shown in FIGURES 1 through 6, the plate 9 greatly increases the hoop strength of the anchorage member in the region subject to the wedging action of the wedges 8.

It should be noted that the plate 9 may be incorporated

in the construction shown in FIGURES 7 and 8 as well as in the structure shown in FIGURES 1 through 6.

Excellent bond is obtained between the exterior of the anchorage, particularly the cylindrical portions, due to the fact that concrete enters the helical groove formed by the convolutions of the wire. By reason of the fact that the bond between the anchorage and the concrete is distributed over a relatively large area, stress concentrations are avoided.

The bond between the concrete and the cylindrical helical coil is surprisingly effective. For example, tests have indicated that such a coil only **2** inches long is sufficient to develop the strength of a one-half inch diameter tendon. Tests have indicated that the ratio of tendon diameter to cylindrical coil length should not be less than 4:1, but need not be greater than 10:1. Furthermore, because of the fact that the convolutions of wire are constrained in the concrete, no failure of the anchorage member because of column load can occur.

Reference is now directed to FIGURES 9 through 13, wherein the anchor structure, designated **29** is forged, or otherwise formed from high strength steel. The anchor structure includes a tapered or conical sleeve **30** having a tapered or conical bore **31**. Midway between its ends, the sleeve is provided with an integral external constraining flange or plate **32** corresponding to the plate **9** of the first described structure.

The plate **32** is preferably square and is provided with nail holes **33** which receive nails **10**. Initially, the sleeve **30** receives a split rubber plug **11** as in the first described structure. The nails hold the sleeve lightly against the cylindrical portion **13** of the plug as shown in FIGURE 11.

The side of the plate **32** facing the cylindrical portion of the plug **11** is provided with gusset webs **34** extending to the sleeve **30**.

The anchorage **29** shown in FIGURES 9 through 13 is installed in the same manner as the first described anchorage. Initially the plug **11** is inserted and the anchorage is secured to the form as shown in FIGURE 11 with the tendon **3** extending therethrough.

After the concrete **1** is poured, the form and plug are removed, segmental wedge elements **8** are inserted, and the tendon is tensioned. The excess length of the tendon is severed, and grouting **16** is placed in the cavity formed by the plug **11**.

Operation of the anchorage **29** is essentially the same as the anchorage **5**, except the entire axial load of the tendon is transferred to the plate **32** for distribution to the surrounding concrete. As in the first described structure, the plate **32** is located midway between the ends of wedging segments and completely protects the concrete from radial forces which would place the concrete under tension.

It should be noted that the anchorage member **5** and plate **9** are formed of metal and therefore, as is well known, have a modulus of elasticity greatly in excess of concrete; for example, in the case of steel, it is ten times as great as concrete.

While particular embodiments of this invention have been shown and described, it is not intended to limit the same to the exact details of the constructions set forth, and it embraces such changes, modifications, and equivalents of the parts and their formation and arrangement as come within the purview of the appended claims.

What is claimed is:

1. In a stressed concrete structure having stressed tendons of essentially circular cross-section mounted in and extending between the anchorage zones at opposite ends of said concrete structure, the combination of an anchorage means confined to at least one anchorage zone of said concrete structure, said means comprising:

(a) wedge-receiving element formed of metal and disposed within at least one zone of said concrete structure, said wedge-receiving element having a conical bore of circular cross-section;

(b) a radially extending rigid metallic constraining plate surrounding said wedge-receiving element intermediate its ends, said plate having a ring of axially directed fastening apertures for receiving fastening means to secure said wedge-receiving element to a casting form for the concrete structure;

(c) and a body of yieldable material conforming to the interior of said wedge-receiving means and including a portion interposed between said wedge-receiving element and said form, and a bore therethrough receiving said tendon;

(d) said body being removable from said concrete structure, upon removal of said casting form, to provide access to the interior of said wedge-receiving element.

2. A structure as defined in claim **1** wherein a portion of said body of yieldable material is of generally cylindrical shape, and larger in diameter than said wedge receiving element and bears at one of its ends on the end of said element, its other end being substantially flat and abutting said casting form.

3. A structure as defined in claim **1** wherein said bore is substantially concentric to said wedge-receiving element, said bore embracing and gripping said tendon and holding the same under slight tension; said body of yieldable material being split longitudinally to facilitate removal thereof.

4. An anchorage as set forth in claim **1**, wherein:

said fastening means clamps and compresses said core member between said form and said anchor and about said tendon.

5. An anchorage as defined in claim **1** including a removable sleeve surrounding said tendon and extending through said body and anchorage means only in said anchorage zone and being slidably removable through said body to leave a grout receiving space around said tendon in said anchorage zone.

6. In a stressed concrete structure having stressed tendons of essentially circular cross-section mounted in and extending between the anchorage zones at the ends of said concrete structure, the combination of an anchorage means confined to at least one anchorage zone of said concrete structure, said means comprising:

(a) a wedge receiving element formed of metal and disposed within at least one zone of said concrete structure, said wedge receiving element having a conical bore of circular cross-section;

(b) and a concial wedge fitting the bore of said wedge receiving element for gripping said tendon;

(c) a cylindrical element rigidly connected to the smaller end of said wedge receiving element and continuing coaxially therewith to receive said tendon;

(d) the length of said cylindrical element being from 4 to 10 times the diameter of said tendon and including a series of axially spaced external interlocking elements directly bonded to the surrounding concrete for transferring axial loads from said tendon to said concrete.

7. A tendon anchorage for concrete structures according to claim **6** wherein:

(a) said conical wedge-receiving element and said cylindrical element are formed of a continuous helically coiled wire.

8. In a stressed concrete structure having stressed tendons of essentially circular cross-section mounted in and extending between the anchorage zones at the ends of said concrete structure, the combination of an anchorage means confined to at least one anchorage zone of said concrete structure, said means comprising:

(a) a wedge receiving element formed of metal and disposed within at least one zone of said concrete structure, said wedge receiving element having a conical bore of circular cross-section;

(b) and a conical wedge fitting the bore of said wedge receiving element for gripping said tendon;

(c) a cylindrical element rigidly connected to the smaller end of said wedge receiving element and continuing coaxially therewith to receive said tendon;

(d) said cylindrical element including a series of axially spaced external interlocking elements directly bonded to the surrounding concrete for transferring axial loads from said tendon to said concrete;

(e) said wedge receiving and cylindrical elements being formed of a continuous helically coiled wire dimensioned to loosely receive said stressing tendon to define therewith an annular grout-receiving cavity;

(f) and a vent tube extending from the axially inner end of said grout-receiving cavity to the exterior of said concrete structure, the axial length of said grout-receiving cavity being sufficient, when filled with grout, to effect transfer by the grout of the axial load of said stressing tendon to said elements independently of said wedge means.

9. An anchorage for post stressed concrete structures adapted to have stressing tendons slidably mounted therein for tensioning after setting of the concrete comprising said structure, said anchorage being located in an anchorage zone inwardly from, but adjacent at least one end of said concrete structure, said anchorage comprising:

(a) a metallic, expansion resisting wedge receiving anchor secured in axial load transmitting relation to said concrete structure within an anchorage zone inwardly from an end of said concrete structure and defining a conical bore to receive a tendon;

(b) a yieldable, removable core member within and substantially filling the wedge receiving anchor and extending to the corresponding end of said concrete structure and forming a grout-receiving cavity, to expose the interior of said wedge receiving anchor

and to afford access to the end of a tendon disposed therein;

(c) said portion of said body of yieldable material is of generally cylindrical shape and larger in diameter than said wedge receiving element and bears at one of its ends on the end of said element, its other end being substantially flat and flush with the end of said concrete structure;

(d) and a vent tube communicating at one end with the axially inner end of said grout-receiving cavity and having its other end abutting and closed by said portion of said body of yieldable material, the axial length of said grout-receiving cavity being sufficient, when filled with grout, to effect transfer by the grout of the axial load of said stressing tendon to said elements independently of said wedge means.

References Cited by the Examiner

UNITED STATES PATENTS

1,940,545	12/1933	Holmes	52—699
2,618,147	11/1952	Freyssinet	52—223
2,637,895	5/1953	Blaton	52—223
2,781,658	2/1957	Dobell	52—223
2,959,835	11/1960	Gates	25—131

FOREIGN PATENTS

544,574	2/1956	Belgium.
1,237,901	6/1960	France.
541,437	11/1941	Great Britain.
612,324	11/1948	Great Britain.
775,744	5/1951	Great Britain.
894,240	4/1962	Great Britain.

FRANK L. ABBOTT, *Primary Examiner.*

J. L. RIDGILL, *Assistant Examiner.*