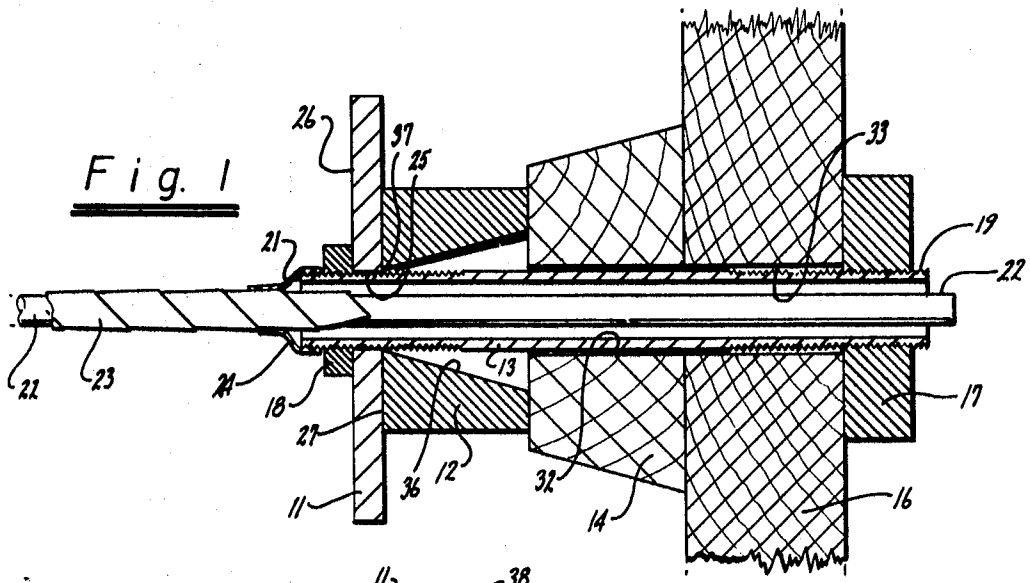
Sept. 20, 1971 G. H. HOWLETT ET AL 3,605,361

TENDON ANCHORAGE

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Fig. 1



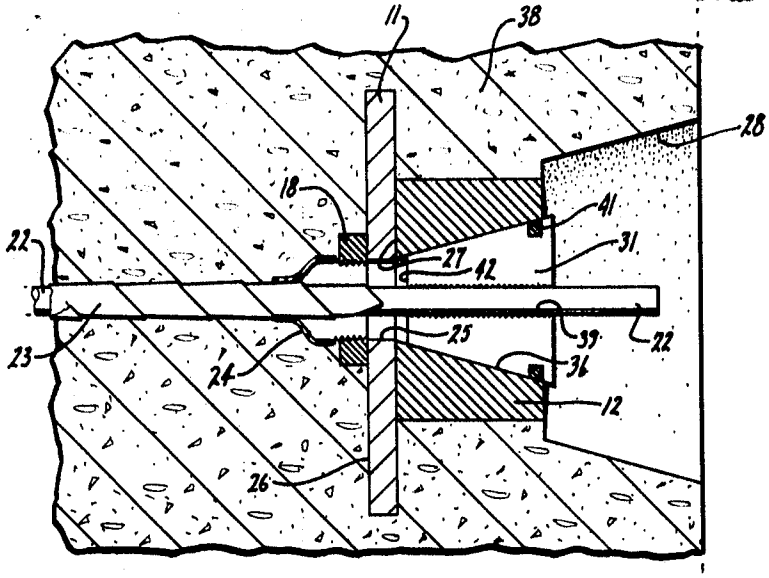


Fig. 2

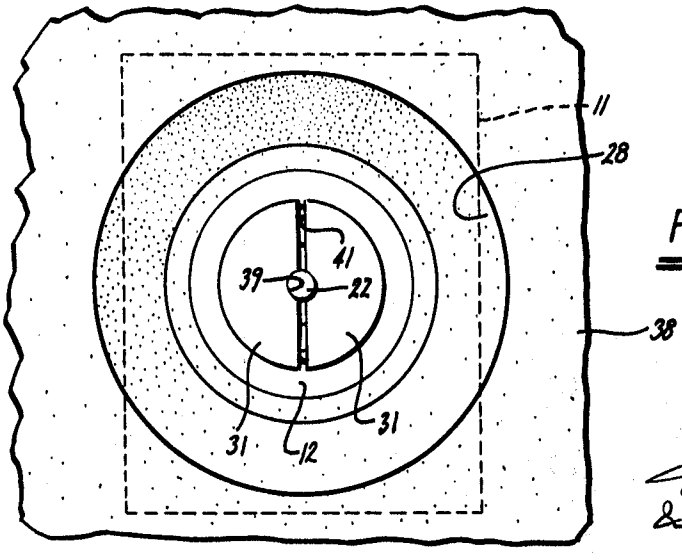


Fig. 3

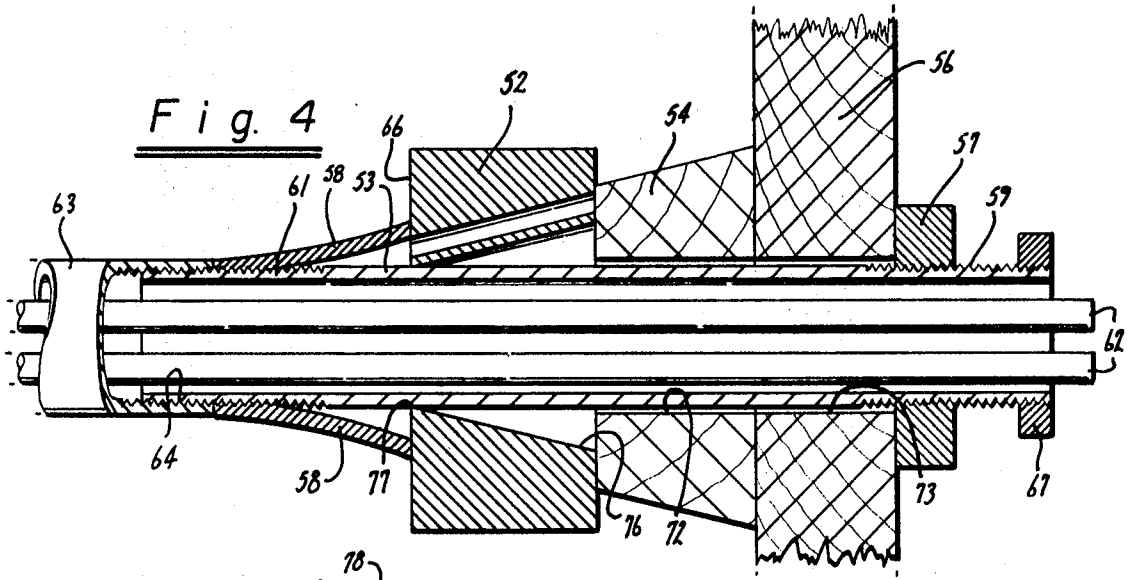
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Sept. 20, 1971 G. H. HOWLETT ET AL 3,605,361

TENDON ANCHORAGE

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Fig. 4



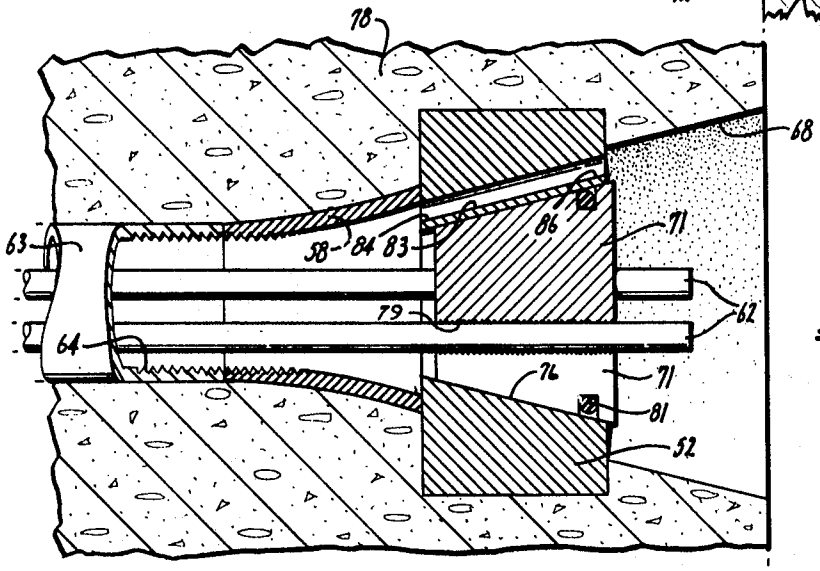


Fig. 5

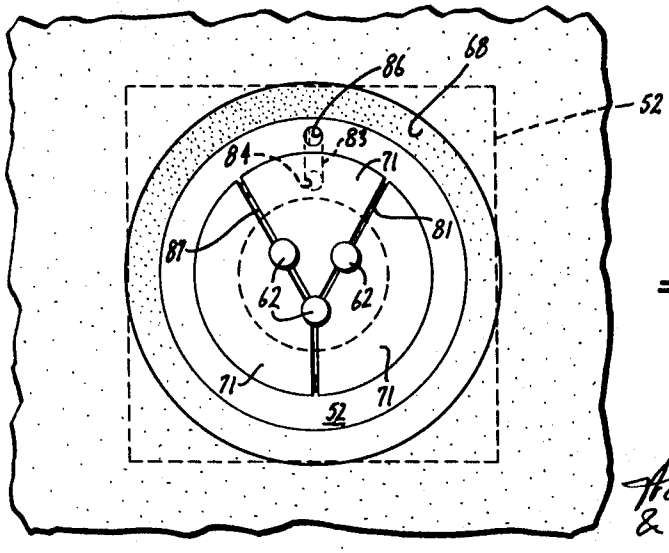


Fig. 6

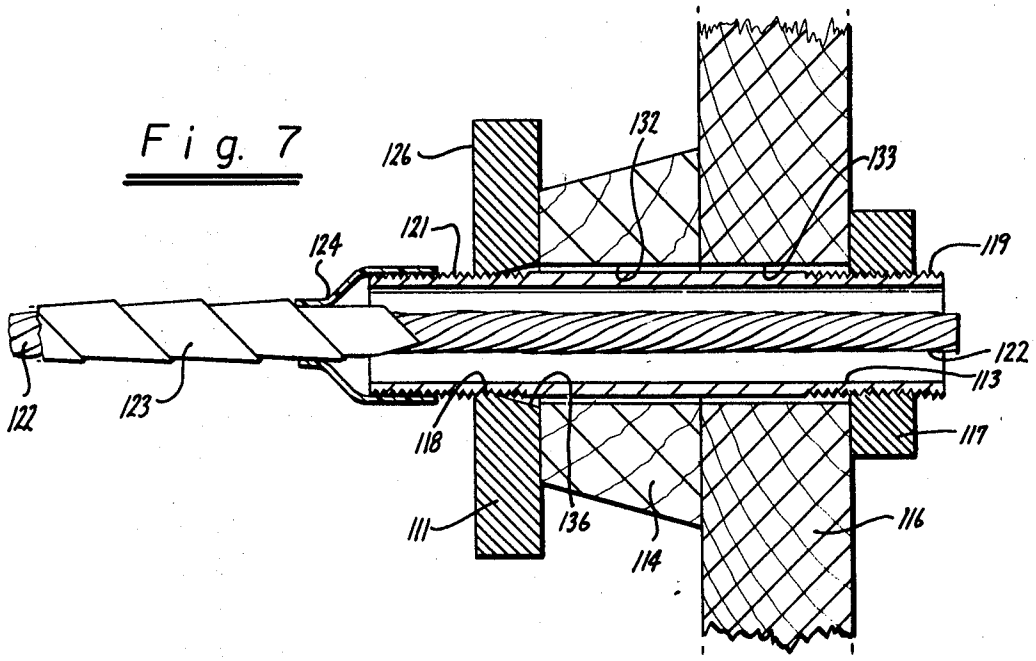
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TENDON ANCHORAGE

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Fig. 7



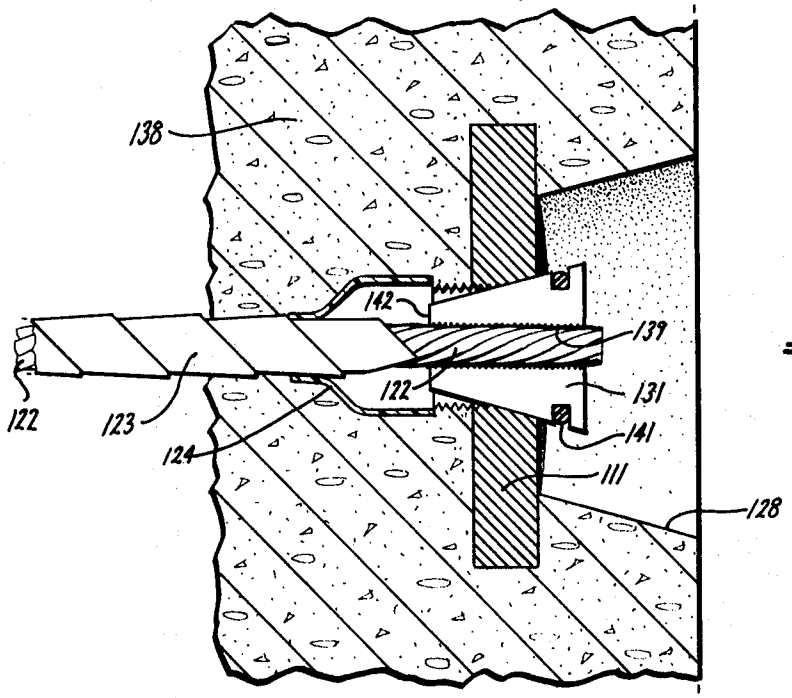


Fig. 8

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United States Patent Office 3,605,361 Patented Sept. 20, 1971

3,605,361

TENDON ANCHORAGE

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Filed Apr. 16, 1969, Ser. No. 816,583
Int. Cl. E04c 5/12; F16g 11/02
U.S. Cl. 52—223L 3 Claims

ABSTRACT OF THE DISCLOSURE

A tendon anchorage for use in prestressing concrete members which preferably includes a tubular mounting means mounted to extend through a wedge supporting bore in the anchorage in order to secure the anchorage in fixed spaced relation to a concrete form for casting the anchorage into the concrete member is disclosed. The mounting tube is formed to secure the anchorage from the side thereof remote to the concrete form and urge the anchorage against a spacing means placed between the anchorage and the concrete form. Bearing plates may similarly be secured by the mounting means through a tendon receiving opening from the remote side thereof. Anchorage grouting apparatus and tendon containing conduits may be secured to the mounting tube. An anchorage wherein the wedges extend from the remote side of the anchorage and are unsupported and achieve gripping action through cantilever forces from the anchorage is also disclosed.

BACKGROUND OF THE INVENTION

In the construction of many concrete members and particularly floor slabs and slab walls it has been found to be particularly advantageous to use a prestressed concrete construction. Typically, a plurality of tendons and tendon anchorages are placed within the concrete forms and the concrete is then poured with the tendon and anchorage being cast-in-place. The forms are then removed and the tendons are tensioned. It also has been found to be desirable in many applications to have the tendon anchorage located in a recess in the end of the concrete member, which recess is subsequently grouted so that the anchorage is completely contained within the finished prestressed concrete member. When this type of construction is used, the tendon anchorage must be located and positioned in fixed spaced relation to the concrete form by means of apparatus which, after casting of the concrete member, afford access to the anchorage for tensioning of the tendon.

Several anchorages have been previously employed in order to provide an anchorage construction which can be cast-in-place at a position interiorly of the ends of the concrete member. One approach has been to cast the anchorage as a single member in which a bearing plate and wedge receiving housing are integrally formed, and the bearing plate is provided with a plurality of openings. A rubber spacing or block-out member is placed next to the concrete form and the anchorage held against the spacing member as nails are driven through the openings in the bearing plate into the concrete form. The nails urge the anchorage against the spacing block and hold the anchorage in fixed spaced relation to the concrete form. This type of construction is illustrated in U.S. Pat. No. 3,293,811.

Another approach has been to provide a unitary anchorage member which is formed with screw threads or a bayonet-type socket on the side of the anchorage facing the form. A mounting member is then screwed into the front of the anchorage and extends therefrom to and through the form. A spacing block is again used, and the mounting member is secured on the outside of the form to urge the anchorage against the spacing block. The concrete member is cast and the form, mounting means, and spacing block removed to allow access to the anchorage.

Prior cast-in-place anchorage systems have been found to have several disadvantages. Primary among these disadvantages is the inflexibility of the system for mounting the anchorage in spaced relation to the concrete form. As will be readily understood, the prestressing requirements of various concrete members may differ considerably. For example, the depth to which a cast-in-place anchorage must be placed in the concrete member may under different construction codes vary from state to state or locality to locality. Similarly, tensioning forces may require various siezs or shapes of bearing surfaces in order to properly distribute the axial loading of the tendon or tendons. Moreover, close grouping of tendons may result in special bearing plate requirements. Still further, special wedge containing anchor members may be required for given stress conditions. Thus, prior tendon anchorages have lacked an interchangeability or flexibility of the elements in the systems which would allow the structural engineer maximum flexibility of design. In prior anchorage systems which were formed by casting as unitary anchorage members, necessary changes in anchorage design were accomplished by varying the mold for the castings in order to meet the design requirements. As will be understood, these systems could only economically accommodate a relatively small number of design variations.

Prior systems have also had other disadvantages. For example, the depth of the spacing block may be so great as to make it impractical or impossible to nail the anchorage to the form. Still further, casting the bearing plate and a wedge containing housing as a unitary piece results in a relatively bulky, heavy and inconveniently shaped anchorage which is not conveniently stored or shipped. Since bearing plates can be quite heavy and yet very easy to form, it can be quite advantageous to form the bearing plates at a location relatively close to the construction site and ship only the tendon gripping wedges and containment housing therefor as a separate item from a more remote area. Moreover, casting the wedge receiving bore into the concrete member results in exposing that bore to rust and concrete leakage past the block-out member.

In some instances it is highly desirable or necessary to cluster tendons in close side-by-side relation. One approach to this problem is also shown in the above referred to U.S. Pat. No. 3,293,811 wherein the tendons must be unnaturally spread apart in order to accommodate the bearing plate portion of side-by-side discrete anchorages. It is quite advantageous, however, to have the tendons continue in side-by-side close proximity and grip them with a single anchorage. Alternatively, if the tendons are spaced apart slightly, they can be gripped by a plurality of anchor members and a single bearing plate having a plurality of tendon receiving openings therein. Prior anchorage systems have not afforded this flexibility.

Another aspect of prior prestressing anchorage systems has been the manner in which the tendon gripping wedges are supported. In general anchorages have been formed so that the tendon gripping wedges are relatively thin and are supported over substantially their entire length by a wedge supporting structure. More particularly, prior tendon anchorages normally include wedges which are formed so that the wedge material between the tendon gripping surface and the outside anchorage engaging surface adjacent the small diameter end of the anchorage is very thin and incapable of supporting substantial bending forces.

These prior tendon anchorage and wedge constructions have been found to have substantial disadvantages when the anchorage is employed for general use and, more particularly, to have substantial disadvantages when the anchorage is employed as a cast-in-place anchorage. The use of relatively thin wedges and support of the wedges over their complete length has resulted in the anchorages having excess metal in the bearing plate or needing a separate wedge containing anchor member, resulting in a substantial overall increase in the anchorage cost.

Accordingly, it is an object of the concrete prestressing tendon anchorage of the present invention to provide an improved anchorage construction and method of anchorage support which affords greater flexibility in meeting design criteria by means of allowing easy interchangeability of the parts while maintaining the characteristic of being rapidly mountable to the concrete form for casting the concrete member.

It is another object of the present invention to provide a tendon anchorage wherein the parts of the anchorage can be readily and easily formed, stored and shipped.

It is still another object of the tendon anchorage of the present invention to provide an anchorage construction which can be conveniently and easily adjusted under field condiitons and minimizes the exposure of the anchorage to damage and corrosion in the field.

Another object of the tendon anchorage of the present invention is to provide an anchorage construction wherein a multiplicity of side-by-side tendons can be conveniently and easily secured.

Still another object of the tendon anchorage of the present invention is to provide an anchorage structure wherein accessories such as grouting apparatus can be easily added to and positively secured in position relative to the anchorage and concrete form.

Still another object of the anchorage of the present invention is to provide an anchorage wherein the tendon gripping forces generated in the anchorage are distributed within the gripping wedges in a manner which insures high reliability of the anchorage, minimizes the volume and weight thereof and improves the gripping profile and adaptability of the anchor member for use in cast-in-place prestressing applications.

SUMMARY OF THE INVENTION

Briefly, the tendon anchorage of the present invention includes, an anchor member having a wall defining a convergently tapered bore dimensioned at the smallest point thereof to receive a tendon to be tensioned, and anchorage mounting means formed to extend from the remote side of the anchor member through the tendon receiving bore to a concrete form in order to position the anchor member in fixed spaced relation to the form during casting of the anchor member into the concrete member. The mounting means is preferably a tube which can be removed from the anchor member after casting of the concrete member. The anchorage is used with convergently actuating gripping means, such as segmental wedges, and with anchor spacing means, such as a spacing block or member formed to prevent entry of concrete between the anchor member and form during casting of the concrete member. Alternatively, the tubular mounting means may extend through a bore located in a bearing plate with the bore being tapered to receive mating wedges or being formed to support a separate anchor member inserted after casting of the bearing plate into the concrete member.

The tubular mounting member is preferably dimensioned on its internal diameter to receive the tendon to be tensioned in order that the anchor member can be cast into the concrete member with the tendon in place. The mounting means is preferably threaded on the end which is secured to the anchor member in order that it may receive a nut or other fastener on the remote side of the anchor member or in order that the mounting means may be threaded directly into the small diameter

end of the bore in the anchor member. The mounting means is further preferably formed for securement of accessories used with the tendon anchorage, such as a grouting apparatus or a conduit to allow post tensioning of the tendon.

A tendon anchorage for use in prestressing concrete members which are cast-in-place or otherwise positioned in the concrete member is disclosed wherein the bore of the anchor member and convergently actuating wedge segments are formed and dimensioned so that the wedge segments extend from the remote side of the anchor member over a substantial unsupported distance, with the wedges gripping the tendon by cantilever action. Additionally, the wedges may extend unsupported for a substantial distance from the ither side of the anchor member.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary, side elevational view, in cross section, of a tendon anchorage constructed in accordance with the present invention and secured to a concrete form for casting of the anchorage into a concrete member.

FIG. 2 is a fragmentary, side elevational view, in cross section, of the anchorage illustrated in FIG. 1 after casting of the concrete member, removal of the concrete form and tensioning of the tendon.

FIG. 3 is a fragmentary end view of the anchorage as illustrated in FIG. 2.

FIG. 4 is a fragmentary, side elevational view, in cross section, of an alternative embodiment of the tendon anchorage of the present invention suitable for anchoring a plurality of tendons.

FIG. 5 is a fragmentary, side elevational view, in cross section, of the tendon anchorage of FIG. 4 after casting of the concrete member, removal of the form and tensioning of the tendons.

FIG. 6 is an end view of the tendon anchorage as illustrated in FIG. 5.

FIG. 7 is a fragmentary, side elevational view, in cross section, of an alternative embodiment of the tendon anchorage of the present invention as secured to a concrete form.

FIG. 8 is a fragmentary, side elevational view, in cross section, of the tendon anchorage of FIG. 7 illustrating the wedge and bearing plate configuration of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 12, and 3, the anchorage of the present invention can be seen to be comprised of a bearing plate **11**, anchor member **12**, mounting means **13**, and spacing means **14**. The anchorage is secured to extend from concrete form **16** by means of a nut **17** located on the outside of the form and a second nut **18** threadably engaging mounting means **13** on the side of the anchor member and bearing plate remote or furthest from form **16**. Either or both of nuts **17** and **18** can be advanced on correspondingly threaded ends **19** and **21** of mounting means **13** in order to urge the bearing plate and anchor member against spacing means **14**. Extending through mounting means **13** is tendon **22**, which is here illustrated as being wrapped with a paper covering **23**. Covering **23** is typically provided with a layer of grease on the inner side thereof so that the tendon may be post-tensioned within covering **23** after casting of the concrete member. Sealing of the juncture between wrapped tendon **22** and mounting means **23** is preferably accomplished by tape **24** which will bridge across the juncture and prevent flow of concrete into the end of the mounting means.

An important feature of the tendon anchorage of the present invention is to provide a construction which allows improved versatility and interchangeability of the various anchorage parts in order to accommodate variations in design of the concrete member into which the anchorage is incorporated. Accordingly, the tendon anchorage mounting structure of the present invention is

constructed so as to reach or extend through the tendon receiving opening in the anchorage to the side thereof remote from the concrete form in order that the anchorage may be urged toward and secured relative to the concrete form from a position on the remote side of the anchorage. Fastening of the anchorage to the concrete form by this technique, affords several substantial advantages. For example, bearing plate **11** can be readily and easily formed to have any one of a number of possible configurations and sizes without the need of providing special openings or sockets to accommodate mounting thereof for casting. Thus, bearing plate **11** may be formed with two or more openings so that anchorages can be positioned in close side-by-side relation. Alternatively, bearing plate **11** may be selected to be of varying lateral dimensions in order to achieve any desired or required distribution of tensioning forces to the concrete member through bearing surface **26**. Still further, while steel is normally employed in formation of the bearing plate, differing heat treatments and formation techniques may result in differing strengths. The structural engineer can select the desired material and strength, which will cause a variation in the thickness of bearing plate **11**, when the anchorage of the present invention is employed.

The ability to interchange bearing plates in the tendon anchorage of the present invention is further important in that it affords greater flexibility in the selection of the tendon anchor member. For example, anchor member **12** may be formed as illustrated in FIG. 1 or, alternatively, a different type of tendon anchorage device could be used which has a much smaller external diameter. This type of anchorage may be dictated from the design requirement that the concrete member be able to withstand stress reversals and accordingly have an anchorage which will not allow the gripping wedges to move backwards out of the anchor member. If the anchor member **12** is of a smaller diameter than illustrated in FIG. 1, the surface area **27** between the bearing plate and anchor member will be reduced resulting in a greater concentration of the axial tension forces on the bearing plate. This may in turn require that the bearing plate **11** be of a greater thickness in order to accommodate the greater stress concentrations caused by the anchorage. The mounting means construction of the present invention affords the ability to both change the anchor member **12** to meet particular design criteria and change the bearing plate **11** correspondingly to meet the design characteristics of the anchor member. This versatility is not found in prior devices which are characteristically cast in one piece and secured to the concrete form from the front side thereof so as to inhibit the interchangeability of parts or building up of the desired anchorage to meet exactly the structural design requirements.

Still another important feature of the tendon anchorage of the present invention is to provide an anchorage construction which can readily and easily secure the anchorage at almost any position interiorly of the concrete form while still maintaining the characteristic interchangeability of parts. It may be desirable or necessary under various local and state laws and codes to bury the tendon anchorage at various depths in the end of the concrete member. Accordingly, spacing member or block-out **14** may be formed with various depth dimensions in order that recess **28** is of sufficient depth to allow later grouting of the tendon anchorage in compliance with the state or local code. Still further, anchor member **12** may have various axial dimensions, depending upon the type of anchorage employed. Thus, bearing plate **11** may be disposed at various spaced distances from form **16**, some of which are far in excess of the length of common fastening means such as nails. The tendon anchorage construction of the present invention, therefore, affords further design flexibility in the location of the tendon anchorage relative to the end of the concrete member. The mounting means can be of virtually any predetermined length and have substantial continuous adjustability from either the concrete form side of the mounting member or the anchor member side thereof. As illustrated in FIG. 1, threaded ends **19** and **21** of tubular mounting member **13** are threaded over a substantial distance and would be suitable for use in connection with spacing members **14** of variable axial length. This important feature will allow take-up of the mounting means at the anchorage which is not possible in prior art devices and can be of considerable practical importance in the field.

Another advantage of having a tendon anchorage which can be assembled in the field is that the anchorage can be more conveniently shipped and stored than anchorages which are cast as a single piece. For example, bearing plates **11** can be stacked flat and easily transported. A plurality of anchor members **12**, mounting means **13** and spacing blocks **14** can similarly be easily stacked, handled and transported. Since the bearing plates and anchor members are usually formed of high strength steels and are quite heavy, it may be advantageous to form the bearing plates, which are relatively simple, at a location adjacent to the area in which the anchorage is to be used and form the anchor member **12** and corresponding segmental wedges **31** at a manufacturing facility more remote, where somewhat more complicated forming equipment can be employed. Bearing plate **11** is typically formed with a shear and punch or drill while anchor member **12** and mating wedges **31** may be formed on a screw machine. In addition bore **25** in bearing plate **11** may be tapped, nut **18** eliminated and mounting means **13** threadably engaging plate **11** to secure the anchorage relative to the form. When flexibility in the type of anchorage needed is required, these formation methods compare quite favorably with the prior art technique of casting, which requires a different mold for each anchorage configuration. Moreover, a cast anchorage inherently will have a lower reliability than anchorages constructed from roll-formed material.

The assembly and use of the anchorage of the present invention can be described as follows. Tendon **22** will be located in the concrete member in accordance with predetermined design criteria and will be anchored at the end opposite the end shown in FIG. 1 by any one of a number of techniques, including an oppositely facing anchorage of the type illustrated in FIG. 1. The wrapping **23** will be removed from the end of the tendon in order that it may be gripped by wedges **31** and yet cover the tendon over the length thereof exposed to concrete. The mounting means **13** with nut **18** positioned thereon may be mounted over the end of tendon **22** and bearing plate **11**, anchor member **12** and spacing means **14** are mounted on member **13**. Spacing block **14** is preferably provided with an axially extending bore **32** in order that it may be readily slipped over the end **19** of mounting means **13**. End **19** of mounting means **13** is then inserted in bore **33** in form **16** until end **19** extends from the form and nut **17** is advanced against form **16** until the anchorage is urged against spacing block **14**. Alternatively, spacing block **14** may be segmented and mounted between anchor member **12** and form **16** after insertion of end **19** of the mounting means through bore **33** in the form.

As here illustrated, anchor member **12** is provided with a frusto-conical bore **36** terminating in a small diameter end **37**. The smallest point in the bore **36**, namely, end **37**, is preferably dimensioned to receive mounting means **13** and tendon **22** simultaneously therethrough. Once secured in place, concrete member **38** is formed by pouring concrete around the anchorage and allowing it to set up. Spacer **14** abuts anchor member **12** and prevents the entry of concrete into the bore **36** while tape **24** prevents entry into the front end of mounting means **13**.

Other techniques can be used to close end **21** of mounting member **13** including rubber grommets. Alternatively, nut **18** can be provided with a plastic skirt or sleeve which

is formed and dimensioned to extend from the nut to encircle and resiliently grip tendon **22** and prevent entry of concrete into the mounting means. Moreover, and very importantly, since mounting means **13** extends through the anchor member, any leakage of concrete will merely pass into the tubular mounting member and not the wedge receiving bore **36**. Prior mounting devices have required much more care in closing the end of the anchorage against entry of concrete into the wedge receiving bore. Moreover leakage onto tendon **22** is not important since the tendon typically elongates 6 inches or more and the surface finally gripped is underneath the wrapping **23**.

As shown in FIG. 2, the mounting means **13** and form **16** have been removed from the anchorage. This is accomplished by unscrewing nut **17** and removing form **16** and spacing block **14**. Still further member **13** may be unscrewed from nut **18** which remains cast into the concrete member. This is done by gripping the mounting means **13** by end **19** (pliers or other gripping tools may be used) and may be accomplished either before or after removal of form **16** and spacing block **14**. Wedges **31** are preferably formed with serrated internal gripping surfaces **39** and are held together for convenience of handling in the field by an O-ring **41**. Tendon **22** is then tensioned by jacking the end thereof, causing the tendon to move relative to the paper wrapping **23**. Wedges **31** will advance into bore **36** and due to the frictional engagement of tendon **22** by serrated surface **39** will convergently grip tendon **22**. Once the wedges have taken the full predetermined tension load of the tendon, the end of the tendon may be cut off by a shearing tool or welding torch so that it is within recess **28**. If the tendon is to be grouted, recess **28** will then be filled with grout (not shown). It should be noted that the thickness of wedges **31** at end **42** must be sufficient to accommodate mounting means **13**. That is, when a tubular mounting means is employed, the small diameter end **37** of bore **36** is larger than would be required simply to allow tendon **22** to pass through anchor member **12**. Accordingly this extra dimension will result in wedges **31** having an overall thickness which is greater than might otherwise be employed.

It should be noted further, however, that mounting means **13** need not be tubular in shape and wedges **31** can be formed of a thinner construction. This can be accomplished if the tendon **22** is not cast into the concrete member but is inserted after casting of member **38**. Insertion of the tendon after casting can be accomplished if a tendon receiving conduit is cast into the concrete member. In such a configuration, member **13** could be formed as a solid rod substantially the same diameter as tendon **22** with threaded ends **19** and **21**. The rod would extend through bearing plate **26** with bore **25** now being only slightly greater than the tendon diameter. End **21** of the solid member **13** would be threaded and a conduit (not shown) could screw onto the exterior threads of member **13** and have an internal dimensioned to receive tendon **22**. In effect, the conduit would replace greased paper **23**. In this configuration removal of mounting means **13** would be followed by insertion of tendon **22** through the conduit, which was positioned and fixed relative to the concrete form by the mounting means. Such a conduit is illustrated in FIG. 4 in which three side-by-side tendons are contained.

As above set forth, in order to reduce the number of elements in the anchorage of the present invention nut **18** can be eliminated from the anchorage construction of the present invention simply by threading internal bore **25** of the bearing plate. Thus, member **13** could be screwed into the bearing plate which would again urge the bearing plate, anchor member and spacing means against concrete form **16**. This construction would similarly allow the interchangeability of various parts in order to meet a variety of design criteria. Similarly, bearing plate **11** could be formed integrally with anchor member **12** or permanently secured thereto (this could be accomplished in the manufacture of the piece or in the field by spot welding) and the smallest diameter portion of bore **36**, namely, end **37**, could be internally threaded to receive threads on end **21** of the mounting tube. This type of construction is illustrated in the anchorage in FIGS. 7 and 8.

Referring now more particularly to the anchorage illustrated in FIGS. 4, 5 and 6, an alternative embodiment of the anchorage of the present invention may be described. Anchor member **52** and spacer **54** are mounted on tubular mounting member **53** and secured by nut **57** and frusto-conical sleeve **58** against concrete form **56**. Ends **59** and **61** of member **53** are externally threaded as above described. The anchorage, as set forth in FIGS. 4–6, is formed to secure a plurality of tendons **62**, which in this case can be seen in FIG. 6 to be three tendons. The tendons are preferably mounted inside conduit **63** which is provided with internal threads **64** in order that the conduit may be threadably mounted onto mounting means **53**. In this configuration, it is possible to cast the concrete member **78** with tendon **62** being pulled through conduit **63** after the concrete member had been cast and the forms removed.

In this form of the tendon anchorage, anchor member **52** has an integrally formed bearing surface **66** and a separate bearing plate has been eliminated. Mounting member **53** is formed to extend through frusto-conical bore **76** in member **52** and particularly through the small diameter end **77** thereof to the remote side **66** of the anchor member. As will be set forth in detail hereinafter, anchor member **53** extends beyond surface **66** and through a funnel shaped grouting member **58** in order to secure the anchorage in fixed spaced relation to form **56**.

The anchorage of FIGS. 4, 5 and 6 is used in a manner similar to that described in connection with the anchorage of FIGS. 1, 2 and 3. In this embodiment of the anchorage, however, a nut **67** is provided which is secured to end **59** of member **53** (by brazing, for example) so that it may not be either advanced or removed from member **53**. This nut can then be used in rotating member **53** so as to release it from the internal threads **64** of conduit **63** and the threads of funnel member **58**. When nut **67** is permanently mounted on end **59** of the mounting member, the anchorage may be assembled by inserting the tendons into end **61** of member **53** and then inserting end **61** through bore **73** in form **76**, bore **72** in spacer **54**, bore **76** in anchor member **52**, and finally the bore in member **58** and the internal diameter of conduit **63**. The anchorage can be adjusted into a fixed rigid position by cinching down on nut **57** and/or advancing grouting funnel **58**. As illustrated in FIGS. 4, 5 and 6, the tendon anchorage of the present invention demonstrates how mounting means **53** can be used in order to support and secure accessories which are commonly employed in prestressing concrete members. Thus, member **53** supports a grouting funnel **58** and supports a tendon containing conduit. It is an important feature of the present invention that the mounting means may be secured to the tendon conduit since this results in a fixed alignment of the tendon anchorage and the tendon. Alignment of the tendon and anchorage is extremely important and reliable since tensioning forces are very high and malalignment can result in serious detrimental stress concentrations in the concrete member and tendon.

Again the versatility of the present invention is illustrated since anchor member **52** can be formed with various configurations including bearing surfaces **66** which are of a larger or smaller area. Upon removal of the form, mounting means and spacing block, recess **68** in member **78** affords access to the anchor member for insertion of tapered segmental wedges **71**. The wedge configuration suitable for gripping a plurality of side-by-side tendon **62** is best seen by reference to FIG. 6. The individual wedges are again preferably held together for convenience by an

O-ring **81** and formed with internal serrated tendon gripping surfaces **79**.

In order to facilitate the grouting of the anchorage of the present invention, a grouting bore **83** is formed in member **52**. Grouting bore **83** terminates in an opening **84** which is disposed radially inwardly of the internal diameter of funnel **58** in order to be in communication with funnel or sleeve **58** and conduit **63**. The other end of bore **83** terminates in an opening **86** which communicates with recess **68**. Thus, grout may be introduced through opening **86** into funnel **58** and conduit **63** with air escaping through the other end of the tendon conduit through a vent opening or through the slotted openings **87** between opposed faces of wedges **71**.

Other forms of grouting apparatus are suitable for use with the anchorage of the present invention. For example, funnel **58** may be replaced by a T-shaped pipe and a grouting tube which extends around member **52** to an exposed end of the concrete member **78**. Again, however, a T-shaped member could be internally threaded so as to be mountable on conduit **53** to urge anchor member **52** against spacer **54**. Similarly, conduit **63** could threadably engage mounting member **53**.

Referring now to FIGS. 7 and 8, there is illustrated an alternative embodiment of the tendon anchorage of the present invention which is particularly well suited for use as a cast-in-place type of anchorage and further useful in other prestressing applications. The anchorage is comprised of a bearing plate **111** and bearing plate locating device consisting of tubular member **113** and spacing or block-out member **114**, which are urged agains tform **116** by nut **117** and threads **118** at the small diameter end of bore **136** in thhe bearing plate. As above described mounting member **113** is formed with externally threaded ends **119** and **121**. Tendon **122** is here illustrated as a strand type of prestressing tendon having a cable-like construction. The strand can be wrapped in paper **133** and conveniently taped or otherwise blocked by member **134** against entry of concrete into the end **121** of mounting means **113**.

Bearing plate **111**, which in this configuration acts as an anchor member, is provided with a bearing surface **126** facing away from the concrete form which will allow transfer of axial tensioning forces to concrete member **138**. The bearing plate is also formed with a frusto-conical bore **136** terminating in threads **118** at the bearing surface or remote side of the bearing plate. As above described, mounting means **113** can be inserted through bores **132** and **133** in the spacing member and form, respectively, and mounting means screwed into the teeth **118** in bearing plate **111**.

It is preferable and an important advantage of the anchorage of the present invention that the mounting means be further formed in order to form a recess in the concrete on the bearing surface side of the anchorage sufficient to accommodate axial advancement of wedges **131** beyond surface **126**. Thus, the mounting apparatus of the present invention functions additionally to provide a recess into which the tendon gripping wedges may move in advancing to a position of maximum radial gripping force.

FIG. 8 illustrates the concrete member with the anchorage of the present invention in place. Form **116** and block-out member **114** have been removed, resulting in recess **128** allowing access to bearing plate **111**. As here illustrated bearing plate **111** is formed with a frusto-conical bore into which segmental wedges **131**, held together by O-ring **141**, are inserted. The segmental wedges are again preferably provided with tendon gripping serrated surfaces **139**. It should be noted and it is an important feature of the present invention that end **142** of the wedges projects past bearing surface **126** a substantial distance. Thus, radial gripping of tendon **122** is accomplished by means of cantilever action from bearing plate **111** to ends **142** of the tendon gripping wedges.

The versatility of the anchorage of the present invention can further be illustrated in that bearing plate **111** can alternatively be formed with a cylindrical bore dimensioned to receive tendon **122**. Spacing block-out member **114** can be dimensioned to have a sufficient thickness so that recess **128** is of sufficient depth to accommodate the later insertion of a wedge containing housing or anchor member of the type illustrated in FIG 1 as member **12**. Thus, the mounting means would be used to locate the bearing plate and upon removal of the spacer and form an anchor member and tendon gripping wedges could be slipped over the end of tendon **122** to allow tensioning of the tendon and later grouting of recess **128**. An anchorage construction wherein the anchor member is subsequently inserted as a separate unit can be highly advantageous. When this approach is used the problem of entry of small amounts of concrete around block-out member **114** into frusto-conical bore **136** is eliminated. Similarly the problem of rust forming in or corrosition of the wedge receiving bore can be controlled and eliminated since the anchor member, if not cast into the beam, can be kept in a controlled environment and properly treated to prevent rust and corrosion.

The spacing or block-out members as illustrated throughout the drawings are formed of wood. Several other materials and constructions, however, will suffice for the apparatus of the present invention. For example, block-out members have previously been formed of rubber, sheet metal and plastic. Moreover, while the spacing members are preferably removable from the concrete member in order that they may be reused in the subsequent placement of anchorages, the block-out and spacing member may consist of a sleeve, as opposed to a solid member, which is permanently left in the concrete member with the interior diameter of the sleeve providing an access recess to the bearing plate or anchor member.

The tendon anchorage illustrated in FIG. 8 and particularly the combination of bearing plate **111** and wedges **131**, while highly advantageously employed in a cast-in-place type of anchorage, may also be advantageously employed in other prestressing applications, such as dry mounting the anchorage on the end of a concrete member. Prior art anchorages employing convergently tapered segmental wedges have been constructed so that the front end of the wedge, corresponding to end **142** of wedges **131**, does not project from the front of the wedge containing structure so as to be unsupported in advance of that structure. Occasionally, some wedge systems have projected forwardly for a very small distance (usually less than $\frac{1}{20}$ the wedge length) and sometimes rearwardly of the anchorage over a short unsupported distance. Accordingly, prior anchorages and wedge systems have been formed with the wedges being relatively thin at the front ends thereof since strength in bending is not of critical importance when the wedges are supoprted over their entire length by an anchor member.

In order to achieve the advantages of radially gripping segmental wedges while reducing the volume and weight of the bearing plate or anchor member required to house and support these wedges, the anchorage of the present invention is formed with segmental wedges which protrude and are unsupported over a substantial distance in advance of the bearing surface side of the bearing plate. In order that these wedges will attain and withstand the very high radial gripping forces necessary to secure tendons at a tension force approaching their yield strength, the segmental wedges of the present invention are formed and dimensioned to be relatively thick and preferably stress relieved in order to avoid delay failure. These relatively thick wedges, therefore, are cantilever supported from the bearing surface side **126** of bearing plate **111**.

The reduction in bearing plate weight and volume can be illustrated as follows. The bearing plate tapered bore **136** must have sufficient surface area so that when the bore engages the exterior surface of wedges **131** there

will not be undue stress concentration in bore **136** which would result in bearing plate **111** permanently deforming or otherwise failing. As the diameter of bore **136** increases, however, the surface area increases with the diameter. This in turn will allow reduction in the thickness of the bearing plate and allows wedges **131** to increase in thickness between the bearing plate and wedge gripping surfaces **139**. The increase in thickness of the wedges affords a greater ability to withstand cantilever support and projection from the bearing plate and increase in bore **136** diameter affords the ability to reduce the volume and weight of the bearing plate by decreasing its thickness. Still further, it has long been thought to be an advantage to have the radial gripping forces created by wedges **131** decrease from a maximum at the midpoint of the gripping surface to a substantially lesser value at end **142** of the wedges. Cantilever support of the wedges results in this desirable tendon gripping force profile.

Another advantage of increasing the diameter of bore **136** and thus thickness of wedges **131** is that the anchorage may more conveniently be used as a cast-in-place type of anchorage since member **113** can readily pass through the smallest diameter of the tapered bore **136**, namely, at threaded end **118**. This in turn will allow both the mounting member **113** and tendon **122** to be simultaneously mounted in place for casting of the concrete member.

By way of example, bearing plate **111** can be formed of C1040 steel having a Rockwell hardness of between about 15 to about 28 on the Rockwell C scale. In order to grip a strand having a nominal diameter of 0.60 the bearing plate may be formed with a thickness of about ¾ to 1 inch, with bore **136** having a diameter at the small end of about 1¼ inches and a taper of about 10°. The wedge material was C1117 steel, case hardened to about 0.015 to 0.020 inch and having a Rockwell hardness of about 62 on the Rockwell C scale. The wedges were stressed relieved at 350° F. to avoid delay failure. Under these conditions, the strand could be tensioned to substantially its yield point by the anchorage without deformation of the bearing plate or failure of the wedges. Teeth **118** were tapped into the front end or small diameter end of the bearing plate, and since they diverge away from the 10° taper of the wedges, they did not interfere with the advancement of the wedges. The wedges were 2 inches in length with approximately one-quarter of their length or ½ inch projecting forwardly of surface **126** at maximum loading thereof. The diameter of end **142** of the wedges was about 1 1/16 inches with the large diameter of the wedges being about 1¾ inches.

What is claimed is:

1. An anchorage assembly for casting an anchorage means into a concrete member for receipt of a tendon for formation of a prestressed concrete member, comprising:

(a) a concrete form having an opening therein to receive assembly mounting means therethrough;

(b) assembly mounting means removably mounted in said opening in said form and extending from an exterior side thereof through said opening and interiorly of said form a distance sufficient to allow mounting of spacing means, anchorage member and grouting thereon;

(c) spacing means mounted on said mounting means and positioned in abutting relation to said form, said spacing means being of a predetermined thickness to position an anchorage means in spaced relation to said form;

(d) anchorage means having a wall defining an axially convergently tapered bore dimensioned at the smallest point thereof to receive said assembly mounting means and a tendon to be tensioned and formed to receive convergently actuating tendon gripping means, said anchorage means including bearing plate means formed with a bearing surface to allow transfer of axial tensioning forces to said concrete member, said anchorage means being releasably mounted on said mounting means with said mounting means extending through said tapered bore and said anchorage means being positioned thereon in abutting relation to said spacing means, said spacing means further preventing the ingress of concrete into said tapered bore in said anchorage means as mounted in abutting relation therewith and being removable from said concrete member to afford access to said tapered bore for insertion of tendon gripping means therein;

(e) securement means releasably mounted on said mounting means on the exterior side of said form; and

(f) grouting member formed to allow introduction of grout adjacent to said tendon after casting of said concrete member and releasably mounted to the inner end of said mounting means in abutting relation to said anchorage means, said securement means, grouting member and mounting means urging said assembly of said anchorage means and spacing means against said form and securing said assembly in close abutting relation thereto during the casting of said concrete member.

2. A tendon anchorage as defined in claim **1** wherein said anchorage means is formed with a grouting passageway therein terminating in a passageway opening on the remote side of said anchorage means, and said grouting member is formed as a hollow internally threaded sleeve for threadably mounting on said mounting means and formed of sufficient internal radius adjacent said anchorage means to communicate with said passageway opening.

3. An anchorage assembly as defined in claim **2**, and a conduit positioned in alignment with said mounting means and formed for receipt of a tendon therein, said conduit being threadably secured to said mounting means and being formed for communication with said grouting member for receipt of grout from said grouting means after casting of said concrete member and removal of said mounting means.

References Cited

UNITED STATES PATENTS

3,293,811	12/1966	Rice	52—223
3,399,434	9/1968	Kelly	24—126

FOREIGN PATENTS

181,068	7/1954	Austria	52—230
195,081	1/1958	Austria	52—230
794,561	7/1958	Great Britain	52—230

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