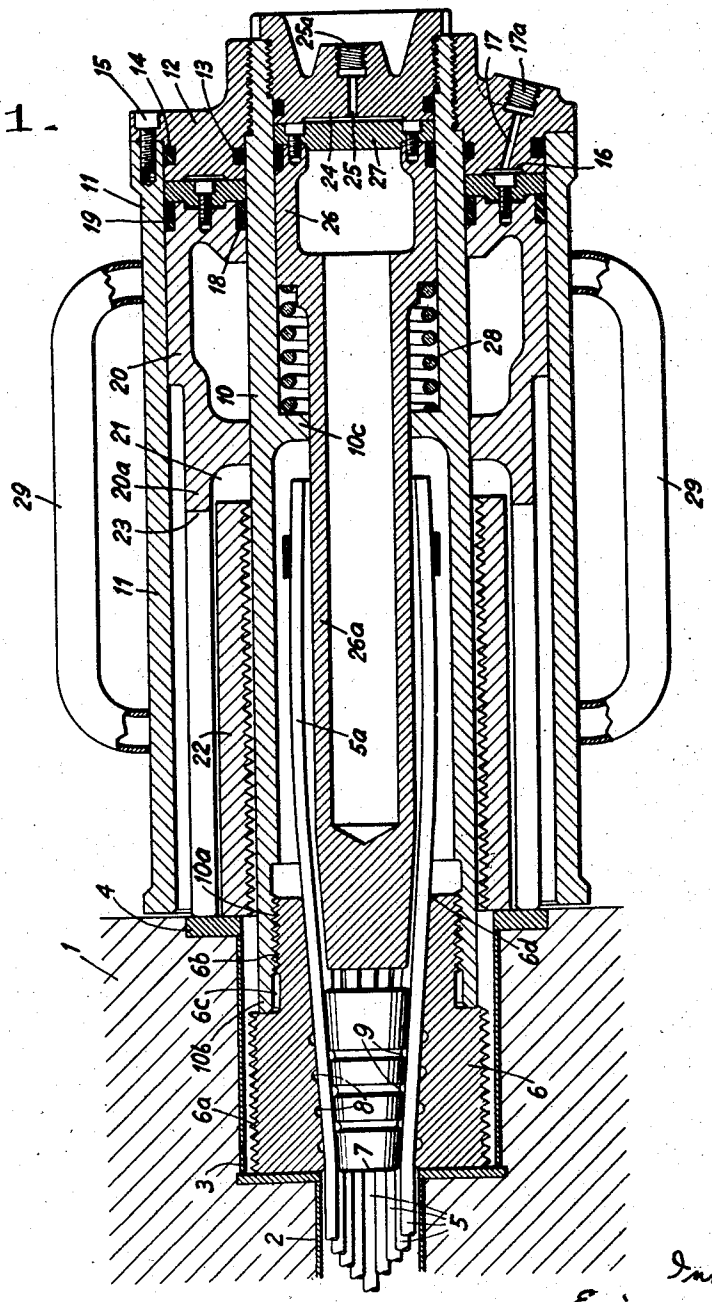
Feb. 3, 1959 E. SIEGFRIED 2,871,554

METHOD FOR POST-TENSIONING THE RE-INFORCING OF A PRESTRESSED CONCRETE STRUCTURE

Filed June 6, 1955 5 Sheets-Sheet 1

Fig-1.



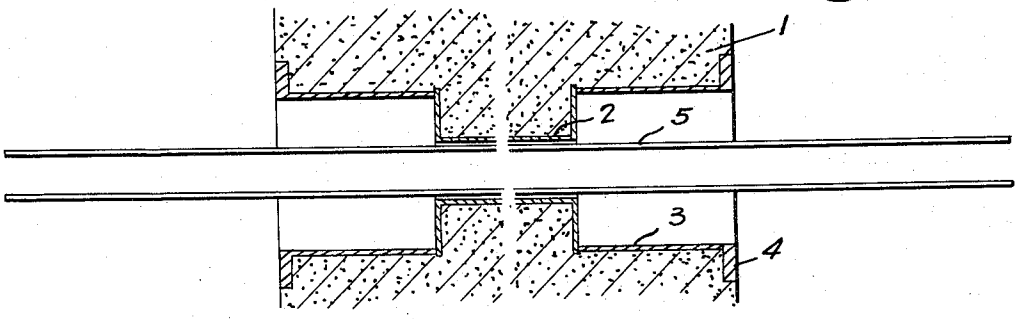
Inventor
Erwin Siegfried
by Stevens Davis Miller & Mosher
his attorneys

Feb. 3, 1959 E. SIEGFRIED 2,871,554

METHOD FOR POST-TENSIONING THE RE-INFORCING OF A PRESTRESSED CONCRETE STRUCTURE

Filed June 6, 1955 5 Sheets-Sheet 2

Fig-2



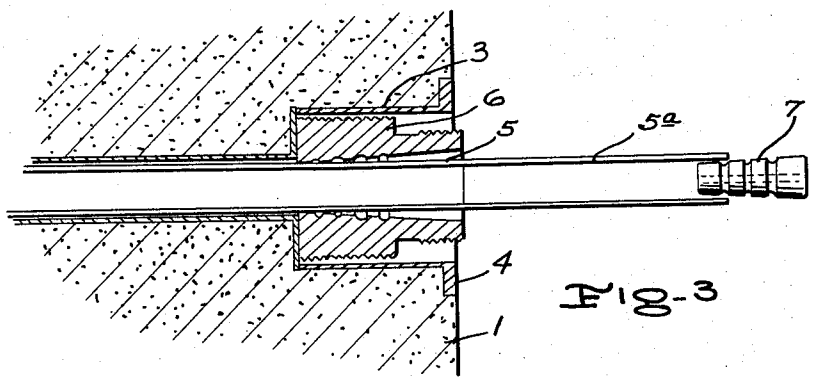
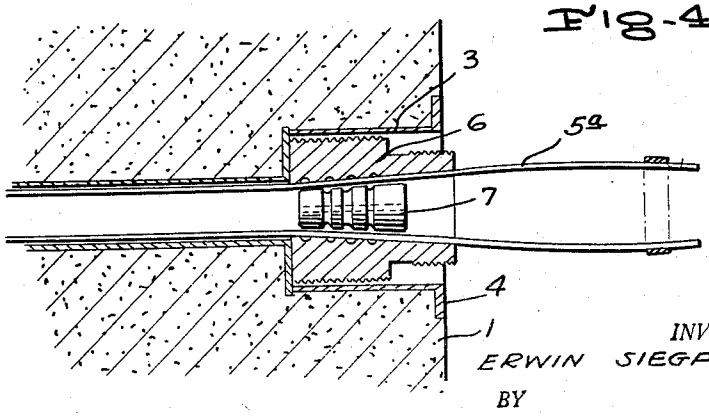


Fig-3

Fig-4



INVENTOR.
ERWIN SIEGFRIED

BY

Stevens, Davis, Miller & Mosher
ATTORNEYS

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METHOD FOR POST-TENSIONING THE RE-INFORCING OF A PRESTRESSED CONCRETE STRUCTURE

Filed June 6, 1955 5 Sheets-Sheet 3

Fig-5

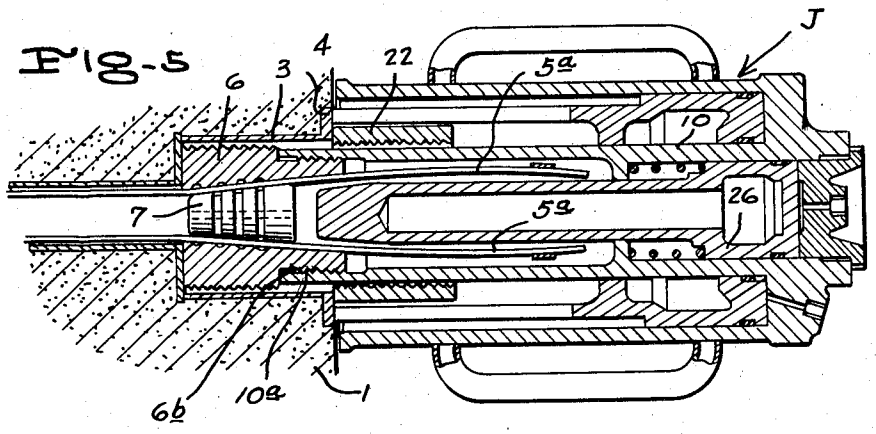


Fig-6

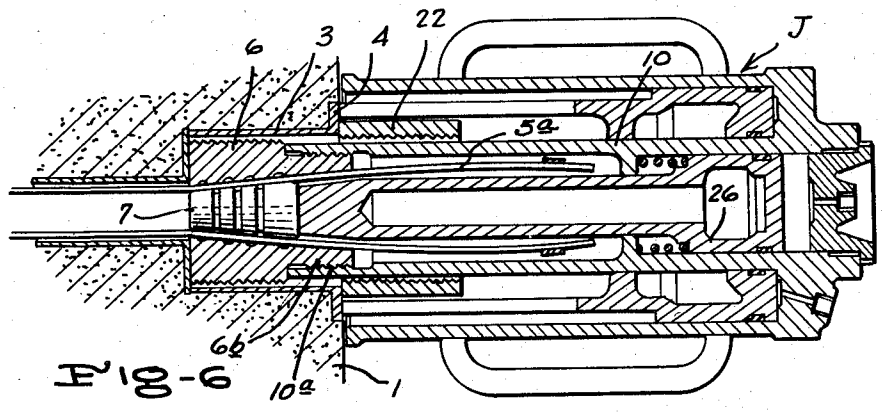
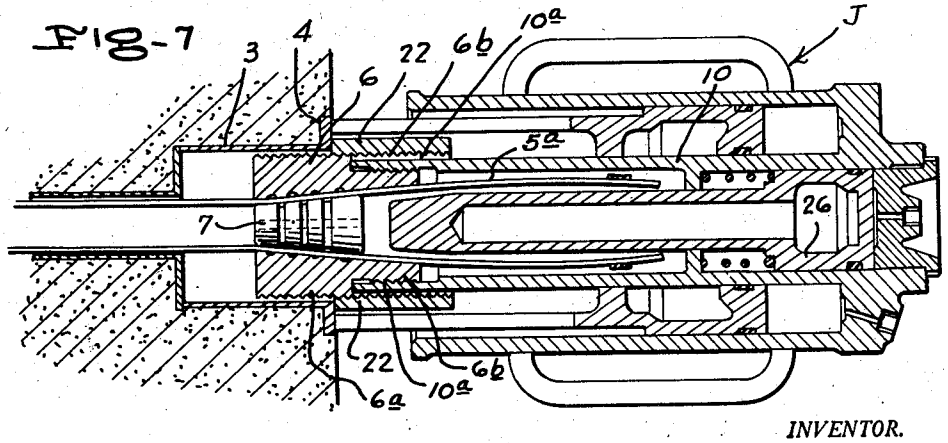


Fig-7



INVENTOR.

ERWIN SIEGFRIED

BY

Stevens, Davis, Miller & Mosher

ATTORNEYS

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METHOD FOR POST-TENSIONING THE RE-INFORCING OF A PRESTRESSED CONCRETE STRUCTURE

Filed June 6, 1955 5 Sheets-Sheet 4

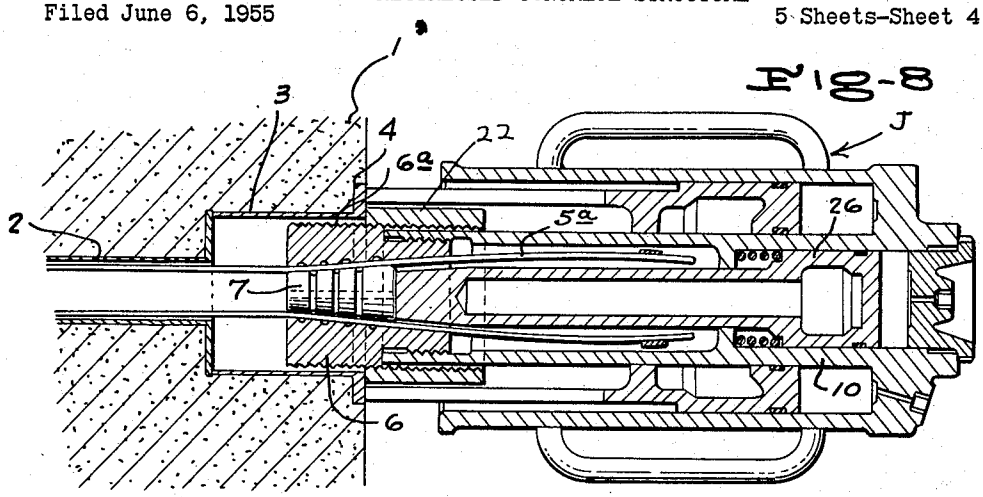


Fig-8

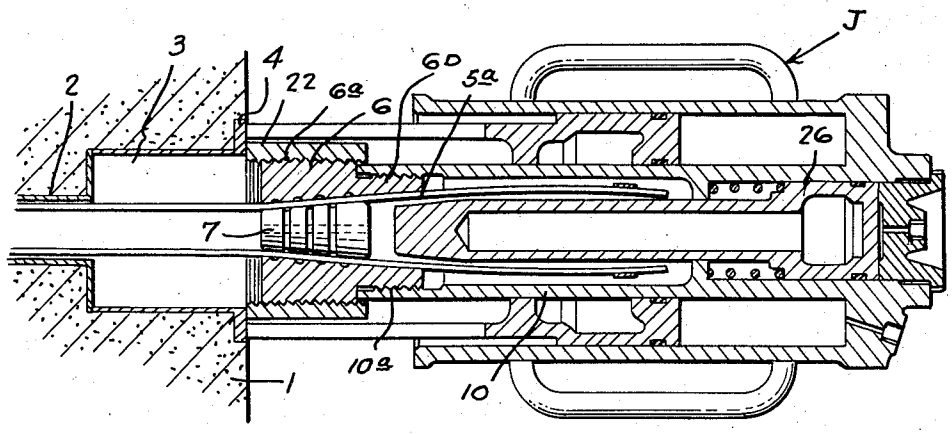


Fig-9

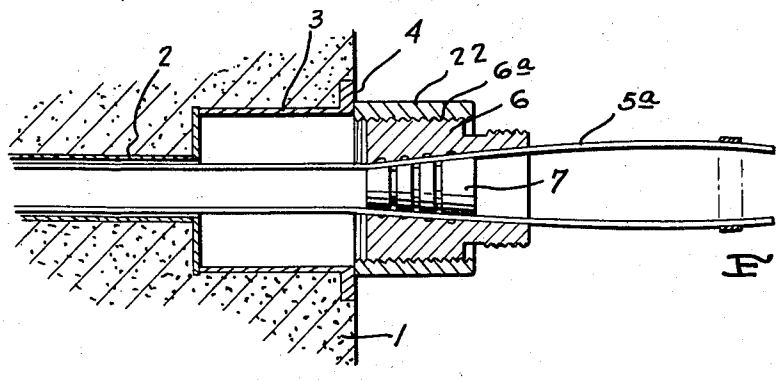


Fig-10

INVENTOR.
ERWIN SIEGFRIED
BY
Stevens, Davis, Miller & Mosher
ATTORNEYS

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METHOD FOR POST-TENSIONING THE RE-INFORCING OF A PRESTRESSED CONCRETE STRUCTURE

Filed June 6, 1955 5 Sheets-Sheet 5

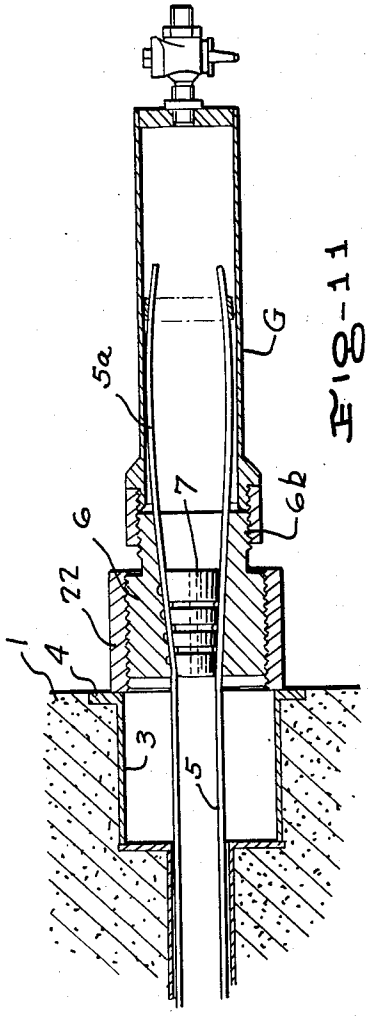


FIG-11

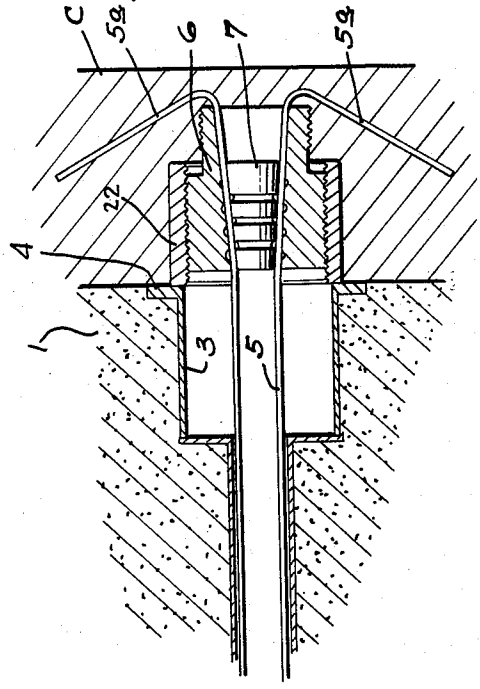


FIG-12

INVENTOR.
ERWIN SIEGFRIED
BY
Stevens, Davis, Miller & Mosher
ATTORNEYS

United States Patent Office

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Patented Feb. 3, 1959

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METHOD FOR POST-TENSIONING THE REINFORCING OF A PRESTRESSED CONCRETE STRUCTURE

Erwin Siegfried, Zollikofen, Switzerland, assignor to Losinger & Co. A. G., Bern, Switzerland

Application June 6, 1955, Serial No. 513,462

Claims priority, application Switzerland June 16, 1954

4 Claims. (Cl. 29—452)

The present invention generally relates to the pretensioning and anchoring the reinforcing of a prestressed concrete structure.

There is a method well known in the art as the Freyssinet-method, according to which a bundle or cable of reinforcing wires are wedged between a conical funnel and a conical wedge both made of reinforced concrete, so that the wires protrude by a substantial amount from the anchoring head formed by said funnel and wedge. The conical extension of the piston of a hydraulic jack is then made to rest on the concrete structure with the front surface of longitudinal ribs between which pass the reinforcing wires protruding from the anchoring head. The end portions of these wires are then locked to noses provided at the outer surface of the jack cylinder, by means of wedges. Thereafter the jack is put into operation to pretension the cable formed by the wires. When this jacking operation is terminated an auxiliary piston reciprocable in the piston of the main jack, is put in operation to wedge the wires in the conical funnel. Eventually the end portions of the wires are unlocked from the cylinder of the jack and, after the removal of the latter, are cut to suitable length, bent outwardly and embedded in concrete.

This method has several drawbacks. First, the wires once they are wedged in the anchoring head, cannot be made free again. Thus step by step pretensioning and subsequent checks of the actual prestress and correction thereof by a further pretensioning operation are excluded. Secondly, the prestress is limited because the conical wedge and the conical funnel are made of concrete and not of steel. Thirdly, the distance between the place where the wires are locked to the cylinder of the jack and the place where the piston of the jack rests on the concrete structure (or on a distribution plate provided thereon) is considerable; therefore the wires must protrude from the anchoring head by an amount which is much greater than that required for finally anchoring these ends in concrete after having bent them outwardly. These wire protrusions are both uneconomical and unpractical. A fourth drawback consists in the fact that on a given circumference of the cylinder of the main jack, only a relatively small number of wires can be locked since the remainder of the circumference is taken up by the noses and the wedges.

According to a similar method known as the Magnel-method, the wires in each cable are placed in layers, four in each layer, and are tensioned, two at a time, and anchored by wedges in sandwich plates bearing against a distributing plate at each end of the concrete member. This, of course, is complicated and time-consuming.

These two methods form a first group featured in that the wires are first locked to the pretensioning device and that only after finition of the jacking operation these wires are held fast in an anchoring device resting on the concrete structure.

In a second group of known prestressing and anchoring methods several wires are anchored in a first step in an anchorage head, then pretensioned in common by means of a jacking device connected to this head; at last the head is made to rest on the concrete structure by releasing and removing the jacking device.

According to one method of this second group the wires are passed through holes of the anchoring head and their ends are upset to form small buttons resting by their back faces on the anchoring head. The upsetting is a delicate work which can only be carried out by qualified workers equipped with expensive upsetting machines. A further drawback of this method resides in the fact that the region of transmission of pull from each wire to the anchoring head is very short.

This is the reason for which these wires often break in said region under the variable strains due to the combined dead and live loads.

The present invention consists in an improvement over another method of this second group, in which the reinforcing wires are conclusively wedged between a conical funnel and a conical wedge of an anchoring head, whereafter this anchoring head is connected to one part of a jacking device having another part which is made to rest on the structure while the jacking device is in operation, the anchoring head then being jacked and a nut being screwed onto an external thread of the anchoring head, to rest on the structure as soon as the jacking device is released.

In this known method reinforcing wires were used which terminated at the outer end of the anchoring head. A pull bolt of the jacking device was screwed into an extension of the funnel. This method has never had practical value, because in view of the experiences made in connection with the first mentioned method the conclusive anchorage of the wires by the mere wedging between the funnel and the conical wedge was severely prejudiced. The uncertainty comes there from the fact that the conclusive anchorage is effected simultaneously with the release of the traction exerted by the jacking device, since at this moment the wedging of the wires to the jacking device becomes ineffective. However, the same does not occur in the method on which the invention is based, since in this case only one anchorage is provided. The real drawback of this method and of the prestressed construction obtained thereby lies in the fact that the wedging of the wires is not an effective anchorage when the prestressed structure is submitted to swelling strains by the combined dead and live loads. The wires are thus likely to "cringe" under such operating conditions, but only if their ends have not been bent out and sealed in concrete. This knowledge is put into practical value by the improved method according to the present invention, the improvement consisting in that the reinforcing wires are made with a length such, and are wedged in the anchoring head at a predetermined distance from one of their ends to present end portions protruding from said anchoring head by said distance; that furthermore the jacking device is passed over these end portions and connected to an annular region of the anchoring head which has an inner diameter greater than the greatest diameter of said conical funnel and an outer diameter smaller than the inner diameter of said screw thread, and that subsequently to the release of the jacking device and its disconnection from the anchoring head said wire end portions are bent outwardly and embedded in concrete to form a supplemental anchorage.

The invention is also directed to a method of using an improved hydraulic jack which is particularly suitable for carrying out this method. This jack is featured in that it comprises a cylinder having besides an inner wall an outer wall coaxial to each other to form an annular

cylinder space, a front wall extending between these walls at one end thereof; means for connecting the other end of said inner wall with the anchoring head for transmission of the jacking pull thereto, a free space being provided inside at least a part of the length of the inner wall measured from the last-mentioned end thereof, to receive the wire end portions protruding from the anchoring head; an annular piston reciprocable in said annular pressure chamber; means for admitting pressure fluid to the annular cylinder space between said front wall and said piston; said piston having at its side which is turned away from said front wall a recessed tubular extension with an inner surface radially spaced from said inner wall to provide an annular space intended to receive a nut to be screwed onto an external thread of the anchoring head as the jacking operation proceeds.

The hydraulic jack which is ordinarily used in the aforementioned method in which the wire ends are upset to form buttons, also has a central hole over its entire length, through which extends a pull rod of which one end is screwably engageable with the anchoring head, whilst the other end has an enlargement or a nut through which the jacking pull is transmitted by the jack to the pull rod and to the anchoring head. Sometimes this pull rod is formed with a longitudinal central hole, simply for the purpose of sparing weight. In the improved jack according to the invention, however, the inner diameter of the inner wall of the annular cylinder has an inner diameter which is sufficiently large to permit such inner wall to be passed over the bundle of wire end portions protruding from the anchoring head. With an inner wall of such diameter particular difficulties had to be surmounted to allow the use of an anchoring nut having a relatively small diameter. It should be noted that in the improved construction the inner wall of the annular cylinder does not only act as such, but also as a pull rod transmitting the jacking force from the jack to the anchoring head. Owing to this double use a maximum of weight could be spared, thus greatly facilitating the handling of the jack on the work place.

Fig. 1 is a longitudinal sectional view of the jacking apparatus mounted on one end of a concrete structure to be prestressed, the jacking apparatus being shown in a state in which it is connected to the anchoring head, but in which it is not exerting a pretensioning pull onto the head and the reinforcing wires which are held fast in the anchoring head;

Figures 2 to 12 diagrammatically illustrate in longitudinal sectional views the successive steps in the herein disclosed method with;

Fig. 2 illustrating the initial positioning of the reinforcing wires in the concrete structure;

Fig. 3 illustrating the conical funnel in its inserted position;

Fig. 4 illustrating the conical wedge in its position within the conical funnel;

Fig. 5 illustrating the jacking apparatus coupled to the anchoring head, which consists of the funnel and the wedge;

Fig. 6 illustrating the conical wedge in a position jacked into the conical funnel;

Fig. 7 illustrating the prestressing in stages of the reinforcing wires;

Fig. 8 illustrating a further prestressing or jacking operation;

Fig. 9 illustrating the final prestressing step in the method;

Fig. 10 illustrating the important step of the method wherein the wires are prestressed and supported against the anchor plate by the nut without the jacking apparatus, which has been removed;

Fig. 11 illustrating the step of injecting grout into the funnel, and

Fig. 12 illustrating the final step of bending the protruding ends of the wires back upon themselves and sealing them in a concrete sealer.

The reference number 1 denotes an end portion of a concrete structure made in a well known manner with a duct 2 having an enlarged end portion 3. A distribution plate is shown at 4. A circular bundle of reinforcing high-quality steel wires 5 extends through the duct and between a conical funnel 6 and a conical wedge 7 which are made of steel and which form together an anchoring head. The outer surface of this anchoring head is staggered. The portion turned towards the central portion of the structure 1 has a screw thread 6*a* the outer diameter of which is slightly smaller than the inner diameter of the enlarged duct portion 3. The outwardly turned portion has a screw thread 6*b* and a smooth surface 6*c* extending to the shoulder of the portion having the thread 6*a*. The thread 6*c* may be a trapezoidal two-pitch or three-pitch thread. The funnel surface has the same conicity as the conical wedge 7. These conical surfaces have circular grooves 8 and 9, respectively, which are shifted with regard to each other, such grooves serving the purpose of increasing the wedging action.

The length of the reinforcing wires is in advance so determined that the latter will protrude from the anchoring head by a substantial amount as shown.

A jacking device J is shown which is constructed as a hydraulic jack having an annular pressure chamber or cylinder. An inner tubular wall 10 of this chamber is rigidly connected to a coaxial outer wall 11 by means of a front wall constituted by a ring 12. This ring 12 is secured to the outer wall 11 by means of screws 15 and is screwed onto a threaded end portion of the inner wall 10. It has circular grooves fitted with packing rings 13 and 14 affording fluid-tight seals at the inner and outer surfaces, respectively, of the ring.

The inner wall 10 at its end 10*b* turned away from the front wall 12 has an inner thread 10*a* engaging the thread 6*b* of the anchoring head. To facilitate the interconnection the end portion 10*b* is bored out over a short length to a diameter slightly greater than the outer diameter of thread 6*b*.

The inner wall 10 has over the major part of its length measured from the front surface of portion 10*b*, a diameter which is larger than the outer diameter of the bundle of wire end portions 5*a* protruding from the anchoring head, so that it can be passed over these end portions 5*a*, as shown in the drawing, when it is being connected to the anchoring head.

The outermost end of the annular pressure chamber of the jack is formed by a circular groove 16 formed in the inwardly turned surface of the front wall ring 12. A canal 17 opening into this groove 16 has an enlarged and tapped outer portion 17*a* for connection with a non represented pressure-fluid feed hose.

An annular piston 20 mounted for axial movement in the annular pressure chamber is fitted with sealing rings 18 and 19 contacting the inner wall 10 and the outer wall 11, respectively, and has on its side turned away from the front wall 12 a tubular extension 20*a* by means of which it rests on the distribution plate 4 during the jacking operation. This extension 20*a* is radially spaced from the inner wall 10 to form a free space 21 receiving a long nut 22 the inner thread of which is conjugate to the outer thread 6*a* of the anchoring head. It has circumferentially spaced, long recesses 23 for the passage of a suitable tool to be engaged with nut 22 as soon as the outer end has moved somewhat away from the concrete structure 1 during operation of the jack.

A central or second pressure chamber is formed inside that portion of the inner wall 10 which is surrounded by the front wall 12. This chamber has for its front wall a plug or cover 24 screwed into the inner wall 10. This cover has a central bore 25 with an enlarged and tapped outer portion 25*a* intended for connection with a further pressure-fluid feed hose. A piston 26 mounted for

axial movement in this central pressure chamber has a disc **27** secured to its side facing the cover **24** and is made integral with a piston rod **26***a* For sparing weight the piston and the major portion of its rod have a central hole which is closed by the disc **27**. When the jack is connected to the anchoring head **6, 7** the piston rod **26***a* extends between the end portions **5***a* of the reinforcing wires **5** and enters the funnel of the anchoring head. When pressure fluid, e. g. oil, is admitted to the central pressure chamber, the piston **26** moves to the left and its rod exerts a thrust onto the conical wedge **7**. It should be noted that the admission and exhaust of pressure fluid can be controlled independently for the annular pressure chamber and the central pressure chamber, by uncomplicated means well known in the art.

A compression spring **28** arranged between an annular shoulder of the piston **26** and an annular flange **10***c* of the inner wall **10** brings the piston **26** back to its rest position, shown in the drawing, as soon as the pressure fluid is permitted to exhaust from the central pressure chamber.

Tubular handles **29** which are welded to the outer peripheral surface of the outer wall **11** greatly facilitate the use of the jacking device on the work place.

The process of prestressing reinforced concrete structures with the aid of the just described apparatus is shown in Figs. 2–12 and is as follows:

At first the reinforcing wires **5** are cut to such length that, when held fast in the anchoring head, they will have protruding end portions **5***a* of sufficient length to afford a substantial additional anchorage when bent outwards and sealed in concrete. As soon as the funnel **6** has been fully introduced into the enlarged tube portion **3**, the reinforcing wires **5** are passed through tube **2** and anchored in some suitable and well known manner to the end of structure opposite to that shown on the drawing. An anchoring head comprising a conical funnel and a conical wedge may for example be used there too. At the end shown in the drawing the conical wedge **7** is then pushed forward between the bundle of protruding wire end portions **5***a* until it has entered the funnel **6**. Thereafter the jacking apparatus together with a nut **22** is coupled to the anchoring head **6, 7** by screwing the portion **10***b* onto the funnel **7** of this head until this portion abuts onto the annular shoulder as shown in the drawing, the segmental portions of the piston extension **20***a* coming then to rest on the distribution plate **4**. The apparatus is maintained in this position while pressure is admitted to the central pressure chamber to effect the wedging of the wires **5** in the anchoring head by virtue of the action of the piston **26** onto the wedge **7**.

The pretensioning or jacking operation can now be carried out by pumping pressure fluid, e. g. oil, into the annular pressure chamber through canal **17**. As the pressure in this chamber increases the anchoring is drawn outwardly from the enlarged tube portion **3** and the outer cylinder wall **11** moves away from structure and gives access to nut **22** through the recesses **23** of the piston extension **20***a* By means of a suitable tool the nut can now be rotated to engage more and more the thread **6***a* of the anchoring head. During this pretensioning operation the wedging device comprising the piston **26** can be put in action once or several times if desired, to repeat the wedging. As soon as the desired pretensioning effort is put onto the cable of wires **5**, this effort being directly proportionate to the pressure of the fluid in the annular pressure chamber and this pressure being indicated by a pressure gauge not shown on the drawing, the nut **22** should be firmly screwed against the distribution plate **4**. The above described jacking operation and/or the subsequent release of pressure fluid from the annular pressure chamber may be carried out in one or several steps. As soon as the pressure fluid is entirely released the whole pretensioning effort is transmitted to the concrete structure by nut **22**; the jacking

apparatus may then be removed by unscrewing its inner wall **10** from the anchoring head **6, 7**. When this is done the end portions **5***a* of the prestressing wires **5** are freely accessible and may easily be bent outwardly around the surface **6***d* of the funnel **6**, and be sealed in concrete C, as shown in Fig. 12, to form a supplemental anchorage. This bending and sealing operation is an important part of the improved prestressing and anchoring method. It may however be carried out any time, say weeks or months, after the pretensioning operation. In this interval the pretensioning effort may be altered once or several times for grounds obvious to those skilled in the art. A substantial "cringing" of the wires in the anchoring head **6, 7** has not to be feared during this time since practically no live loads are allowed before the structure is entirely terminated. Afterwards, when the structure has been put into service, any cringing is rendered impossible by the sealing of the bent-out end portions **5***a* in concrete.

The conical wedge **7** may conveniently be provided with a central hole to permit grouting of the wires in the usual technique by means of a conventional grouting device G, as shown in Fig. 11, before sealing the wire end portions in concrete.

Several modifications could be made to the apparatus just described. One modification would consist in providing an internal thread instead of external thread **6***b*, in the annular region of the anchoring located between the conical funnel surface and the outer thread receiving the anchoring nut. A corresponding change ought of course to be made to the inner wall **10***a* of the jack, or a connecting tube be used. The screw connection might be replaced by an equivalent, e. g. by a bayonet-joint.

The hydraulic auxiliary device comprising the central pressure chamber and the piston **26** may be omitted and a self-contained corresponding unit be used for performing the wedging operation. The inner wall **10** of the annular pressure chamber may then have on its whole length an inner diameter which is larger than the outer diameter of the bundle of protruding wire end portions **5***a*.

The clamping surfaces of the funnel and of the wedge might depart slightly from the conical shape.

What is claimed is:

1. In a method for tensioning and anchoring the reinforcing wires of a prestressed concrete structure, of the kind in which the terminal ends of the reinforcing wires are wedged between a conical funnel and a conical wedge of an anchoring head, whereafter such anchoring head is connected to one part of a jacking device with another part thereof being adapted to rest on the structure, the anchoring head then being jacked and a nut being screwed onto the anchoring head, to rest on the structure as soon as the jacking device is released; the improvement consisting of making the reinforcing wires with such a length and wedging them in the anchoring head at a predetermined distance from one of their ends, that they present end portions protruding from said anchoring head by said distance; passing the jacking device over these end portions and connecting it to the funnel, and, subsequently to the release of the jacking device and its disconnection from the anchoring head, bending said wire end portions outwardly and embedding them in concrete to form a supplemental anchorage.

2. The method as set out in claim 1, wherein the wedging is repeated several times during the jacking operation.

3. The method of tensioning and anchoring the reinforcing wires of a prestressed concrete structure of the kind in which reinforcing wires are wedged between a complemental conical funnel and a conical wedge of an anchoring head; comprising the steps of loosely arranging the wires in substantially circular formation, surrounding the wires with the conical funnel to be located at a distance from the ends of the wires whereby the wires have extending end portions, positively moving the

conical wedge into the funnel, so as to lockingly wedge the wires between the funnel and the wedge, applying jack force to the funnel thereby to apply stress to the wires, locking the funnel in place by a threaded locking element bearing on the concrete structure, and then discontinuing the application of jacking force to the funnel and bending the extending end portion of the wires outwardly and embedding them in the concrete to provide a supplemental anchorage.

4. The method of tensioning and anchoring the reinforcing wires of a prestressed concrete structure of the kind in which reinforcing wires are wedged between a conical funnel and a conical wedge of an anchoring head, comprising the steps of loosely arranging the wires in substantially circular formation, surrounding the wires with the conical funnel to be located at a distance from the ends of the wires whereby the latter have extending end portions, positively moving the conical wedge into the funnel, so as to lockingly wedge the wires between the funnel and the wedge, applying jack force to the funnel thereby to apply stress to the wires, locking the

funnel in place by a threaded locking element bearing on the concrete structure, repeating the application of jack force to the funnel and subsequent locking thereof so as to effect repeated stressing of the wires and then discontinuing the application of jacking force to the funnel and bending the extending end portions of the wires outwardly and embedding them in the concrete to provide a supplemental anchorage.

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