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COMPLETE SPECIFICATION

Apparatus for Tensioning and Anchoring Stressing Members Forming Together a Stressing Cable

We, LOSINGER & Co., A.G., a Swiss Body Corporate, of Monbijoustrasse 49, Berne, Canton of Berne, Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to apparatus for tensioning and anchoring of several stressing members which form together a stressing cable and which consist each of a wire or a strand, this apparatus comprising an anchor head which is provided with clamping means for anchoring the stressing members by wedging. As is well known, such apparatuses are widely used in the technique of pre-stressed, post-tensioned concrete structures.

Apparatuses of this kind are known in many designs. The development tends to use stressing cables with a great number of individual stressing members. Of course, there is a limit to the number of stressing members that can be arranged to form a ring and more complex arrangements in a stressing cable pose further problems with regard to reliable anchoring of the individual stressing members of such a cable in one and the same anchor head, with regard to the structural shape of the anchor head and the stressing equipment and with regard to the work to be carried through successively.

Lately an anchor head for a stressing cable consisting of a plurality of stressing members has been suggested where, within an annular anchor head body, the stressing members are fixed in sections (by groups) by clamping effect, on the one hand by serrated wedge elements which are supported by the body, and on the other hand by spacer elements which are positioned

between the stressing members of each group, the spacer elements being of constant cross section along their length, but serrated at their radially outer surfaces like the wedge elements. There can be no doubt that such an anchor head fulfils its task reliably. However, in other respects it has several disadvantages. On the one hand, the manufacture alone of its various components is rather expensive. Moreover, auxiliary devices have to be provided, with the result that during the tensioning process the wedge and intermediate elements must be prevented from being taken along by the stressing members when these elongate during the tensioning operation or else they would leave their correct position within the anchor head body. Eventually, the wedge and intermediate elements must, by manually operated tools or by means of an auxiliary press attached to the tensioning press, be brought to a position in which a frictional contact with the stressing members exists to such an extent that on decrease of the pull exerted by the tensioning press on to the ends of the stressing members, the clamping anchoring takes place reliably.

The present invention has for its object to procure a tensioning and anchoring apparatus of the type mentioned above, which is free from these disadvantages.

According to the present invention we provide apparatus for tensioning and anchoring a plurality of elongate stressing members in a structure such apparatus comprising an anchor head of unitary construction; anchor head supporting means at the face of the structure and extending around stressing members to be tensioned; said anchor head having a plurality of uniform passages extending from one face to an opposite face which abuts said supporting means, said passages receiving respective

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ones of said stressing members, and including uniform conical portions opening outwardly into the first mentioned face of the anchor head; a plurality of uniform conical wedge clamps received in the conical portions of the passages and surrounding the stressing members with internal surfaces of said wedge clamps in frictional engagement with said stressing members; a tensioning device; a tensioning device support member of unitary construction for supporting said tensioning device means with respect to said structure and including a plurality of passages receiving respective ones of said stressing members; means for mounting said support member with respect to said anchor head supporting means in a position adjacent said first mentioned face of the anchor head and with the passages in said support member aligned with the passages in said anchor head; and means provided in said passages of said support member for limiting movement of said wedge clamps out of the passages in said anchor head upon tensioning movement of said stressing members, whereby the wedge clamps are self relaxing upon elongation of the associated stressing members and self applying upon contraction of the stressing members.

30 The economy of such an apparatus results in the following way:

- a) the uniform bores in the anchor head and the uniform clamps associated therewith, as well as a similar traction head which in a predetermined construction may be associated with a tensioning jack, and have further similar clamps used therewith, can be manufactured cheaply by conventional techniques and apparatus;
- b) once the anchor head and the tensioning equipment have been placed in position, the tensioning and anchoring process, even if a multi stage process is planned, is very simple and quick and yet very reliable, mainly due to the self-acting clamps;
- c) rationalization is achieved, especially in the maintenance of stocks, since when employing stressing cables which consist of a greater or smaller number of stressing members, a different number of the same clamps can be used, in both the anchor head and the traction head.

Compared with many known tensioning and anchoring apparatus the advantage of the proposed apparatus is of great importance because, for all the stressing members of a stressing cable, uniform gripping and clamping conditions exist and accordingly no non-uniform slip and consequent eccentric pull can occur.

Since, in pre-stressed structures, it is usual for several stressing cables to be anchored as close together as possible, the associated anchor heads should advantageously require as little space as possible.

Besides it is preferable that, when stressing cables of considerable length and great tensioning elongation, it is not necessary to provide a correspondingly long recess in the structure for the movement of the anchor head. These requirements are achieved by a apparatus as proposed in this application. Moreover the apparatus according to the invention, on account of its self acting clamps, is especially suitable where the tensioning (pre-stressing) process may take place as several successive stages during each of which the anchoring means and the tensioning agents are alternately effective.

The convenient form of stressing apparatus includes, between each clamp and the tensioning device support member, one of a plurality of springs arranged to oppose movement of the associated clamp in the direction of release. Such springs, even if rather stiff cup springs are chosen, naturally allow a slight withdrawal movement of the clamps with the stressing members, but subsequently they cause the clamps to return to their clamping condition. These to and fro movements succeed one another in a substantially random pattern and thus, when the anchoring process is about to begin, the various clamps may be in different positions and accordingly a variable degree of slip of the associated stressing members will result during the anchoring process.

However, in a simpler, cheaper and preferred construction, a support member is provided directly in front of and stationary with regard to the anchor head. This member is provided with bores constituting passageways for the individual stressing members and being associated with a supporting surface on which the clamps directly rest during a tensioning (stressing) process. The supporting surfaces serve instead of the springs of the previously described construction.

The invention will now be further described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a longitudinal section of one embodiment of the tensioning and anchoring apparatus, showing also a portion of a concrete structure and of a cable of stressing members with which the apparatus co-operates to pre-stress this structure, the movable parts being shown in the position which they occupy when the last stage of the multi-stage tensioning process is terminated.

Figure 2 is an end view of the anchor after this operation and after removal of those parts of the apparatus which may then be used at another location.

Figure 3 is a longitudinal section of a portion of the apparatus at an enlarged scale, the movable parts being shown in a

position during one of the first stages of the tensioning process.

Figures 4 and 6 are section views similar to Figure 3, of a portion of an improved embodiment, Figure 4 showing the clamp in its active position, whilst Figure 6 shows this clamp in its released position, and

Figures 5 and 7 are cross-sectional views corresponding to Figure 4 and to Figure 6, respectively.

As shown more particularly in Figure 1, a concrete structure 1 includes one or several channels each including a corrugated tube 1a; as is usual for pre-stressed post-tensioned concrete structures. A pre-stressing cable consisting of nine stressing members 2, is freely movable in its longitudinal direction through the concrete structure 1, up till the instant of final injection of cement mortar. The stressing members 2 each consist of a single wire or a wire strand. An anchor head 5 is supported with respect to the structure 1 by supporting means comprising a supporting plate 3 embedded in the head end of the structure 1 and a spacer plate 4 which has a comb-like configuration (Figure 2) and which is inserted between the anchor head 5 and the supporting plate 3 only at the last tensioning stage. The anchor head 5 consists of a square steel ingot, which has a number of uniform parallel bores 13 corresponding to the number of stressing members 2, the bores 13 being conical along most of their length, but cylindrical at the narrow end next to the spacer plate 4, for guiding the stressing members 2. In the conical part of each bore 13 is a clamp 6, which is conical at its outside and cylindrical at its inside 6a; this clamp consists, as illustrated in Figures 1 to 3, of three individual sections. The inner face 6a is serrated and case-hardened to improve its gripping power and at the narrow end of each clamp 6 the serrated inner face has a rounded chamfer 6b.

The tensioning and anchoring apparatus includes a hydraulic tensioning jack of known construction, the stationary part of which (cylinder) is referenced 7 and on the movable part 8 (piston) of which is resting a traction head 9. This traction head is similar to the anchor head 5 and is also equipped with clamps 15 which are similar to the clamps 6.

A tensioning jack support member 10 provided in the equipment shown in Figures 1 to 3 is mounted on the supporting plate 3 by mounting means in the form of an annular extension 10a, and supports the cylinder 7 of the tensioning jack during a tensioning process. This support member 10 also includes stepped bores 11 forming passage-ways for the stressing members 2, and is

equipped with compression springs 12 positioned in the wider part 11a of the stepped bores 11 and projecting slightly out of the bores.

The tensioning and anchoring process is carried out in several stages. In all tensioning stages, with the exception of the last one, the tensioning jack 7, bears, during the actual tensioning phase, against the supporting plate 3 and the concrete structure 1, through the agency of the tensioning jack support member 10.

Every time when, during such a tensioning phase, the piston 8 of the tensioning jack, the traction head 9 and adjacent end portions of the stressing members 2 cover the first part of their tensioning stroke the clamps 6 are withdrawn from their position of action, but, since they remain under the pressure of their individually assigned springs 12 they stay in frictional contact with the corresponding stressing member 2 until the entire tensioning stroke of the tensioning stage in question has been completed. Therefore the clamps 6 are automatic in that whenever, during the second phase of such a tensioning stage, the pull effected by the tensioning jack on the ends of the stressing member 2 is released, these clamps 6, owing to their continuous frictional contact with the stressing members, are caused to return immediately to their position of action by entering the conical part of the anchor head bore 13. The slight degree of traction loss as the clamp 6 enters the bores upon clamping is known as "retraction-slip" and must be taken into account beforehand.

Before the tensioning in the last stage, a horseshoe-shaped flat spacer 14 is inserted between the support member 10 and the supporting plate 3, the thickness of this spacer being at least equal to the length of retraction slip expected.

In the tensioning process of the last stage the anchor head 5 with the stressing members 2 anchored therein, is lifted from the supporting plate 3 to such an extent that the width of the thus formed gap renders possible the insertion of the spacer plate 4 through the opening of the above-mentioned horseshoe-shaped spacer 14. As soon as the spacer plate 4 is in place and the pull effected by the tensioning jack has been relaxed, the anchor head 5 is immediately brought to rest by means of the spacer plate 4 on the supporting plate 3, and the whole tensioning and anchoring process is finished. The traction head 9, the tensioning jack 7, 8, and support member 10 with springs 12 and the horseshoe-shaped spacer 14 can be removed and used in another location if required. The thickness of the spacer plate 4 is chosen according to the size of the retraction slip of the clamp

6 and the retraction slip is thereby compensated for during this last tensioning stage.

After cement mortar as been injected into the channel including the tube 1a and the mortar has hardened the stressing members 2 can be severed in the usual manner at or near the spacer plate 4 with a flame torch, thereby releasing the anchor head 5 and associated clamps 6 which can be used repeatedly.

Considerations confirmed by practical experience show that during a tensioning and anchoring process each clamp 6 which is subject to the effect of the associated spring 12 moves alternately away from its position of action under frictional contact with the assigned stressing member 2 and then jumps back under pressure of the springs 12 towards its position of action. The amplitude of this movement to and fro depends on the strength and stiffness of the springs 12 and the degree of frictional contact between the clamp 6 and stressing member 2. If the clamp 6 has already been in action once and is being released in a second or subsequent tensioning stage (with the exception of the last stage) the frictional contact will initially be specially intense due to form-locking of the serrations or teeth 6a. Therefore, when the stressing members 2, which together form a stressing cable, undergo the tensioning stroke of a tensioning stage, the clamps 6 execute their movements to and fro in a casual and non-synchronized rhythm. Therefore, at the moment that the stressing members have covered the tensioning stroke, they may be at different distances from their respective positions of action (clamp positions) and may therefore cover differing distances of travel during the subsequent retraction. Thus the individual stressing members may undergo "retraction slips" of different length. With regard to the whole tensioning stroke these differences are so small that they can in most cases be accepted.

Figures 4 to 7 show an improved and even simplified embodiment according to this invention and in which such differences no longer appear. This result is obtained by two measures, namely

- 1) the clamps, referenced 16 in Figures 4 to 7 are separated into two halves only along a diametral plane;
- 2) the springs 12 are omitted and thus the stroke w which the clamps 16 cover between their position of action (Figure 4) and a position in which they rest on the flat bottom surface 18a of a recess 18 in the support member 17, is so determined that the clamps 16 when released from the position of action during the tensioning process are soon prevented from further rearward movement by contact with the surface 18a. Hence as shown in Figure 7, they

still have a part of their circumference in frictional contact with the respective stressing members 2 but they have each been limited to a stroke w which is equal to the stress of the dimension k by which the clamps 16 in their position of action are recessed within the exterior front surface of the anchor head 5, and the depth t of the recess 18. If $k = 0$, then $t = w$.

These measures serve to guarantee the automatic action of the clamps and to ensure that the retraction depth or retraction slip for each stressing member 2 has a predetermined value. Provided the anchor head bores 13 and the clamps 16 are uniform, and that the stressing members have a uniform diameter and the depth t is the same throughout, a uniform retraction slip results for all stressing members 2 of a stressing cable.

WHAT WE CLAIM IS:

1. Apparatus for tensioning and anchoring a plurality of elongate stressing members in a structure such apparatus comprising an anchor head of unitary construction; anchor head supporting means at the face of the structure and extending around stressing members to be tensioned; said anchor head having a plurality of uniform passages extending from one face to an opposite face which abuts said supporting means, said passages receiving respective ones of said stressing members, and including uniform conical portions opening outwardly into the first mentioned face of the anchor head; a plurality of uniform conical wedge clamps received in the conical portions of the passages and surrounding the stressing members with internal surfaces of said wedge clamps in frictional engagement with said stressing members; a tensioning device; a tensioning device support member of unitary construction for supporting said tensioning device with respect to said structure and including a plurality of passages receiving respective ones of said stressing members; means for mounting said support member with respect to said anchor head supporting means in a position adjacent said first mentioned face of the anchor head and with the passages in said support member aligned with the passages in said anchor head; and means provided in said passages of said support member for limiting movement of said wedge clamps out of the passages in said anchor head upon tensioning movement of said stressing members, whereby the wedge clamps are self relaxing upon elongation of the associated stressing members and self applying upon contraction of the stressing members.

2. Apparatus according to claim 1, wherein said tensioning device comprises a hydraulic tensioning jack for simultaneously

6 and the retraction slip is thereby compensated for during this last tensioning stage.

After cement mortar as been injected into the channel including the tube 1a and the mortar has hardened the stressing members 2 can be severed in the usual manner at or near the spacer plate 4 with a flame torch, thereby releasing the anchor head 5 and associated clamps 6 which can be used repeatedly.

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These measures serve to guarantee the automatic action of the clamps and to ensure that the retraction depth or retraction slip for each stressing member 2 has a predetermined value. Provided the anchor head bores 13 and the clamps 16 are uniform, and that the stressing members have a uniform diameter and the depth t is the same throughout, a uniform retraction slip results for all stressing members 2 of a stressing cable.

WHAT WE CLAIM IS:

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2. Apparatus according to claim 1, wherein said tensioning device comprises a hydraulic tensioning jack for simultaneously



15
tensioning all of said stressing members with equal force, said tensioning jack having one end abutted against said support member with the support member located between said anchor head and said tensioning jack.

3. Apparatus according to claim 2, wherein said tensioning jack has an outer fixed casing abutted against said support member and an internal movable casing adapted to tension said stressing members through the agency of a further set of similar wedge clamps.

4. Apparatus according to claim 2 or 3 and wherein said means for limiting movement of the anchor head clamps includes compression springs received in said passages of said support member and about the respective stressing members with one end of each spring engaged against a portion of said support member and the opposite end engaged against the associated clamp.

5. Apparatus according to any of claims 1 to 3, wherein the means for limiting movement of the anchor head clamps comprise abutment surfaces associated with the passages of the support member to engage said clamps and thereby to limit their movement upon tensioning of said stressing members, the abutment surfaces lying in a common plane which extends transversely of the axis of said anchor head such that said clamps undergo the same degree of limited movement upon tensioning of said stressing members whereby upon relaxation of the tension, the stressing members undergo uniform slip and will be uniformly stressed.

6. Apparatus according to claim 5, wherein each of said passages in the support member includes a narrow portion dimensioned to receive freely an associated stressing member, and an enlarged portion dimensioned to receive an associated anchor head clamp; and wherein said abutment surfaces comprise shoulders formed between the narrow and enlarged portions of said passages.

7. Apparatus according to any preceding claim, wherein said clamps each comprise three equiangularly spaced sections engaged about the associated stressing member.

8. Apparatus according to any one of claims 1 to 6, wherein said clamps each comprise two half sections engaged about the associated stressing member.

9. Apparatus according to claim 8, wherein the internal surfaces of said clamp sections are formed with teeth to enhance engagement with the stressing members.

10. Apparatus according to any preceding claim, wherein said support means includes a first spacer position between said anchor head and said anchor head supporting means and wherein a second spacer is positioned between said support member and said anchor head supporting means.

11. Apparatus for tensioning and anchoring a plurality of stressing members in a structure, such apparatus being constructed and arranged substantially as hereinbefore described with reference to Figures 1 to 3 of the accompanying drawings.

12. Apparatus according to claim 11, when modified substantially as hereinbefore described with reference to Figures 4 to 7 of the accompanying drawings.

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