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BY A. P. C.

E. FREYSSINET

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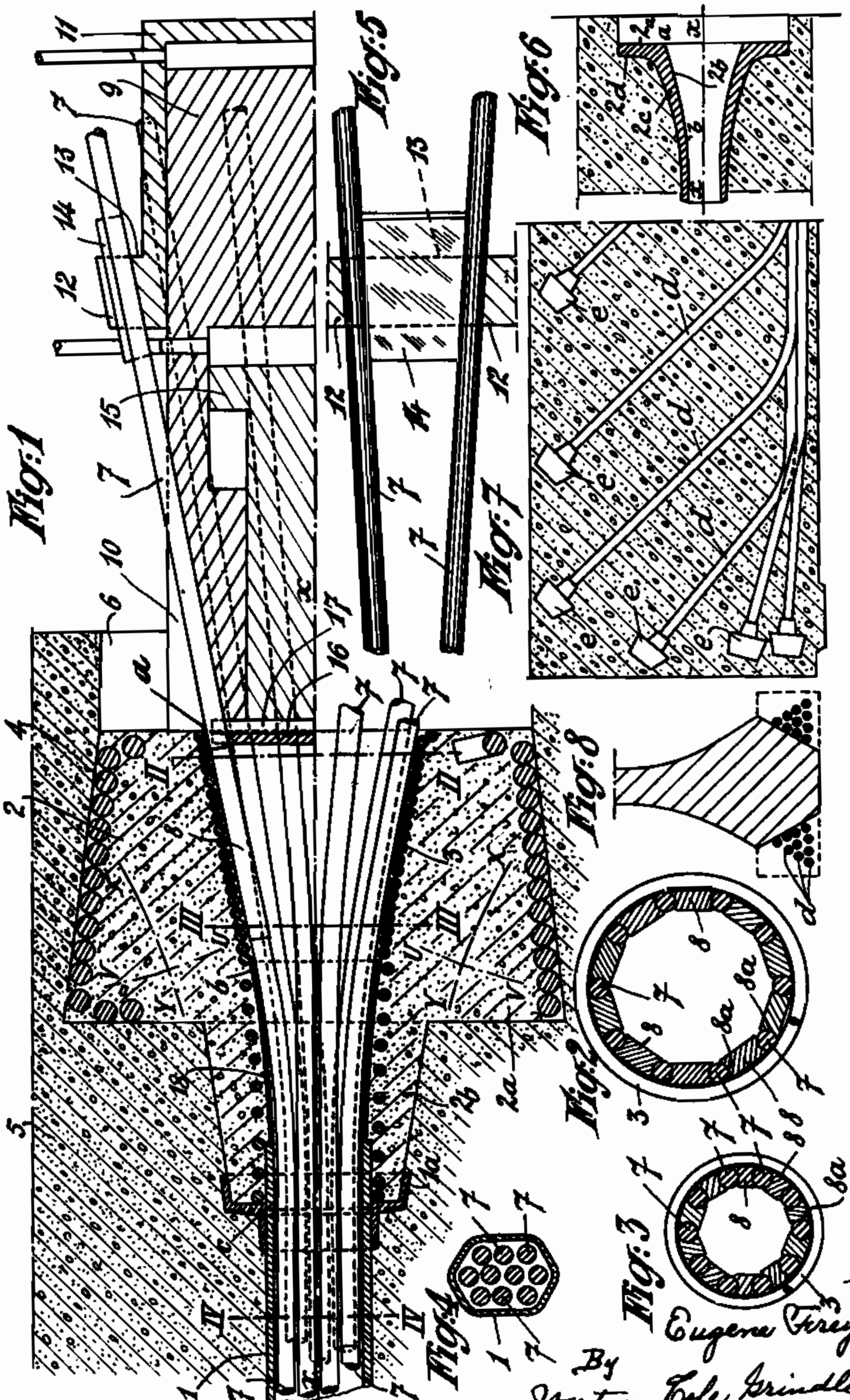

Inventor
Eugene Freyssinet

By Watson, Cole, Grindle & Watson
Attorneys

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PROCESS AND DEVICE FOR THE TENSIONING AND ANCHORING OF CABLES, PARTICULARLY IN CONCRETE CONSTRUCTIONS

Eugène Freyssinet, Neuilly-sur-Seine, France; vested in the Alien Property Custodian

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It is well known that the characteristics of reenforced concrete constructions are considerably improved by artificially submitting the reenforcements to preliminary tensile stresses sufficiently high in order that the concrete is subjected to permanent compressive strains (see my U. S. Patent No. 2,080,074). The tension may be imparted to the reenforcements either before the setting of the concrete, or after its setting and hardening, on condition that, in the latter case, provision be made for suitable means to suppress the adhesion of the steel to the concrete, in order to allow the elongation of this steel embedded in the set and hardened concrete.

Such reenforcements are frequently constituted by means of steel wire cables having a high elastic limit. In general, the devices used for tensioning and anchoring comprise projections exterior to the concrete to be compressed, and do not allow the compressive stresses to be increased beyond a certain maximum which is very inferior to the resistance of the concrete to be compressed.

My invention has for object a process and a device for tensioning and anchoring cables, the said device being incorporated to the concrete to be compressed without requiring any projection or addition to the concrete for the purpose of concealing the anchorings. This device allows moreover the increasing of the preliminary stresses to the yielding point of the concrete.

This process is applicable in particular to prestressed concrete constructions in the case where the tension is imparted to the reenforcements after the setting of the concrete, although it can also be utilized in constructions other than concrete or in concrete constructions when the reenforcements are tensioned before the setting of the concrete.

In what follows, only the application of the process to concrete will be considered for the sake of simplicity, it being understood that the other application also fall within the scope of my invention.

According to one practical application of this process, an anchoring organ which can be embedded in the concrete to be compressed and which presents a funnel-shaped orifice, the little base of which faces the length of cable to be tensioned is utilized in combination with a set of wedges placed between the wires of the cable which wires are pressed down against the wall of the said orifice, so that after the tensioning of the wires by means of a jack or other organ, the pressing of the wedges between the wires and finally the releasing of the tension exerted by the jack, the tension of the wires is maintained by the wedging, in the female cone, of the male cone composed of the wires and the wedges pressed one against the other.

The anchoring organ comprises then essentially a funnel-shaped cavity, the inner surface of which is capable of withstanding the stresses of expansion imparted to it by the wedging of the male cone, and means for transferring to the concrete to be compressed that component of these stresses which is parallel to the cable.

It may be made up, for example, of an organ of cast steel, embedded in the concrete, comprising, in the first place, a funnel-shaped cavity the inside of which is machined to obtain the desired shape and, in the second place, one or more surfaces bearing on the concrete, of sufficient area to subject the concrete to sustainable stresses.

But the same results may be obtained more economically by having recourse to means proper to reenforced concrete. The truncated cone may be hollowed out in the concrete itself and the wall of this cavity rendered capable of resisting the stresses of expansion by embedding in the concrete a first reenforcement which may consist in a truncated tube or in a coil formed by helicoid turns of steel wire, having preferably a high elastic limit, or in a combination of both means. The transmission of the strains from this first reenforcement or coil to the concrete to be compressed may be ensured by a second transverse reenforcement of the concrete in which it is embedded. This second reenforcement consists either of a coil of steel wire helically wound and located at a certain distance from the first one, or of rectangular reenforcements, perpendicular to the axis of the cone.

In order to ensure a better acheievment of the truncated aperture or cavity, it is possible to pouring in advance concrete slabs, each provided with a cavity and with the reenforcing coil or coils. These slabs may contain more anchoring cavities.

This or these anchoring organs are embedded in the concrete of the construction which concrete can, in the proximity of the anchoring organs, be additionally reenforced by rectangular reenforcements or subjected to preliminary stresses perpendicularly to the anchoring to be obtained.

The appended drawing, purely illustrates and not inclusive of all cases, represents various embodiments of my invention.

Figure 1 is an axial sectional view of a concrete anchoring slab constructed in conformity with my invention. This figure showing also a sectional view of a part of an hydraulic jack utilized in tensioning a cable.

Figures 2 to 4 are transverse sectional views along axes II—II, III—III and IV—IV of fig. 1.

Figure 5 represents a plan view of the device utilized for the fixation of the wires to the jack.

Figure 6 shows a sectional view of another embodiment of an anchoring block.

Figure 7 shows diagrammatically in longitudinal section the extremity of a pre-stressed concrete beam, provided with anchoring blocks constructed in accordance with my invention.

Figure 8 represents a sectional view of a prestressed concrete beam provided with these anchoring blocks.

In the example illustrated by the drawing, the application of the anchoring device to the tensioning of the reenforcements of a concrete construction has been presumed to occur after the setting and hardening of the concrete. Each reenforcement, composed of a cable, is set in a sheath 1 which is set in place in the molds before the pouring of the concrete and serves to insulate the said reenforcement from the concrete in order to allow the elongation of the reenforcement.

This sheath may consist of a tube of steel or of other material, thin sheet steel rolled into a cylindrical shape, and clasped by bending back the edges. It may even consist merely of a plain coating of a greasy substance or of a plastic one of low melting point, basically composed of bitumen, pitch or rubber which is applied to the wires. This coating can be protected by swathing with paper or other fibres impregnated with substances of the same nature.

Each extremity of a reenforcement or only one of the extremities, if the other be securely fastened to the concrete by any well known anchoring system, is inserted in the anchoring slab or block, which is going to be described with respect to figures 1 to 5.

This slab or block comprises, in a high-resistance concrete mass 2, an aperture or cavity the contour of which is generated by a complete revolution of the straight line a—b about the axis x—x, which forms with line a—b an angle having a tangent of approximately 1/5, the said straight line being joined to the generant of tube 1 parallel to axis x—x by a curve b—c.

About the wall of the orifice so formed, a steel reenforcement 3 is embedded in the concrete 2. This reenforcement may be composed of helicoid turns of a steel wire having a high elastic limit so that the coil thus formed can resist the strains to which the wall of the cavity is subjected in operation. In the example described, the slab or block has the form of a solid of revolution composed of a head 2a and of a prolongation 2b having the shape of a truncated cone which is joined to the extremity of sheath 1 by a junction 1a of tissue or of paper impregnated with a plastic substance, such as tape. About the head 2a, the concrete is reenforced by a second coil 4 which may be of soft steel.

The concrete 5 of the construction or of the piece to be built is poured about tube 1 and about the block taking care to allow provision for a hole 6 through which it will be possible to accede to the extremity of the cable (passing through head 2) from the exterior of the construction. The wires 7 composing this cable are spread out and pressed against the inner wall a—b of the truncated cone and between these wires steel wedges 8 are set. The sides of these wedges are provided with cylindrical grooves 8a corresponding to the shape of the wires, so that these wedges, inserted between the wires are maintained by the latter and form together with them a sort of male cone which comes to bear against the inner wall a—b of the female cone.

For the operation of tensioning, in the case under consideration, an hydraulic jack is utilized, the piston 9 of which can bear against head 2. This piston is provided with slots 10 equal in number to that of the wires of the cable and used for the passage of the wires, whereas the cylinder 11 comprises devices for the fastening of these wires. These devices consist in trapezoidal slots 12 provided on a rim 13 of the cylinder 11 and of wedges 14 which are inserted in these slots between two wires of the cable; the number of slots is consequently equal to half the number of wires, which condition requires, in this embodiment, the use of cables having an even number of wires.

In the interior of piston 9, a second piston 15 may displace itself and come to bear on the extremity of wedges 8 by means of a small plate 16 provided with slots for the passage of the wires. Piston 9 is provided with a hollow 17 the diameter of which corresponds to that of the small plate.

The organs being disposed as shown on fig. 1 and pressure being admitted in cylinder 11, this cylinder draws away from piston 9 and tensions wires 7. The wedges follow the movement of the wires at the start until they run against plate 16, they then leave between themselves sufficient clearance to allow the wires, pulled by cylinder 11, to slide freely.

In zone b—c of the anchoring head, the wires press against the concrete of this head and to limit their friction, this zone is lined by a casing 18 of tinplate for example.

When the tension stress, which can be determined from the pressure in cylinder 11, attains the desired value, the pressure is maintained in the cylinder, and piston 15 is put under pressure. The latter obtains a compression of the wedges between the wires by expanding the male cone and by compressing it against the inner wall of the female cone.

The pressure in the two jacks may then be released, the wires withdrawn from slots 12 of the jack and the latter removed; the anchoring is finished. The tensioned cable, subjected no longer to any external force, wedges the male cone composed of the wires and of the wedges in the female cone. The wires could, as a matter of fact, slip between the wedges only if the angle of friction between wedges and wires fell below a value β such that tang.

$$\beta=\frac{\pi\ \text{tang.}\alpha}{n}$$

α being the value of ½ the angle at the top of the cone and n the number of wires. But this angle β is chosen much smaller than the angle of friction which renders slipping impossible regardless of the condition of the surfaces of the wires and of the wedges and even if these surfaces were abundantly greased. The pressures between wedges and wires are, besides, of such magnitude that the grease, if there were any, would be completely driven away.

In order that the anchoring may resist it is therefore sufficient that the wall of the female cone withstand the tension of the cable and be able to transmit it to the concrete.

It is at this point that the purpose of the hard steel coil **3** appears. It must bear the stresses which make with the axis of the cone an angle which is the sum of the angle at the top of the cone and of the angle of friction steel on concrete.

Under the action of the tensioned cable, there results, finally, an equilibrium between the deformations of coils **3** and **4**, of the concrete **2** and that of the underlying concrete **5**, an equilibrium which allows a relatively large deformation of coil **3**, a relatively much smaller deformation of coil **4** and a triple compression stress accompanied by a plastic deformation of the concrete **2** with the obtention of isostatic lines such as UV, XY.

In that portion of the concrete where the head bears on the concrete **5** of the construction, this concrete may be profitably reenforced by rectangular reenforcements.

It is to be noted that nothing prevents the jack from being set in place for operation a second time; the wires may be tensioned again by means of the jack, the wedges loosened, the initial tension increased (or even reduced, if a means for preventing the wedges from jamming by themselves be provided). So the tensioning operations may be effected in a progressive manner, they may be rectified, in case of error, etc. . . .

Once the tensioning has been completed, hole **6** may be stopped up by concrete, and the extremities of projecting wires embedded in concrete which fills up a small recess provided for in the mass subjected to preliminary stresses, which process offers the advantage of an additional security by opposing the slipping of the wires against the wedging organs.

Figure 6 shows a cast steel anchoring block **2***a* provided with a female cone **2***b*, the surface **2***c*, **2***d* of which block bears on the concrete and transmits the strains developed by the tensioned cable. This anchoring block is utilized in the same manner as that described for the concrete slab.

Figure 7 shows the extremity of a beam provided with reenforcements *d* set in sheathes, the reenforcements being tensioned and anchored as has just been described. The anchoring heads *e* are located at the extremities of the reenforcements in the housings provided for, prior to the pouring of the concrete.

The block may have also a square or rectangular cross-section and comprise anchoring devices for several cables. In this case, coils **4** may be replaced by rectangular reenforcements perpendicular to the cable.

In the case where the cables are embedded in a plastic substance of low melting point, this substance may be softened at the time of the tensioning by means, for example, of an electric current sent throughout the reenforcements.

It can be seen, in the process described, that the jack which tensions the wires uses, as fulcrum, the concrete which constitutes the final anchoring, so that the temporary tension (during the tensioning operation) and the final tension are both directed along the same axis and act on the same substance, which conditions allow the compressing of the entire surface of the concrete to a maximum stress consistent with its resistance.

The invention is not limited to the case where the tensioning is effected after hardening of the concrete.

The concrete in which the tensioned reenforcements are embedded may be poured only after the tensioning of these reenforcements, on condition that fulcrums for the anchoring blocks be available while the tensioning is in process; these fulcrums can be chosen on the molds or on a portion of the concrete of the construction in which the reenforcements are not embedded, which concrete is poured in advance and has already hardened prior to the tensioning.

For example, in the case of a beam having a cross-section as represented on figure 8, it is possible, after setting in place reenforcements *d* and the anchoring blocks, to pour first the concrete represented by the hatchings in which concrete the reenforcements are embedded only at the extremities of the beam. When this concrete has hardened, those reenforcements, the anchoring blocks *e* of which utilize the said concrete, as fulcrum, may then be tensioned. Once the tension and anchoring operations are completed, the rest of the concrete (see the dotted lines in fig. 8) may be poured about the tensioned reenforcements *d*.

The device for tensioning and anchoring constructed according to my invention also offers a practical means of obtaining, by tensioned reenforcements, a uniting into a single structure of distinct concrete pieces laid out end to end for example. The tensioning of the reenforcements which will be placed for example in the holes provided in these pieces, will result in their compression one against the other.

It is obvious that the embodiments which have just been described constitute only examples and that these can be departed from without affecting the scope of the invention. The invention is applicable not only to the case where the elements of the cable to be tensioned consist in simple wires, but also to the case where these elements consist of strands or of groups of wires. In the claims hereunder, the word "wire" must be understood as designing not only a single wire properly speaking, but also a group of wires or a strand.

EUGÈNE FREYSSINET.