Jan. 20, 1942. E. FREYSSINET 2,270,240

ANCHORING OF TENSIONED CABLES IN CONCRETE CONSTRUCTIONS

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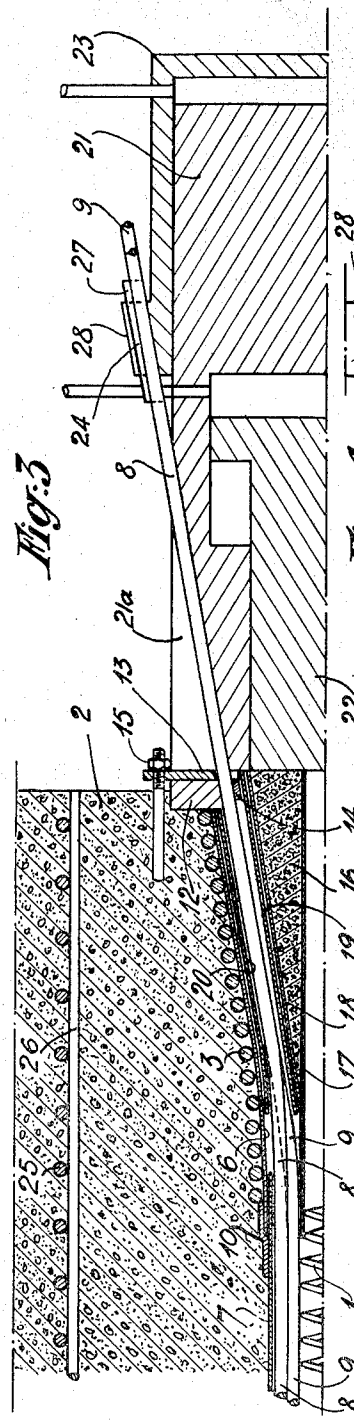

Fig:3

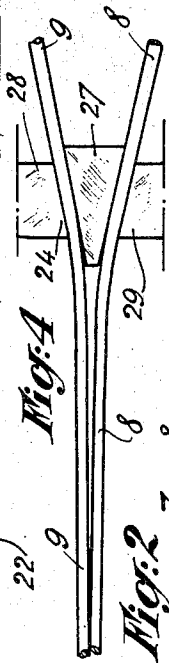

Fig:4

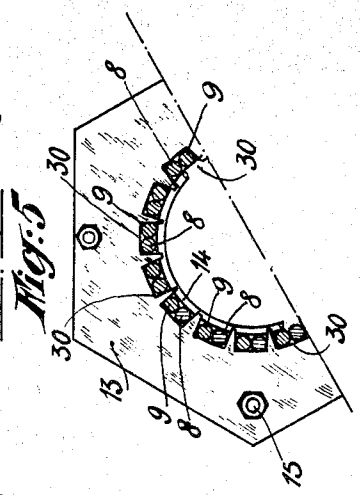

Fig:5

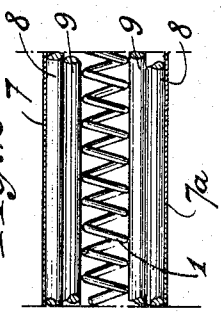

Fig:2

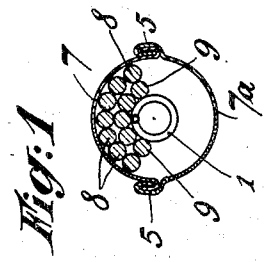

Fig:1

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ANCHORING OF TENSIONED CABLES IN CONCRETE CONSTRUCTIONS

Eugène Freyssinet, Neuilly-sur-Seine, France

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In France August 26, 1939

14 Claims. (Cl. 72—71)

I have already shown that the characteristics of various constructions of this nature can be considerably improved by utilizing reenforcements of steel having a high elastic limit subjected initially to strong tensile stresses which produce in the construction a set of preliminary stresses opposite in direction to those produced by the application of loads (see U. S. Patent 2,080,074). The tensile strain may be imparted to the reenforcements before or after the setting of the concrete. In the latter case, the reenforcements, composed of cables or bundles of high resistance, drawn out, steel wires, are laid out in hollows left in the concrete to this effect. These reenforcements, which in this case, do not adhere to the concrete, are subjected to tensile stresses when using the hardened concrete as fulcrum for the tensioning devices.

A difficulty of this well known process, lies in the anchoring members to be established on the wires or cables under tension to prevent sliding of the latter in the concrete.

To this effect, steel or concrete gripping members have already been devised comparable to those used in the anchorage of the cables of suspension bridges and consequently exterior to the construction, the tension in the reenforcements being obtained by the use of jacks acting between these gripping members and the main part of the construction. These devices are expensive and the space they occupy prevents an extension of their application to current constructions such as bridges or buildings.

My present invention has for its object to provide gripping members which, among other advantages, eliminate all projections exterior to constructions of concrete or other materials subjected to preliminary compression stresses.

This process is particularly applicable to constructions of concrete when the tensile strain 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 strained 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 applications fall within the scope of the invention.

The general principle of my new process is as follows: In the construction, at the point where the extremity of the cable to be strained is located, a very resisting element or member is embedded in the concrete or in whatever other material of the construction—to be subjected to preliminary stresses. The said member is provided with a cavity through which the cable passes; the elemental wires or strands of this cable are spread out against the inner surface of the cavity, they are then put under tension and, while they are so strained, they are pressed against the inner surface of the cavity with sufficient compressive force to produce between said wires or strands and said surface a friction capable of counterbalancing the tension of the wires and thus to prevent the sliding of the tensioned wires in the concrete.

It is preferable to increase this compressive force to such a value that it will produce an elastic expansion of the wall of the cavity which condition will contribute to holding the wires fast.

The compression of the wires of the cable against the inner surface of the cavity can be obtained by means of metallic wedges or pegs driven in by a jack or by a hammer in the axis of the cable or between its wires, or by hydraulic jacks composed of a sort of malleable bag which can be inflated by the injection under pressure, in the liquid state, of a substance capable of ultimate hardening such as synthetic resin.

One method of obtaining this condition consists in embedding the wires of the cable, against the inner surface of the cavity, while these wires are under tension, in a substance adhering to the wires and capable of hardening, such as cement mortar to which it is profitable to mix silicious or aluminous sand and asbestos to increase the friction of the wires on the mortar. Then a strong compression of this mortar against the inner surface of the cavity is obtained by introducing into the latter a suitable instrument. It is advisable to line the inside surface of the cavity with a metallic lining and to put grease or an equivalent lubricant between the said lining and the inner wall of the cavity in order to reduce the friction. The cavity having the shape of a truncated cone, and the compression of the mortar being obtained by a male cone wedged in the axis of the cable, the slipping, which tends to occur on the greased surface as a result of the tension of the wires when tensioning apparatus is released, compresses still more the mortar and increases the anchorage of the wires.

The body containing the cavity of which the cable is held fast may be constructed in reenforced concrete; in this case, the cavity where the cable is held fast will be hollowed out in the concrete itself and the inner surface of

this cavity will be made capable of resisting the stresses of expansion by embedding in the concrete a steel reenforcement which encircles the cavity and is put in place before the concrete is poured. This reenforcement may consist of a steel tube or of helicoid turns of steel wire, having preferably a high elastic limit or of a combination of such a tube and turns of wire wound about it.

In order to obtain an effective transfer to the concrete of the strains borne by the said reenforcement, it is possible to provide a second transverse reenforcement of the concrete and composed either of a second coil formed by a steel wire, helically wound and located at a certain distance from the first one, or of rectangular reenforcements perpendicular to the axis of the cable.

My invention also comprises the apparatus necessary to the practical realization of my process.

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

Figure 1 represents a transverse sectional view of the cable and of its sheath according to a first way of realization, the section being cut at a point located beyond the anchorage.

Figure 2 is a partial longitudinal sectional view of this cable.

Figure 3 is a longitudinal half sectional view of the anchoring device and of the tensioning jack at one end of the construction.

Figure 4 is the front view of a group of 2 wires and of an anchoring jaw on the jack.

Figure 5 is part of the front view of a slotted washer perpendicular to the cable, the function of which is to separate the wires prior to their tensioning.

In the practical example represented on Figures 1 to 5, the cable to be tensioned and anchored comprises 2 layers of wires or strands 8 and 9 (having in all an even number of wires or strands, 32 for example) grouped around a core consisting of a long pitch helicoid spring 1. It is enclosed in a sheath composed of, for example (Fig. 1) two metallic sheets 7, 7*a*, hooked one to the other by bending back their edges. This sheath is put in place in the molds before the concrete of the construction is poured and serves to insulate the cable with regards to the concrete in order to allow the elastic elongation of this cable at the moment of tensioning, even if at this moment the concrete has already set and hardened.

As can be seen in Figure 3, the extremity of the cable penetrates into a truncated steel member 6 provided with a funnel-shaped cavity and hooped by a hardened steel wire 3 having, for example, an elastic limit superior to 35 kg. per square millimeter. This part 6 and the coil 3 are embedded in the concrete 2 poured about them. A concrete tight junction 10, of tape for example, joins part 6 to sheath 7 to prevent the concrete from penetrating into this part and into this sheath. At the end of the slab of concrete 2, there is a thick steel washer 12 the purpose of which is to sustain the thrust of the tensioning jack and to transmit it to the concrete. A slotted plate 13 a portion of which figures in the front view on Figure 5 and which is fixed by bolts 15 embedded in the concrete is coupled to a hoop-iron washer 14 which maintains the wires of the cable by pairs in the slots of plate 13. A cone 16 of very hard mortar and considerably reenforced longitudinally is poured between a tube 17 (the axis of which lies along that of the cable) and a conical casing of smooth and polished sheet steel 18 enclosed in another casing 19 made of brass or tin plate. A conic casing 20, also made of tin plate or brass, is inserted in member 6, the surface of contact between member 6 an dcasing 20 being lubricated so as to obtain a coefficient of friction of the order of 5 to 10%. The piston 21 of a jack bears upon washer 12 and is provided with sixteen radial slots 21*a* which allow the wires of the cable to pass by pairs. This piston 21 contains an auxiliary piston 22 bearing upon cone 16. Cylinder 23 of piston 21 has sixteen anchoring jaws 24 each one of these receiving two wires of the cable which are separated by an intermediate wedge 27 (a front view of which is seen on Figure 4 between the projections 28 and 29 which make up the anchoring jaws).

The concrete slab 2 comprises moreover a number of turns 25 of ordinary soft steel and a set of reenforcements 26 parallel to the cable.

The cable with its sheath having been correctly placed in the molds of the construction, the extremity of the cable having been passed through casing 20 which lines the inside of the hollow member 6, and finally the coils 3 and 25 being in place, the concrete 2 is poured.

Once the concrete has hardened, the wires of the cables are separated by pairs and made to pass between washers 12 and 14 and in the slots of plate 13, which fastened by bolts, holds in place the whole fixture.

Then, cone 16 with its tube 17, its casing 18 and the second casing 19, are inserted into the central hollow of the cable, and fresh plastic mortar containing silicious sand or asbestos is packed into the interval between casing 19 and casing 20. By means of the jack, the piston 21 of which bears, through the medium of washer 12, on the concrete surrounding tube 6, the steel wires, held fast by pairs on the anchoring jaws 24 of the cylinder of this jack, are tensioned; the cylinder drawing away from the concrete when pressure is admitted into the cylinder.

Then, the wires being kept under tension, piston 22 is made to drive in cone 16, the metallic casing 18 then sliding on casing 19 with a moderate friction of metal against metal. The cone produces an intense compression of the mortar between casings 19 and 20 of the order of 400 kg. per square centimeter in the particular example which the drawing illustrates.

The mortar loses its excess water and becomes very hard, and a high value is obtained for the friction angle of the mortar on itself and on the steel; at the same time, the mortar takes up a minimum volume.

When the pressure in the cylinder of the jack is released the tension in the steel is entirely transferred to that part of the device composed of cone 16, casings 18 and 19, and the mortar between 19 and 20 and casing 20. This ensemble attracted by the tension then slides along the lubrified surface between tube 6 and casing 20, which condition produces a very strong gripping effect of the mortar on the wires of an approximate value of 800 to 1000 kg. per square centimeter. This gripping effect obtains a perfect bond between the mortar and the wires, the angle of friction between surfaces 6 and 20, increased by the slope of the cone, being inferior to the inner friction of the wires on the mortar.

The elastic swelling of tube 6 and of coil 3 com-

presses the concrete which lies between coils 3 and 25 and so transmits the strains developed in the anchorage to the whole reenforced slab by means of reenforcements 25, 26. Jack 21, 23 may then be removed and those parts of the wires which jut out from the construction may be cut off. Then, through the centrally located tube 17, a substance protective against rust may be injected such as liquid cement, a synthetic resin capable of setting, or any other filler; it is even possible by these means to establish a bond between the wires and their sheath. A warm substance, easy to melt, such as bitumen or a resin, may be injected after having heated the interior of the cables by injecting hot air or steam.

The function of the core composed of the helicoid spring 1 is to ensure the possibility of this injection and the regularity of the cable itself in the curves which it assumes.

My invention is not confined only to the case where the tensioning occurs after hardening of the concrete. The concrete in which the reenforcements under tension are embedded can be poured after the tensioning of these reenforcements, on condition that supports for the anchorage heads are available during this tensioning; these supports can be on the molds or on a portion of the concrete slab in which the reenforcements are not embedded and which is poured in advance, and which has already hardened at the time of the tensioning.

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.

For example, in the case when the reenforcements are tensioned after the setting and hardening of the concrete, the sheath insulating the reenforcement with respect to the concrete may 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 and which is applied to the wires and protected if need be by swathing with paper or other fibres. This plastic substance of low melting point may be softened at the time of the tensioning by means, for example, of an electric current sent throughout the reenforcements.

My invention is applicable to the case where the elements of the cable to be tensioned are constituted by strands or groups of wires in lieu of single wires. The word "wire" in the following claims is intended to cover as well as a single wire properly speaking a strand or a group of wires.

What I claim is:

1. The process for anchoring the extremity of a group of steel wires constituting a reenforcement of a concrete construction or the like which comprises: the provision of a cavity in the construction at the place where the said extremity is located, the setting of the group of wires in this cavity, the spreading out of the wires against the inner surface of the said cavity, the tensioning of these wires by an external force, then the compressing of the tensioned wires against the surface of the said cavity by a compression adapted to produce between the wires and the said surface a friction capable of withstanding the tension of the wires, after which the said external force is removed.

2. The process for anchoring the extremity of a group of steel wires constituting a reenforcement of a concrete construction or the like which comprises: the provision of a cavity in the construction at the place where the said extremity is located, the setting of the group of wires in this cavity, the spreading out of the wires against the inner surface of the said cavity, the tensioning of these wires by an external force, the embedding of the tensioned wires in a pasty substance adhering to the wires and capable of hardening, then the compressing of this substance, after its hardening, against the inner surface of the cavity, after which the said external force is removed.

3. The process for anchoring the extremity of a group of steel wires constituting a reenforcement of a concrete construction or the like which comprises: the provision of a funnel-shaped cavity, in the construction, at the place therein where the extremity of the group is located, the said funnel-shaped cavity having its larger opening facing the said extremity, the setting of the group of wires in this cavity, the spreading out of the wires against the inner surface of this cavity, the tensioning of these wires, by an external force, then the compressing of these tensioned wires against the surface of the said cavity by a compression adapted to produce an elastic deformation of the wall of the cavity, after which the said external force is removed.

4. The process for anchoring the extremity of a group of steel wires constituting a reenforcement of a concrete construction which comprises: the provision of a funnel-shaped cavity, in the concrete at the place therein where the said extremity is located, the said funnel-shaped cavity having its larger opening facing the said extremity, the reenforcing of the wall of this cavity by means of a reenforcement embedded in the concrete about this cavity, the setting of the group of wires in this cavity, the spreading out of the wires against the surface of the said cavity, the tensioning of these wires by an external force, then the compressing of the tensioned wires against the surface of the said cavity by a compression adapted to produce an elastic expansion of the said embedded steel reenforcement, after which the said external force is removed.

5. The process for anchoring the extremity of a group of steel wires constituting a reenforcement of a concrete construction which comprises: the provision of a funnel-shaped cavity, in the concrete at the place therein where the said extremity is located, the said funnel-shaped cavity having its larger opening facing the said extremity, the reenforcing of the surface of this cavity by means of steel embedded in the concrete about this cavity, the setting of the group of wires in this cavity, the spreading out of the wires against the surface of the said cavity, the tensioning of these wires by an external force, then the compressing of the tensioned wires against the surface of this cavity by means of at least one wedge inserted in the cavity with a force adapted to produce an elastic expansion of the said embedded steel after which the said external tensioned force is removed.

6. The process for anchoring the extremity of a group of wires constituting a reenforcement of a concrete construction which comprises: the provision of a funnel-shaped cavity in the concrete at the place wherein the said extremity is located, the said funnel-shaped cavity having its larger opening facing the said extremity, the reenforcing of the surface of this cavity by means of a steel coil embedded in the concrete about this cavity, the setting of a hollow funnel-shaped

part in the interior of the said cavity, the provision of a lubricant between the said part and the surface of the cavity, the setting of the group of wires in the interior of the said hollow part, the spreading out of the wires against the inner surface of the said hollow part, the tensioning of these wires by an external force, the embedding of the tensioned wires in a cement mortar adhering suitably to the wires and poured in the said hollow part, then the compressing of this mortar after its hardening, against the surface of the cavity, by means of at least one wedge inserted in the said mortar with a force adapted to produce an elastic expansion of the said coil after which the said external force is removed.

7. A device for anchoring a group of tensioned wires constituting a reenforcement of a concrete construction, the said device comprising in combination: a concrete part in which is provided a funnel-shaped cavity, the inner surface of which surrounds the extremity of the wires, the said cavity having its larger opening facing the exterior of the construction, a steel reenforcement embedded in the concrete about the said cavity and means in the said cavity adapted to compress the wires against the surface of the said cavity whereby the steel constituting the said embedded reenforcement is elastically tensioned.

8. The process of simultaneous tensioning and anchoring of a group of steel wires constituting a reenforcement of a concrete construction which comprises the setting of a hollow, funnel-shaped, steel shell over the extremity of the said group, the larger opening of the said hollow shell facing the exterior of the construction, the pouring of the concrete about the said hollow shell, the spreading out of the wires against the inner surface of the said shell, the setting of at least one wedge in the said shell, the tensioning of the wires after the hardening of the concrete, by applying an external tension to the extremity which projects out from the concrete, using the said concrete as fulcrum, then while maintaining this external tension, the driving in of the wedge towards the smaller opening of the said hollow shell by a force adapted to produce an expansion of the said shell, after which the said external tension is removed.

9. In a concrete or similar structure, in combination, a mass of concrete or the like, a longitudinally tensioned reinforcement passing therethrough and comprising an elongated member having a divided end portion comprising a plurality of strands, the mass of concrete adjacent one surface being provided with a cavity surrounding the stranded end of said reinforcement, said end being flared by the spreading out of the strands and embedded in an adherent plastic material which prevents relative movement between the strands and which forms therewith a hollow body in contact with the walls of the cavity, and means exerting pressure in a direction generally radially of the axis of the member and forcing said body firmly against the walls of said cavity.

10. In a concrete or similar structure, in combination, a mass of concrete or the like, a longitudinally tensioned reinforcement passing therethrough and comprising an elongated member having a divided end portion comprising a plurality of strands, the mass of concrete adjacent one surface being provided with a conical outwardly flared cavity surrounding the stranded end of said reinforcement, said end being flared by the spreading out of the strands and embedded in an adherent plastic material which prevents relative movement between the strands and which forms therewith a hollow frusto-conical body in anti-frictional contact with the walls of the cavity, and a conical wedge exerting pressure in a direction generally radially of the axis of the member, disposed in anti-frictional contact with said body and forcing said body firmly against the walls of said cavity.

11. In a concrete or similar structure, in combination, a mass of concrete or the like, a longitudinally tensioned reinforcement passing therethrough and comprising an elongated member having a divided end portion comprising a plurality of strands, the mass of concrete adjacent one surface being provided with a conical outwardly flared cavity surrounding the stranded end of said reinforcement, reinforcement means for the wall of said cavity, said stranded end being flared by the spreading out of the strands and embedded in an adherent plastic material which prevents relative movement between the strands and which forms therewith a hollow frusto-conical body in contact with the walls of the cavity, and means exerting pressure in a direction generally radially of the axis of the member and forcing said body firmly against the walls of said cavity.

12. In a concrete or similar structure, in combination, a mass of concrete or the like, a longitudinally tensioned reinforcement passing therethrough and comprising an elongated member at least an end portion of which is divided into a plurality of strands, the mass of concrete adjacent said end portion of the reinforcement being provided with a conical outwardly flared cavity surrounding said end portion and with a metallic reinforcement embedded in said concrete near the wall of said cavity, said end portion being flared by the spreading out of the strands, means disposed between the spread strands and which forms therewith a substantially rigid frusto-conical body, said body being pressed firmly against the wall of the cavity and tending to produce an elastic expansion thereof.

13. In a concrete or similar structure, in combination, a mass of concrete or the like, a longitudinally tensioned reinforcement passing therethrough and comprising an elongated member having a divided end portion comprising a plurality of strands, the mass of concrete adjacent one surface being provided with a conical outwardly flared cavity surrounding the stranded end of said reinforcement, said end being flared by the spreading out of the strands and embedded in an adherent plastic material which prevents relative movement between the strands and which forms therewith a hollow frusto-conical body in contact with the walls of the cavity, means exerting pressure in a direction generally radially of the axis of the member and forcing said body firmly against the walls of said cavity, and metal sheathing covering the walls of said cavity and both the inner and outer walls of said frusto-conical body.

14. A device for anchoring a group of tensioned wires constituting a reinforcement of a concrete construction, the said device comprising in combination, a concrete part in which is provided a funnel-shaped cavity, the inner surface of which surrounds the extremity of the wires, the said cavity having its larger opening facing the exterior of the construction, a metallic reinforcement embedded in the concrete about the said

cavity, means in the said cavity adapted to compress the wires against the surface of the said cavity whereby the metal constituting the said embedded reinforcement is elastically tensioned, and a second metallic reinforcement embedded in said concrete part, disposed about said first named reinforcement, and spaced radially therefrom, whereby the annular portion of the mass of concrete between the two reinforcements is placed under greater compression than the rest of the concrete part when said first named reinforcement is tensioned.

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