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(54) Prestressing strand for concrete structures and concrete structures containing such strand.

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Description

The invention relates to a prestressing strand for post-tensioning a concrete structure, having at least one central core wire and a plurality of outer wires extending helically around the said core wire so as to envelop the core wire. Such strands are often used as the tensioned reinforcing elements in prestressed concrete structures, in which they may for example be inserted in curved conduits in the concrete structure. The conduits are formed for example by tubes of steel or another material, which are pre-cast into the concrete structure. The invention also relates to a process of manufacturing such strand and to a concrete structure containing such strand.

From "Techniques de l'ingénieur", pages C 360— 5, 6; Hütte Bautechnik vol. I, page 726, par. 4-9-3-3-1-3, and GB—A—1194758 it is known to helically wrap outer wires around a central core wire. GB—A—1194758 is concerned with the provision of such a multi-wire strand which has a greater adhesion to the concrete. Therefore, each individual outer wire is provided with shallow circumferential recesses which cause improved anchoring of the concrete on the strand.

Also from Hütte, Bautechnik vol. I, the application of profiled wires is known. Further the core wire should be some 5 to 7% larger in diameter than the outer wires. According to Techniques de l'ingénieur this slightly larger diameter of the core wire is necessary to ensure that movement of the core wire relative to the outer wires is possible during the tensioning of the strand.

Very surprisingly, however, the invention arrived after extensive trials to a different insight with respect to the construction of the strand at the process of manufacturing such a strand, which will be explained in the following.

The present invention arises because, for prestressing strand, investigations do not appear to have resulted in the most suitable practical strand construction for use in post-tensioning.

In the post-tensioning of a prestressing strand, usually the elongation properties of the strand under tensioning in an unhindered straight condition are employed. In this it has been found that the ratio between the mean stress over the cross section of the strand and its strain deviates little from the elasticity modulus E (Young's modulus), of the wire material. Small deviations can arise, in dependence on the production method of the strand and its construction.

In the use of prestressing strands in curved conduits through concrete structures, in different cases different tension forces appear at the strand ends after tensioning. By means of calculations it is possible to find a relationship between the total elongation of the strand in the curved channel and these tension forces at the ends, from which it is then possible to learn about the behaviour of the tension forces in the strand along its length, by applying a predetermined elongation to the strand.

It has now been found that in such cases, as a consequence of variations in the frictional properties inside the strand, variations in the production methods of the cable and possibly other factors, great deviations can be formed between the calculated elongations and elongations actually occurring in the tensioning of prestressing strand. If the quotient of the mean stress over the strand cross section and the measured elongation of the strand per unit length is referred to by the expression "modulus of deformation", then it is found that, when tensioning strand in curved conduits, this deformation modulus as a rule deviates considerably and unpredictably from the modulus of elasticity E of the wire material. More specifically it is found that the modulus of deformation in cases of substantial variation is as a rule smaller than the modulus of elasticity. This is the more serious, because in the application of a calculated elongation to the prestressing strand, an uncertainty exists whether along the whole length, the designed tension exists in the strand, and whether the concrete structure arrives at the desired condition of prestress.

The tension condition and the deformation condition of a prestressing strand in a curved configuration, in which the strand is subjected to transverse forces and frictional forces, is highly complex, and is dependent on a great number of factors which are related to the properties of the material and the production methods for the strand.

A complete understanding of this has not yet been achieved, though by an empirical method the inventors of the present application can indicate systematic variations. The method of testing strands is described below.

The object of the present invention is therefore to make it possible to control and minimize variations in tension in prestressing strand in curved conduits.

The inventors have realised that a considerably better consistency between the modulus of deformation and the modulus of elasticity can be obtained when the core wire can be more adequately tensioned over its whole length and can cooperate better as a load bearing element.

To enable this consistency between the modulus of elasticity and the modulus of deformation, it has surprisingly been found, contrary to what was the opinion in the state of the art, that the strand must sufficiently remain integral in order that slip between the core wire and the outer wires is prevented, since this slip has the result that locally the core wire is no longer fully under load.

It has been found that such improved prestressing strands of the above referred to type can be obtained if the said core wire has a modified surface resulting in a reduced tendency to movement (e.g. increased coefficient of friction) of the core and outer wire relative to each other.

Thus, only the core wire has been subjected to a treatment to modify the wire surface so that the resistance of relative longitudinal movement of the core wire and the outer wires is greater than it would be if the treatment had not been performed.

One treatment method for the core is to form mechanically identations in the core wire surface.

Another treatment method is to only modify the surface condition of the core wire so as to increase the coefficient of friction between the core wire and the outer wires. Thus, instead of accepting undesired variations in the frictional properties inside the strand, use is made of these frictional properties, by increasing this friction in order to reduce or even prevent any movement in longitudinal direction between the core wire and the outer wires.

Various alternative methods are available for modifying the surface condition of the core wire in order to increase the coefficient of friction. One possibility is that the surface of the core wire is given a thin oxide layer resulting from heating the wire in an oxidising atmosphere. It will be clear that even a very thin oxide layer can drastically influence the frictional properties of the wires, without affecting the strength and durability of the wire and of the prestressing strand as a whole. Anyone skilled in the art will know how for each type of core wire such a thin oxide layer can be achieved by selection of oxidising atmosphere, process temperature and a period of treatment of the wires, without affecting the relevant physical properties of the wire material, such properties being for example (but not exclusively) the mechanical properties and the durability.

It has also been found that the surface condition of the wire can be adequately modified by subjecting it to a chemical etching treatment. Chemical etching treatments of steel products are generally known, which means that no further explanation needs to be given how such etching is to be performed in order to achieve a slight roughening of the surface, without unduly affecting the physical properties of the material.

Also, it has been found that the object of the present invention may be obtained, without modifying the wire itself, if a resin coating in which an abrasive powder, e.g. a grinding powder such as carborundum, is admixed is applied to the wire. In prestressing strand constructed with such a coated wire, the particles of the grinding power prevent or at least reduce movement between the various wires.

Yet another possibility for the wire treatment consists in depositing a friction-increasing substance upon the wire by an electrochemical or an electrostatic process. In this field there are many options available to the expert for achieving suitable deposition.

Although several different alternatives have been discussed for modifying the surface of the wire, combinations of two or more of such surface modification processes can be employed in the present invention.

The invention also relates to the process of manufacture of the prestressing strand and to a concrete structure containing one or more tensioned strands according to the invention, as described above. In such a manufacturing process, it is assumed that the manufacturing steps start from wire of surface condition hitherto conventional in this field, e.g. as supplied by wire manufacturers.

Brief Introduction of the Drawings

Embodiments of the invention will be described below by way of non limitative example with reference to the accompanying drawings, in which:

Figs. 1 and 2 show a prestressing strand;

Fig. 3 shows a test apparatus for prestressing strand in plan view;

Fig. 4 is a front view of the apparatus of Fig. 3;

Referring now to Figs. 1 and 2 of the accompanying drawings, these show a prestressing strand having a single core wire b and six outer wires a in longitudinal view and in cross section respectively. Fig. 1 also indicates the pitch of the helices in which each of the outer wires lies. For the whole strand, this pitch S is referred to herein by the expression "helical pitch length". Fig. 2 indicates the greatest cross sectional dimension which is herein called the maximum diameter of the strand. It is usual to express the helical pitch length as a multiple of the strand diameter. For prestressing strands, this length S generally lies between 12 and 18 times the diameter, although a value of S in this range is not essential for the present invention.

Figs. 3 and 4 show a concrete plate 1 with a thickness of 22 cm. Through this plate 1 there extends a conduit 3 which over an angle of 5.07 radians is curved with a radius of curvature R of 100 cm. The length L_2 of the curved conduit part is consequently 507 cm. Against each end of the conduit 3 there is located a support beam 2 with at the left hand side a wedge anchoring 5 for a prestressing strand and at the right hand side a similar wedge anchoring 5 behind a hydraulic press 4 (schematically shown).

After a strand is inserted through the conduit 3, the strand is secured by the wedge anchors 5, whereupon it is tensioned by the hydraulic press 4. The tensioned strand then consists of a straight section of length L_1 of 175 cm, a curved section of length L_2 of 507 cm and another straight section of length L_3 of 210 cm.

Tests were carried out using the most common prestressing strand of thickness D of 0.5 inches, and having a core wire and six outer wires. First the strand was brought under nominal tension, in order to stretch it sufficiently, whereupon the tension force was increased up to a value near the usual full load value used in tensioning technology. During the increase of the tension force, the elongation and the tension force in the strand were measured continuously.

Using the "element method", the strand was considered to be divided into elements, and for each element the stress and strain conditions were calculated with the application of a frictional force between the channel wall and the prestressing strand. By means of separate tests with small angles of wrap, frictional coefficients between the strand and the channel wall at various tension forces in the strand were determined. Per element, these friction coefficients were introduced into the calculation so that it was possible to determine by calculation, what tension forces should be present in the strand, on the basis of the total measured extension of the strand between the anchors 5. The value was compared with the actual tension forces obtained, from which a value could be obtained for the modulus of deformation in each test performed.

This test was repeated with strands having a modified core wire according to the invention, but otherwise of the same dimensions. In each case, in a corresponding manner, a value for the modulus of deformation was determined.

The values thus found by measurement and calculation for the modulus of deformation showed that in all cases with the use of modified core wires according to the invention a substantial increase of the modulus of deformation was found, while also the difference between the modulus of deformation and the modulus of elasticity became unimportant.

Claims

1. Prestressing strand for post-tensioning a concrete structure, having at least one central core wire (b) and a plurality of outer wires (a) extending helically around the said core wire (b) so as to envelop the core wire (b): characterized in that only the said core wire (b) has been subjected to treatment to give it a modified surface such that as a result of said treatment the resistance to longitudinal movement of the core wire (b) relative to the outer wires (a) is greater than if said treatment was not performed.

2. Prestressing strand according to Claim 1 wherein said treatment of the core wire (b) comprises mechanically forming indentations in the wire surface.

3. Prestressing strand according to Claim 1 wherein said treatment of the core wire (b) comprises modifying the core wire surface condition so as to increase the coefficient of friction between the core wire (b) and the outer wires (a).

4. Prestressing strand according to Claim 3 wherein said treatment is at least one of the following:

a) creation of a thin oxide layer by heating the wire in an oxidizing atmosphere;

b) chemical etching of the wire;

c) application to the wire of a resin coating containing an abrasive powder;

d) deposition on the wire surface of a friction-increasing substance.

5. A concrete structure containing at least one post-tensioned prestressing strand in a conduit according to one of Claims 1 to 4.

6. A concrete structure according to Claim 5, wherein the said post-tensioned strand extends along a curved conduit within the concrete structure.

7. A process of manufacture of a post-tensioning strand according to Claim 1, comprising providing at least one central core wire and a plurality of outer wires and wrapping said outer wires helically around the core wire so as to envelop the core wire, characterized in that prior to said wrapping step, the method further comprises subjecting the core wire only to treatment so as to give it a modified surface such that as a result of said treatment the resistance to longitudinal movement of the core wire relative to the outer wires is greater than if said treatment was not performed.

8. A process according to Claim 7 wherein said treatment of the core wire comprises mechanically forming identations in the core wire surface.

9. A process according to Claim 7 wherein said treatment of the core wire comprises modifying the wire surface condition so as to increase the coefficient of friction between the core wire and the outer wires.

10. A process according to Claim 9, wherein said treatment to increase the coefficient of friction comprises at least one of the following steps:

a) forming a thin oxide layer by heating the wire in an oxidizing atmosphere;

b) chemically etching the wire surface;

c) applying to the wire a resin coating containing an abrasive powder;

d) depositing on the wire surface a friction-increasing substance.

Patentansprüche

1. Vorspannkabel zum nachträglichen Vorspannen einer Betonkonstruktion mit zumindest einem mittigen Kerndraht (b) und einer Vielzahl von äußeren Drähten (a), die sich schraubenförmig um diesen Kerndraht (b) erstrecken, um den Kerndraht (b) zu umhüllen, dadurch gekennzeichnet, daß nur dieser Kerndraht (b) einer Behandlung unterzogen wurde, um ihm eine modifizierte Oberfläche zu geben, sodaß als Ergebnis dieser Behandlung der Widerstand gegen eine Längsbewegung des Kerndrahtes (b) relativ zu den äußeren Drähten (a) größer ist, als wenn diese Behandlung nicht ausgeführt worden wäre.

2. Vorspannkabel gemäß Anspruch 1, wobei diese Behandlung des Kerndrahtes (b) das mechanische Formen von Vertiefungen in der Drahtoberfläche umfaßt.

3. Vorspannkabel gemäß Anspruch 1, wobei diese Behandlung des Kerndrahtes (b) das Modifizieren des Oberflächenzustandes des Kerndrahtes umfaßt, um den Reibungskoeffizienten zwischen dem Kerndraht (b) und den äußeren Drähten (a) zu vergrößern.

4. Vorspannkabel gemäß Anspruch 3, wobei diese Behandlung zumindest eine der folgenden ist: a) Erzeugen einer dünnen Oxidationsschicht durch Erwärmen des Drahtes in einer oxidier-

enden Atmosphäre; b) chemisches Ätzen des Drahtes; c) Aufbringen eines Schleifpulver enthaltenden Harzüberzuges auf den Draht; d) Ablagern einer reibungserhebenden Substanz auf der Drahtoberfläche.

5. Eine Betonkonstruktion mit zumindest einem nachträglich vorgespannten Vorspannkabel in einem Rohr gemäß einem der Ansprüche 1 bis 4.

6. Eine Betonkonstruktion gemäß Anspruch 5, wobei sich dieses nachträglich vorgespannte Kabel entlang eines gekrümmten Rohres innerhalb der Betonkonstruktion erstreckt.

7. Ein Verfahren zur Herstellung eines nachträglich vorspannbaren Kabels gemäß Anspruch 1, wobei zumindest ein mittiger Kerndraht und eine Vielzahl von äußeren Drähten vorgesehen wird und die äußeren Drähte schraubenförmig um den Kerndraht gewickelt werden, um den Kerndraht zum umhüllen, dadurch gekennzeichnet, daß vor diesem Wickelschritt das Verfahren weiters das Unterziehen nur des Kerndrahtes einer Behandlung umfaßt, um ihm eine modifizierte Oberfläche zu geben, sodaß als Ergebnis dieser Behandlung der Widerstand gegen eine Längsbewegung des Kerndrahtes relativ zu den äußeren Drähten größer ist, als wenn diese Behandlung nicht ausgeführt worden wäre.

8. Ein Verfahren nach Anspruch 7, wobei diese Behandlung des Kerndrahtes das mechanische Formen von Vertiefungen in der Drahtoberfläche umfaßt.

9. Ein Verfahren nach Anspruch 7, wobei diese Behandlung des Kerndrahtes das Modifizieren des Oberflächenzustandes des Kerdrahtes umfaßt, um den Reibungskoeffizienten zwischen dem Kerndraht und den äußeren Drähten zu vergrößern.

10. Ein Verfahren nach Anspruch 9, wobei diese Behandlung zumindest eine der folgenden ist: a) Erzeugen einer dünnen Oxidationsschicht durch Erwärmen des Drahtes in einer oxidierenden Atmosphäre; b) chemisches Ätzen des Drahtes; c) Aufbringen eines Schleifpulver enthaltenden Harzüberzuges auf den Draht; d) Ablagern einer reibungserhebenden Substanz auf der Drahtoberfläche.

Revendications

1. Câble de précontrainte prévu pour postcontraindre un ouvrage en béton, comportant au moins une âme centrale (b) et une pluralité de fils extérieurs (1) s'enroulant hélicoïdalement autour de cette âme centrale afin de l'envelopper, caractérisé en ce que seule l'âme (b) a été soumise à un traitement qui modifie sa surface de telle manière que, en conséquence de ce traitement, la résistance au déplacement longitudinal de l'âme (b) par rapport aux fils extérieurs (a) est plus grande que si le traitement n'avait pas été effectué.

2. Câble de précontrainte suivant la revendication 1, dans lequel ce traitement de l'âme (b) comprend la formation mécanique d'empreintes dans la surface de l'âme.

3. Câble de précontrainte suivant la revendication 1, dans lequel ce traitement de l'âme (b) comprend la modification de l'état de surface afin d'augmenter le coefficient de frottement entre l'âme (b) et les fils extérieurs (a).

4. Câble de précontrainte suivant la revendication 3, dans lequel ce traitement est au moins l'un des suivants:

a) création d'une mince couche d'oxyde par chauffage du fil dans une atmosphère oxydante;

b) attaque chimique du fil;

c) application sur le fil d'un revêtement résineux contenant une poudre abrasive;

d) dépôt sur la surface du fil d'une substance qui augmente le frottement.

5. Ouvrage en béton contenant au moins un câble de précontrainte postcontraint dans une canalisation suivant l'une des revendications 1 à 4.

6. Ouvrage en béton suivant la revendication 5, dans lequel ce câble postcontraint se prolonge le long d'une canalisation courbe prévue à l'intérieur de l'ovrage en béton.

7. Procédé de fabrication d'un câble de précontrainte suivant la revendication 1, comprenant la fourniture d'au moins une âme centrale et d'une pluralité de fils extérieurs et l'enroulement hélicoïdal de ces fils extérieurs autour de l'âme de manière à l'envelopper, caractérisé en ce que, préalablement au stade d'enveloppement, le procédé comprend en outre l'application à l'âme seule d'un traitement de manière à lui donner une surface modifiée telle qu'à la suite de ce traitement, la résistance au déplacement longitudinal de l'ame par rapport aux fils extérieurs est plus grande que si ce traitement n'avait pas été effectué.

8. Procédé suivant la revendication 7, dans lequel ce traitement de l'âme comprend la formation mécanique d'empreintes dans la surface de l'âme.

9. Procédé suivant la revendication 7, dans lequel ce traitement de l'âme comprend la modification de l'état de surface du fil de manière à augmenter le coefficient de frottement entre l'âme et les fils extérieurs.

10. Procédé suivant la revendication 9, dans lequel le traitement effectué pour augmenter le coefficient de frottement comprend au moins l'un des stades suivants:

a) formation d'une mince couche d'oxyde par chauffage du fil dans une atmosphère oxydante;

b) attaque chimique de la surface du fil;

c) application sur le fil d'un revêtement résineux contenant une poudre abrasive;

d) dépôt sur la surface du fil d'une substance qui augmente le frottement.

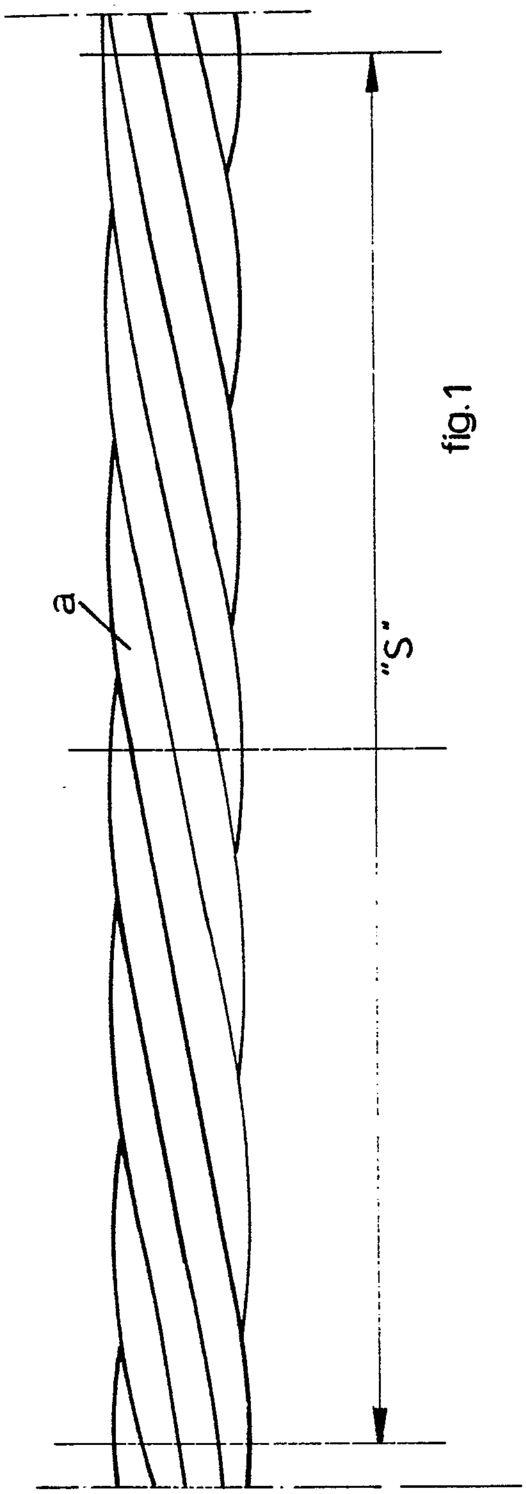

fig.1

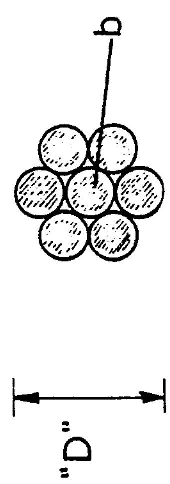

fig. 2

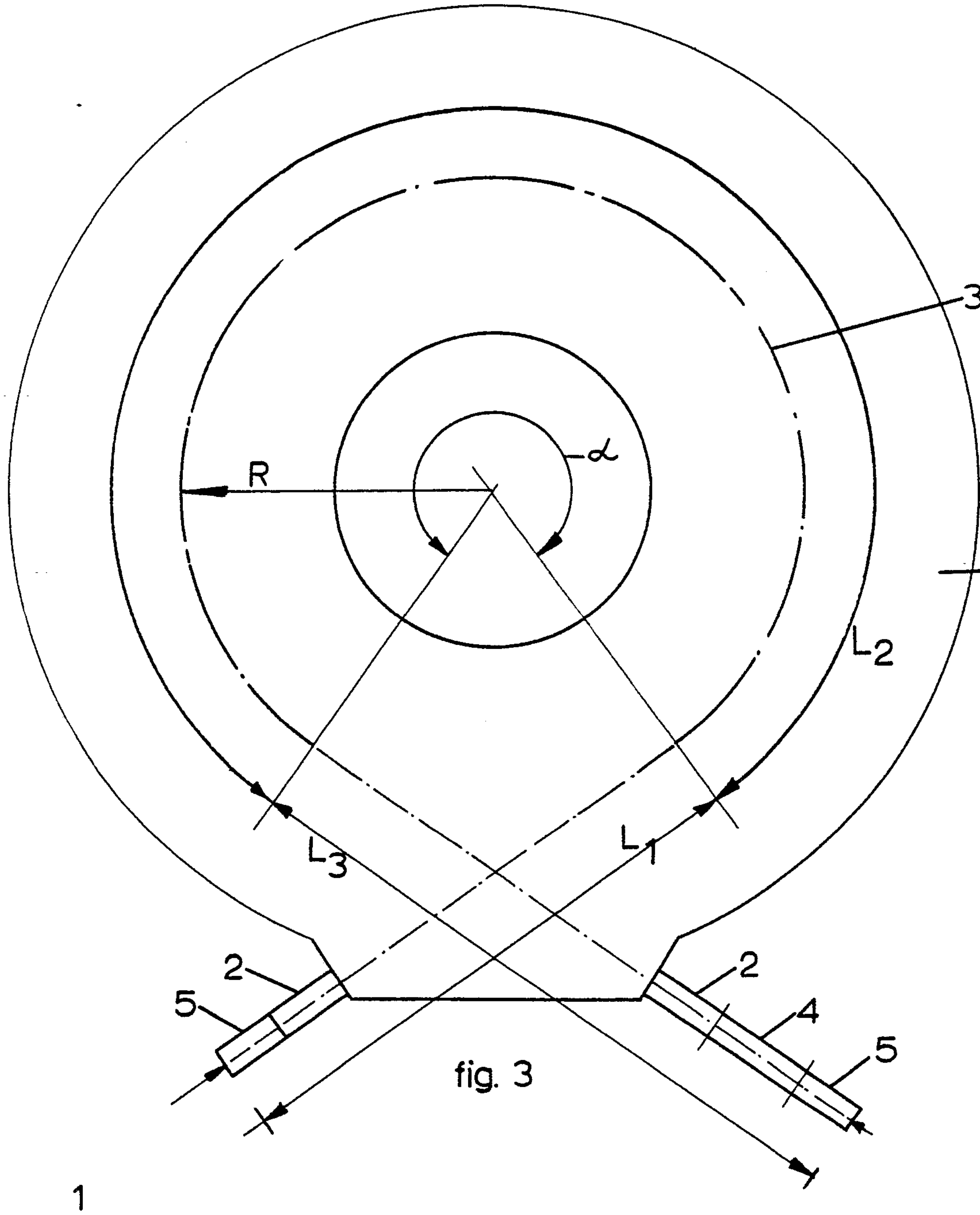

fig. 3

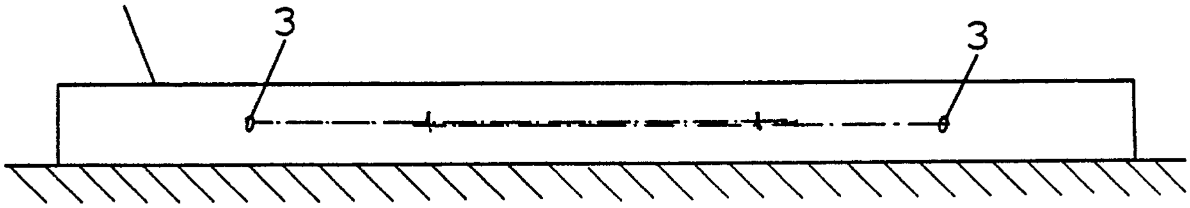

fig. 4