(19) DANMARK

(10) **DK/EP 2857731 T3**

(12) Oversættelse af europæisk patentskrift

Patent- og Varemærkestyrelsen

(51) Int.Cl.: *F 16 L 9/08 (2006.01)* *B 32 B 1/08 (2006.01)* *B 32 B 5/26 (2006.01)* *B 32 B 7/12 (2006.01)* *B 32 B 13/14 (2006.01)*

(45) Oversættelsen bekendtgjort den: **2017-02-13**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2016-11-02**

(86) Europæisk ansøgning nr.: **14186344.9**

(86) Europæisk indleveringsdag: **2014-09-25**

(87) Den europæiske ansøgnings publiceringsdag: **2015-04-08**

(30) Prioritet: **2013-10-04 DE 202013009289 U** **2013-10-04 DE 102013220150**

(84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**

(73) Patenthaver: **Wayss & Freytag Ingenieurbau AG, Eschborner Landstrasse 130-132, 60489 Frankfurt am Main, Tyskland**

(72) Opfinder: **Osthoff, Günter, Hermann-Stehr-Straße 108a, 59348 Lüdinghausen, Tyskland**
Sunkel, Alexander, Clausthal-Zellerfelder-Straße 33a, 40595 Düsseldorf, Tyskland

(74) Fuldmægtig i Danmark: **Zacco Denmark A/S, Arne Jacobsens Allé 15, 2300 København S, Danmark**

(54) Benævnelse: **Forpresningsrør**

(56) Fremdragne publikationer:
EP-A2- 0 151 930
EP-A2- 0 360 758
DE-A1- 10 359 912
DE-U- 6 913 721
US-A- 3 742 985

The invention relates to an accessible jacking pipe, in particular for transporting aggressive media, comprising an inner pipe made of a chemically resistant material, and an outer pipe made of concrete.

Jacking pipes are used in pipe jacking, a method for trenchless laying of pipes. An accessible jacking pipe is understood here to mean a jacking pipe having a nominal diameter of at least 1400 mm. During pipe jacking, usually starting from a vertical shaft, a media line which corresponds to the planned pipe route is introduced into the earth by means of a tunnel boring machine. Such a media line sometimes runs at great depths. Directly following the tunnel boring machine, jacking pipes are lowered into the vertical shaft, installed, and subsequently jacked. In the process, the preceding pipes are pushed or driven forward by the pipes which follow. By use of this laying technique, excavation and trench filling after the pipes are laid are dispensed with, which for the first time allows laying at great depths. During such pipe jacking, large normal forces occur which must be absorbed by the pipe material. Conventional jacking pipes are typically made of concrete or reinforced concrete. These materials have sufficient stability to absorb the normal forces which occur. However, concrete-based pipes have only limited suitability for transporting some aggressive media. The aggressive media may attack the concrete material and thus impair the structural integrity of the jacking pipes.
DE 103 59 912 A1 relates to composite semi-finished products for all types of pipelines, wherein an inner pipe is made of plastic, and an outer pipe is made of metal and adhesive, or glass fiber with resin, or concrete. A coupling layer made of an appropriate plastic material, which is the same as that of the inner pipe and which absorbs electromagnetic radiation, and an adhesion-promoting layer is provided between the inner pipe and the outer pipe. A portion of the material of the adhesion-promoting layer is internally embedded in the material of the inner pipe, and a portion protrudes outwardly

in the direction of the outer pipe, so that the material of the outer pipe may be connected thereto.

The object of the present invention is to provide a jacking pipe, i.e., a pipe which may be laid during pipe jacking, which is suitable for transporting aggressive media and which may be manufactured and laid in a simple and cost-effective manner.

This object is achieved by a jacking pipe of the type mentioned at the outset, which according to the invention is characterized in that the inner pipe is formed by a fiber composite material, that the fiber composite material has at least one supporting layer which includes 50 wt-% to 80 wt-% of fibers that are wound in a circumferential direction and/or helically and also in multiple layers, and that the supporting layer includes 20 wt-% to 40 wt-% of matrix material based on reactive resin, that the fiber composite material has a radially outer surface layer which includes at least 70 wt-% of alkali-resistant reactive resin, in particular a substantially completely saturated reactive resin, and that the outer pipe made of concrete is cast onto the completely cured radially outer surface layer.

The jacking pipe according to the invention has the advantage that during pipe jacking, in the direction of advancement, i.e., in the longitudinal direction of the pipe, normal forces which occur are absorbed by the concrete outer pipe, while the inner pipe due to its composition provides high resistance to chemically induced material damage. The composition of the inner pipe also ensures that the inner pipe can absorb forces which act on the pipe in the laid state, in particular in the radial direction, even if the outer pipe fails or is damaged. An example of such a force is hydrostatic pressure, which is relevant for pipes laid at great depths. The inner pipe is therefore self-supporting in the laid state.

According to one preferred embodiment of the present invention, the supporting layer includes up to 20 wt-%, in particular 10 wt-% to 20 wt-%, of fibers, based on the weight of the supporting layer, which extend substantially along a longitudinal direction of the jacking pipe. A jacking pipe which includes fibers having this orientation has advantageous mechanical properties, and in particular normal forces, i.e., forces along the longitudinal direction, are absorbed by the inner pipe.

According to another preferred embodiment of the invention, the alkali-resistant reactive resin of the radially outer surface layer is a bisphenol A-based reactive resin, in particular a bisphenol A-based vinyl ester resin. Reactive resins of this type are particularly resistant to alkaline media. The radially outer surface layer of the inner pipe is in contact with the concrete outer pipe. Moisture has an alkaline effect on components of the concrete. With unsuitable reactive resins, this may result in a saponification reaction of the reactive resin. Such saponification leads to increased material damage of the inner pipe, which may impair the mechanical integrity of the inner pipe. Use of the mentioned reactive resins according to the invention reliably prevents such a saponification reaction.

It has also proven to be advantageous when the inner pipe includes ECR glass fibers. ECR glass fibers have particularly high chemical resistance.

According to the invention, the matrix material of the supporting layer is likewise a polyester resin. Use of a polyester resin allows cost-effective manufacture of the jacking pipe according to the invention.

The jacking pipe may advantageously have an additional layer, on an inner side of the supporting layer, which includes a resin, in particular a polyester resin, and a random fiber

fabric. This additional layer according to the invention provides further protection of the inner pipe from chemical-related material damage and mechanical stress due to the aggressive media transported in the jacking pipe. This prevents the supporting layer from being exposed to harmful influences.

It has also proven to be advantageous for the jacking pipe to have, in the area of a spigot end, at least one circumferential seal, in particular a sliding wedge seal or a rolling ring seal, which is situated circumferentially on a radially outer surface of the spigot end in the circumferential direction. Such a circumferential seal prevents leakage of the medium to be transported in the pipeline.

Within the meaning of the invention, a jacking pipe is also encompassed which has at least two circumferential seals in the area of a spigot end which are situated circumferentially on a radially outer surface of the spigot end in the circumferential direction at an axial distance from one another, so that an annular space is formed between the circumferential seals. Starting from the annular space, at least one test opening is advantageously provided which extends inwardly from the annular space and opens into an inner surface of the jacking pipe. The seal-tightness of the circumferential seals adjoining the annular space may be tested in the laid state via the test opening.

It is also advantageous for an end face of a spigot end and an end face of a butt-end edge of the jacking pipe to have an epoxy resin-based thin bed coating. This prevents material damage to the concrete outer pipe due to contact with the transported aggressive media.

Another preferred embodiment of the jacking pipe is characterized in that the fiber composite material has

interspersed particles, in particular interspersed mineral particles, which are visually detectable with respect to the fiber composite material, and in particular are black. These interspersed mineral particles according to the invention allow an automated inspection system to be oriented in order to inspect the laid pipe for damage, for example.

It has also proven to be advantageous when an inner surface of the jacking pipe is formed by a nonwoven-reinforced resin layer which includes at least 80 wt-% reactive resin, in particular polyester resin. This nonwoven-reinforced resin layer is particularly resistant to corrosive media.

Also within the meaning of the invention, the jacking pipe has a cylindrical sleeve, in particular made of steel, at a butt-end edge. This cylindrical sleeve assists with flush, coaxial laying of multiple jacking pipes to form a pipe string.

It has proven to be particularly advantageous when the sleeve is anchored in a form-fit manner in the outer pipe, preferably by casting a fastening element of the sleeve into the outer pipe.

It has also proven to be particularly advantageous when the inner surface of the inner pipe has a roughness, so that the inner surface has a coefficient of friction of at least 0.7. Such a roughness allows the use of automated mobile inspection systems in the jacking pipe, and provides a good grip for this purpose.

The coefficient of friction is determined on a plane having an adjustable, readable angle of inclination. The plane is formed from a plate which has the same design as the corresponding inner pipe. A test piece having a smooth surface made of Vulkollan 18 is placed on the plane. Vulkollan 18 is a polyurethane material from Bayer which is produced by polyaddition using only Desmodur 15, polyester polyol, and a

crosslinker. The angle of inclination of the plane is increased.

An angle of inclination at which the test piece begins to slide off the plane is measured. The coefficient of friction corresponds to the tangent of the angle of inclination at which the test piece begins to slide off the plane.

In one preferred embodiment, the outer pipe of the jacking pipe is manufactured using reinforced concrete. Using reinforced concrete for manufacturing the outer pipe allows large normal forces to be absorbed during the pipe jacking.

Within the meaning of the invention, a jacking pipe string is also encompassed which includes multiple coaxially extending jacking pipes according to the invention, in which, in a laid state, an end face of a butt-end edge of a first jacking pipe is situated at a distance from an end face of a spigot end of a second jacking pipe.

In one refinement of the jacking pipe string according to the invention, in the laid state a force transmission element, in particular a wooden disk, is situated in each case between the end face of the butt-end edge of the first jacking pipe and the end face of the spigot end of the second jacking pipe, and preferably situated only between the concrete outer pipes.

Using such a force transmission element allows jacking of the jacking pipe string according to the invention without damage, since due to the force transmission element, direct contact of the end faces of the spigot edge and the butt-end edge and an application of force on the inner pipe are avoided.

Further features, particulars, and advantages of the invention result from the accompanying patent claims, the illustrations in the drawings, and the following description of several preferred embodiments of the jacking pipe according to the

invention and the jacking pipe string according to the invention.

The drawings show the following:

Figure 1 shows a simplified schematic sectional view of a jacking pipe according to the invention;

Figure 2 shows an enlarged sectional view of a portion of the inner pipe from Figure 1;

Figure 3 shows a sectional view of a portion of another embodiment of a jacking pipe according to the invention; and

Figure 4 shows a schematic sectional view of a portion of a jacking pipe string.

Figure 1 shows a schematic sectional view, not to scale, of a jacking pipe 10 according to the invention. The jacking pipe 10 includes an inner pipe 12 made of a chemically resistant fiber composite material 13, and an outer pipe 14 made of concrete. A circumferential direction is denoted by reference numeral 16, and a longitudinal axis of the jacking pipe is denoted by reference numeral 18.

Figure 2 shows a detailed schematic illustration of an enlarged area of the inner pipe 12 from Figure 1. The fiber composite material 13 forming the inner pipe 12 has a multilayer construction. Viewed from an inner side 22 to an outer side 26, the fiber composite material 13, and thus also the inner pipe, is made up of a nonwoven-reinforced resin layer 30, an additional layer 34, wherein the nonwoven-reinforced resin layer 30 and the additional layer 34 include interspersed mineral particles 36 illustrated as dots, a first supporting layer 38, a filler layer 39, a second supporting layer 40, and a radially outer surface layer 42. The filler

layer includes sand which is embedded in a reactive resin matrix. However, the sand in such a filler layer 39 may also be replaced by other filler materials, in particular mineral filler materials. The interspersed mineral particles 36 may be contained in each of the layers 30, 34, 38, 39, 40, 42 of the fiber composite material 13. The interspersed mineral particles 36 are preferably contained at least in the nonwoven-reinforced resin layer 30 and/or the additional layer 34.

Figure 3 shows a spigot end 46 and a butt-end edge 50 of a jacking pipe 10. An end-face side 54 of the spigot end 46 has a thin bed coating 56. An end-face side 58 of the butt-end edge 50 has a thin bed coating 60. A cylindrical sleeve 64 is situated at the butt-end edge 50 of the jacking pipe 10. The cylindrical sleeve 64 is fastened via a fastening element 68 which is cast into the outer pipe 14. A first circumferential seal 72 and a second circumferential seal 73 extending in the circumferential direction 16 are situated in the area of the spigot end 46. An annular space 76 is formed between the circumferential seals 72, 73. A test opening 80 extends from the annular space 76 and opens into an inner surface 82 of the jacking pipe 10.

Figure 4 shows the connection of a first jacking pipe 10a to a second jacking pipe 10b to form a jacking pipe string 11 according to the invention. Corresponding reference numerals are based on the suffixes a or b for the respective pipes 10a, 10b. The butt-end edge 50a of the first jacking pipe 10a is in operative connection with the spigot end 46b of the second jacking pipe 10b. The spigot end 46b is introduced into the cylindrical sleeve 64a. A force transmission element 84 is situated between the thin bed coatings 58a, 54b of the two pipes 10a, 10b.

During the pipe jacking, the second pipe 10b pushes the first pipe 10a forward via the contact by means of the force

transmission element 84. In the laid state, medium to be transported flows through the pipe interiors 82a and 82b. In the process, the medium to be transported comes into contact with the inner pipes 12a, 12b and the thin bed coatings 58, 54.

The inner pipes 12a, 12b in combination with the thin bed coatings 58a, 54b, the circumferential seals 72b, 73b, and the cylindrical sleeve 64 prevent medium to be transported from coming into contact with the outer pipe 14. Material damage to the outer pipe 14 is prevented in this way.

Patentkrav

1. Tilgængeligt forpresningsrør (10), især til transport af aggressive medier, omfattende et indre rør (12) af et kemikaliebestandigt materiale og et ydre rør (14) af beton, **kendetegnet ved, at** det indre rør (12) er dannet af et fiberkompositmateriale (13),
at fiberkompositmaterialet (13) har mindst et bærende lag (38, 40), som omfatter 50 vægt-% til 80 vægt-% af fibre, som er viklet i en omkredsretning (16) og/eller skrueformet og også i flere lag, og
at det bærende lag (38, 40) omfatter 20 vægt-% til 40 vægt-% af matrixmateriale, som er baseret på reaktiv harpiks,
at fiberkompositmaterialet (13) har et radialt udvendigt overfladelag (42), som omfatter mindst 70 vægt-% af alkalibestandig reaktiv harpiks, især af en i det væsentlige fuldstændigt mættet reaktiv harpiks,
og at det ydre rør (14) af beton er påstøbt det fuldstændigt udreagerede radialt udvendige overfladelag (42).

2. Forpresningsrør (10) ifølge krav 1, **kendetegnet ved, at** det bærende lag (38, 40) baseret på vægten af det bærende lag (38, 40) omfatter op til 20 vægt-%, især 10 vægt-% til 20 vægt-% af fibre, som forløber i det væsentlige langs en langsgående retning af forpresningsrøret (10).

3. Forpresningsrør (10) ifølge krav 1 og/eller krav 2, **kendetegnet ved, at** den alkalibestandige reaktive harpiks af det radialt udvendige overfladelag (42) er en bisphenol-A-baseret reaktiv harpiks, især en bisphenol-A-baseret vinylesterharpiks.

4. Forpresningsrør (10) ifølge et eller flere af de foregående krav, **kendetegnet ved, at** det indre rør (12) omfatter ECR-glas-fibre.

5. Forpresningsrør (10) ifølge et eller flere af de foregående krav, **kendetegnet ved, at** det bærende lags (38, 40) matrixmateriale er en polyesterharpiks.

6. Forpresningsrør (10) ifølge et eller flere af de foregående krav, **kendetegnet ved, at** fiberkompositmaterialet (13) på en indvendig side af det bærende lag (38, 40) har et yderligere lag (34), som omfatter en polyesterharpiks og en fladestruktur af tilfældigt orienterede fibre.

7. Forpresningsrør (10) ifølge et eller flere af de foregående krav, **kendetegnet ved, at** det i området ved en spids ende (46) har mindst en omkredstætning (72, 73), især en glidekiletætning eller en rulleringtætning, som i omkredsretningen (16) er anbragt omløbende på en radialt udvendig overflade af den spidse ende (46).

8. Forpresningsrør ifølge et eller flere af de foregående krav, **kendetegnet ved, at** det i området ved en spids ende (46) har mindst to omkredstætninger (72, 73), som i omkredsretningen (16) er anbragt omløbende på en radialt udvendig overflade af den spidse ende (46) i en aksial afstand i forhold til hinanden, således at der mellem omkredstætningerne (72, 73) er dannet et ringrum (76), og at der er tilvejebragt mindst en kontrolåbning (80), som strækker sig indad fra ringrummet (76) og udmunder i en indvendig overflade (22) af forpresningsrøret (10).

9. Forpresningsrør (10) ifølge et eller flere af de foregående krav, **kendetegnet ved, at** en endeflade (54) af en spids ende (46) og en endeflade (58) af en stump ende (50) har en tyndlagsbelægning (56, 60) baseret på epoxidharpiks.

10. Forpresningsrør (10) ifølge et eller flere af de foregående krav, **kendetegnet ved, at** fiberkompositmaterialet (13) har indstrygninger (36), især mineralske indstrygninger (36), som kan detekteres optisk i forhold til fiberkompositmaterialet (13), og især er sorte.

11. Forpresningsrør (10) ifølge et eller flere af de foregående krav, **kendetegnet ved, at** en indvendig overflade af forpresningsrøret (10) er dannet af et non-woven-forstærket harpikslag (30), som omfatter mindst 80 vægt-% reaktiv harpiks, især polyesterharpiks.

12. Forpresningsrør (10) ifølge et eller flere af de foregående krav, **kendetegnet ved, at** det ved en stump ende (50) har en cylindrisk manchet (64), især af stål.

13. Forpresningsrør (10) ifølge krav 12, **kendetegnet ved, at** manchetten (64) er formsluttende forankret i det ydre rør (14), fortrinsvis at et fastgørelseselement (68) af manchetten (64) er støbt ind i det ydre rør (14).

14. Forpresningsrør (10) ifølge et eller flere af de foregående krav, **kendetegnet ved, at** en indvendig overflade af det indre rør (12) har en ruhed, således at den indvendige overflade har et friktionstal på mindst 0,7.

15. Forpresningsrørstreng (11), som omfatter mindst to koaksialt forløbende forpresningsrør (10) ifølge et eller flere af de foregående krav, **kendetegnet ved, at** en endeflade (58) af en stump ende (50) af et første forpresningsrør (10) i en lagt tilstand er anbragt i afstand fra en endeflade (54) af en spids ende (46) af et andet forpresningsrør (10), et kraftoverføringselement (84) er anbragt mellem endefladen (58a) af den stumpe ende (50a) af det første forpresningsrør (10a) og endefladen (54b) af den spidse ende (46b) af det andet forpresningsrør (10b), især i området ved de ydre rør (14a,b) af det første forpresningsrør (10a) og det andet forpresningsrør (10b).

Fig. 1

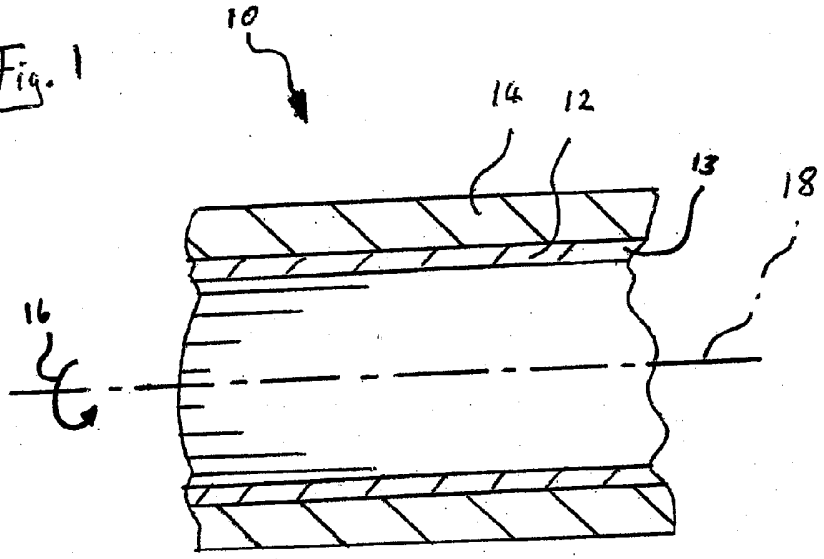


Fig. 2

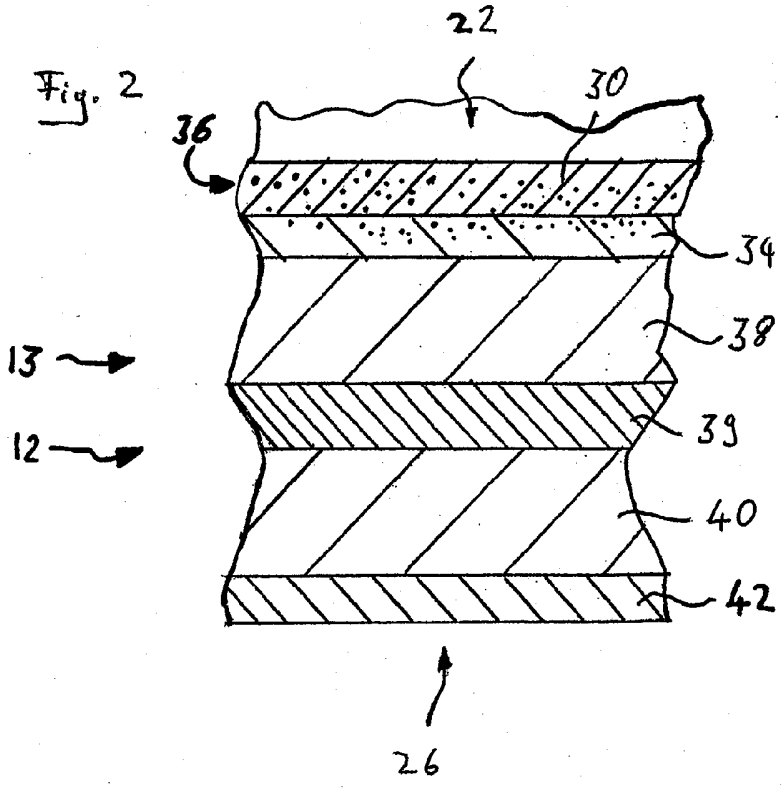


Fig. 3

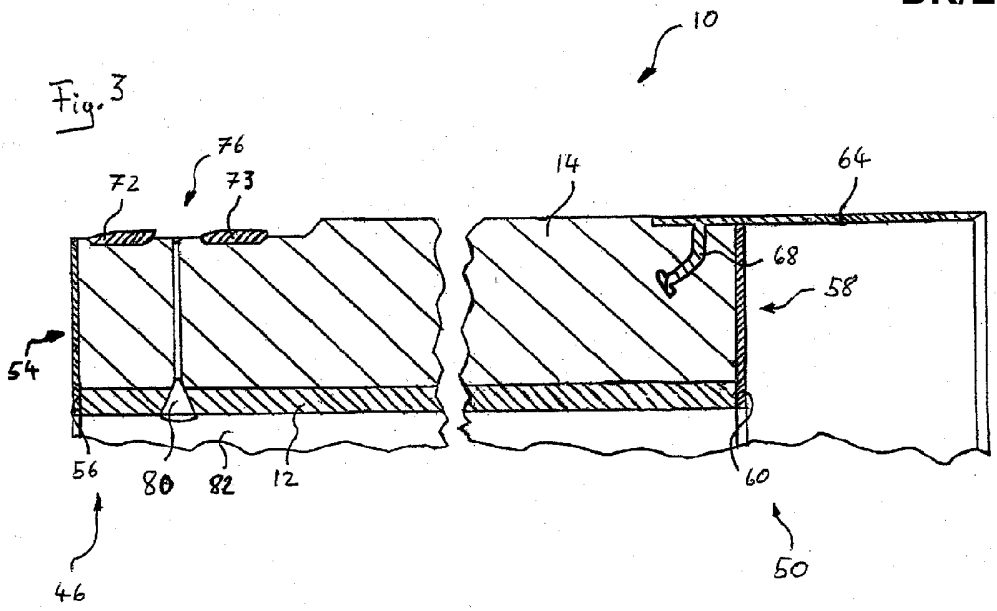
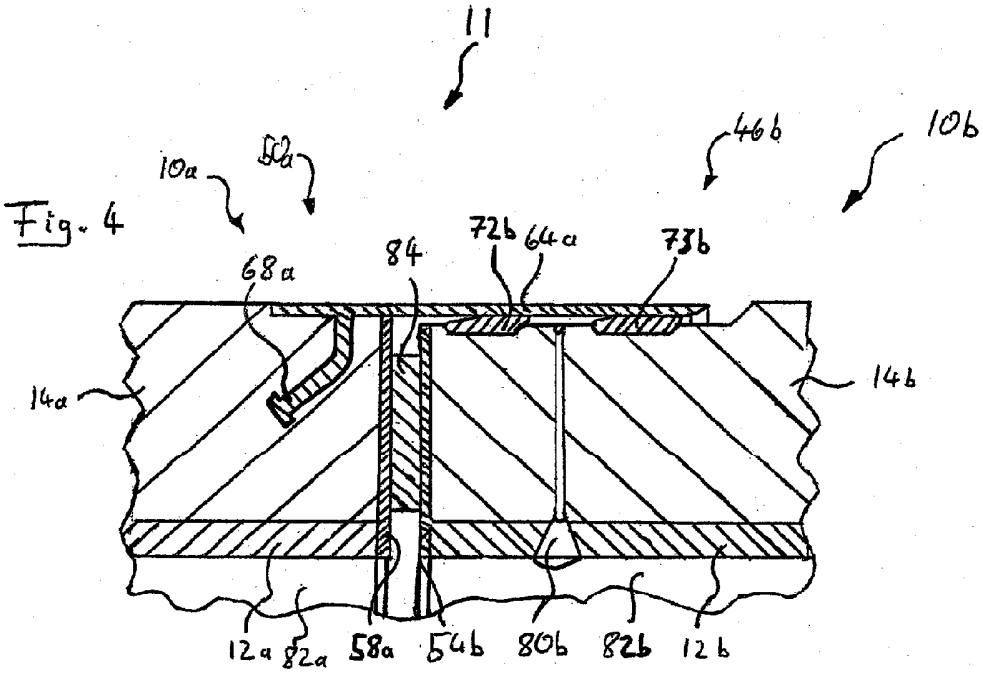

10
76
72
73
14
64
68
58
54
56
80
82
12
60
50
46

Fig. 4


11
46b
10b
10a
58a
72b
64a
73b
84
68a
14a
14b
12a
82a
58a
54b
80b
82b
12b