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(54) **Expandable sleeve**

(57) An expandable sleeve for use in a well, comprises a tubular structure including an external sealing layer (10) comprising a compliant material; an intermediate expandable tubular body (12) made from a plastically deformable material; and an internal spring structure (14) such as a helically wound spring; wherein the external sealing layer is disposed on the outer surface of the tu-

bular body, and the internal spring structure is disposed inside the tubular body and acts so as to exert a radial force on the body when in an expanded state. Such a sleeve can be used to seal off perforations (18), and in well completions using slotted liners or in drilling applications.

Description

Technical field

[0001] This invention relates to an expandable sleeve of the type that are generally used for lining oil or gas wells.

Background art

[0002] Expandable sleeves have been known for some time in the oil and gas industry as a technique for lining and stabilising wells for the production of fluids. In use, the sleeve is introduced into the well in a contracted form and then expanded until it contacts the wall of the well bore. Expansion can be achieved by a number of means, including inflation with compressed fluid or cold working with a mandrel or rotating expansion tool. The advantages of expandable sleeves (sometimes called 'expandable tubulars' or just 'expandables') are well known. In cased wells, expandables can be used to shut off perforations or close other holes in the casing. In open hole, expandables can be used to stabilise the well. Expandables have also been used to shut off perforations in steam injection wells as is discussed in US 2003015246 A. One approach to sealing off perforations described in this document is the use of a sealing sleeve comprising a cylindrical steel portion with rubber-like gasket material bonded on the outer surface of the steel sleeve. Certain problems are identified with such a construction. Another approach to sealing such perforations that is stated as addressing these problems is the use of a spirally wound metal patch. Upon deployment, the patch unwinds within the wellbore and seals the perforation in the casing wall. Spring tension tends to keep the patch securely fixed over the perforation.

[0003] Where the expandable consists of a steel tube that is expanded, the steel undergoes plastic deformation in order to provide the increase in diameter required. However, even though plastic deformation will have taken place, the steel retains some elasticity and so may relax following removal of the mandrel or expanding tool after expansion. This relaxation may be sufficient to compromise the seal against the perforations or wellbore.

[0004] The present invention aims to mitigate the effect of such relaxation.

Disclosure of the Invention

[0005] A first aspect of the invention comprises an expandable sleeve for use in a well, comprising a tubular structure including:

- an external sealing layer comprising a compliant material;
- an intermediate expandable tubular body made from a plastically deformable material; and
- an internal spring structure;

wherein the external sealing layer is disposed on the outer surface of the tubular body, and the internal spring structure is disposed inside the tubular body and acts so as to exert a radial force on the body when in an expanded state.

[0006] Preferably, the internal spring structure comprises a helically wound spring. In a particularly preferred construction, the spring comprises a helically wound wire of rectangular section.

[0007] The spring can be provided with formations that resist compression, for example, inter-engaging teeth formed on adjacent edges of the spring windings.

[0008] The tubular body is typically formed from solid metal such as steel.

[0009] To assist in achieving good expansion ratios for the sleeve, the tubular body can have a corrugated structure prior to expansion.

[0010] The external sealing layer is preferably natural or synthetic rubber.

[0011] A second aspect of the invention comprises a method of installing an expandable sleeve according to the first aspect of the invention in a well, comprising:

- lowering the sleeve in an unexpanded form into the well; and
- expanding the sleeve such that the external layer engages the wall of the well.

[0012] In one embodiment, the internal spring is installed in the tubular body in a compressed state prior to lowering the sleeve into the well.

[0013] Another embodiment comprises lowering the tubular body into the well and lowering the spring into the tubular body after it has been lowered into the well. In this case, the spring can be lowered into the tubular body after the tubular body has been expanded.

[0014] By providing the internal spring structure, the tendency of the tubular body to relax is resisted. Also, the spring can provide mechanical support allowing potentially thinner material to be used.

[0015] The invention also comprises a method of completing a well, comprising installing a completion string including at least one sleeve according to the invention in the well.

[0016] Preferably, the completion string comprises an array of slotted liners having sleeves dispersed at various locations along the array.

[0017] In one embodiment, the sleeves are expanded on installation of the completion. In another embodiment, one or more of the sleeves is expanded after installation to allow production management operations to be performed in the region between the expanded sleeves.

[0018] At least one further sleeve can be installed between adjacent expanded sleeves in the completion string to isolate that region.

[0019] Sleeves according to the invention can also be used during drilling operations to stabilise the formation being drilled.

Brief description of the drawings

[0020] Figure 1 shows a horizontal section through a sleeve according to an embodiment of the invention in a well;

Figure 2 shows a part vertical section of the sleeve of Figure 1;

Figure 3 shows a part exploded view of the sleeve of Figures 1 and 2;

Figure 4 shows a horizontal section through a corrugated sleeve according to a further embodiment of the invention;

Figure 5 shows a sleeve with axial reinforcement;

Figure 6 shows a wireline conveyed expansion tool for use with sleeves according to the invention;

Figure 7 shows a well completion using expandable sleeves according to an embodiment of the invention;

Figure 8 shows the use of an expandable sleeve according to an embodiment of the invention to isolate a water producing region of a completion as shown in Figure 6; and

Figure 9 shows a well completion with length compensation sections.

Mode(s) for carrying out the invention

[0021] Expandable sleeves in accordance with the invention are particularly useful in wells such as oil and gas wells. They can be applied during the well construction process to stabilise the formation through which the well is drilled, or after completion to repair damage or to seal off perforations that are producing unwanted fluids. Other uses will be apparent.

[0022] Referring to Figures 1-3, the embodiment of the invention shown comprises a sleeve constructed in three layers: an outside layer 10, and intermediate layer 12 and an internal layer 14. In Figures 1-3, the sleeve is installed in a well that has been completed with a steel casing 16 secured in the well by cement 17 to provide zonal isolation and physical support. Communication with the producing formation 19 is via perforations 18 formed through the casing in the usual manner.

[0023] The outside layer 10 comprises a thin layer of a sealing compound such as natural or synthetic rubber. The exact material will be selected according to the physical and chemical environment to which the sleeve will be selected. The principal function of this layer is to provide a seal between the sleeve and the wall outside. The outside layer 10 is pressed against the borehole wall (either open formation or previously installed tubular such as a casing 16) by the other layers of the sleeve.

[0024] The intermediate layer 12 is a thin solid layer. It is typically could be made of metal such as steel of from 1 to 3 mm thickness (larger thicknesses may be used according to requirements). The intermediate layer 12 ensures proper uniform compression of the outside rub-

ber layer 10 against the external wall of the well or casing 16. The thickness of the intermediate layer 12 is a compromise between the need to for it to deform easily during the expansion operation, while still being able to support the internal well over-pressure, without being extruded into holes in the well wall or tubular 16 such as perforation 18 or slots.

[0025] The internal layer 14 is a spring device 20 that provides elastic expansion of the sleeve against the well wall after the expanding tool (not shown) has finished the expansion process. Furthermore, this structure resists potential collapse of the intermediate layer 12 when an external pressure is being applied onto the sleeve system.

[0026] As is shown more clearly in Figure 2, the primary seal is provided by the rubber outside layer 10 which is pressed against the perforated tubular 16 by the expansion force of the thin intermediate metal layer 12 reinforced by the radial force generated by the energizer spring 20.

[0027] The energizer spring 20 can be an helical spring made of an wound thick wire of a rectangular section. The rectangular wire section allows a smooth contact between the outer surface 22 of the spring 20 and the intermediate thin metal layer 12.

[0028] This spring 20 is used to generate a radial expansion to push the sleeve against the well wall.

[0029] One method of constructing a spring for this application is to start for a tube of an elastic metal. This tube should be slightly too large to enter in the well (especially if the thicknesses of the rubber outer layer 10 and thin metal intermediate layer 12 are taken into account). The metal tube is then cut following a spiral line to form the spring helix. To install the spring, it is necessary to reduce its diameter: for this action, an axial force is applied to stretch the helicoidal structure (to separate the coils) then a torque is applied to reduce the helix diameter.

[0030] This spring 20 can have a number of functions when installed in the well in the sleeve. For example, the spring 20 can ensure that the intermediate metal layer 12 is maintained in a cylindrical shape after its plastic deformation in the expansion process. This can be particularly useful if the sleeve was initially vertically corrugated prior to expansion as is shown in Figure 4.

[0031] The spring 20 can also act to reinforce the sealing effect of the outer rubber layer 10 against the well wall (either open-hole well-bore or the perforated casing 16, or the slotted liner, or any other metal tubular). The extra energization may be useful because the intermediate metal layer 12 has been plastically deformed against the well-wall: when the mechanical force applied for this deformation (expansion) is removed, the intermediate metal layer 12 will relax slightly due to the elastic property of the metal.

[0032] The spring 20 will act to support the sleeve when external pressure from the formation is applied. On its own, the relatively thin intermediate layer 12 would have tendency to collapse, as it is thin and typically not fully

cylindrical after its plastic expansion against the well wall.

[0033] When installed in the well, the spring 20 can provide a reserve of potential energy, so that the sealing effect of the out rubber layer 10 can be maintained and re-adjusted in case of slight movement either of the sleeve or the wall. Such movement may occur due to thermal and pressure variation, or due to some slight displacement of the structure relative to the wall. Such movement can occur in open-hole situations, as the wall itself may move due to change in fluid wetting or subsidence effects.

[0034] It is particularly preferred that the spring 20 is designed for a locking effect after installation. This effect can be achieved by friction between the spring 20 and the inner wall of the intermediate layer 12, or by a ratchet effect created by the structure of the edges of the coils of the spring 20. For example, the helicoidal cut used to make the spring can be in the form of a toothed line so that the teeth on adjacent parts of the coils interact and lock the spring in place. The locking effect is preferably directional, so that the spring can expand but retraction is resisted by the interlocking formations.

[0035] The spring may be installed in the sleeve in a number of ways. In some cases, the spring may be lowered into the well directly with the intermediate and outer layers as a single unit, with the spring in its compressed state. Such an approach can apply particularly when the sleeve expansion ratio is limited. However, when large sleeve expansion ratios are envisaged (particularly when a corrugated structure is used to provide a greatly reduced starting diameter), it may be easier to install the spring after the intermediate and outer layers have been installed and expanded. In such a case, the expandable structure may be installed and expanded in a first run of a setting tool and the spring installed after expansion by a second run of a setting tool.

[0036] The basic sleeve according to one embodiment of the invention includes a intermediate thin layer 12. Typically, this is initially cylindrical. While this layer is usually metal, other materials capable of easy plastic deformation are also possible. This layer will be plastically deformed to the final diameter, by a mechanical device which generates a radial expansion. Starting with a cylindrical intermediate layer, the expansion is limited typically to 20 % - 30%. Expansion is limited by the intrinsic properties of the material of the intermediate layer. For larger expansion ratios, the intermediate metal layer may need to be corrugated prior to installation as is shown in Figure 4.

[0037] The intermediate layer can be optimised for minimizing the force required for expansion. One approach is to use a slightly corrugated sleeve with corrugations of relatively small depth and relatively but short in circumferential extent (small wavelength pattern) so that many corrugations can be formed over the circumference. Such small but numerous corrugations allows extension of the sleeve under a relatively small force. However, the maximum extension may be limited. The

use of a corrugated sleeve allows the energizer spring to act more freely to apply the sleeve against the wall. When the corrugations are axial, they may also provide some support over perforations, so that internal pressure does not extrude the thin intermediate layer into the perforations.

[0038] In case of open-hole application, the small numerous corrugation sleeve may be replaced by a small numerous dimples sleeve. With this sleeve, the wavy pattern is available for all direction, so that the sleeve can comply to more type of deformation of the open-hole surface.

[0039] A sleeve according to the invention can be used in the role of an external casing packer (ECP) or a liner packer. In this role, the sleeve is installed as a special tubular between either screen sections or slotted liners, during the installation of the completion. The sleeve is handled and installed as the other elements of the completion. Used in such an application, the sleeve will typically have certain characteristics, including:

- a sleeve diameter similar to that of the screens or slotted liners;
- connections provided at both ends of the sleeve, similar to the screens or liners.
- axial load and torque strength similar to the screens or slotted liners; and
- a length adapted to the particular field needs (typically recommended to be longer than 3 meters to ensure sufficient sealing after expansion).

[0040] When compared to a conventional ECP, the expandable sleeve according to the invention is more simple, as the control and setting mechanisms can be contained in a wireline setting tool. Compared to an ECP, the expandable sleeve has the advantage of not being susceptible to leaks in the packer element (which, when they appear in an ECP prohibit proper setting).

[0041] The expandable sleeve according to the invention contains its "reserve" of potential energy to adapt its seal when required due to small movement of the formation or the device itself. Such adaptation is not possible with a conventional ECP.

[0042] For an ECP-like application, the sleeve is preferably initially cylindrical and expanded to final diameter by plastic deformation (typically less than 20 %). In such a case, the intermediate layer preferably is able to support the weight of the completion while running in the hole. However, if this layer has insufficient strength to support this axial load, a slotted liner sleeve may be added at the inside the intermediate layer and attached to both end of the expandable sleeve as is shown schematically in Figure 5. The cuts in the slotted sleeve 23 are parallel to the axis of the tubular so that relatively high axial loads can be supported, while relatively little effort is required during radial expansion.

[0043] For this application, the spring may have to generate a relatively high radial force to deform the interme-

diate layer (as it may be relatively thick). Consequently, a thick helicoidal spring may have to be forced into place with a high axial load. Extreme axial loads can be achieved by hammering axially onto the spring in-situ.

[0044] In an ECP-like application, it is not necessary that the sleeve be expanded initially. Production may start without expansion. The expansion would be performed only when fluid management is required. This situation may be particularly preferable if the length of the sleeve is large compared to the total length of the completion; with the non-expanded situation, production may be provided in front of the none-expanded sleeve.

[0045] Another application of sleeves according to the invention is in the domain of through-tubing fluid shut-off. The expansion of metal is typically less than 30% in the plastic domain, but for some applications, larger expansion may be required. In the case of perforation shut-off, the sleeve may need to be lowered through the production tubing to enter the well, and then expanded to the casing. In this application, the required expansion may be up to three-fold. To achieve this large ratio, a corrugated sleeve such as that shown in Figure 4 may be used. The intermediate layer may need to be relatively thin as large bending deformation is required. The rubber outer layer may also be of variable thickness in the corrugated shape, so that it has a uniform thickness after expansion into a cylindrical shape. Typically, it is thinner at the tip of the corrugation, and thicker at the recess part of the corrugation.

[0046] This sleeve may have a retraction effect after setting, trying to move elastically to its initial shape (usually only by a small percentage of the deformation). To avoid this retraction, the inside layer provided, for example, by the energizer spring is required. The length of the sleeve can be selected depending of the length of entry port (perforation, slots) to be sealed.

[0047] When installed over slotted liner or screens, the water shut-off sleeve should extend across a perforated/slotted section and reach the adjacent sections without perforations or slots. Furthermore, these adjacent sections need to seal in the outside annulus.

[0048] For these and other applications, once the sleeve has been lowered to the proper depth in the well, it must be expanded. One way in which this expansion can be performed is by use of a wireline expansion tool such as is shown in Figure 6. It is common that installation of expandable sleeves may have to take place in a well that is lined with a casing 16 and has production tubing 24 secured therein by means of a packer 26. Consequently, the expansion tool 28 will be dimensioned to pass through production tubing. The sleeve 30, preferably in corrugated form, is located on the expansion tool 28 and the two are positioned together in the well prior to expansion of the sleeve, after which the tool 28 is withdrawn.

[0049] The expansion tool ensures the cold forming of the sleeve to its final diameter, pressing the sleeve against the well wall. Various expanding processes can

be used:

- Use of a set of rollers that rotates inside the sleeve with a slow vertical displacement.
- Use of a cone, which is forced axially inside the sleeve. This cone has to expand the diameter of the sleeve in order for it to pass through. The contact between the cone and the sleeve could be via rollers.

[0050] In some applications, it may be necessary to retrieve a sleeve that has been installed within a completion for production management (or treatment management). For this application, it may be necessary to retrieve the energizing spring must first. Therefore, the spring design may be adapted for this requirement:

- For example, both ends of the spring may be equipped with easy to connect termination, so that the wireline tool can connect to it and apply torque and tensile load to make the overall diameter of the spring shrink to its original dimension. Then the spring is maintained in the retracted shape and returned to surface. The termination could for example be rolled towards the inside of the bore to approximately 180 deg (and in a small radius).
- Another connection technique is to equip both ends of the spring with small holes to allow a finger on the recovery tool to connect and apply the retraction load.
- Another alternative is to push the spring out of the sleeve and leave it in the well below (or above the sleeve).

[0051] Following this, there are several techniques for removal of the sleeve:

- Make a axial cut in the sleeve, so that it can rolled on itself and removed out of the well.
- Use a sleeve with an axial weak line. Thanks to the weak-line, the sleeve can be stripped away from the wall. After being stripped, the sleeve can be rolled as in the solution proposed above. The weak line can be provided by the construction of the sleeve which can be formed by rolling a sheet and welding it as a cylinder. The weld can be made fragile (especially when the proper force is being applied). One way to achieve the weak weld is to use a band which is "glued" or spot-welded on to the extremities of the intermediate layer to form a joint to create the tubular form. To break the sleeve, the lower end of the band is grabbed by the recovery tool, for example by a hook; the recovery tool can then pull the band away.

[0052] Another application of expandable sleeves according to the invention is as replacement for packer (ECP) as is shows schematically in Figure 7. The expandable sleeves 30 are installed as completion tubulars

between screens or slotted liners 32, for example in a horizontal section of a well 34. Multiples sleeves 30 can be installed in one completion string (possibly as many as 100 in a long horizontal well). The completion (typically also comprising the slotted liners 32) is installed at the desired depth. An expansion tool is lowered to the end of the completion, and then pulled to the last sleeve (already in place with the completion) which needs expansion. The expansion tool ensures all the expansion of all sleeves in one single run in the hole. After the expansion of all of the sleeves 32, the contact with the reservoir is compartmented.

[0053] Thanks to the compartmentalisation, it is possible to control water production by isolating any sections producing water, for example section 36 in Figure 7, while leaving the remaining sections 38 open to produce oil. This isolation can be performed by installing another expandable sleeve for internal bore use as is shown schematically in Figure 8. This sleeve 40 is sized to extend over the distance between two successive completion sleeves 30 to ensure isolation of the water producing section 36.

[0054] Isolation of the water producing sections can be performed either at the beginning of the production phase (if the well passes through zones producing water and oil) or when the problem starts (for example when the oil water contact moves as the reservoir becomes depleted).

[0055] In another version of this application, expansion of the sleeves 30 of the completion is not performed at the time the completion is installed. In this case the sleeves 30 are expanded only when water entry occurs. A further modification of this approach is to only expand the sleeves 30 at both ends of the water-producing section 36. This can give more flexibility for the operation, while ensuring maximum producing contact with the reservoir.

[0056] Another application for the invention can be for length compensation following expansion as is shown in Figure 9. The expanded sleeve has a shorter length after expansion. As first approximation, the sleeve typically shrinks in length at the same percentage as it has been expanded. For example, a 5 meter sleeve expanded by 10% in diameter could shrink in length by 0.5 meter.

[0057] When multiple sleeves are installed in the completion, problems may occur when the sleeves are not expanded in the successive order. For a completion equipped with three or more expandable sleeves (see Figure 9), if sleeves 30' at the extremities are expanded first, the screens (or tubulars) 30 between them are normally in a neutral state. When a sleeve 30 in the middle is expanded, shrinkage occurs in length, generating a tensile load on the whole tubular completion. To avoid this situation, the intermediate expandable sleeve 30 can be equipped with a "length-compensation" tubular 42. When the intermediate sleeve shrinks its length, this section of compensation tubular extends under low axial load.

[0058] The length compensation tubular section 42 can be made of circumferentially corrugated pipe (bellows shape). It can also be made of pipe with a spiral deformation (such as a thread). This shape allows axial deformation under load. Such a structure may be limited in axial load capability. For this purpose, the length compensation tubular may need axial reinforcement to support the maximum weight of the completion. If present, any axial load member providing such reinforcement needs to be deactivated before starting the expansion of the neighbouring expandable sleeve, so that length compensation can be performed by the compensation sleeve. The deactivation of the axial reinforcement members of the length compensation sleeve can be obtained at the beginning of the expansion process by cracking links radially, for example by local radial deformation of the reinforcement members. This can be achieved by the radial expansion device used to expand the sleeve. Alternatively, a latch system can be disengaged radially to free this axial reinforcement system.

[0059] During drilling operations, certain formations may be encountered that can give rise to problems if left untreated while drilling continues. In some case, these formation may be mechanically fragile or unconsolidated, or chemically reactive with the drilling fluid, or fractured so as to lead to high fluid loss. An insulating sleeve according to the invention can be installed over the problematic zone and drilling may continue. To avoid loss of well diameter after the sleeve installation, it may be desirable to under-ream the well bore before the sleeve installation. The sleeve is then lowered with the expansion tool. The sleeve is expanded over the under-reamed section.

Claims

1. An expandable sleeve for use in a well, comprising a tubular structure including:

- an external sealing layer comprising a compliant material;
- an intermediate expandable tubular body made from a plastically deformable material; and
- an internal spring structure;

wherein the external sealing layer is disposed on the outer surface of the tubular body, and the internal spring structure is disposed inside the tubular body and acts so as to exert a radial force on the body when in an expanded state.

2. A sleeve as claimed in claim 1, wherein the internal spring structure comprises a helically wound spring.
3. A sleeve as claimed in claim 2, wherein the spring comprises a helically wound wire of rectangular sec-

- tion.
4. A sleeve as claimed in claim 2 or 3, wherein the spring is provided with formations that resist compression. 5
 5. A sleeve as claimed in claim 4, wherein the formations comprise inter-engaging teeth formed on adjacent edges of the spring windings. 10
 6. A sleeve as claimed in any preceding claim, wherein the tubular body is formed from solid metal.
 7. A sleeve as claimed in claim 1, wherein the tubular body has a corrugated structure prior to expansion. 15
 8. A sleeve as claimed in any preceding claim, wherein the external sealing layer is natural or synthetic rubber. 20
 9. A sleeve as claimed in any preceding claim, further comprising an axial reinforcement structure for supporting axial load on the sleeve.
 10. A sleeve as claimed in claim 9, wherein the axial reinforcement structure is provided by a further layer located inside the intermediate layer and attached at the extremities of the sleeve. 25
 11. A method of installing an expandable sleeve as claimed in any preceding claim in a well, comprising: 30
 - lowering the sleeve in an unexpanded form into the well; and
 - expanding the sleeve such that the external layer engages the wall of the well. 35
 12. A method as claimed in claim 11, wherein the internal spring is installed in the tubular body in a compressed state prior to lowering the sleeve into the well. 40
 13. A method as claimed in claim 11, comprising lowering the tubular body into the well and lowering the spring into the tubular body after it has been lowered into the well. 45
 14. A method as claimed in claim 13, comprising lowering the spring into the tubular body after the tubular body has been expanded. 50
 15. A method of completing a well, comprising installing a completion string including at least one sleeve as claimed in any of claims 1-10 in the well.
 16. A method as claimed in claim 15, wherein the completion string comprises an array of slotted liners having sleeves as claimed in any of claims 1-10 dispersed at various locations along the array. 55
 17. A method as claimed in claim 16, wherein the sleeves are expanded on installation of the completion.
 18. A method as claimed in claim 16, wherein one or more of the sleeves is expanded after installation to allow production management operations to be performed in the region between the expanded sleeves.
 19. A method as claimed in claim 17 or 18, further comprising installing at least one further sleeve as claimed in any of claims 1-10 between adjacent expanded sleeves in the completion string to isolate that region.
 20. A method as claimed in any of claims 16-19, further comprising associating axially deformable sections with at least some of the expandable sleeves so as to compensate for changes in length of the completion string on expansion of sleeves.
 21. A method as claimed in claim 20, wherein the axially deformable sections comprise circumferential or helical corrugations.
 22. The use of a sleeve as claimed in any of claims 1-10 during drilling operations to stabilise the formation being drilled.

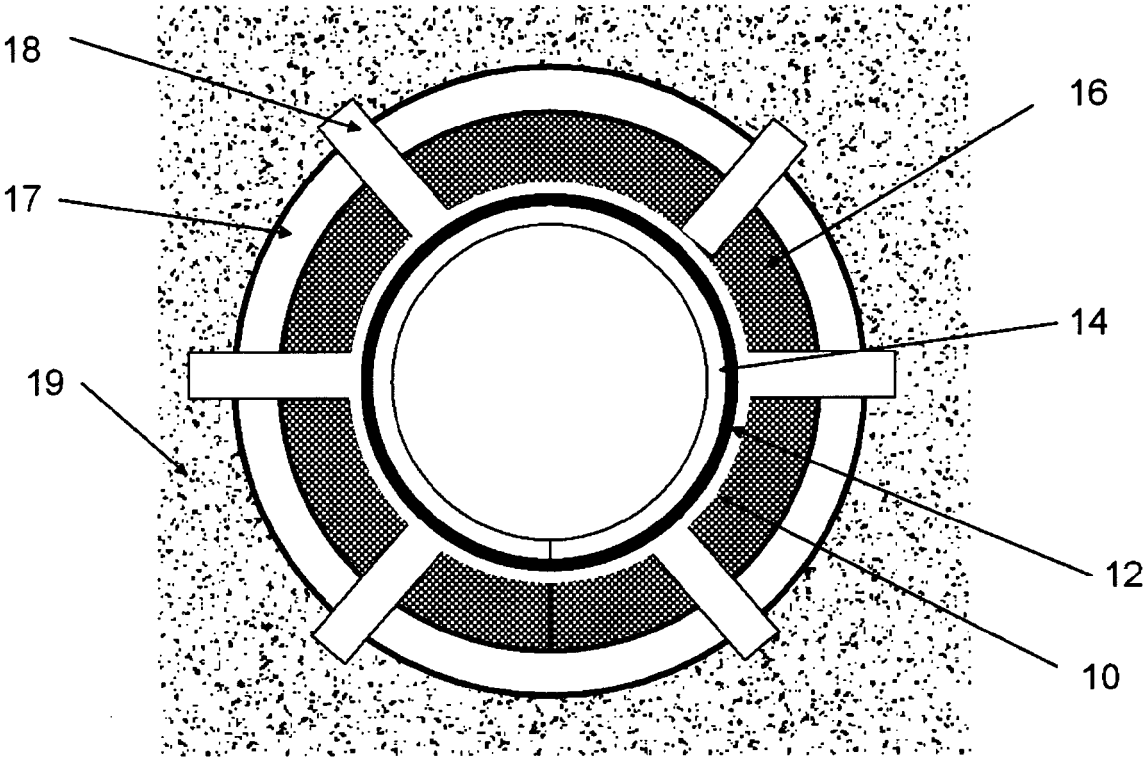


Fig. 1

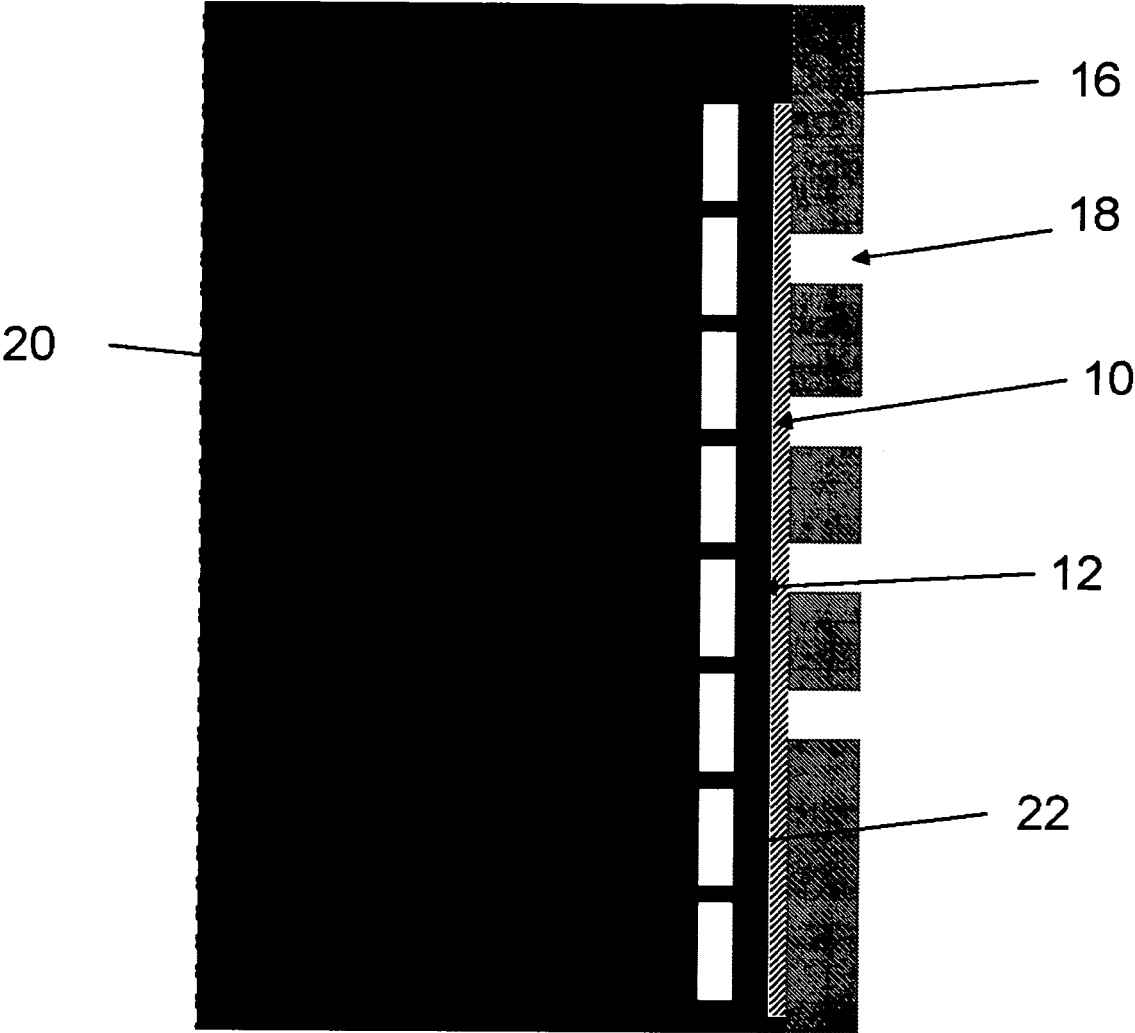


Fig. 2

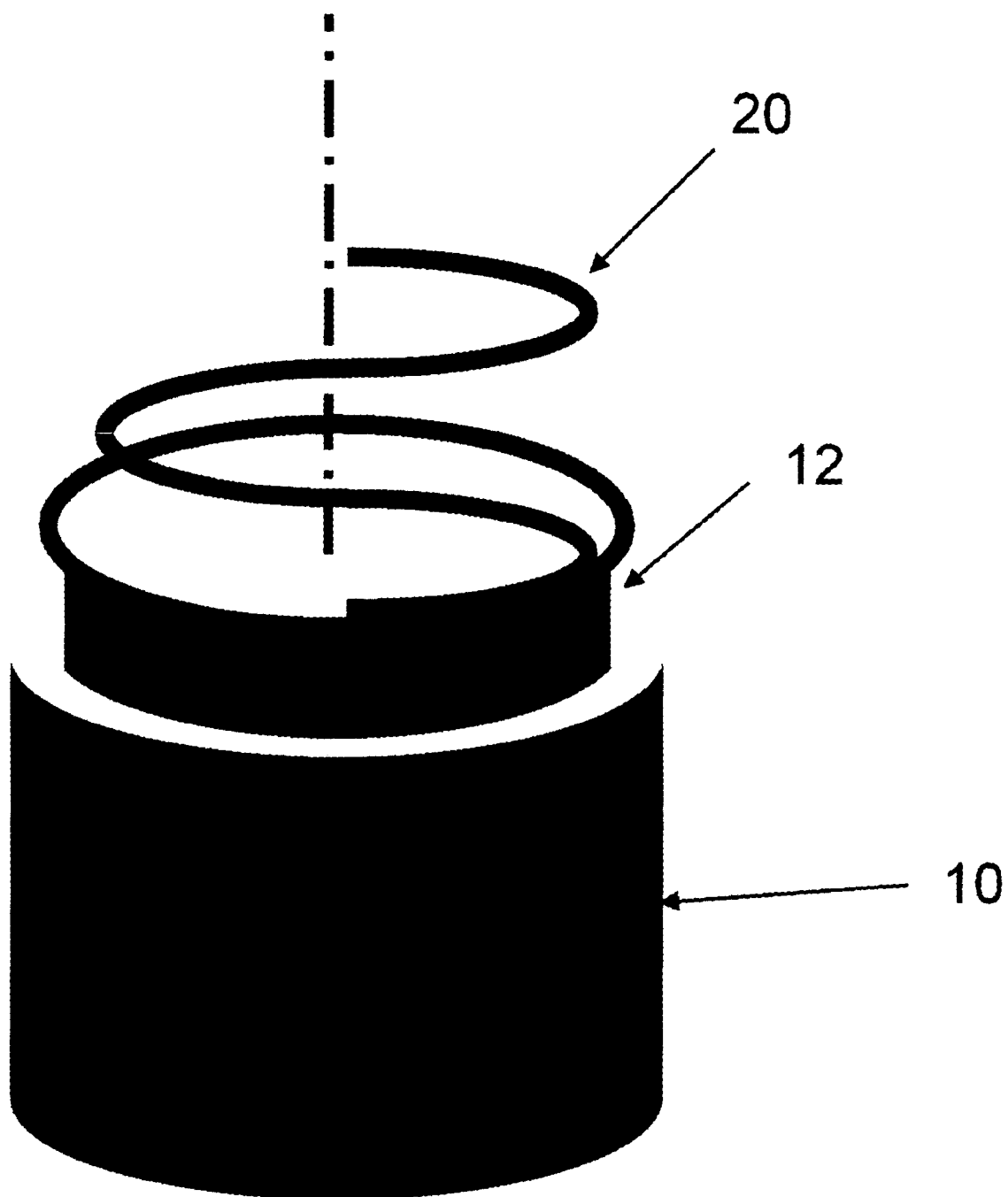


Fig. 3

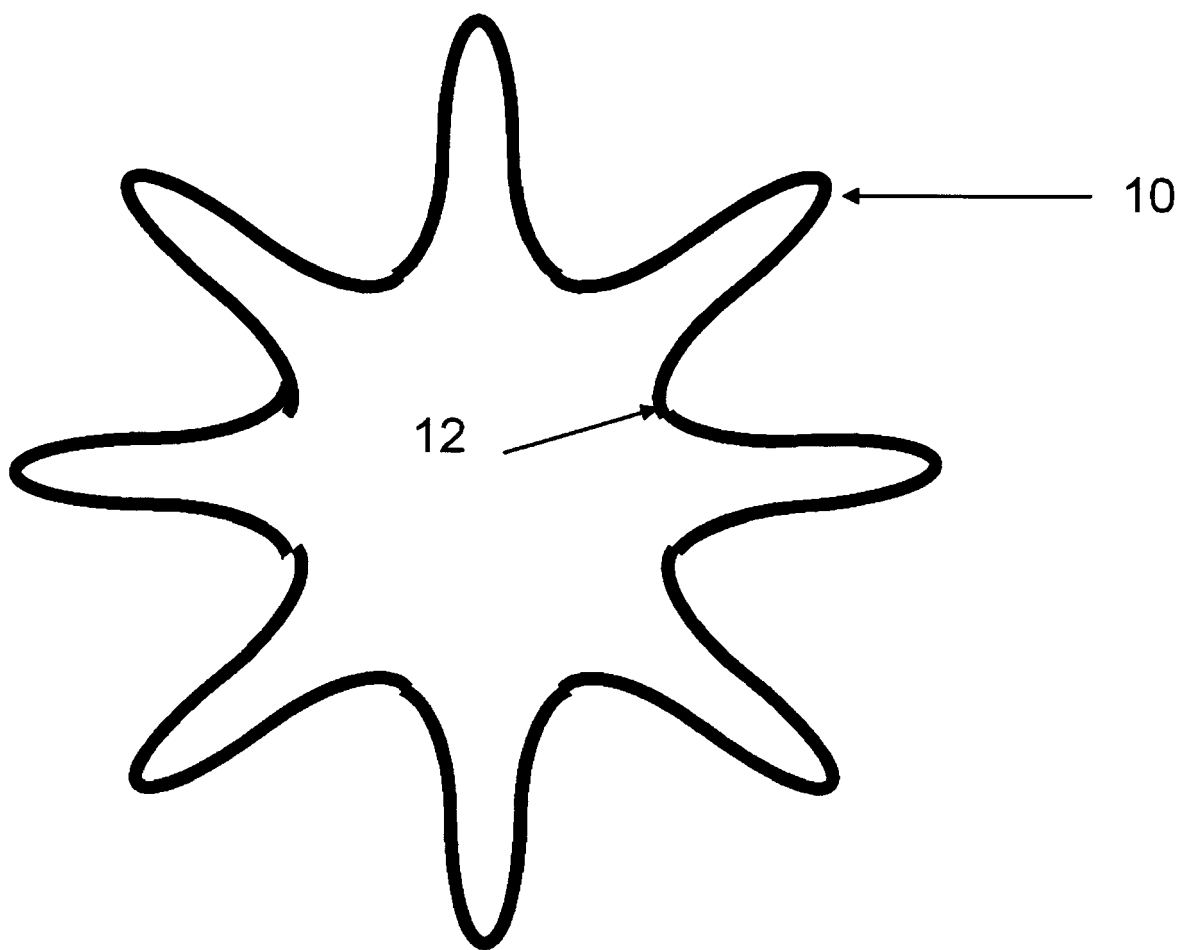


Fig. 4

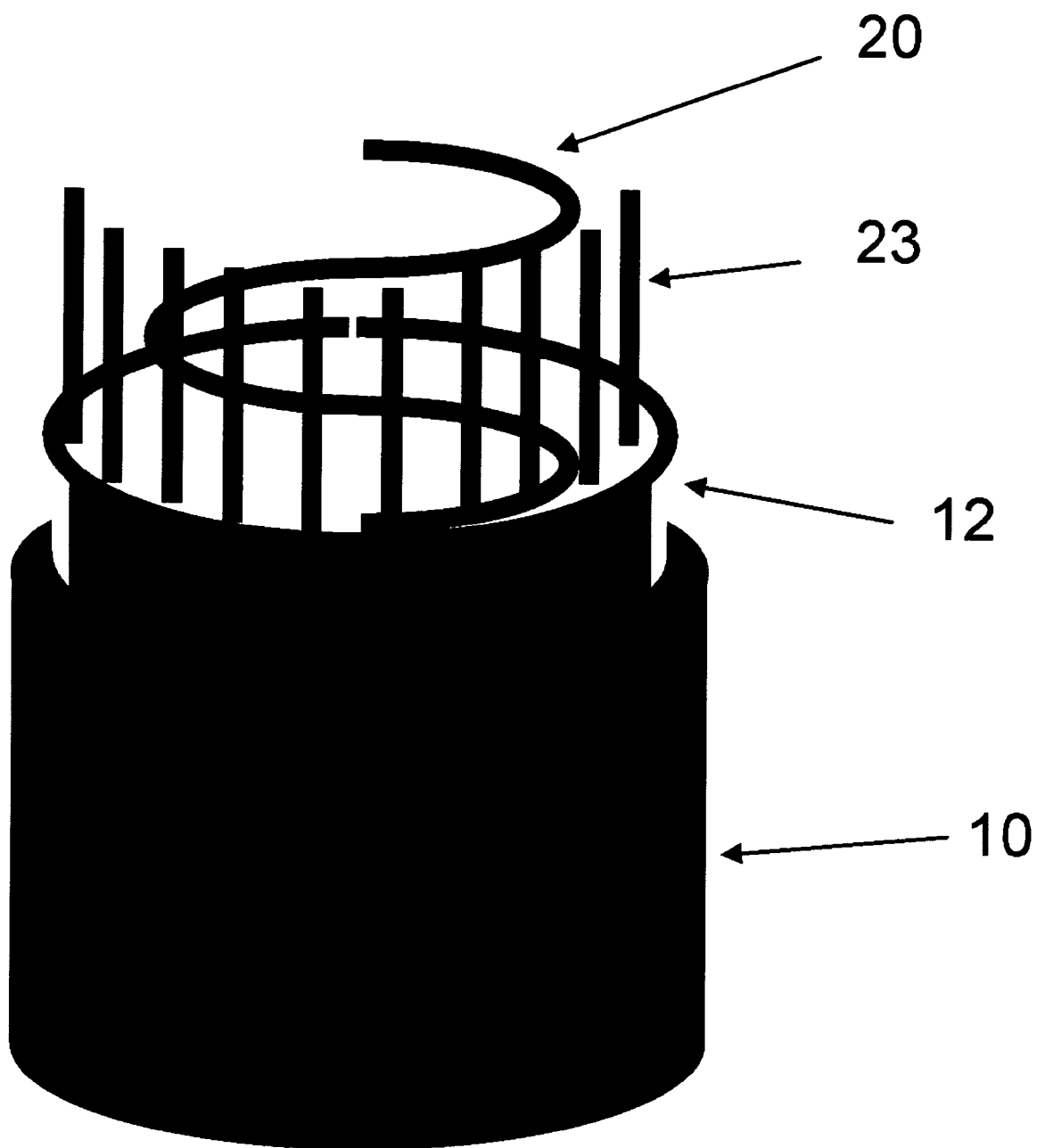


Fig. 5

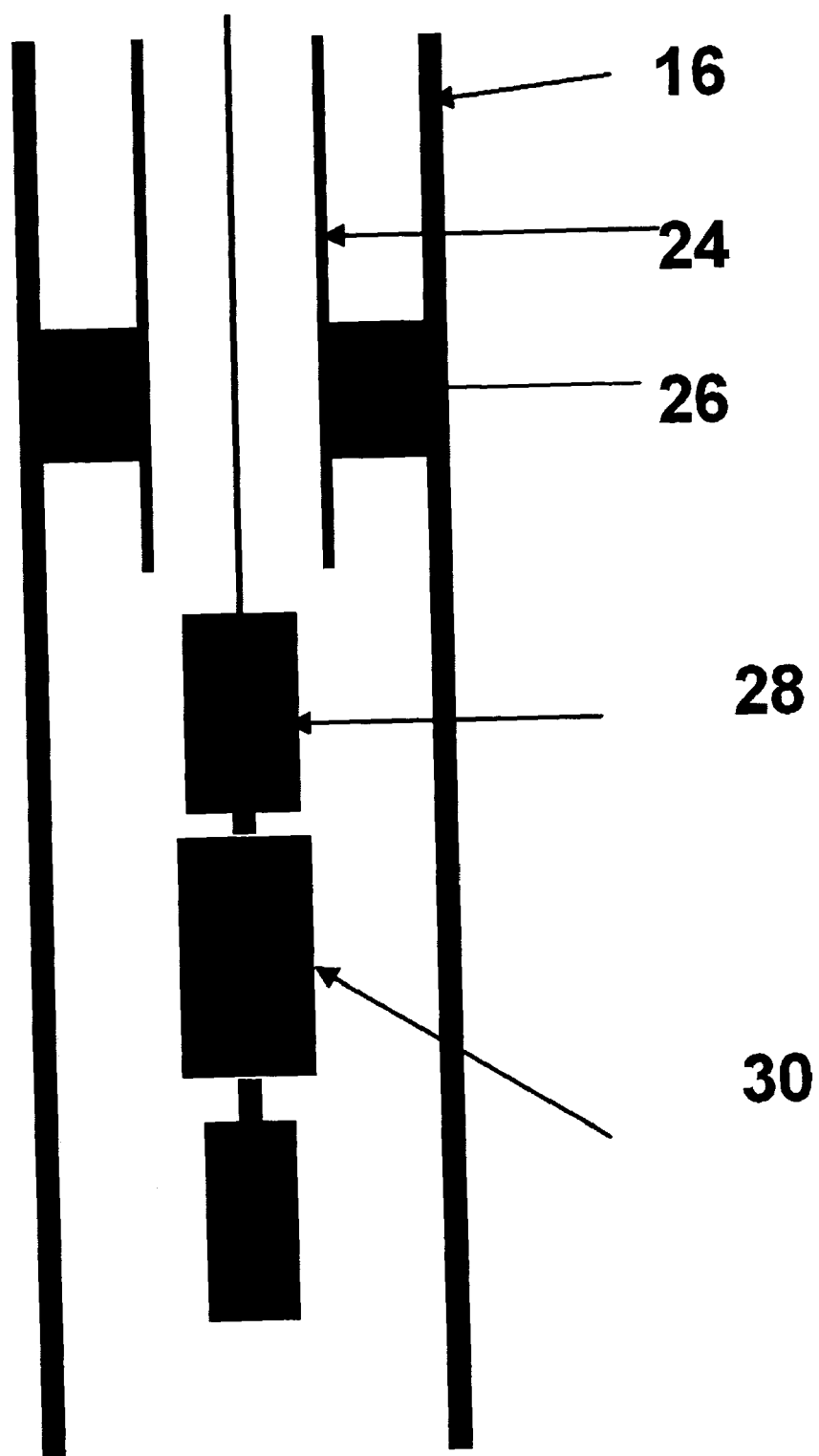


Fig. 6

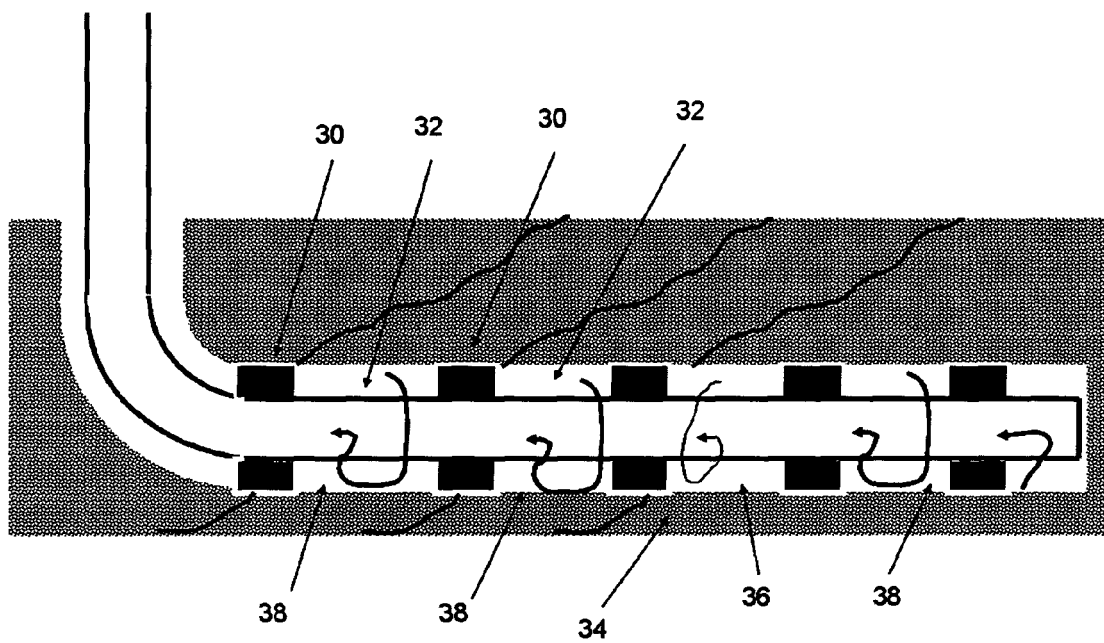


Fig. 7

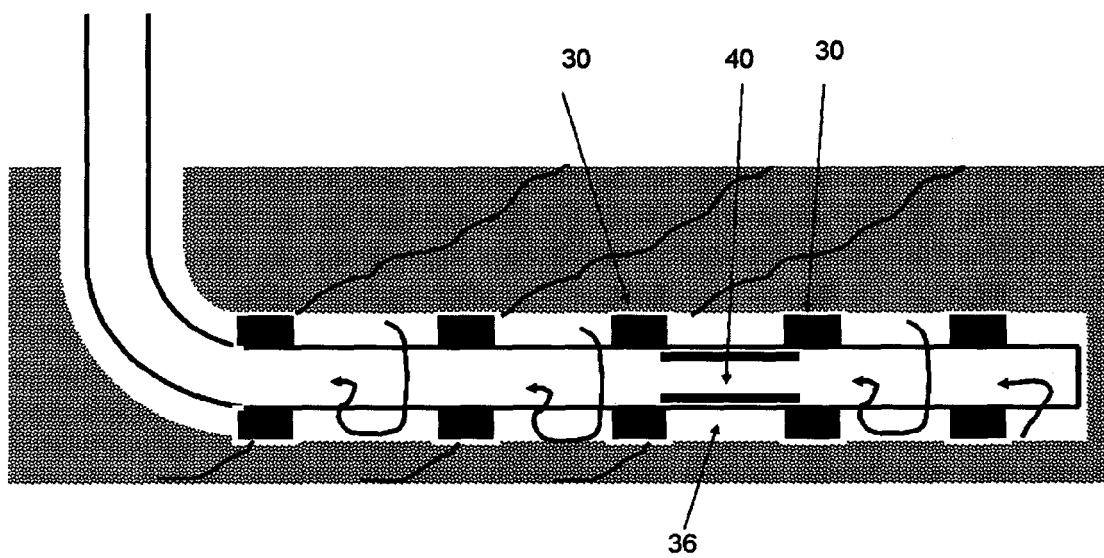


Fig. 8

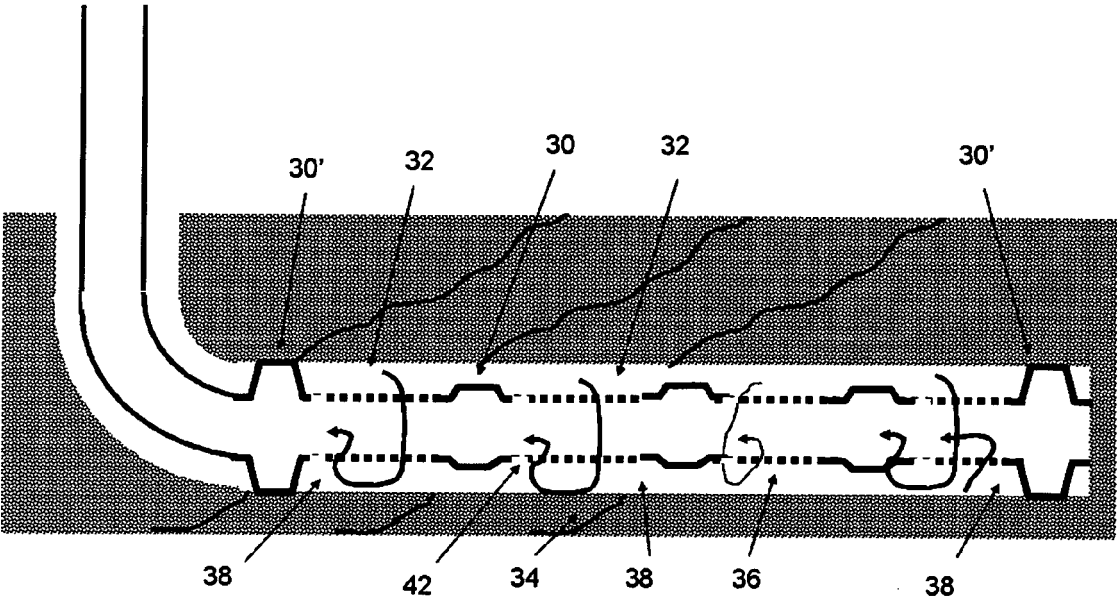


Fig. 9



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 29 0982

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 3 October 2005	Examiner van Berlo, A
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**CLAIMS INCURRING FEES**

The present European patent application comprised at the time of filing more than ten claims.

- ☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- ☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
- ☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:
- 1-6,8,11,13,15,22



The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-6,8,11,13,15,22

Expandable sleeve

2. claim: 7

Corrugated structure

3. claims: 9,10

Reinforcement structure

4. claims: 12,14

Spring installation

5. claims: 16-21

Completion string comprising slotted liners

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 05 29 0982

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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