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(54) **Method for manufacturing a turbulator**

(57) A method for manufacturing a turbulator, in particular for swirling a cooling medium in a blast furnace cooling system, comprising the steps of providing a flat sheet (10) having an upper surface (12) and an opposite lower surface (14), a downstream edge (16) and an opposite upstream edge (18), a first side edge (20) and an opposite second side edge (22); making at least one incision (24, 24', 24'', 24''') in the sheet (10); transforming

part of the sheet (26, 26', 26'', 26''') at the incision (24, 24', 24'', 24''') so as to form a vane (30, 30', 30'', 30''') on the upper surface (12) of the sheet (10). According to an important aspect of the present invention, the method comprises the further step of transforming the sheet (10) into an essentially cylindrical body (36) by bringing the first side edge (20) in proximity to the second side edge (22).

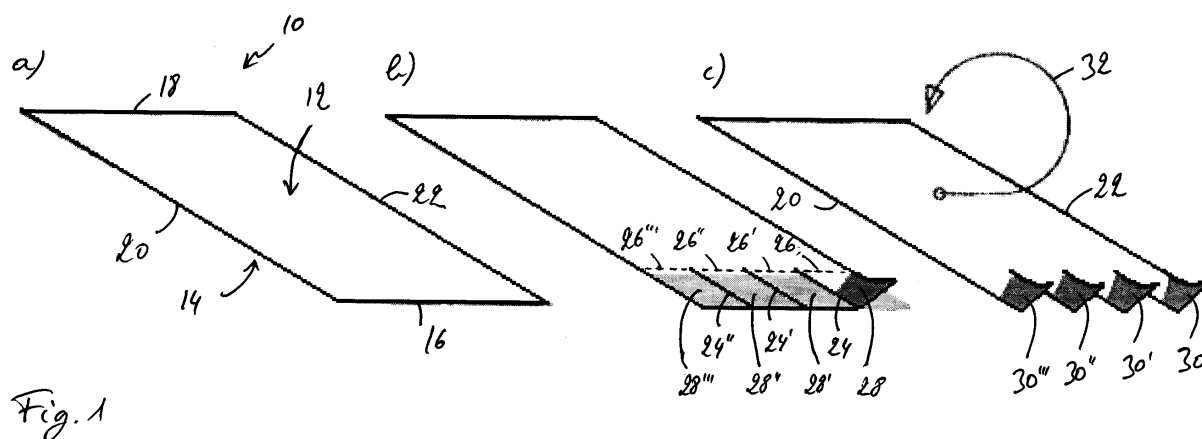


Fig. 1

## Description

### Introduction

**[0001]** The present invention relates to a method for manufacturing a turbulator and a turbulator manufactured with this method. The turbulator can be used for swirling a cooling medium in a blast furnace cooling system, in particular in connection with cooling staves of such a system.

**[0002]** Heat exchange applications employ at least one flowing medium, liquid or gaseous or a mixture of both flowing through a conduit. Efficiency of thermal transfer depends partly on relative velocity of the medium. One way of improving efficiency is to increase axial velocity of the medium. In order to increase axial velocity, the discharge rate of the medium must be increased, which is generally not desired. Another way of improving efficiency is to add a transversal velocity component to the medium. Due to such a transversal velocity component the flow velocity of the medium is increased near the walls of the conduit, whereby the heat transfer is improved. By optimizing the transversal velocity, considering the required heat transfer, the total discharge rate of the medium can be reduced considerably. Turbulators are commonly used as passive elements in such heat exchange applications to add or increase a transversal velocity component of a medium, or in other words to curl or swirl the medium so as to benefit from aforementioned increase in efficiency.

**[0003]** Different methods for manufacturing such turbulators are known. US-B-6 530 422 discloses a conduit for petrochemical applications with a swirl creating, helical baffle directly connected to, and cast together with the conduit by precision casting. It is clear that this manufacturing process is both complex and expensive. A cheaper alternative is to form a turbulator from a flat sheet to be subsequently inserted into a conduit. EP-B-0 181 711 discloses a turbulator for waste gases made from a single flat sheet, which is slitted and has tabs bent to a generally right angle with flow direction and is helically twisted before it is longitudinally inserted into a conduit. FR-A-2 211 111 discloses a turbulator made from a single flat sheet, having tabs bent out of the sheet and inserted longitudinally into a conduit.

**[0004]** While the known embodiments present the advantage of increasing efficiency of thermal transfer, they also present disadvantages related to their manufacturing and properties. Disadvantages of these embodiments are mainly an elaborate and expensive manufacturing process, but also considerable flow resistance and lack of firm fixation means inside heat exchanger conduits.

### Object of the invention

**[0005]** The object of the present invention is to provide a simplified method for manufacturing a turbulator. This

object is achieved by a method as claimed in claim 1 and a turbulator as claimed in claim 17.

### General description of the invention

**[0006]** In order to overcome the abovementioned problems, the present invention proposes a method for manufacturing a turbulator, in particular for swirling a cooling medium in a blast furnace cooling system. The method comprises the steps of providing a flat sheet having an upper surface and an opposite lower surface, a downstream edge and an opposite upstream edge, a first side edge and an opposite second side edge; making at least one incision in the sheet; transforming, e.g. through bending or folding, part of the sheet at the incision so as to form a vane on the upper surface of the sheet. According to an important aspect of the present invention, the method comprises the further step of transforming the sheet into an essentially cylindrical body by bringing the first side edge in proximity to the second side edge.

**[0007]** This method provides an simplified fast and cheap way of producing turbulators having an essentially cylindrical body. Also, the vanes can be arranged so as to impart a swirling motion to the medium, without having an excessive flow restriction or resistance.

**[0008]** Preferably, the incision is such as to describe an open contour on the sheet, the open contour being complemented by a base line so as to define a vane area. The base line provides a connection between the vane area and the sheet.

**[0009]** The base line of the vane area can be directed towards the upstream edge of the sheet. Alternatively, base line of the vane area can be directed towards one of the side edges of the sheet.

**[0010]** Advantageously, the incision extends from the downstream edge into the flat sheet and in a direction generally towards the upstream edge. The incision can be perpendicular to the downstream edge. Providing an incision from the downstream edge of the flat sheet is particularly easy and quick, thereby further simplifying the method. It is however not excluded to provide the incision in other parts of the sheet.

**[0011]** Preferably, the vane is formed by bending the vane area out of the surface of the sheet.

**[0012]** A plurality of vanes are preferably provided in the flat sheet so as to improve the turbulence of the medium.

**[0013]** The vane can have a first free corner and a second free corner, the first free corner being moved further away from its original position than the second free corner. Such a vane has a surface imparting, on its own, a swirling motion to the medium.

**[0014]** The base line of the vane can be arranged at an angle with respect to the direction of flow of the medium, thereby imparting a swirling motion to the medium.

**[0015]** In the case of a plurality of vanes, the latter can

be offset in a direction of flow in order to impart a swirling motion to the medium.

**[0016]** Advantageously, the flat sheet is transformed into an essentially cylindrical body so as to arrange the vanes inside the essentially cylindrical body. The vanes provide a restriction to the flow of a medium through the essentially cylindrical body, thereby imparting a swirling motion to the medium. It will be appreciated that it is also possible to arrange the vanes outside the essentially cylindrical body, e.g. if the medium flows through an essentially annular conduit having a central core.

**[0017]** The flat sheet can be made of metal or plastic material. The material should be chosen depending on the intended use. The material can e.g. be steel, preferably stainless steel, or copper. Any other suitable material which has the properties of being resistant to thermal fatigue, corrosion resistant, machineable, thermally conductive and of sufficient strength can also be used.

**[0018]** The essentially cylindrical body is preferably inserted into a conduit and forms a turbulator therein. Any medium flowing through the conduit is turbulated as it hits the vanes of the essentially cylindrical body.

**[0019]** Preferably, the essentially cylindrical body is fixed in the conduit by deformation of the conduit in the region of the essentially cylindrical body. The conduit can e.g. be deformed by making a recess on an outer surface of the conduit, thereby deforming an inner surface of the conduit. Such a recess can change the inner cross-section of the conduit, thereby preventing the cylindrical body from being displaced or dislodged. The conduit can also be deformed by bending of the conduit in the region comprising the essentially cylindrical body. If the direction of the axis of the conduit is changed, the essentially cylindrical body is prevented from being displaced or dislodged.

**[0020]** The essentially cylindrical body can also be fixed in the conduit by resilience of the sheet. The flat sheet can have a resilience, which, once the sheet has been deformed into a cylindrical body, urges the sheet back into its original form. When confined in a conduit, the sheet then pushes against the inner wall of the conduit and is thereby locked in place. It will be understood that this only works if the first and second side edges are not fixedly connected, e.g. through welding.

**[0021]** Further fixing means between the sheet and the conduit, such as e.g. welding seams or spots or adhesive means, can also be provided.

**[0022]** The present invention also relates to a turbulator, in particular for swirling a cooling medium in a blast furnace cooling system, comprising an essentially cylindrical body formed from a flat sheet and at least one vane protruding from a surface of the sheet, the vane being formed by making an incision in the sheet and bending the sheet at the incision.

**[0023]** It will be understood that the essentially cylindrical body is, although preferred, not limited to a circular cross-section.

### **Detailed description with respect to the figures**

**[0024]** The present invention will be more apparent from the following description of not limiting embodiments with reference to the attached drawings, wherein

Fig.1: is a perspective view of steps for manufacturing a turbulator according to a first embodiment of the present invention;

Fig.2: is a cross sectional view of a conduit containing the turbulator manufactured according to the first embodiment;

Fig.3: is a longitudinal sectional view of a conduit containing the turbulator manufactured according to the first embodiment;

Fig.4: is a perspective view of steps for manufacturing a turbulator according to a second embodiment of the present invention;

Fig.5: is a perspective view of steps for manufacturing a turbulator according to a third embodiment of the present invention; and

Fig.6: is a longitudinal sectional view of a conduit containing the turbulator manufactured according to the second embodiment, wherein the turbulator is securely fixed by a knee bend in the conduit.

### **Description of preferred embodiments**

**[0025]** Fig.1 shows the steps for manufacturing a turbulator according to a first embodiment of the invention. In a), a flat, generally rectangular sheet 10 is provided. This sheet 10 has an upper surface 12, an opposite lower surface 14, a downstream edge 16 and an opposite upstream edge 18, a first side edge 20 and an opposite second side edge 22. The sheet 10 is made from steel, preferably stainless steel, or copper. Any other suitable material, such as e.g. plastic material, which has the properties of being resistant to thermal fatigue, corrosion resistant, machineable, thermally conductive and of sufficient strength can be used.

**[0026]** In b), the flat sheet 10 is provided with incisions 24, 24', 24'', e.g. by means of cutting or punching. According to the first embodiment of the invention, these incisions 24, 24', 24'' are essentially straight, perpendicular to and starting at the downstream edge 16 of the sheet 10.

**[0027]** The incisions 24, 24', 24'' are such as to describe open contours on the sheet 10, which are complemented by base lines 26, 26', 26'' so as to form vane areas 28, 28', 28'', 28''' in the sheet 10. The vane areas 28, 28', 28'', 28''' are then transformed, generally by bending, into vanes 30, 30', 30'', 30'''. This can be

achieved e.g. by bending upwards (with respect to upper surface 12 and lower surface 14), only one corner of the vane areas 28, 28', 28'', 28'''. The thickness of the sheet 10 is chosen such that the vanes 30, 30', 30'', 30''' resist operational stress of the turbulator without being deformed.

[0028] In c), the flat sheet 10 is shown with all of the vane areas 28, 28', 28'', 28''' transformed into vanes 30, 30', 30'', 30'''. The sheet 10 is then transformed, e.g. by bending or coiling, as shown by arrow 32, into a generally cylindrical body, wherein the first side edge 20 and the second side edge 22 meet. In order to maintain the shape of the turbulator, first side edge 20 can be welded to the second side edge 22.

[0029] Fig.2 and Fig.3 show a conduit 34 with the turbulator having a generally cylindrical body 36 arranged therein. The vanes 30, 30', 30'', 30''' of the generally cylindrical body 36 can also be seen. The conduit 34 can be a tube in a heat exchange application, e.g. in a blast furnace cooling system. The conduit 34 can be a tube arranged in a cooling stove.

[0030] Fig.4 shows the steps for manufacturing a turbulator according to a second embodiment of the invention.

[0031] In b), the flat sheet 10 is provided with incisions 24, 24', 24'', e.g. by means of cutting or punching. According to the second embodiment of the invention, these incisions 24, 24', 24'' are essentially U-shaped and describe open contours on the sheet 10, which are complemented by base lines 26, 26', 26'' so as to form vane areas 28, 28', 28'' in the sheet 10. The vane areas 28, 28', 28'' are then transformed, generally by bending, into vanes 30, 30', 30''. With respect to a direction of flow of the medium, the base lines 26, 26', 26'' are arranged at an angle. Furthermore, the incisions 24, 24', 24'' are offset in a direction of flow of the medium. These measures ensure that a swirl motion is imparted to the medium.

[0032] Fig.5 shows the steps for manufacturing a turbulator according to a third embodiment of the invention.

[0033] In b), the flat sheet 10 is provided with incisions 24, 24', 24'', e.g. by means of cutting or punching. According to the third embodiment of the invention, these incisions 24, 24', 24'' are essentially trapezium-shaped and describe open contours on the sheet 10, which are complemented by base lines 26, 26', 26'' so as to form vane areas 28, 28', 28'' in the sheet 10. The base lines 26, 26', 26'' are the longer base of the trapezium. The vane areas 28, 28', 28'' are then transformed, generally by bending, into vanes 30, 30', 30''. With respect to a direction of flow of the medium, the base lines 26, 26', 26'' are arranged at an angle. These measures ensure that a swirling motion is imparted to the medium.

## Claims

1. A method for manufacturing a turbulator, in partic-

ular for swirling a cooling medium in a blast furnace cooling system, said method comprising the steps of:

- providing a flat sheet having an upper surface and an opposite lower surface, a downstream edge and an opposite upstream edge, a first side edge and an opposite second side edge;
- making at least one incision in said sheet;
- transforming part of said sheet at said incision so as to form a vane on said upper surface of said sheet;

characterized in that the method comprises the further step of:

- transforming said sheet into an essentially cylindrical body by bringing said first side edge in proximity to said second side edge.

2. The method according to claim 1, wherein said at least one incision is such as to describe an open contour on said sheet, said open contour being complemented by a base line so as to form a vane area, said base line providing a connection between said vane area and said sheet.

3. The method according to claim 1 or 2, wherein said base line is directed towards said upstream edge of said sheet.

4. The method according to claim 1 or 2, wherein said base line is directed towards a side edge of said sheet.

5. The method according to any of claims 1 to 4, wherein said at least one incision extends from said downstream edge into said flat sheet and in a direction generally towards said upstream edge.

6. The method according to claim 5, wherein said at least one incision is perpendicular to said downstream edge.

7. The method according to any of claims 2 to 6, wherein said vane is formed by bending said vane area out of the plane of said sheet.

8. The method according to any of the previous claims, wherein a plurality of vanes are provided in said flat sheet.

9. The method according to any of claims 2 to 8, wherein said vane has a first free corner and a second free corner, said first free corner being moved further away from its original position than said sec-

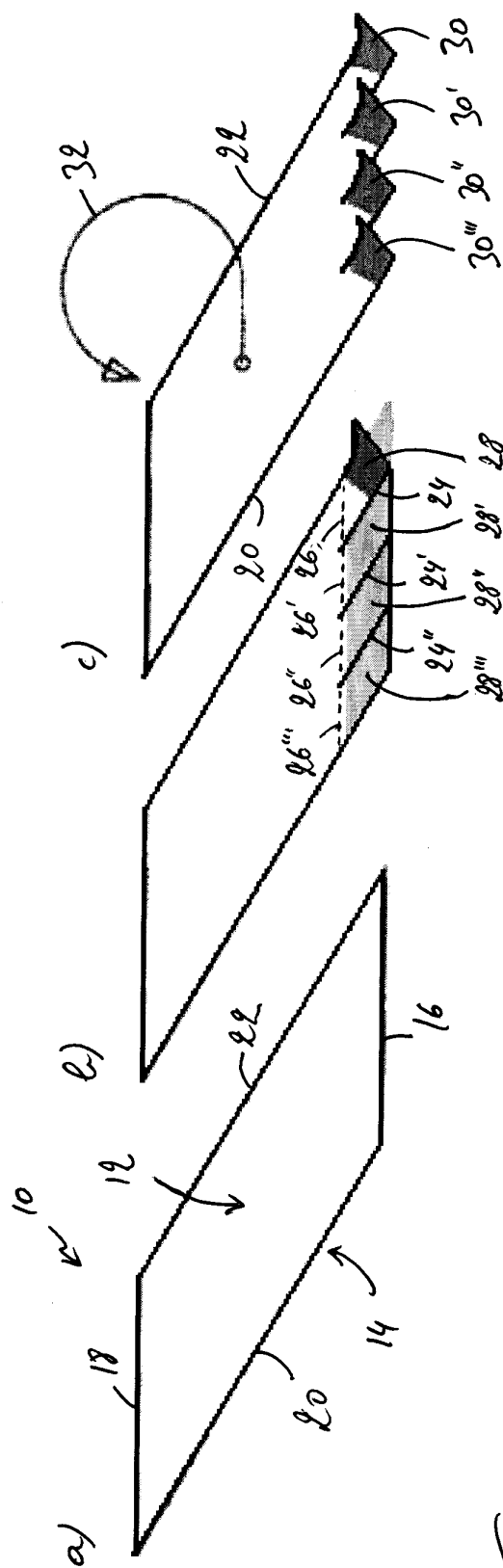
ond free corner.

10. The method according to any of claims 2 to 9, wherein the base line of the vane is at an angle with respect to the direction of flow of a medium. 5
11. The method according to any of claims 8 to 10, wherein said plurality of vanes are offset in a direction of flow. 10
12. The method according to any of the previous claims, wherein said flat sheet is transformed into an essentially cylindrical body so as to arrange said at least one vane inside said essentially cylindrical body. 15
13. The method according to any of the previous claims, wherein said flat sheet is made of metal or plastic material. 20
14. The method according to any of the previous claims, wherein said essentially cylindrical body is inserted into a conduit.
15. The method according to claim 13, wherein said essentially cylindrical body is fixed in said conduit by deformation of said conduit in the region of said essentially cylindrical body. 25
16. The method according to claim 13, wherein said essentially cylindrical body is fixed in said conduit by resilience of said sheet. 30
17. A turbulator, in particular for swirling a cooling medium in a blast furnace cooling system, comprising an essentially cylindrical body formed from a flat sheet, 35  
at least one vane protruding from a surface of said sheet, said vane being formed by making an incision in said sheet and bending said part of sheet at said incision. 40

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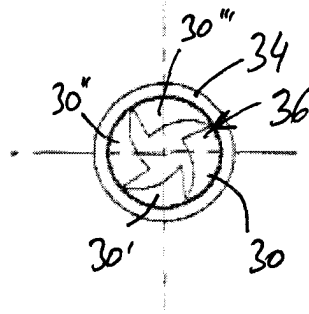


Fig. 2

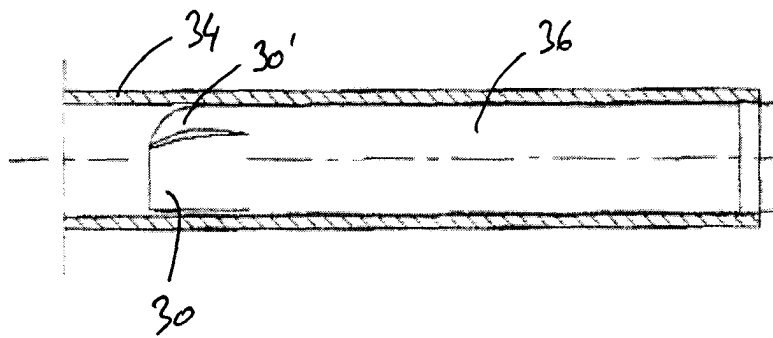


Fig. 3

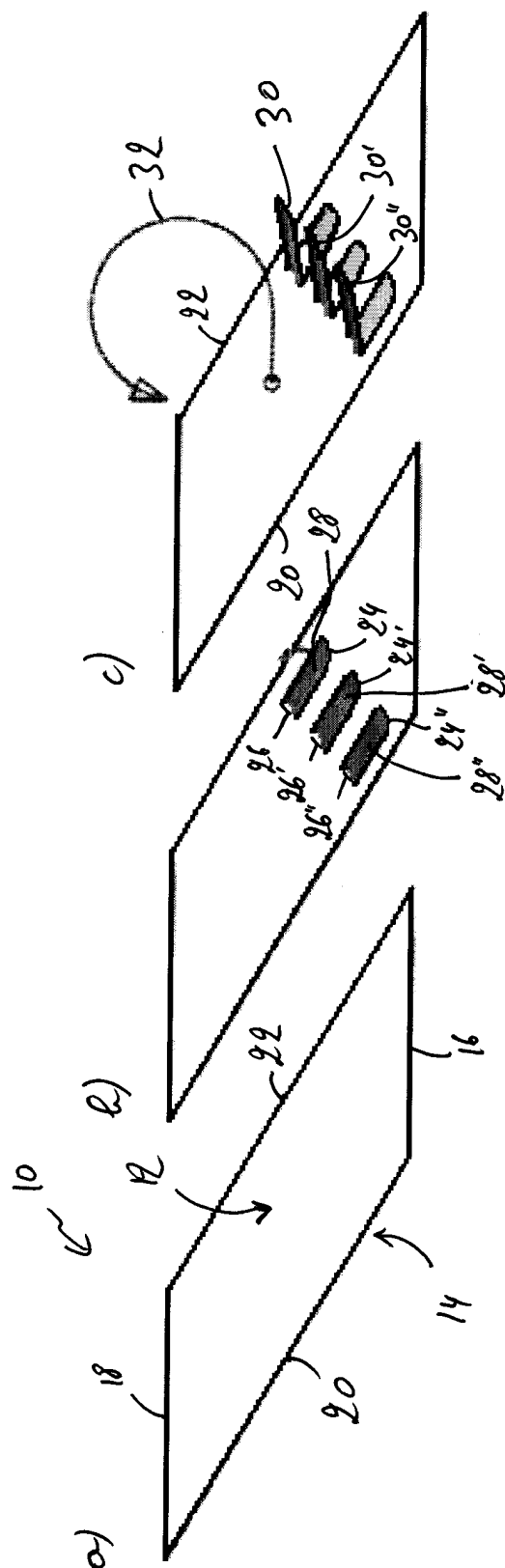


Fig. 4

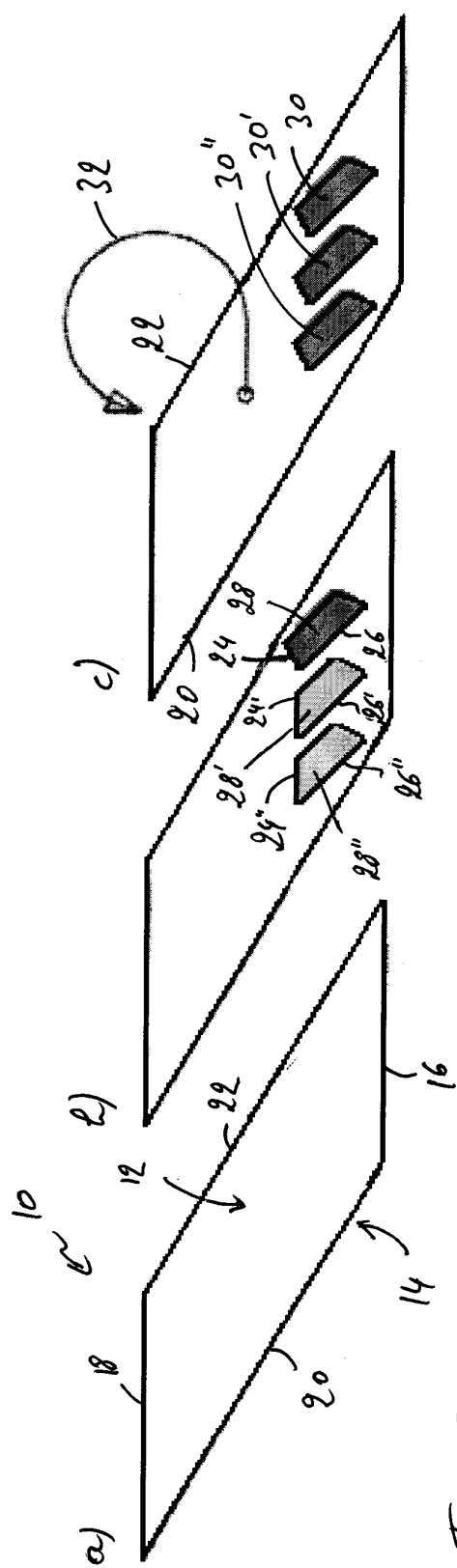


Fig. 5

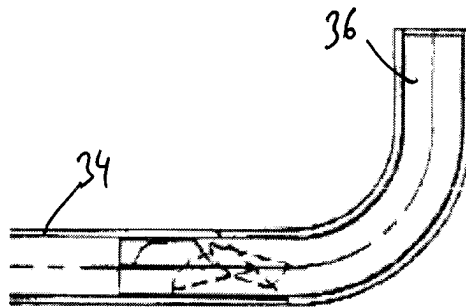


Fig. 6



European Patent  
Office

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Application Number  
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| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                           |                                                 |                                              |
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| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document<br>T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |                                                                                                                                                                                                                                                           |                                                 |                                              |

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**ANNEX TO THE EUROPEAN SEARCH REPORT  
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