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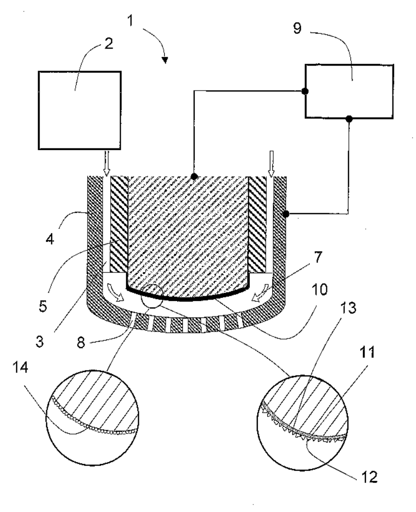
(54) Title: AN ELECTROSTATIC ATOMISER



(57) Abstract: An electrostatic atomiser (1), comprises a channel (3) through which, in use, a fluid passes; one or more orifices (8) to allow the fluid to exit the atomiser (1); and at least two electrodes (4, 6) in contact with the fluid, when the atomiser is in use, so that when an appropriate potential is applied to said electrodes (4, 6), fluid particles are charged; at least one of said electrodes (4, 6) presents a fluid contacting region which comprises a closely contiguous array of non-fibrous conducting elements (13) generally protruding from the electrode (6) so as to form an array of individual electrode points where the field generated by the atomiser is concentrated.

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PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)

— *of inventorship (Rule 4.17(iv)) for US only*

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AN ELECTROSTATIC ATOMISER

Field of the Invention

The invention relates to electrostatic atomisers applied in any practical system where the atomisation of fluid is required. It may be for example employed in a system for the supply of combustion fuel, liquid solutions in say the delivery of drugs, cosmetic fluids and other synthesized solutions in say household sprays. The invention as set out in this application is not limited to any of these particular applications and is intended to be applicable to any atomiser which falls within the scope of the claims which are included at the end of this application.

Prior Art known to the Applicant(s)

The present inventive concept is generally concerned with improving atomisation in electrostatic atomisers by proposing radical departures from the prior art known to the applicant and detailed herein.

Typically, prior art atomisers comprise a central electrode, an outer electrode located around said central electrode, and sufficiently spaced from one another to form a channel in which fluid particles are charged prior to exiting through orifices. In this configuration, a high potential is customarily applied to the central electrode whilst the outer electrode is grounded. Reversing these potentials - i.e. applying the high potential to the outer electrode – is not practical as in its environment there would be either the risk of electrocution should an operator inadvertently touch the outer electrode or the superfluous requirement of incorporating an additional insulating layer such as a ceramic sheath which would add unnecessary complexity. Consequently, prior art systems exclusively apply the high potential to the central electrode not to the outer electrode.

Figure 1 shows some of the constraints under which prior art atomisers operate. Atomisation is a balance between maximum voltage potential, percentage of potential charge retained in the discharged fluid and the electrode gap (distance separating the electrodes). In prior art systems as the electrode gap is increased the maximum voltage potential may be increased but the critical percentage of potential charge retained in the discharged fluid is reduced, thus resulting in relatively poor atomisation beyond a given electrode gap for a given atomiser.

One of the objectives of the present invention is to offer a radically different approach to atomisation which would to a large extent remove the strict barriers of design to which prior art systems are generally constrained.

Within the present inventive concept, other more specific prior art systems are deemed to be relevant and are detailed as follows.

One type of known prior art teaches the use of a single central electrode in an atomisation system terminating in a sharp point at its fluid interface so as to generate a relatively high electrical field about that point. One example of such a system is disclosed in US patent number 6,206,307 (Arnold J Kelly) where an electrode protrudes into a passing fluid in the form of a generally conical tip. This patent discloses in its section which provides a detailed description of the figures that the tip is formed from a fibrous material having electrically conductive fibres extending generally in the axial direction of the electrode and of the body, each such fibre having a microscopic point, these points co-operatively constituting the surface of the tip. The surfaces defining the orifice are deprived of any such fibres and are even preferably required to be smooth. This particular atomiser generally terminates in a point which for adequate performance requires to be precisely aligned with its orifice 22. Consequently, strict concentricity tolerances are required to be applied during its manufacturing. Furthermore, if for any reason, the alignment of the tip with its orifice is altered during the lifecycle of the atomiser efficiency will unavoidably suffer.

Another fibrous tip is disclosed in a separate US patent number 4,627,903 (Alan T Chapman) which discloses the use of composite fragments in the sharp point electrode tip containing sub-micron metallic fibres uniformly arrayed in a non-conducting (insulating) matrix.

Another type of prior art system discloses electrode tips terminating in a bell shape (with an annular sharp edge). This configuration is usually utilised in atomisers incorporating circumferentially arrayed orifices. One example of such a configuration can be seen in Figure 2 in a paper presented by A. J. Kelly circa July 1998 at DOE (Diesel Engine Emissions Workshop). Another example of such an electrode configuration is disclosed in US patent number 5,725,151 (Robert Hetrick).

Each of these bell shaped electrodes has similar stringent concentricity tolerances requirements to the above presented conical electrodes.

Every prior art configuration referenced above requires strict tolerances to be achieved and precise electrode tip geometry to be selected for given orifice arrangements.

One of the objectives of the present invention is to provide an atomiser whose electrode's geometry may be applied to a wide variety of orifice configurations. The present invention therefore aims to provide an altogether more flexible system with less stringent requirements for tolerances and of tip geometry.

A further objective of the invention is to provide an atomiser whose design and manufacture is carried out with improved freedom and which will also be particularly well suited to high volume production.

A further objective of the invention is to provide an atomiser with improved atomisation properties both for single orifice atomisers and multi-orifice atomisers.

Summary of the Invention

In its first broad independent aspect, the invention presents an electrostatic atomiser, comprising a channel through which, in use, a fluid passes; one or more orifices to allow the fluid to exit the atomiser; and at least two electrodes in contact with the fluid, when the atomiser is in use, so that when an appropriate potential is applied to said electrodes, fluid particles are charged; characterised by the fact that at least one of the said electrode presents a fluid contacting region which comprises a closely contiguous array of non-fibrous conducting elements generally protruding from the electrode so as to form an array of individual electrode points where the field generated by the atomiser is concentrated.

This configuration is advantageous because it removes the complex requirements of having to precisely align the electrode tip with a particular orifice. Furthermore, a multi-orifice atomiser may in this configuration be produced with a relatively high radius tip instead of the prior art system where the electrode tip terminates in a sharp point or a sharp perimeter edge in the case of the bell shaped tip. This configuration will also achieve an advantageously even atomised spray from its orifices. Its manufacturing will also be simplified as compared to the previously discussed prior art systems.

In a second broad independent aspect, the invention covers an electrostatic atomiser, comprising a channel through which, in use, a fluid passes; one or more orifices to allow the fluid to exit the atomiser; and at least two electrodes in contact with the fluid, when the atomiser is in use, so that when an appropriate potential is applied to said electrodes, fluid particles are charged; characterised by the fact that at least one of said electrodes presents a fluid contacting region which comprises one or more faceted conducting elements.

Similar advantages to those listed with regard to the first broad independent aspect apply to the second broad independent aspect above. These advantages are also present even when the atomiser only comprises a single faceted conducting element. Faceted conducting elements have the additional benefits of being generally particularly hard wearing and therefore particularly advantageous in atomising high frequency injected fluids and also particularly when applied in systems where the atomisation is followed by an explosion of the atomised fluid.

In a third broad independent aspect, an electrostatic atomiser, comprises a channel through which, in use, a fluid passes; one or more orifices to allow the fluid to exit the atomiser; and at least two electrodes in contact with the fluid, for charging fluid particles when the atomiser is in use, wherein the or each orifice is part of an electrode to which a high potential is applied in use and said electrode presents a fluid contacting region which comprises a closely contiguous array of conducting elements generally protruding from the electrode so as to form an array of individual electrode points where the field generated by the atomiser is concentrated.

This configuration marks a radical departure from the prior art thinking that the electrode surface at the orifice is to be preferably smooth. This aspect teaches literally the opposite. It also considers applying the high potential to the orifice electrode. By so doing, many of the prior art constraints are lifted. Particular advantages of this configuration are presented in Figure 2, where strict compliance to a given range of electrode gap as was the requirement of systems according to figure 1, is no longer a requirement. The percentage of potential charge retained in the discharge fluid is high almost irrespective of the electrode gap. Atomisation is therefore improved and achievable over a larger range of geometries as compared to the prior art systems.

Furthermore, the advantages disclosed with reference to the first and second broad independent aspect are also present in this configuration.

In a fourth broad independent aspect, an electrostatic atomiser, comprising a channel through which, in use, a fluid passes; one or more orifices to allow the fluid to exit the atomiser; and at least two electrodes in contact with the fluid for charging fluid particles when the atomiser is in use, wherein the or each orifice is part of an electrode to which a high potential is applied in use and said electrode presents a fluid contacting region which comprises one or more faceted conducting elements.

Similar advantages are present in this configuration as those presented in the context of the previous broad independent aspects. The specific advantages of the third broad independent aspect are also present when a single faceted conducting element is located in the fluid contacting region of an orifice.

In a subsidiary aspect in accordance with any of the preceding broad independent aspects, the elements are diamond compounds or are carbon based compounds having similar properties to diamond. Utilising diamonds or the like compounds is particularly advantageous because of the combination of properties of diamond compounds – particularly when considering their toughness, electrical conductivity and ability of being retained by the electrode itself.

In a further subsidiary aspect, the elements form part of a diamond coating. A diamond coating is particularly advantageous as it may readily be applied to a wide variety of electrode geometries and is particularly well suited to high volume production.

In a further subsidiary aspect, the elements are fullerene molecules. These often have an icosahedral or a so-called 'soccer ball' configuration constituted of an even-numbered clusters of C_m species with $m>40$. This configuration has a surprisingly advantageous effect on atomisation despite its relative smoothness when compared to diamond crystals.

In a further subsidiary aspect, the elements are carbon 64 compounds. This additional feature is particularly advantageous as its application achieves improved atomisation and renders the system flexible and suitable for high volume production.

In a further subsidiary aspect, the size of one or more elements is under 500 microns. Below this size, the atomiser configuration becomes advantageously flexible doing away with the prior art stringent tolerance requirements and restrictions as to the electrode's geometry.

Advantageously, the size of one or more elements may be comprised within the range of 10 to 150 microns. At these levels, flexibility is even further improved while maintaining advantageous atomisation properties. The cost of manufacturing atomisers within this range is also particularly beneficial.

In a further subsidiary aspect, a first electrode incorporates an array of said orifices and a second electrode is spaced from said first electrode to permit the passage of fluid between them, the fluid contacting surface of said second electrode incorporating an array of said elements located essentially over said array of orifices. One of the advantages of this particular configuration is that atomisation is further improved by being particularly well balanced between the atomiser's various orifices.

Advantageously, the second electrode's surface provided over the or each section located between orifices may be deprived of said elements. Adapting the atomiser in this manner reduces the amount of elements necessary to achieve improved atomisation and is equally susceptible of being produced in high volumes.

In a further subsidiary aspect, a first electrode incorporates an array of said orifices and a second electrode is spaced from said first electrode to permit the passage of fluid between them, the first electrode incorporating in addition an array of elements.

In this configuration, a higher concentration of electrical fields at the orifices may be achieved which would result in an improvement of the atomisation properties.

Advantageously, the or each orifice may be adapted to achieve an essentially radial flow and the array of elements may take the form of a ring spaced from the or each orifice to permit the passage of fluid through the or each orifice and located essentially over the or each orifice.

This configuration is advantageous because as it may be able to wrap around an object while still improving the atomisation of a fluid whilst doing away with the constraints of the prior art, particularly as to concentricity tolerances evident when using bell shaped electrode tips.

Brief Description of the Figures

Figure 1 shows the characteristics of a prior art system.

Figure 2 shows the characteristics of an inventive configuration.

Figure 3 shows a schematic cross-sectional view of part of an illustrative atomiser in accordance with a first embodiment of the present invention.

Figure 4 shows a further schematic cross-sectional view of part of an atomiser in accordance with a second embodiment of the invention.

Figure 5 illustrates a further cross-sectional view of part of an atomiser according to a third embodiment of the invention.

Figure 6 represents a further cross-sectional view of part of an atomiser according to a fourth embodiment of the invention.

Figure 7 shows a cross-sectional view of part of an atomiser in accordance with a fifth embodiment of the invention.

Figure 8 shows a cross-sectional view of part of an atomiser in accordance with a sixth embodiment of the invention.

Figure 9 shows a cross-sectional view of part of an atomiser in accordance with a seventh embodiment of the invention.

Detailed Description of the Figures

Figure 1 and figure 2 are discussed in detail in the context of the previous sections.

Figure 3 shows an electrostatic atomiser generally referenced 1. The atomiser operates in conjunction with a fluid supply system 2 which conducts fluid into the atomiser first through a fluid passage 3 annular and essentially concentric with the longitudinal axis of the atomiser. Fluid passage 3 is formed between wall 4 and insulator 5. The insulator wraps about the outer surface of a central electrode 6 so as to electrically isolate the fluid in passage 3 from the central electrode 6.

After the fluid passage 3, the fluid enters an atomisation chamber 7.

In the lower region of wall 4, there is provided an array of orifices such as that referenced 8.

A high voltage power source 9 is connected to both central electrode 6 and wall 4. Power source 9 is not intended in any way to be limited to any particular configuration and may for example be a direct current (DC) or even an alternative current (AC) power source. The person skilled in the art will naturally select an appropriate potential to be applied and any beneficial time dependencies, if necessary, from known alternatives. It is also envisaged within the scope of the invention that the electrodes with which the power source is to operate may be either positive or negative electrodes. Any such modification will undoubtedly be self-evident to the skilled addressee of this application and are therefore not detailed any further for the purposes of this description.

The central electrode 6 has the characteristic of terminating in a high radius curve covered by a diamond coating 10 covering the entire fluid contacting surface of the electrode.

The diamond coating 10 is constituted of diamond elements of say 10 microns such as that referenced 11 which protrudes from the electrode so as to form an electrode point 12. At this element size, the manufacturing process involved in coating may be a mechanical adhesion process whereby a fixer shown as layer 13 in the figure is first applied onto the surface of the electrode followed by the deposition of the array of elements 11. The person skilled in the art may also coat the electrode by other known processes such as plasma or gas deposition. The plasma deposition process will be particularly envisaged for element depositions in the nano-scale.

Alternatively, elements 11 may be replace by carbon 64 compounds such as that referenced 14 in the figure. Element 14 may be of general spherical shape and protrudes from the electrode so as to form individual electrode points which achieve the advantageous field concentration required for improved atomisation.

The invention also envisages the use of a so-called 'diamond like' coating. This may be a carbon based compound having similar properties (for example hardness) to diamond.

The invention also envisages that the elements of the same material as the electrode itself by for example etching away specific sections of the electrode's surface so that elements are formed which protrude from the electrode and are part of an array of individual electrode points to concentrate the field generated by the atomiser.

Figure 4 represents an electrostatic atomiser where identical components to those used in Figure 2 are given the same numerical reference followed by a prime sign. A distinctive feature of this embodiment is the incorporation of a diamond coating 15 on the inner surface of wall 4'. In addition, a high potential is intended to be applied to wall electrode 4' by power source 9' whilst the central electrode may be grounded. While a diamond coating 15 is a preferred configuration of atomiser 1', it may be in fact also constituted of fibrous conductive material selected by the person skilled in the art to generate a concentration of potential charge which would be transmitted to fluid particles as they exit the atomiser. In the context of this application fluid particles naturally extend to any parts or elements of a fluid including the actual molecules or atoms of said fluid.

In this configuration atomisation occurs particularly evenly through each orifice. One of the results of this configuration is shown as previously discussed in Figure 2.

Figure 5 shows a further embodiment of an atomiser generally referenced 16 with a central electrode 17, an insulator 18 and a wall 19. Central electrode 17 has the particularity of terminating in a conical tip 20 incorporating an array of elements disposed in a coating of diamond 21.

Figure 6 shows a further atomiser generally referenced 22 with a power source 23 applying a difference in potential between a central electrode 24 and a wall electrode 25 in order to charge fluid particles travelling between them. Three orifices such as that referenced 26 are represented in the figure. A region of elements in for example a diamond coating are located directly over orifice 26 and is referenced 27. A second region 28 is located directly over orifice 29 whilst a third region 30 is located directly over orifice 31. The portions located directly over the sections located between the orifices such as that referenced 32 are deprived of elements. This configuration achieves enhanced atomisation while at the same time reducing the amount of elements required to achieve this kind of multi-orifice atomisation.

Figure 7 represents an atomiser 33 with a central electrode 34 and a wall electrode 35 provided with orifice 36 capable of achieving essentially radial flow. Around the lower region of central electrode 34, there is provided a ring 37 of elements which allows the field generated by the atomiser to be evenly concentrated in any radial direction.

Figure 8 shows a further atomiser 38 with a fluid supply system 39 and a power source 40. Power source 40 applies a relatively high voltage on outer electrode 41 whilst a low potential is applied to central electrode 42. The outer electrode 41 incorporates a number of orifices respectively referenced 43, 44 and 45. On the inner surface of outer electrode 41, there are provided portions of elements 46, 47 and 48. Each of these portions of elements forms a ring around the inlet of the various orifices. The inner surface of outer electrode 41 between these portions is deprived of any such elements.

Figure 9 represents an atomiser 49 which incorporates three electrodes 50, 51 and 52. An electrical insulator 53 may be provided between electrodes 50 and 51. Such a configuration may be electrically connected in a variety of modes. One of the modes of electrical connection would be to ground electrode 52 whilst a very high potential (eg. 30 to 40 kV) is applied to electrode 50 and a high potential (eg. 6 to 10 kV) is applied to electrode 51. Another mode of connection would be to supply a very high potential of for example 30 to 40 kV to the outer electrode 52, whilst a high potential of 6 to 10 kV is applied to electrode 51 and electrode 50 is grounded. A further mode of operation would be to apply a high potential to electrode 52 whilst electrodes 50 and 51 are grounded. In this embodiment, element portion 54 is located adjacent to orifice 55. It is envisaged within the scope if the invention that element portions such as that referenced 54 may be used at any appropriate location in the atomiser's exit path.

CLAIMS

1. An electrostatic atomiser, comprising a channel through which, in use, a fluid passes; one or more orifices to allow the fluid to exit the atomiser; and at least two electrodes in contact with the fluid, when the atomiser is in use, so that when an appropriate potential is applied to said electrodes, fluid particles are charged; characterised by the fact that at least one of said electrode presents a fluid contacting region which comprises a closely contiguous array of non-fibrous conducting elements generally protruding from the electrode so as to form an array of individual electrode points where the field generated by the atomiser is concentrated.

2. An electrostatic atomiser, comprising a channel through which, in use, a fluid passes; one or more orifices to allow the fluid to exit the atomiser; and at least two electrodes in contact with the fluid, when the atomiser is in use, so that when an appropriate potential is applied to said electrodes, fluid particles are charged; characterised by the fact that at least one of said electrode presents a fluid contacting region which comprises one or more faceted conducting elements.

3. An electrostatic atomiser, comprising a channel through which, in use, a fluid passes; one or more orifices to allow the fluid to exit the atomiser; and at least two electrodes in contact with the fluid for charging fluid particles, when the atomiser is in use, wherein the or each orifice is part of an electrode to which a high potential is applied in use and said electrode presents a fluid contacting region which comprises a closely contiguous array of conducting elements generally protruding from the electrode so as to form an array of individual electrode points where the field generated by the atomiser is concentrated.

4. An electrostatic atomiser, comprising a channel through which, in use, a fluid passes; one or more orifices to allow the fluid to exit the atomiser; and at least two electrodes in contact with the fluid for charging fluid particles, when

the atomiser is in use, wherein the or each orifice is part of an electrode to which a high potential is applied in use and said electrode presents a fluid contacting region which comprises one or more faceted conducting elements.

5. An atomiser according to any preceding Claim, wherein the elements are diamond compounds.

6. An atomiser according to any preceding Claim, wherein the elements are carbon based with similar properties to diamond.

7. An atomiser according to any preceding Claim, wherein the elements form part of a diamond coating.

8. An atomiser according to any preceding Claim, wherein the elements are fullerene molecules.

9. An atomiser according to any preceding Claim, wherein the elements are Carbon 64 compounds.

10. An atomiser according to any preceding Claim, wherein the size of one or more elements is under 500 microns.

11. An atomiser according to Claim 7, wherein the size of one or more elements is comprised within the range of 10 to 150 microns.

12. An atomiser according to any preceding Claim, wherein a first electrode incorporates an array of said orifices and a second electrode is spaced from said first electrode to permit the passage of fluid between them, the fluid contacting surface of said second electrode incorporating an array of said elements located essentially over said array of orifices.

13. An atomiser according to Claim 12, wherein the second electrode's surface provided over the or each section located between orifices is deprived of said elements.

14. An atomiser according to Claims 1, 2 and 5 to 11, wherein a first electrode incorporates an array of said orifices and a second electrode is spaced from said first electrode to permit the passage of fluid between them, the first electrode incorporating in addition an array of elements.

15. An atomiser according to any preceding Claim, wherein the or each orifice is adapted to achieve an essentially radial flow and the array of elements takes the form of a ring spaced from the or each orifice to permit the passage of fluid through the or each orifice and located essentially over the or each orifice.

16. An atomiser as hereinbefore described with reference to and/or illustrated in any appropriate combination of the accompanying text and/or drawings.

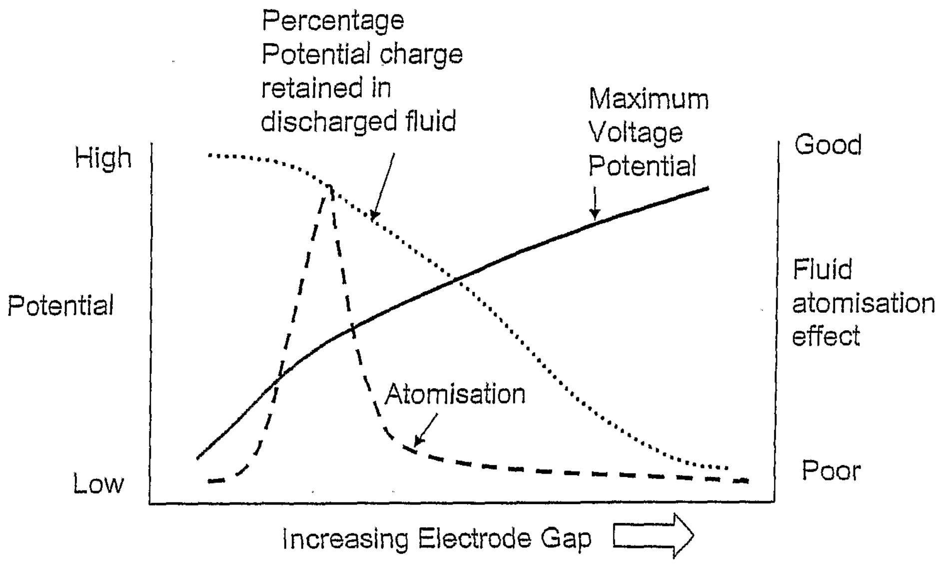
Percentage
Potential charge
retained in
discharged fluid
Maximum
Voltage
Potential
High
Good
Potential
Fluid
atomisation
effect
Atomisation
Low
Poor
Increasing Electrode Gap

FIGURE 1

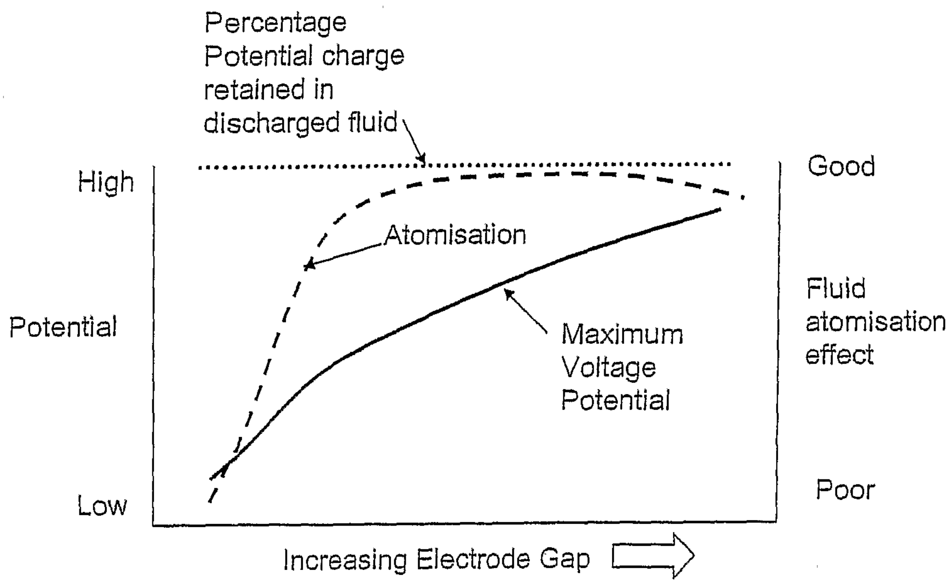
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FIGURE 2

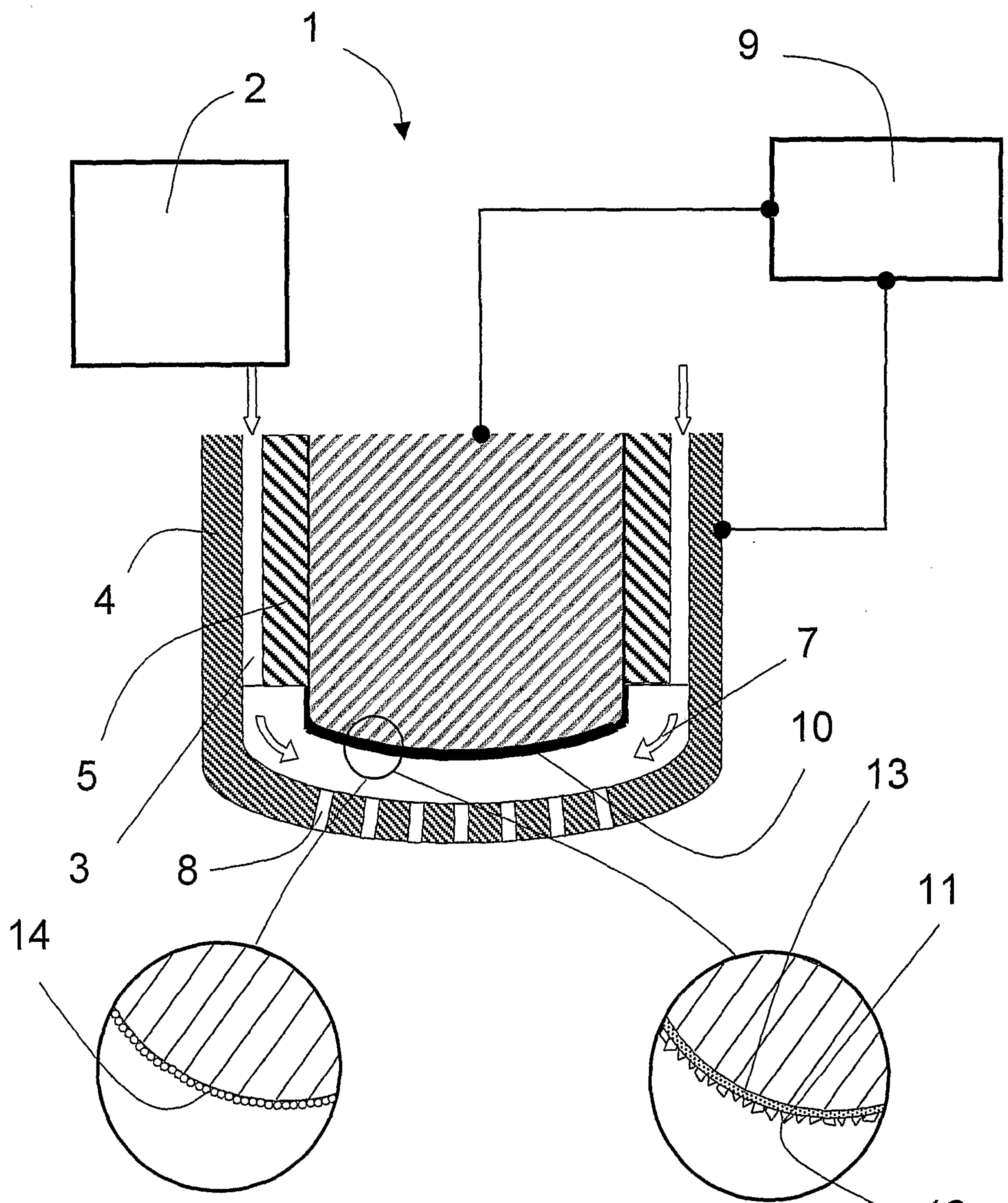

FIGURE 3

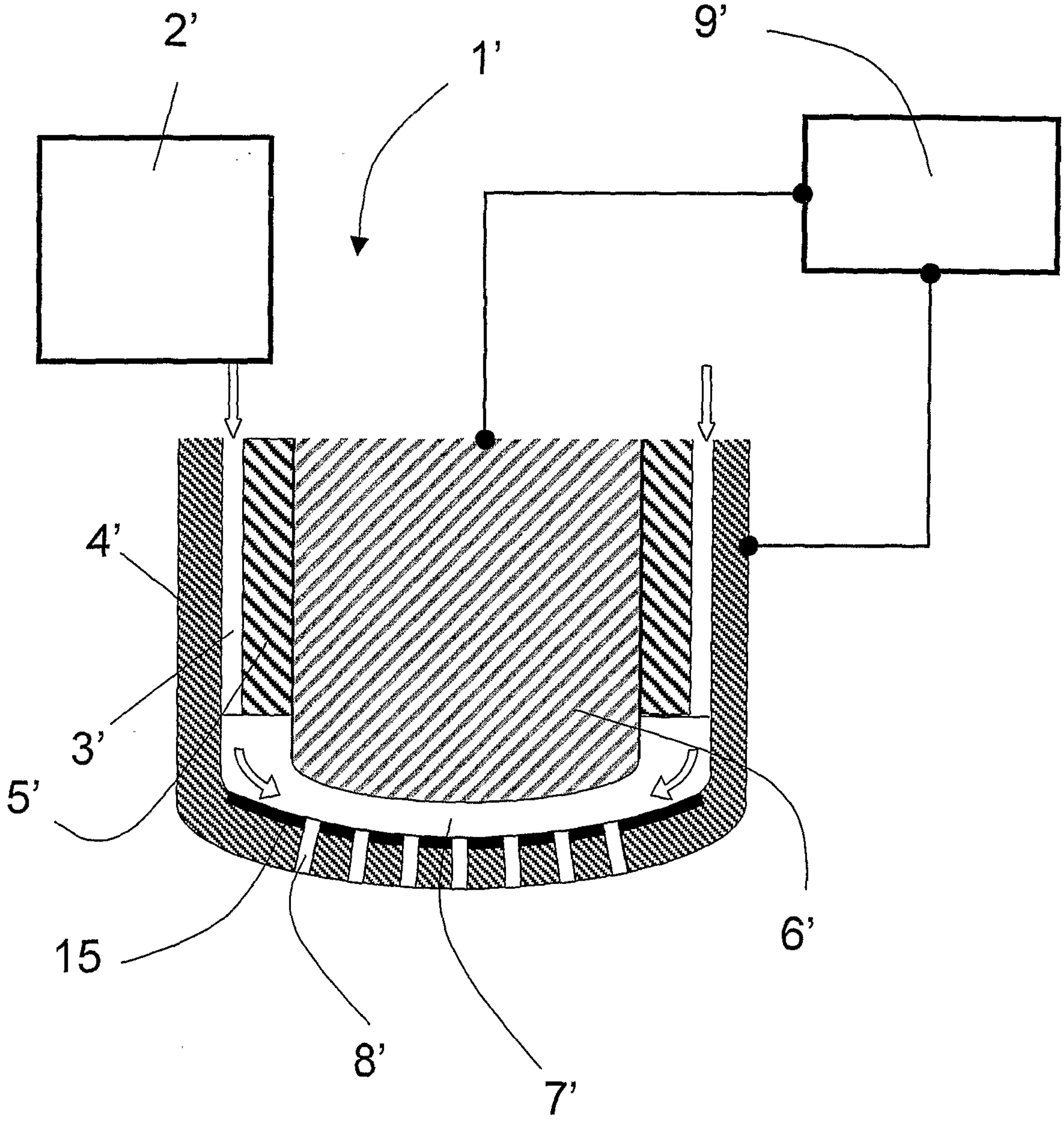

FIGURE 4

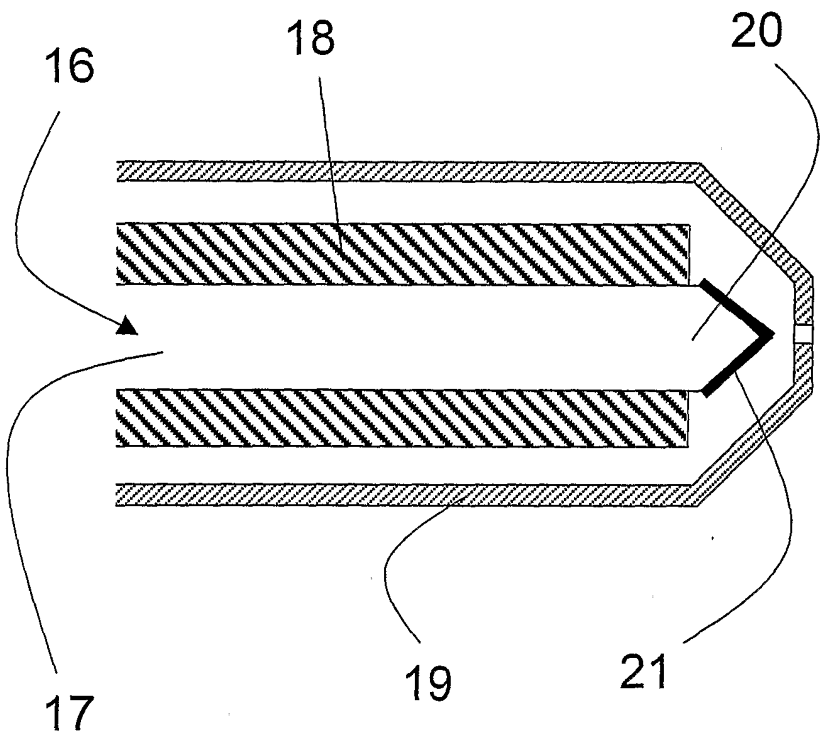

FIGURE 5

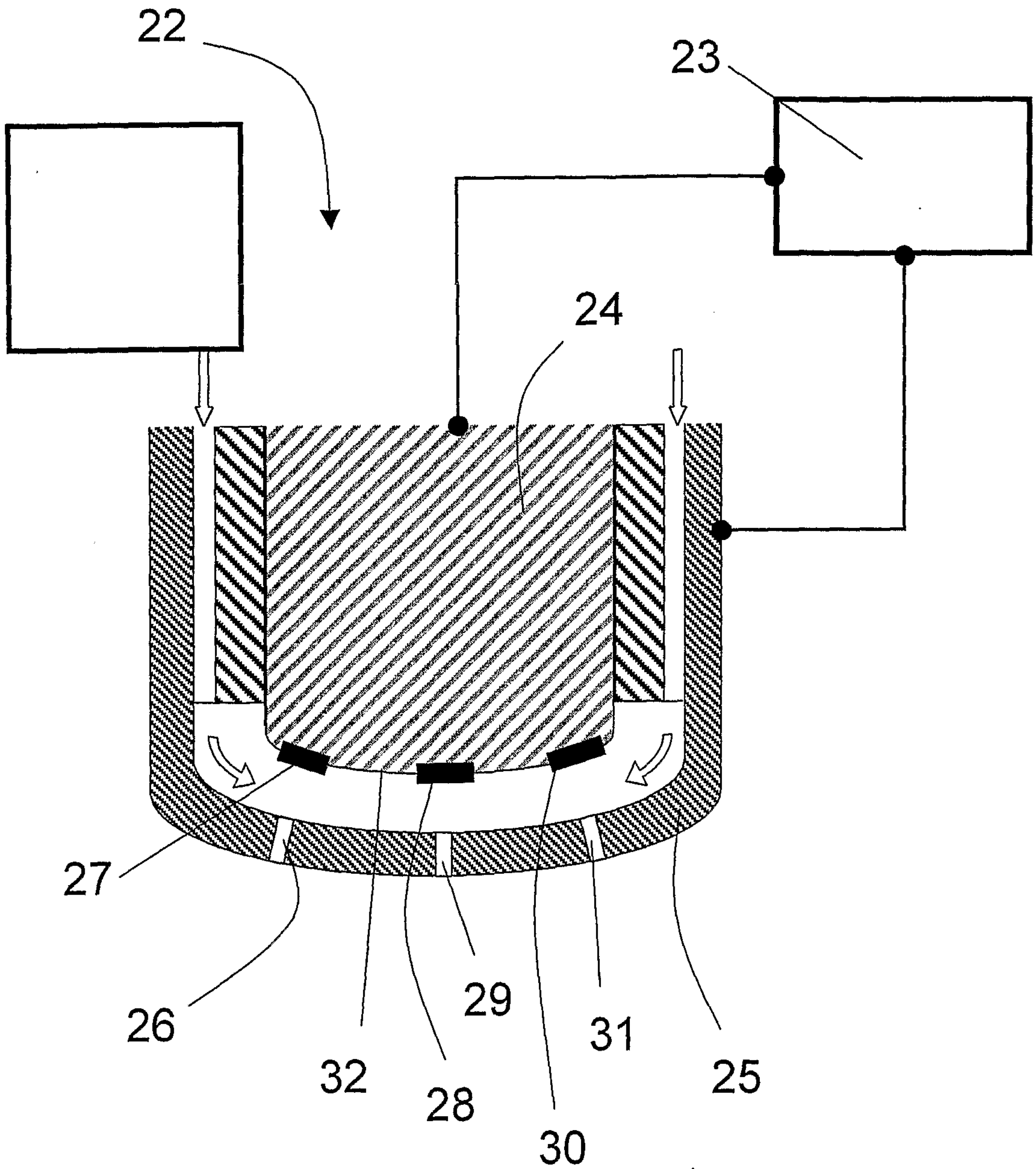

FIGURE 6

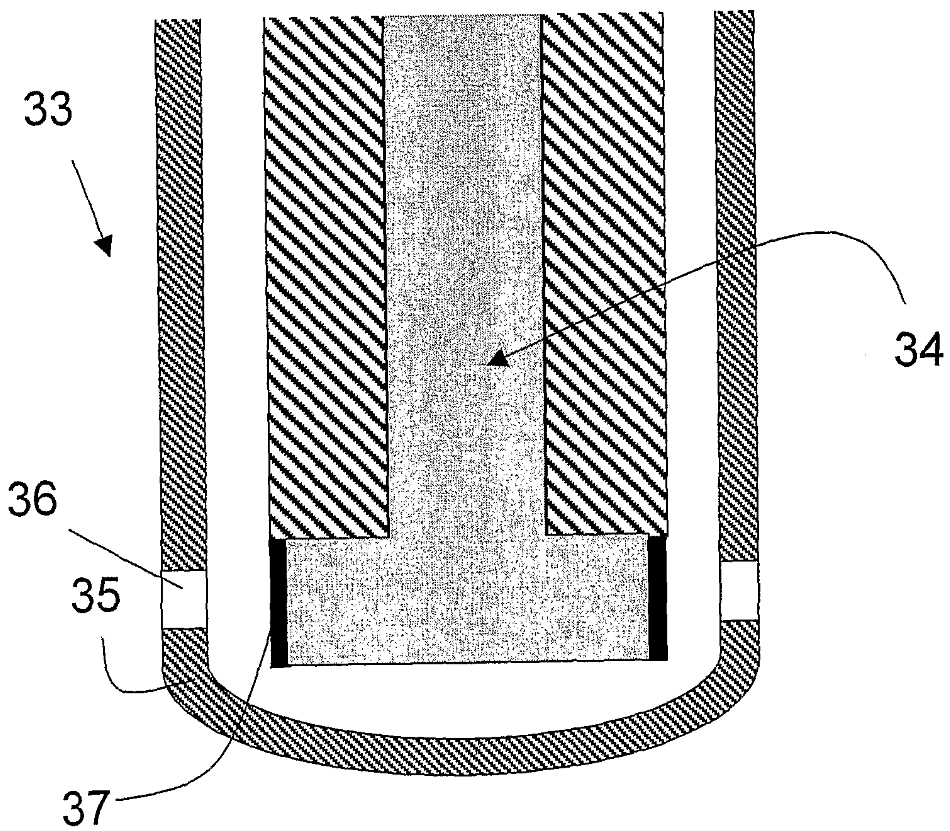

FIGURE 7

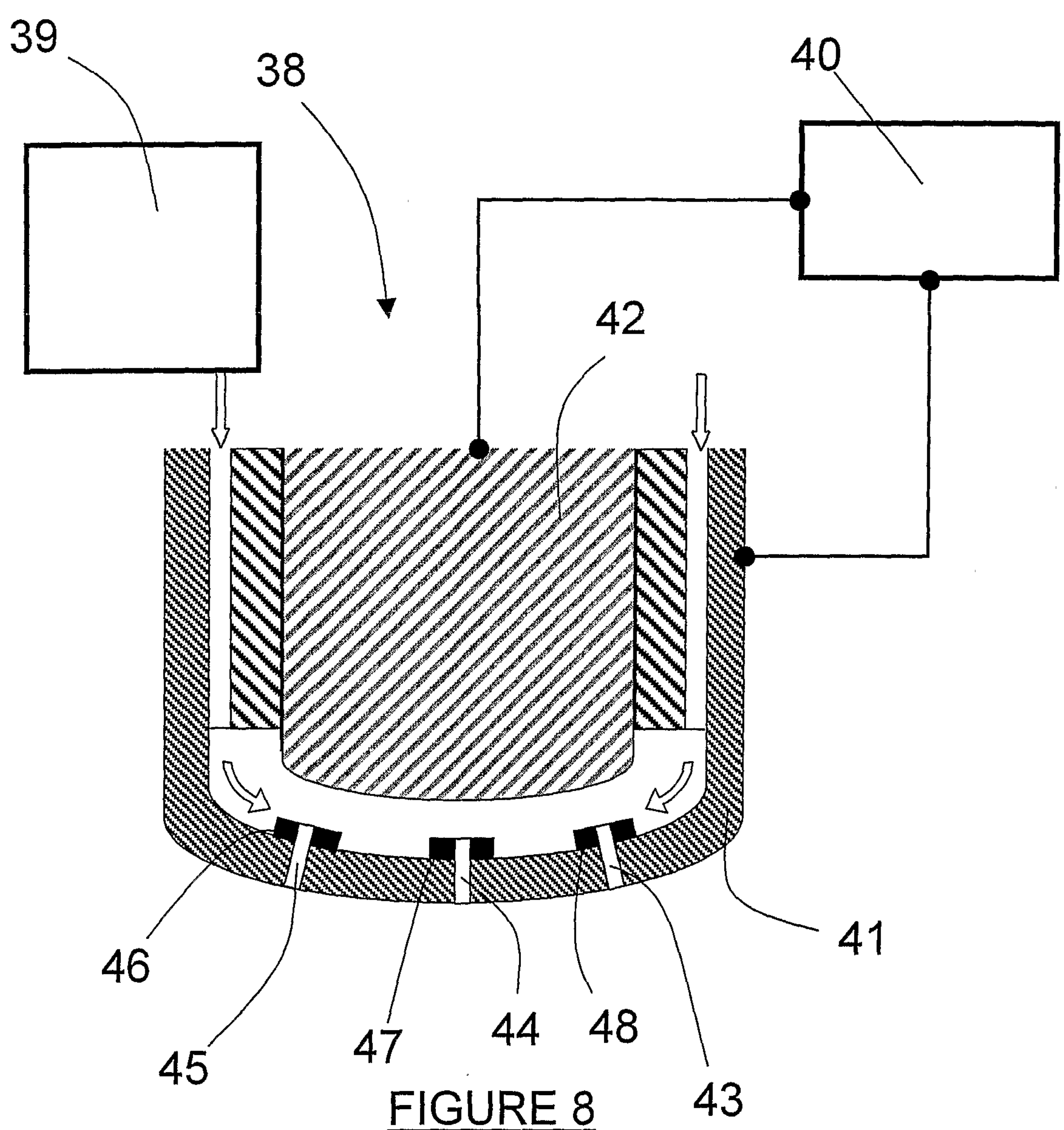

FIGURE 8

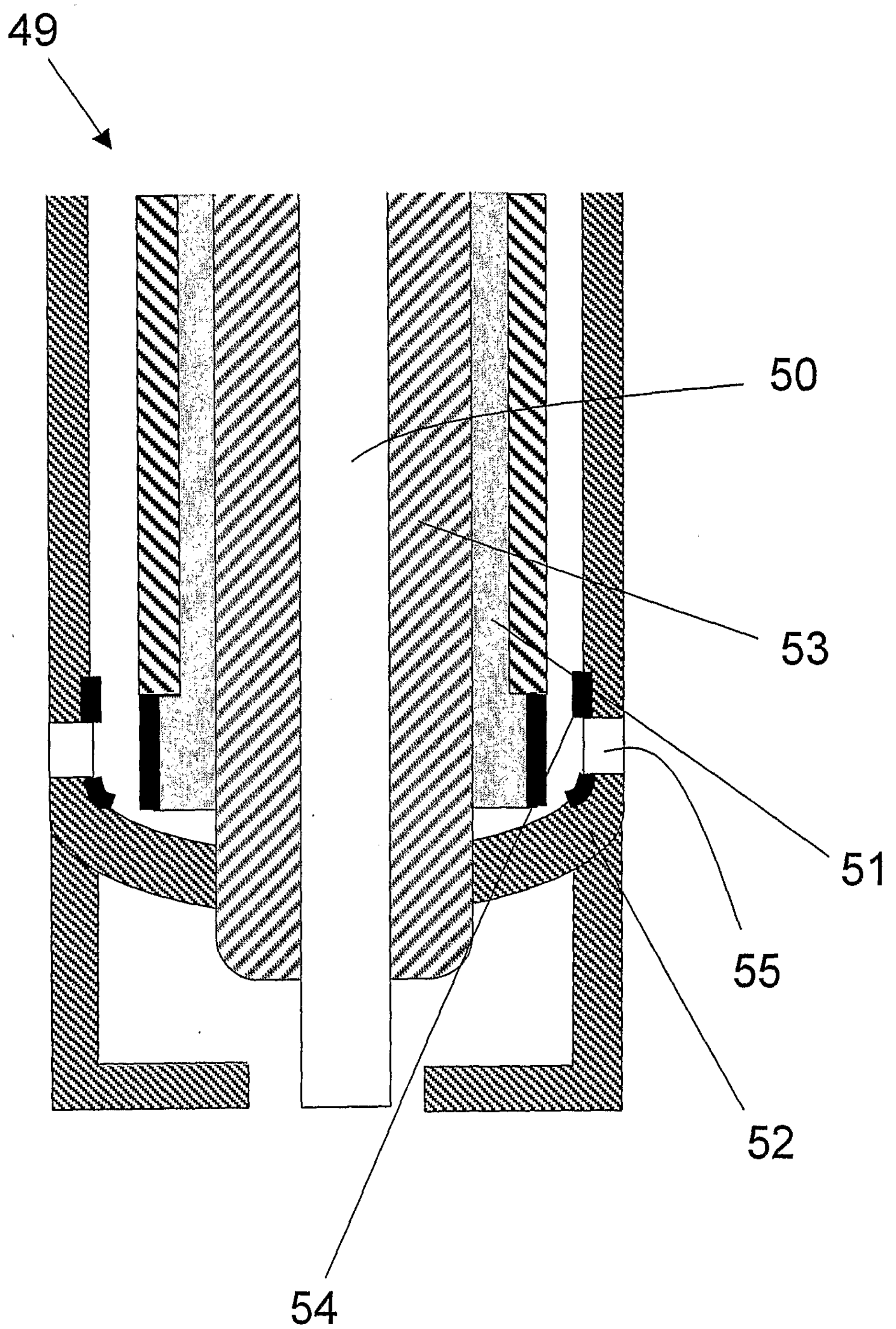

FIGURE 9

INTERNATIONAL SEARCH REPORT

:ional Application No
PCT/GB2004/000458

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B05B5/053

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F23D B05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 206 307 B1 (KELLY ARNOLD J ET AL) 27 March 2001 (2001-03-27) column 5, line 57 - column 6, line 57; figure 1	1-4,16
A	US 2001/046599 A1 (KELLY ARNOLD J) 29 November 2001 (2001-11-29) paragraph ‘0042! - paragraph ‘0043!; figure 1	1-4,16
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☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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24 May 2004	14/06/2004

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