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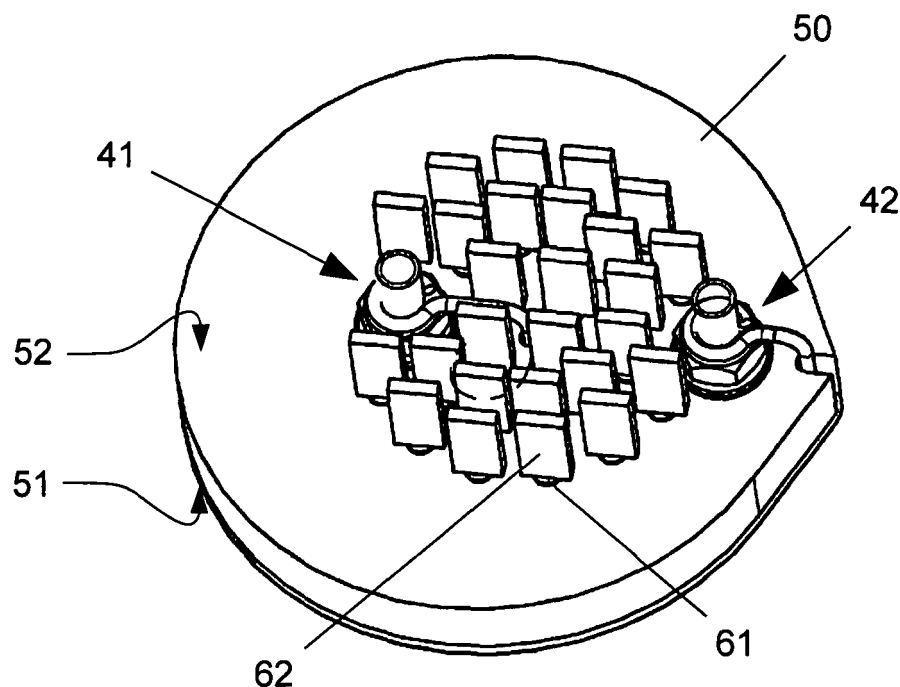
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AL BA HR MK RS(71) Applicant: **Dornier MedTech Systems GmbH****82234 Wessling (DE)**(72) Inventor: **Eizenhöfer, Harald****82234 Wessling (DE)**(74) Representative: **Grünecker, Kinkeldey,****Stockmair & Schwanhäusser****Anwaltssozietät****Leopoldstrasse 4****80802 München (DE)**(54) **Coil carrier with cooling fins**

(57) The present invention relates to an electromagnetic shockwave emitter with an improved cooling arrangement for eliminating the heat dissipated during operation of the electromagnetic shockwave emitter. It is the particular approach of the present invention to provide cooling elements (62) on a back surface of the coil

carrier (52). These cooling elements (62) are implemented within axial holes of the coil carrier plate (50) and protrude from its back surface so as to transfer the heat generated by the coil to the surrounding environment. Due to the inventive back surface cooling mechanism, the temperature of the coil can be reduced, resulting in a significantly prolonged lifetime.

Fig. 4

Description

[0001] The present invention relates to an electromagnetic shockwave emitter with an improved cooling arrangement for eliminating the heat dissipated during operation of the electromagnetic shockwave emitter.

BACKGROUND OF THE INVENTION

[0002] Acoustic shockwaves play an important role in the therapeutic treatment of medical conditions caused by calculi such as kidney stones and various orthopaedic and dermatological symptoms. A conventional apparatus for generating acoustic shockwaves is known, for instance, from reference EP-A-0 798 693 and consists of a flat coil that is driven by a pulsed high-voltage power source for generating an extremely quickly rising magnetic pulse. The magnetic pulse induces eddy currents in an electrically conducting membrane that is in contact with an acoustic propagation medium. The eddy currents, in turn, generate a magnetic field that is oppositely directed to the magnetic pulse produced by the flat coil. The resulting force of repulsion accelerates the membrane so that a pressure pulse within the acoustic propagation medium is generated. Apart from the mechanical energy that is actually delivered to the acoustic propagation medium, the entire electric energy provided by the high-voltage power source is ultimately dissipated within the shockwave emitter, raising its operation temperature. In order to avoid inadmissibly elevated temperatures, a cooling of the shockwave emitter is required.

[0003] Cooling of the shockwave emitter is conventionally achieved by circulating the acoustic propagation medium, a fluid, through a heat exchanger. In this manner, heat generated by the resistive loss of the membrane can reliably be eliminated. Heat generated by the resistive loss of the coil, however, is more difficult to remove, because the coil is bonded to an electrically non-conductive coil carrier with very poor heat conductivity. Moreover, the coil carrier has to have a certain minimum thickness in order to provide sufficient mechanical stability against recoil movements during pulse generation. Hence, in the conventional cooling system, virtually all the heat removal from the coil is across the air gap into the membrane and from there into the acoustic propagation medium. For high energy-density shockwave emitters, this form of "front side cooling" may be insufficient. Insufficient cooling of the coil may result in thermal stress and a significantly reduced lifetime.

[0004] From US patent No. 5,350,352 an alternative cooling system for an acoustic pressure pulse generator is known. This cooling system consists of a cooling unit and a pump which circulates a liquid coolant through channels that are formed on the front side of the coil carrier plate directly beneath the flat coil. Alternatively, the flat coil may also be formed by a hollow wire through which the coolant flows. Although this cooling system may effectively eliminate ohmic heat generated by the

flat coil, it suffers from its complex design.

[0005] There is thus a need in the art for a cooling arrangement for electromagnetic shockwave emitters that is capable of efficiently eliminating excessive heat dissipated by the coil during operation of the emitter.

SUMMARY OF THE INVENTION

[0006] The aim of the present invention is to provide an improved cooling arrangement for electromagnetic shockwave emitters. It is a further aim of the present invention to prolong the lifetime of the coil of an electromagnetic shockwave emitter.

[0007] This is achieved by the features as set forth in the independent claim.

[0008] Preferred embodiments are the subject matter of dependent claims.

[0009] It is the particular approach of the present invention to provide cooling elements on a back surface of the coil carrier.

[0010] According to a first aspect of the present invention, an electromagnetic shockwave emitter is provided. The electromagnetic shockwave emitter comprises a coil carrier; a coil arranged on a front surface of the coil carrier; and a metallic membrane for generating a shockwave in an acoustic propagation medium in response to a magnetic pulse generated by the coil, and is characterized by at least one cooling element arranged on a back surface of the coil carrier. In this manner, the coil of the electromagnetic shockwave emitter can be efficiently cooled via the back surface of the coil carrier, thus prolonging the lifetime of the coil.

[0011] Preferably, the cooling element is formed as a cooling finger. Further, the cooling finger may be a cylindrical pin protruding from the back surface of the coil carrier. Preferably, the cooling finger consists of a counter sunk bolt. In this manner, the cooling element can easily be manufactured and can ensure an efficient heat transfer from the coil to the back surface of the coil carrier.

[0012] Preferably, the cooling element is formed as a cooling fin, so that heat transfer from the cooling element to the surrounding medium is improved.

[0013] Preferably, the cooling element comprises a heat pipe. In this manner, heat transfer from the coil to the back surface of the coil carrier can be further improved.

[0014] Preferably, the cooling element is installed within a blind hole of the coil carrier. In this manner, heat transfer between the coil and the cooling element can be improved while keeping them electrically well insulated from each other. Furthermore, the mechanical stability of the coil carrier is not affected.

[0015] Preferably, the cooling element is installed within a through hole of the coil carrier. In addition, the cooling element is preferably flush with the front surface of the coil carrier. In this case, heat transfer between the coil and the cooling element is optimized while the mechanical stability of the coil carrier remains unaffected.

[0016] Preferably, several cooling elements are electrically insulated from each other, so that spurious eddy currents can be minimized.

[0017] Preferably, the cooling element is composed of a thermally well conducting material, especially from brass, aluminium or, more preferably, from copper, in order to provide for an efficient heat transfer. Alternatively, the cooling element may be composed of an electrically insulating material that exhibits a high thermal conductivity such as synthetic diamond, aluminium nitride and sapphire. These materials may be particularly advantageous in a high voltage environment.

[0018] Preferably, the at least one cooling element is in contact with a cooling fluid. Further, the electromagnetic shockwave emitter may preferably comprise a circulating means for circulating the cooling fluid and/or a heat exchanger for cooling the cooling fluid. In this manner, heat generated during operation of the electromagnetic shockwave emitter can be efficiently eliminated.

[0019] Preferably, the electromagnetic shockwave emitter further comprises tubing for physically separating at least one of the circulating means and the heat exchanger from the at least one cooling element. In this case, the circulating means may be placed in a main apparatus body separate from a therapy head so that annoyances caused by noise of a fan can be avoided by providing proper noise damping. Moreover, the heat exchanger may also be placed in the main apparatus body so that size and weight of the therapy head can be reduced.

[0020] Preferably, the cooling fluid is air, a liquid cooling fluid such as water, or the acoustic propagation medium itself. Each of these options has its specific advantages, viz. air can easily be circulated by convection or by means of a fan, whereas a liquid coolant can generally remove more heat per unit time due to its large specific heat capacity. Using the propagation medium itself has the additional advantage of simplifying the overall design since the propagation medium needs to be circulated and cooled anyway.

[0021] The above and other objects and features of the present invention will become more apparent from the following description and preferred embodiments given in conjunction with the accompanying drawings, in which:

Fig. 1 is a schematic drawing illustrating a cross section of an electromagnetic shockwave emitter according to an embodiment of the present invention;

Fig. 2 is a schematic drawing illustrating a configuration of a hand-held therapy head and an associated main apparatus body according to an embodiment of the present invention;

Fig. 3 is a perspective view of the back surface of a coil carrier plate and the cooling elements ar-

ranged thereon according to a first embodiment of the present invention; and

Fig. 4 is a perspective view of the back surface of a coil carrier plate and the cooling elements arranged thereon according to a second embodiment of the present invention.

DETAILED DESCRIPTION

[0022] Figure 1 is a schematic cross section of an exemplary hand-held therapy head comprising an electromagnetic shockwave emitter according to an embodiment of the present invention. Such a hand-held therapy head is particularly well suited for near-surface applications as in dermatology, orthopedics, etc. The present invention, however, is not restricted to hand-held therapy heads, but may also be applied to other electromagnetic shockwave emitters such as those of lithotriptors.

[0023] The exemplary therapy head 10 of Fig. 1 comprises a housing with an applicator surface 11, tubing 22 for circulating an acoustic propagation fluid 20 through a cooling unit and a bubble separator arranged within a main apparatus body 100, an optional acoustic lens 25 for focusing the shockwave to a target, a metallic membrane 30 that is deflected by a magnetic pulse generated by a flat coil 40, and a coil carrier 50 formed as a planar plate on which the flat coil is mounted. A plurality of cooling elements 60 is provided on the back surface of the coil carrier in order to improve heat transfer from the flat coil 40 through the coil carrier 50. An optional fan 70 in conjunction with ventilation openings 12 and/or an optional air/fluid heat exchanger 80 may be provided in order to avoid accumulation of heat within the housing of the therapy head 10.

[0024] The coil carrier 50 is generally manufactured from an electrically insulating material, such as Isoval® 11, which is a glass fibre reinforced resin material. This material has a very poor thermal conductivity of 0.003 W / K cm. The cooling element, on the other hand, preferably consist of metal, especially copper, having a thermal conductivity of 7.1 W / K cm. Alternatively, cooling elements of brass with a thermal conductivity of 2.2 W / K cm, may be employed. Due to the thermal conductivity of the cooling elements, which is 1000-fold larger than that of the coil carrier, implementation of only a few, preferably four, cooling elements into the coil carrier already leads to a significant improvement in heat elimination.

[0025] As an alternative to metal as the preferred material for the cooling elements, electrically insulating materials with high thermal conductivity, such as synthetic diamond, aluminium nitride, and sapphire may be employed. Further, spurious eddy currents can be reduced by employing a plurality of small cooling elements that are electrically insulated from each other, rather than using a single large cooling fin.

[0026] Instead of using cooling elements that consist of a compact piece of metal, miniature heat pipes may

be employed. A heat pipe is a heat transfer mechanism based on evaporation of a liquid at a hot end, condensation of the liquid at a cold end, and a transport of the liquid back to the hot end by capillary action. In this manner large quantities of heat can be transported.

[0027] As can be seen from Fig. 1 the cooling elements are implemented into the coil carrier in an axial direction. Specifically, the cooling elements are mounted in blind holes (as indicated in Fig. 1) or in through holes (not shown) of the coil carrier. In the latter case, the cooling elements may consist of counter sunk bolts with their ends protruding from the back surface 52 of the coil carrier 50.

[0028] Implementing the cooling elements in through holes is advantageous in order to achieve a good heat transfer between the coil and the cooling elements. On the other hand, blind holes provide additional electrical insulation between the metallic cooling elements and the coil.

[0029] In Fig. 1, the cooling elements release the heat generated by the coil to a cooling fluid 21 within the housing of the therapy head 10. The cooling fluid 21 may be a liquid coolant or simply air. In the latter case, passive thermal conduction may suffice to finally release the heat to the external environment, although ventilation openings 12 and a fan 70 may be provided in order to avoid accumulation of heat within the housing. Ventilation openings and/or a fan in the therapy head, however, are disadvantageous regarding the risk of water entering into the housing or annoyances due to noise and airflow caused by the fan.

[0030] Therefore, the heat dissipated by the cooling elements may preferably be removed by means of an air/fluid heat exchanger 80, preferably in conjunction with the circulation of the acoustic propagation fluid 20. Employing an air/fluid heat exchanger may avoid mechanical problems that might otherwise arise due to the strong recoil movement of the coil carrier if a fluid heat exchanger would be attached directly to the cooling elements.

[0031] It is to be noted that the shockwave emitter shown in Fig. 1 is by way of example only and that the present invention may be applied to various alternative emitter configurations. The configuration shown in Fig. 1, for example, is based on a flat coil configuration, although the present invention is by no means restricted in this aspect. Instead of electromagnetic shockwave emitters with a flat coil, the present invention may also be applied to shockwave emitters that have a differently shaped coil, such as in form of a cylinder or a spherical cap. Moreover, the form of coil carrier and of the membrane may be adapted to the shape of the coil and may deviate from the planar configuration shown in Fig. 1. Further, the acoustic lens in Fig. 1 may be omitted or replaced by an appropriately shaped reflector. The present invention, however, may be applied to any of these emitter configurations.

[0032] Figure 2 is a schematic drawing illustrating a configuration of a hand-held therapy head 10 and an as-

sociated main apparatus body 100 according to an embodiment of the present invention.

[0033] The therapy head is connected to the main apparatus body 100 by means of tubing 13, 22. The tubing 22 is used to circulate the propagation medium 20 by means of a pump 175 through a cooling unit 170, 180 and/or a bubble extractor (not shown). A similar tubing or the envelope tubing 13 itself may be employed to circulate the cooling fluid 21 that serves as a coolant for the cooling elements 60. However, the propagation medium may at the same time be employed as the coolant for the cooling elements. In this case, the configuration of the electromagnetic shockwave emitter can be substantially simplified since no extra tubing, etc., is required.

[0034] In case that air is used as the cooling fluid, the fan 70 for circulating the air may preferably be arranged within the main apparatus body rather than within the therapy head. In this manner, proper noise damping may be provided within the main apparatus body in order not to disturb the user by the noise generated by the fan. Moreover, since the main apparatus body is usually physically separated from the therapy head, any disturbances by the airflow generated by the fan may be avoided, too.

[0035] Figure 3 is a perspective view of the back surface 52 of a coil carrier 50 formed as a planar plate and the cooling elements arranged thereon according to a first preferred embodiment of the present invention, as well as connector terminals 41, 42 of the coil. According to this embodiment, each of the cooling elements consists of a cylindrical finger 61 that protrudes from the back surface 52 of the coil carrier plate 50. Each of these cooling fingers may consist of a brass bolt with 2.5 mm diameter, although cooling fingers from a different material, different diameter, etc. may be employed without deviating from the invention as defined by the attached claims. Moreover, a different number of cooling fingers or an arrangement of the cooling fingers on the back surface of the coil carrier plate that differs from the one shown in Fig. 3 may likewise be adopted.

[0036] Figure 4 is a perspective view of the back surface 52 of a coil carrier 50 formed as a planar plate and the cooling elements arranged thereon according to a second preferred embodiment of the present invention. This figure is similar to Fig. 3, wherein like elements are denoted by like reference numerals, a repetition of a detailed description of which will be omitted. The second embodiment differs from the first embodiment shown in Fig. 3 in that the cooling fingers 61 are additionally provided with cooling fins 62. The cooling fins enlarge the surface of each cooling element that is exposed to the surrounding cooling fluid so that a heat transfer from the cooling finger to the cooling fluid is improved.

[0037] It is to be noted that the coil carrier plates shown in Figs. 3 and 4 are by way of example only and that the present invention may also be applied to electromagnetic shockwave emitters having coil carriers with a form that differs from the planar plate shown in the figures. In particular, the coil carrier may also be formed as a cylindrical

tube or a spherical cap, without deviating from the present invention as defined in the annexed set of claims.

[0038] Summarizing, the present invention relates to an electromagnetic shockwave emitter with an improved cooling arrangement for eliminating the heat dissipated during operation of the electromagnetic shockwave emitter. It is the particular approach of the present invention to provide cooling elements on a back surface of the coil carrier. These cooling elements are implemented within axial holes of the coil carrier and protrude from its back surface so as to transfer the heat generated by the coil to the surrounding environment. Due to the inventive back surface cooling mechanism, the temperature of the coil can be reduced, resulting in a significantly prolonged lifetime.

Claims

1. An electromagnetic shockwave emitter comprising a coil carrier (50); a coil (40) arranged on a front surface (51) of the coil carrier (50); and a metallic membrane (30) for generating a shockwave in an acoustic propagation medium (20) in response to a magnetic pulse generated by the coil (40);
characterized by at least one cooling element (60) arranged on a back surface of the coil carrier (50).
2. An electromagnetic shockwave emitter according to claim 1, wherein the cooling element (60) is formed as a cooling finger (61).
3. An electromagnetic shockwave emitter according to claim 2, wherein the cooling finger (61) is a cylindrical pin protruding from the back surface of the coil carrier (50).
4. An electromagnetic shockwave emitter according to claim 3, wherein the cooling finger (61) consists of a counter sunk bolt.
5. An electromagnetic shockwave emitter according to any of claims 1 to 4, wherein the cooling element is formed as a cooling fin (62).
6. An electromagnetic shockwave emitter according to any of claims 1 to 5, wherein the cooling element (60) comprises a heat pipe.
7. An electromagnetic shockwave emitter according to any of claims 1 to 6, wherein the cooling element (60) is installed within a blind hole of the coil carrier (50).
8. An electromagnetic shockwave emitter according to any of claims 1 to 6, wherein the cooling element (60) is installed within a through hole of the coil carrier (50).
9. An electromagnetic shockwave emitter according to claim 8, wherein the cooling element (60) is flush with the front surface (51) of the coil carrier (50).
10. An electromagnetic shockwave emitter according to any of claims 1 to 9, wherein several cooling elements (60) are electrically insulated from each other.
11. An electromagnetic shockwave emitter according to any of claims 1 to 10, wherein the cooling element (60) is composed of a thermally well conducting material.
12. An electromagnetic shockwave emitter according to claim 11, wherein the cooling element (60) is composed of either one of copper, brass, and aluminium.
13. An electromagnetic shockwave emitter according to claim 11, wherein the cooling element (60) is composed of either one of synthetic diamond, aluminium nitride, and sapphire.
14. An electromagnetic shockwave emitter according to any of claims 1 to 13, wherein the at least one cooling element (60) is in contact with a cooling fluid (21).
15. An electromagnetic shockwave emitter according to claim 14, further comprising a circulating means (70; 175) for circulating the cooling fluid (21).
16. An electromagnetic shockwave emitter according to claim 14 or 15, further comprising a heat exchanger (80; 180) for cooling the cooling fluid (21).
17. An electromagnetic shockwave emitter according to claim 15 or 16, further comprising tubing (13, 22) for physically separating at least one of the circulating means (175) and the heat exchanger (180) from the at least one cooling element (60).
18. An electromagnetic shockwave emitter according to any of claims 14 to 17, wherein the cooling fluid (21) is air.
19. An electromagnetic shockwave emitter according to any of claims 14 to 17, wherein the cooling fluid (21) is a liquid cooling fluid.
20. An electromagnetic shockwave emitter according to any of claims 14 to 17, wherein the cooling fluid (21) is water.
21. An electromagnetic shockwave emitter according to any of claims 14 to 17, wherein the cooling fluid (21) is the acoustic propagation medium (20).

Fig. 1

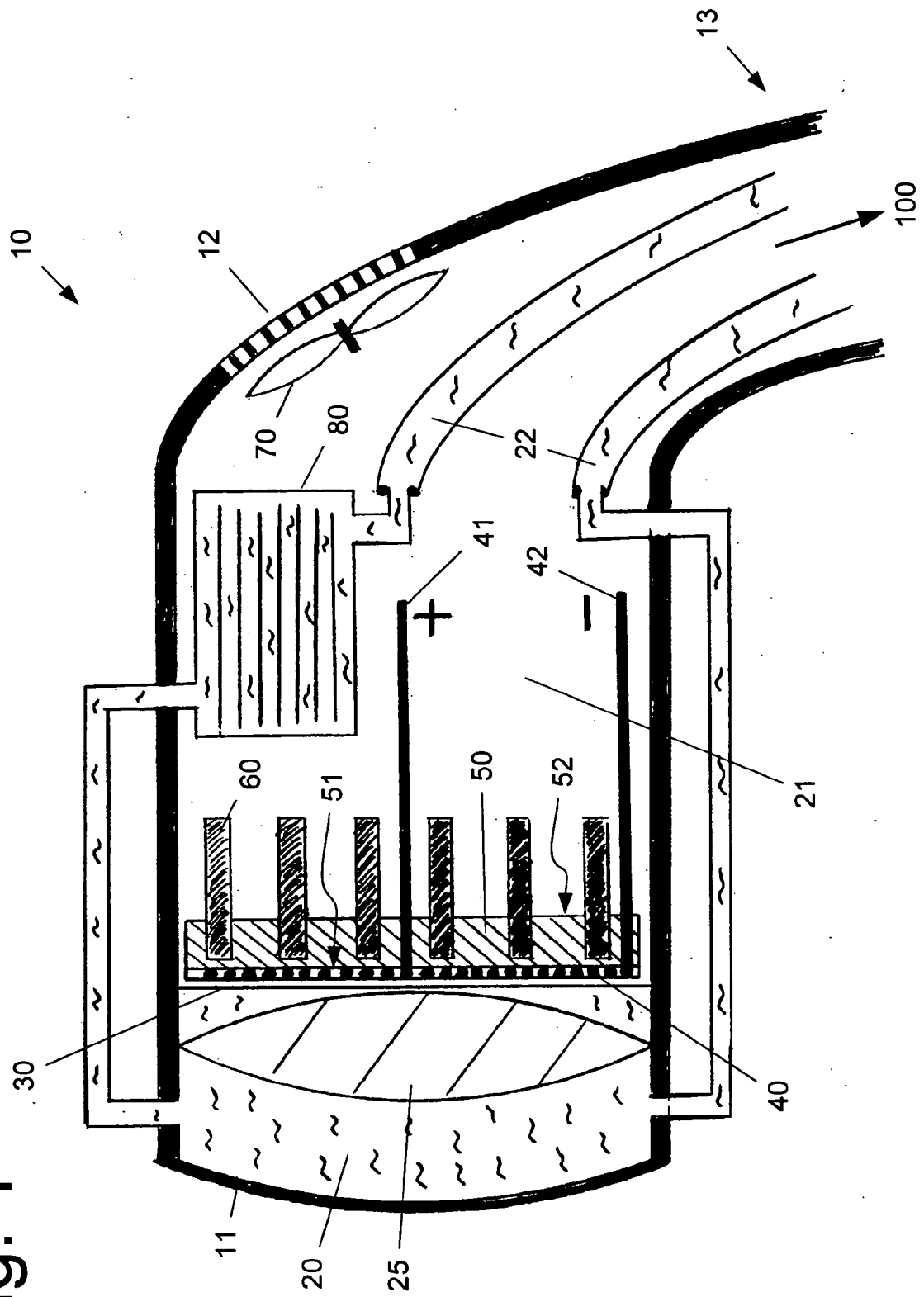


Fig. 2

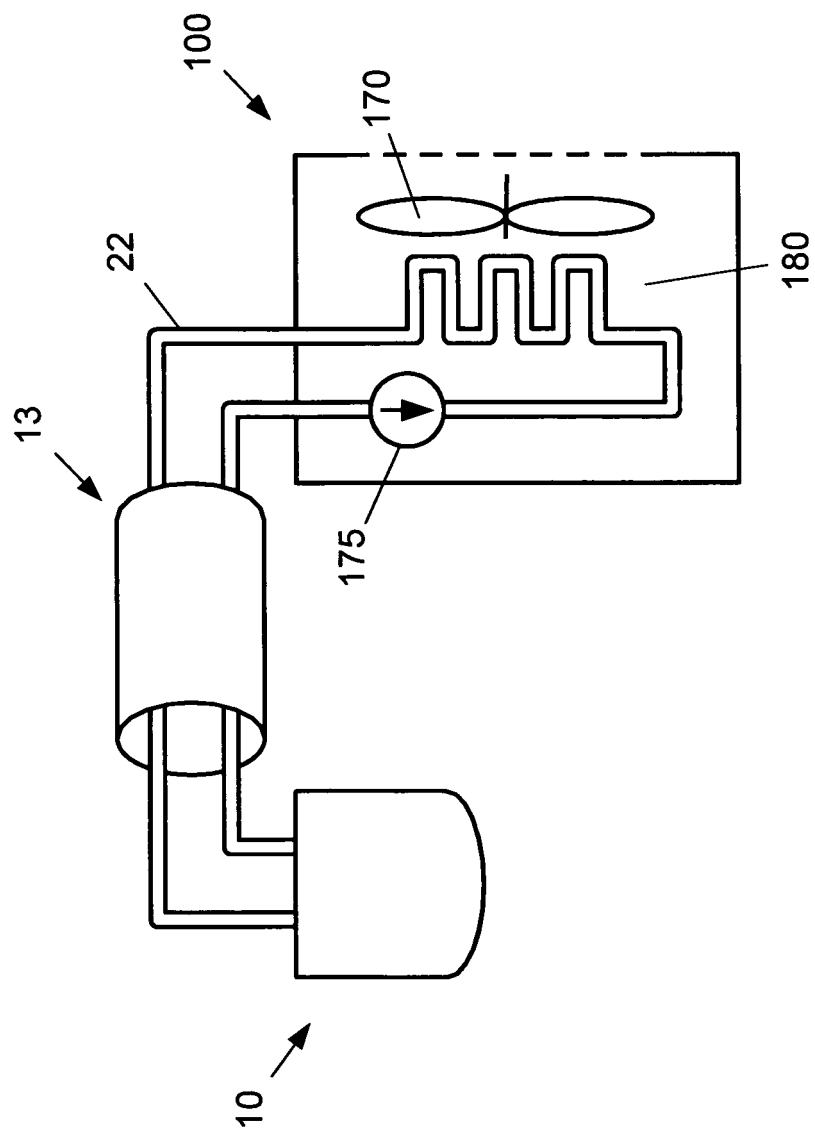


Fig. 3

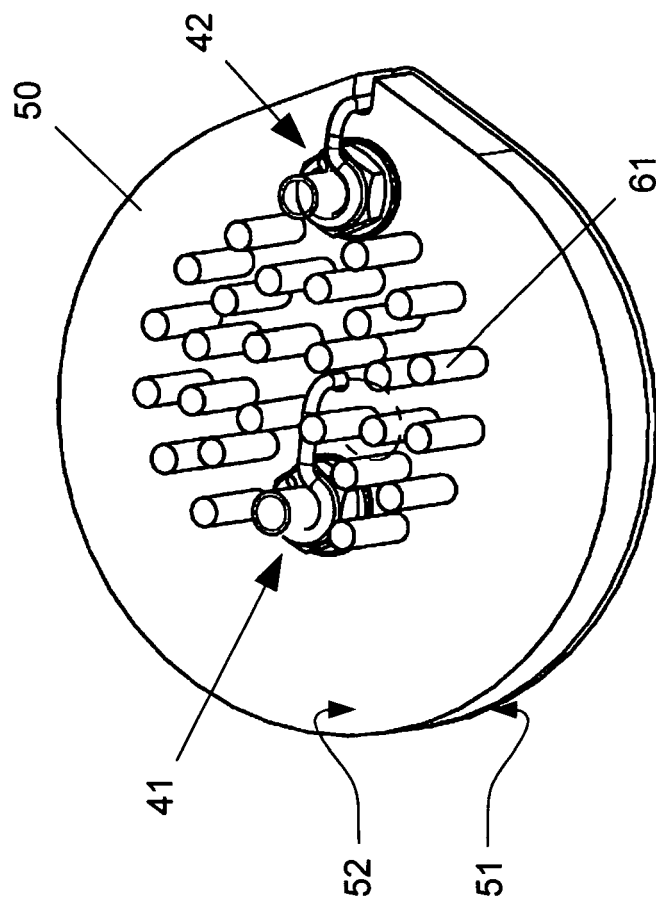
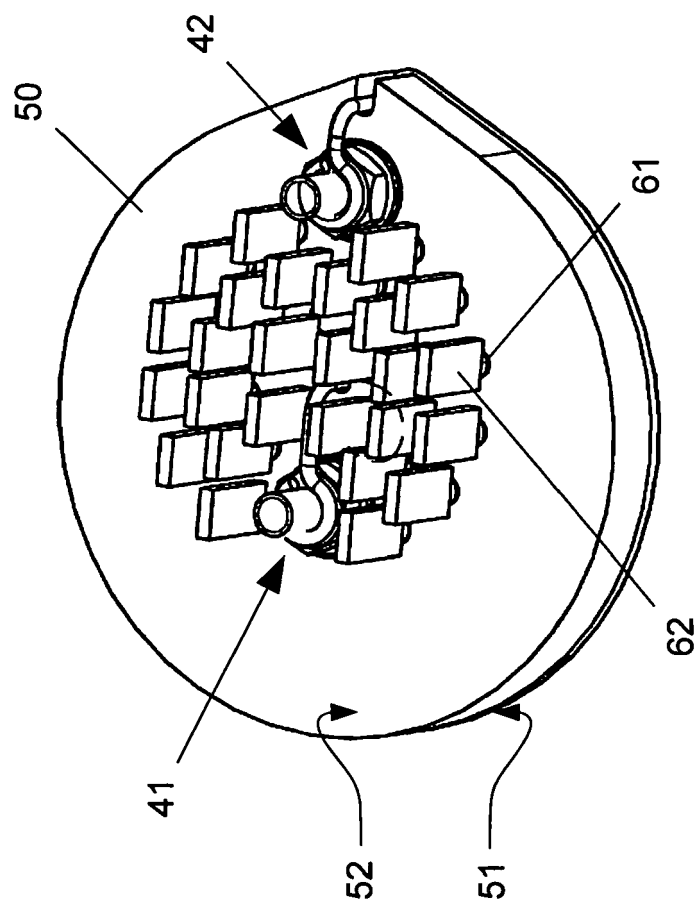


Fig. 4





DOCUMENTS CONSIDERED TO BE RELEVANT			
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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 24 June 2008	Examiner Vollmer, Thorsten
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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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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24-06-2008

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