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(54) **An apparatus and method for electrochemically protecting and/or cleaning surfaces of a heat exchanger**

(57) An apparatus and methods for electrochemically protecting and/or cleaning surfaces of a heat exchanger (20) are disclosed. The apparatus comprises heat transfer plates (6,6',6'',6''') forming at least one flow channel (40,42) there between. At least one electrode plate (3,3') is arranged in the flow channel between the heat transfer plates (6,6',6'',6'''), the at least one electrode (3,3') plate substantially resembling from the size and shape thereof the adjacent heat transfer plates (6,6', 6'',6'''). Insulating means (9) for providing electrical isolation between the at least one electrode plate (3,3') and the heat transfer plate (6,6',6'',6''') and at least one conductive element (1,21,44) for conducting current to the at least one electrode plate (3,3') are also provided.

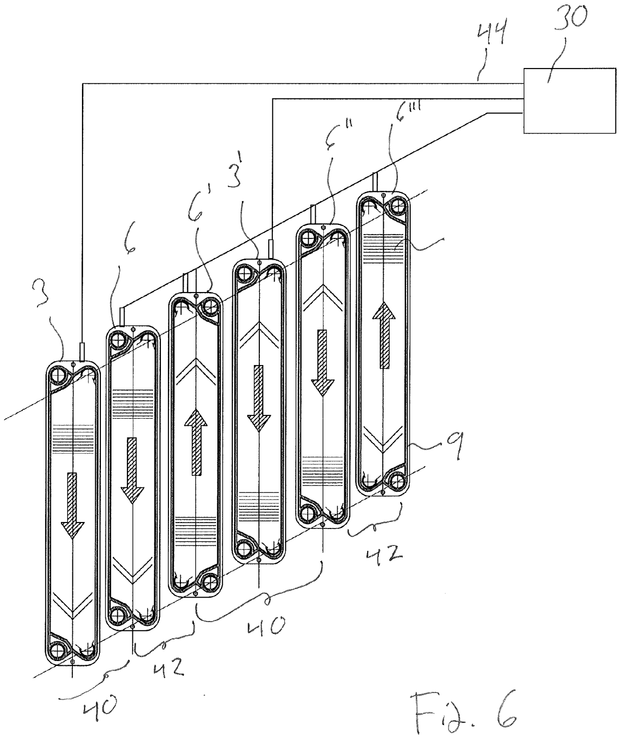

Fig. 6

EP 2 372 292 A2

Description

[0001] This invention relates to heat exchangers and more particularly to electro-chemical protecting and/or cleaning of surfaces of heat exchangers.

[0002] Heat exchangers are used in various industries for cooling hot liquids and other fluids and also for heating cold fluids. The most common types of heat exchangers are plate heat exchangers and shell and tube heat exchangers. In a typical plate heat exchanger a plurality of parallel metal heat transfer or exchange plates are arranged such that they form alternate cold chambers and hot chambers. A heat exchanger is divided into two flow circuits or channels so that one of the circuits is connected to the hot chambers and another to the cold chambers. Heat from the hotter chamber will become transferred through the transfer plate to the colder chamber, and thus the temperature of the fluid to be processed can be controlled in a desired manner. In shell and tube heat exchangers fluids to be processed are led through a shell including a plurality of tubes so that the heat transfer between the colder and the hotter liquids occurs through the walls of the tubes. One of the flows is provided within the tubing whereas the second flow is arranged within the shell and outside the tubing walls.

[0003] A problem with heat exchangers is corrosion. Corrosion may be caused by the corrosive nature of the fluids to be processed, for example because aggressive acids such as sulphuric acids are processed. Build up of deposits, commonly known as fouling, on the surfaces may also lead into corrosion. Chemical deposits are often referred to as scale, whereas primarily organic deposits cause biofouling. Deposits building up on the surfaces of the heat exchanger can also decrease the efficiency thereof, and may even cause blockages.

[0004] When designing a heat exchanger an aim is to provide as narrow channels as possible so that the flow can be made turbulent. Turbulence in the flow is typically desired since it can improve heat transfer through heat transferring elements. However, this can make the heat exchangers less resistant to fouling. Fouling can substantially reduce the capability of the heat transfer elements to transfer heat and increase the amount of energy required for heating or cooling. One way of preventing fouling is to increase and maximize the flow through the heat exchanger. However, this can increase the power requirement of the pumps of the system. Fouling can cause a pressure difference between the inlet and outlet of the heat exchanger that may not be on acceptable levels. Use of larger channels and conduits does not prevent fouling either, and may not be desirable because of the less efficient heat transfer capability. Because of the fouling heat exchangers need to be regularly taken out of service and washed. However, this disturbs the production and is costly.

[0005] Electrical current has been used to protect metallic parts of a heat exchanger. Electric current has also been used for cleaning surfaces and for preventing fouling of surfaces. Such methods, know also by the name electrochemical protection, are well know as such. The electrochemical protection method can be cathodic or anodic, or a combination of these. An example of known electrochemical protection methods can be found from US Patent 4,586,562 disclosing a plate heat exchanger assembly that is provided with an anodic protection system such that some of the heat exchanger plates mounted to the frame are connected to positive current and some of the plates are connected to negative current. The plates are insulated from each other to provide electrolytic chamber means for selectively applying a voltage across the adjacent plates. However, the arrangement does not necessarily enable application of optimal potential in the plates. Control of polarizations of the transfer plates can be difficult. Control of polarizations versus time may become a particularly challenging task. Another example can be found from US Patent 7,225,863 where a plate type heat exchanger is protected against corrosion by inserting a cathode in the inlet passage and outlet passage so that the cathodes are in contact with the sulfuric acid to prevent corrosion. In this arrangement the heat transfer plates are connected to a positive pole of the power source and thus the plates provide the anodes of the system. US Patent 4,800,007 discloses yet another example of an arrangement where the cathodes are placed in the inlet channel. A cathode in the inlet and/or outlet channel, however, may not necessarily provide protection for the entire area of the heat exchanger plates. US6357516 discloses a heat exchanger including a plurality of specific electrode plates inserted in the refrigerant channels between the heat transfer plates. The electrodes are connected to a voltage source by a rod extending in refrigerant exit tube.

[0006] Examples of shell and tube type heat exchangers with electro-chemical protection are disclosed in US Patents 4,588,022, 5,515,913and 5,513,694. In these arrangements a cathode is placed within the shell of the heat exchanger between the tubing.

[0007] Although the proposed solutions are believed to work, the inventor has found that it is possible to further improve the efficiency and/or operation of the anticorrosion and/or anti-fouling properties of a heat exchanger.

[0008] It is noted that the above discusses only examples, and the issues are not necessarily limited to any particular environment and heat exchanger type but may occur in any heat exchanger where fouling and/or corrosion may occur.

[0009] Embodiments of the invention aim to address one or several of the above issues and to provide an apparatus and method by means of efficiency of a heat exchanger can be improved.

[0010] An apparatus according to the invention is defined in independent claim 1. Methods according to the invention are defined in independent claims 13 and 14. Dependent claims define more detailed embodiments.

[0011] Various other aspects and further embodiments are also described in the following detailed description of examples embodying the invention and in the attached claims.

[0012] The invention will now be described in further detail, by way of example only, with reference to the following examples and accompanying drawings, in which:

Figure 1 shows as an example a sectional view of a heat exchanger assembly;
Figures 2 and 3 shows examples of electrodes in accordance with certain embodiments;
Figure 4 shows an example of an electrode and transfer plate arrangement:
Figure 5 shows an enlargement of a detail of Figure 1;
Figures 6 and 7 show certain embodiments;
Figure 8 shows a control apparatus;
Figures 9A and 9B show a cross sectional view of shell and tube heat exchanger from side and end thereof;
Figures 10 and 11 shows certain details of Figure 9A; and
Figure 12 shows a further embodiment.

[0013] In the following certain exemplifying embodiments are explained with reference to a plate type heat exchanger, Figure 1 showing a cross sectional view from the side of a plate heat exchanger 20. The heat exchanger body comprises a shell provided by end plates 7 and side walls 5 between the end plates. The body of the heat exchanger can be manufactured by any appropriate technique, including welding, bolting, pressing, casting, moulding and so forth. Within the shell are provided heat transfer plates 6 as described in more detail below.

[0014] A primary flow channel 2 is provided between an inlet 11 and an outlet 12. In the example the primary flow channel is for the flow of the fluid to be processed, i.e. heated or cooled. The primary flow will first enter an inlet channel 2, then be passed into contact with the heat transfer plates 6, collected at an outlet channel 4 and let out from the outlet 12. In this example the secondary flow channel is provided between inlet 13 and outlet 14. The secondary flow channel is for the flow of the treating fluid, i.e. either heating or cooling fluid. The secondary flow is guided into spaces 36 between the heat transfer elements 6 such that the fluid evenly contacts the secondary sides of the heat transfer plates. The basic operational principles of a plate heat exchanger are well known, and therefore they are not explained in any greater detail here.

[0015] Figure 1 shows further an electrode element 3 placed between two heat transfer plates 6 of the heat exchanger. A system 30 for controlling the operation and for providing current for the electrode element is also shown. The electrode element can be provided by means of an electrode plate. The shape and size of the periphery thereof can substantially resemble the shape and size of the adjacent heat transfer plates. Because the electrode element is positioned between the heat transfer elements, a similar polarization can be applied to each adjacent element. Regardless of whether the electrode element is driven into anodic or cathodic mode, each of the heat transfer elements can be subjected to same polarization in uniform manner.

[0016] Figure 2 shows a cross section of the heat exchanger 20 along section A-A of Figure 1. More particularly, a rectangular electrode plate 3 is shown in more detail from the front thereof. Figure 3 shows another cross sectional view along section A-A where it is assumed that the heat exchanger has a circular cross section. Thus a circular electrode plate 3 is provided. Circular cross section of the heat transfer plate and of the electrode may be desired in certain applications, for example because of improved strength and ease of manufacture. It is noted that although the rectangular and circular shapes are the most common a heat exchanger may also have any other appropriate cross sectional shape.

[0017] Figure 4 shows schematically the relationship between heat transfer plates 6 of the heat exchanger and electrodes 3. As can be seen, every other plate can be a heat transfer plate 6 and every other plate can be an electrode 3. An electrode plate can be positioned between each heat transfer plate pair of a heat exchanger. The heat transfer plate pair can form a primary or a secondary channel. As shown, the electrode plate between the heat transfer plates can be substantially identical with the heat transfer plates.

[0018] In accordance with an embodiment, only one type of plates is used. Instead of a honeycomb structure where every second plate is reversed, the plates can be arranged such that there are three plates in a first orientation and the next three plates are in another orientation and so on. This is illustrated by Figures 6 and 7.

[0019] Figure 5 shows an enlargement of the circled area B of Figure 1. In the example the heat transfer plates are provided as a module that is welded to the inlet tubing 2 such that side walls 26 of the heat transfer plate module 6 provide each a heat transfer plate. The electrode element 3 is placed between the plates 26. Each electrode element 3 is shown to be isolated from the respective heat transfer element 6 by means of appropriate nonconductive insulator 9. Therefore the heat transfer plates 26 in each side of the electrode element 3 are not in electrical contact with the electrode. The isolator between the electrode element and the heat transfer plates can be provided on the entire circumference of the plate as shown in figure 4. Alternatively, appropriate isolator pieces can be provided on the circumference of the electrode plate, as shown in figures 2 and 3. The isolator 9 can be provided from, for example, EPDN isolator tape, ceramic or plastic isolator material, or from any other dielectric material. Because of the isolation 9 the electrodes 3 are not in contact with any part of the body of the heat exchanger.

[0020] As is also shown in figure 5, a gap 25 is provided in each side of the electrode plate between the adjacent heat transfer plate and the electrode. The width of the gap can be designed based on the particular requirements set for the heat exchanger. For example, the gap can be in the order of 2mm.

[0021] Figures 1, 4 and 5 show further a conductive elongated element 1 extending through the heat exchanger. In accordance with an embodiment the conductive element can be provided by conductive rod or bar 1. The elongated conductive element 1 can extend within the tubing of the primary flow channel 2. As shown in Figures 4 and 5 the conductive element can extend through openings 22 in the heat transfer plates 6. The openings 22 are dimensioned such so that no contact is made between the conductive element 1 and the heat transfer plate 6.

[0022] Typically this can mean that normal openings of a heat transfer plate for an inlet channel can be used.

[0023] The conductive elements can be covered by an appropriate insulating material. The insulating material may extend on the entire length of the conductive element that is exposed to the fluid. This can assist in conducting all the current to the electrode elements. In accordance with a possibility only a portion or certain portions are isolated. This may be used for example to provide an additional electrode in a certain section of the heat exchanger, for example if it is desired that anodic protection is provided in a portion of the flow channel. It is also possible to have a conductive element that also has the double function of an electrode element over the entire length thereof. According to a possibility the conductive element is provided by means of wiring.

[0024] As is shown in figure 4 the bar receiving arrangement 24 in the electrode plate 3 comprises an opening 15 for receiving the conducting bar such that electrical connection is provided there between. As shown in figure 5 in detail, the conducting bar 1 can be welded into the electrode plate. Other ways of providing an appropriate joining may also be used, including threaded assembly, pressed assembly, gluing, and so on. At least one further opening 8 is provided in the vicinity of opening 15 so that the fluid in the channel 2 can flow through the electrode plate 3.

[0025] Figures 1 and 4 show also a second conductive element 21, for example a conductive bar, extending through the heat transfer plates and the electrode plates. The second bar 21 can be provided in addition to the first bar 1 extending in the inlet channel 2. Figure 1 shows also a third conductive bar 31 extending in the outlet channel 4.

[0026] According to an embodiment a sole conductive bar 21 is provided as an alternative positioning for a bar in the primary inlet flow channel 2. Such sole current supplying bar can in principle be positioned anywhere in the cross section of the heat exchanger. In certain applications, in particular if fouling does not occur in any particular location, it may be desired to position the conductive bar about the middle of the heat exchanger cross section. Any number of conductive bars may be provided in an appropriately distributed manner over the cross section such that none of them extends in the inlet or outlet channels. In accordance with an embodiment a plurality of conductive bars can extend through an opening provided in the transfer and electrode plates.

[0027] The number of conductive bars and positioning thereof depends on the application. More than one bar may be needed for example if a plurality of different electrode circuits is desired. Figure 1 shows four circuits C1 to C4. The circuits can be controlled independently. For example, the power and/or polarity of each circuit can be controlled independently. Also, the control can be such that only one or two of the available circuits are operational at a certain time. This can be used to reduce the total current needed. Also, it may be, depending on the application, that one section of the heat exchanger is more prone to fouling, and therefore requires different control. The circuits can be controlled by the control apparatus 30.

[0028] The rod receiving opening of the electrode plates can be arranged such that plates belonging to a circuit have a rod receiving and engaging opening only for the rod of that circuit whereas the other opening are wider allowing pass through of rods of other circuits. That is, electrodes that are not to be connected to a circuit controlled via a conducting bar are simply provided by a larger opening and therefore isolated from the bar. For example, rod engaging openings 15 can be provided in a corner or two corners of the plate whereas the other corners have larger opening allowing the rods of other circuits to pass through.

[0029] For example a rectangular plate heat exchanger provided with electrode plates as shown in figure 2 can have four circuits. Five circuits are possible if the opening 15 in the middle of the plate is also used. If more circuits are desired, more conducting rods and respective openings can be provided. This provides freedom in designing an appropriate amount of circuits for a heat exchanger and also an appropriate amount of electrodes to be connected to any circuit.

[0030] The power in the separated circuits C1 to Cn can be controlled independently from each other. It is possible to supply current to all electrodes at the same time. Polarity of the circuits can be changed independently. Current can be supplied to the electrode plates, i.e. to circuits C to Cn in a cyclical fashion or otherwise such that only one set of electrodes are in use at a time. This can enable use of a single current source.

[0031] An electrode plate can resemble substantially from the size, periphery and shape thereof the heat exchange plates. In accordance with an embodiment the heat transfer and electrode plates are identical. An electrode plate can be manufactured as a smooth plate. Alternatively, the electrode plate can be provided with formations such that turbulence within the conduit between the plates is improved and thereby the heat transfer efficiency of the heat transfer plate is increased. The formations can comprise chevron like corrugations as shown in figures 2 to 4, other types corrugations or recesses, bosses /protuberances, dimples, grooves, openings such as slots or holes and so forth. In principle any formation causing turbulence to the passing by flows can be used for this purpose. In accordance with an embodiment the electrode plates comprise free flow plates. Free flow plates can provide an advantage in better pressure strength due to the formations thereon and their increased thickness.

[0032] In accordance with an embodiment adjacent electrode plate and heat transfer plate have different thicknesses. For example, the electrode plate 3 can be manufactured to be thicker than the heat transfer plates. As a non-limiting example of the thickness ranges to give an idea what they might be, the electrode plate can be manufactured from material that is in the order of 0.1 to 2 mm and the heat transfer plates can be manufactured from material that is in the order of 0.2 to 2 mm. It is noted that different thicknesses can be used, depending on the application. The plates can be manufactured from same or different materials. For example, the electrode plate may be manufactured from more heat and/or wear resistant material. The electrode plate may also be coated by an appropriate coating. The coating may be applied for example to improve the operational life time of the plate, to improve the electrical properties thereof, and/or to influence the flow against the plate. It is also possible to influence the cathodic reaction and thus formation of gases by means of coating. For example, it is possible to form sodium chlorate by means of a titanium electrode coated by ruthenium oxide.

[0033] The fouling prevention and protection arrangement may be arranged to be anodic, cathodic or it can be switched between anodic and cathodic operational modes by the controller apparatus 30. In accordance with an embodiment some of the circuits C1 - Cn are driven in anodic mode where as some other circuits are driven in cathodic mode. The protection can be provided in the primary and/or secondary flow circuits.

[0034] The current supplying conductive element can be provided in various manners, and can be external or internal to the heat exchanger. The current supplying element can be engaged with the electrodes based on the welding, pressure fixture, nuts, threads and so forth. The conductive element can be an elongated bar extending within and trough the electrode plates. According to a possibility the conductive element is provided by wiring extending outside the shell of the heat exchanger. What is essential in here is that a secure electrically conductive engagement is provided between the conducting element and the electrode.

[0035] In accordance with the embodiment isolating elements such as pieces of insulating material can be positioned between the heat transfer plate and the electrodes to keep them separated. The heat transfer plate can be provided with recesses, protrusions or similar to held the pieces in place. An insulating and/or supporting strip extending partially or entirely the length of the electrode plate may also be provided. The strip may extend directly from top to bottom, be slightly angled or have a curved or otherwise shaped path. The isolating elements can also be fixed to at least one of the plates by gluing, mechanical fittings such as screws, bolts rivets and so on. Appropriate isolating coating may also be applied on the plates.

[0036] Figure 6 shows a perspective view of an assembly of the plates. In the example six plates are shown, plates 3 and 3' being electrode plates and the other plates heat transfer plates 6, 6', 6" and 6"'. The plates may comprise free flow plates. A primary flow channel 40 is formed between plates 6' and 6". Secondary flow channels 42 are formed between plates 6, 6', and 6", 6"'. It is noted that in a real life heat exchanger assembly more plates can be provided and that the six plates are shown herein to illustrate the principle. The electrode plate 3' arranged in the primary flow channel 40 between the heat transfer plates 6' and 6" substantially resembles from the size and shape thereof the adjacent heat transfer plates. Insulating means 9 for providing electrical isolation between the electrode plates and the heat transfer plates is also shown. Conductive means 44, for example wiring, for conducting current to the electrode plate and the heat transfer plates from power and/or control module 30 is also shown.

[0037] The plates can be provided with formations 46 on at least one surface thereof. The plates can have a first orientation and a second orientation in relation to the formations. In group 40 the two heath transfer plates 6' and 6" and the electrode plate 3' are in the first orientation whereas the plates of the adjacent group of the plates are assembled in the second orientation. For example, the three plates in the adjacent groups can be turned 180 degrees in view of the formations relative to each other. By means of this groups, each forming a primary flow channel, can be provided such that no abutting formations occur within the flow channel. In Figure 6 the channel opening in the plates are shown to be in one side of the plate. However, plates where openings are provided in opposing corners can also be provided.

[0038] Another manner of providing the orientation of the plates is illustrated in the sectioned view of Figure 7. In this example the plates of the adjacent groups are turned vertically relative to each other such that the producing formations of the heat transfer plates 6 and the electrode plates 3 do not touch each other in the primary flow channel 40. The bosses of a plate can be located in between the formations on the adjacent plate and/or can extend inside a recess in the adjacent plate. The formations on the plates of a group can thus be arranged such that there is no electric contact even if the width of the primary channel is less than the height of the formations.

[0039] If required, appropriate fitting arrangement means may be provided between the plates and/or plates of different three plate groups. For example, adapters may be used to adjust the width of the flow channel, to provide appropriate sealing and/or isolation arrangement and/or conductivity between the plates. It is also noted that although the heat transfer and electrode plates substantially resemble each other from the size and shape thereof, plates turned to a different orientation may need in certain applications a modification e.g. in view of the flow openings and/or seal guides.

[0040] In general, Figure 7 is only an example of plates provided with concave recesses or cavities 70 on one side and thus protruding formation 72 on the other side. As shown, adjacent plates can be provided with abutting boss formations 70 in the secondary channel. This can be provided to increase the strength the facing plates. The formations can be manufactured by any suitable forming technique, for example, by stamping, embossing or roll forming. It is noted that the formations can be provided only one of the plates. The abutting formations can also be fixed to each other at the abutting locations. The fixing can be provided at only some but not all of the abutting locations. If no electrode plate is positioned between the adjacent plates, the fixing may be provided, for example, by means of spot welding, laser welding, TIG welding or the like welding technology. Abutting formations can also be provided on an electrode plate and a heat transfer plate. In this case an appropriate isolation needs to be provided between the plates.

[0041] In Figures 6 and 7 the electrode plates are arranged only within one of the channels, namely the primary channel. However, depending on the application, it is also possible to have the electrode plates in the primary and secondary channels. The channels with the electrode plates can wider than the channels without the electrode plates.

[0042] In accordance with an embodiment the current conducting elements such as bars can be used to provide support for the electrode plates to keep them apart from the heat transfer plates.

[0043] Less pure metal can be positioned in certain embodiments between an electrode element and a heat transfer element to provide a galvanic pairing.

[0044] In accordance with another embodiment shown in figure 9A and B a shell and tube type heat exchanger 60 is provided. In accordance with the embodiment at least one electrode element 62 is located amongst the tubing 61 of the heat exchanger, extending substantially the entire length thereof. According to a possibility the at least one electrode element is provided within a tube 61 of the tubing, as shown in Figures 10 and 11. The electrode element 62 can extend between end plates 64 and 65. The fixing can be such at least at one end thereof that is allows for expansion and shrinkage of the electrode element due to variation in temperature. This can be provided, for example, by means of spring action fixtures 66. At least one of the end plates 64, 65 provided within the shell can be connected to a source of electrical current and/or control apparatus, thus providing a conductive element for the electrodes extending within or amongst the tubing.

[0045] Such an apparatus for electrochemically protecting and/or cleaning surfaces of a shell and tube heat exchanger can comprise at least one electrode element arranged in amongst the heat transfer tubing, insulating means for providing electrical isolation between the at least one electrode element and the heat transfer tubing, and at least two end plates provided for supporting the at least one electrode element and providing a conductive element extending within the shell of the heat exchanger for conducting current to the at least one electrode element. The at least one electrode element can extend within the heat transfer tube.

[0046] In accordance with an embodiment shown in Figure 12 at least one electrode element is located amongst the tubing of the heat exchanger, extending substantially the entire length thereof. The electrode element 62 is provided with turbulence enhancing formations 64 thereby improving the heat transfer. The formations may be corrugations, recesses, bosses, holes, slots, grooves and so forth. In accordance with a further embodiment the tube 61 is also formed such that it provides in cooperation with the electrode element and turbulence within the tube or in the near vicinity of the tube. That is, the heat transfer tube can be provided with turbulence generating formations that are co-operative with the formation of the electrode element. The electrode can be provided, for example, in connection of the heat exchanger 60 of Figures 9 to 11.

[0047] The required data processing apparatus and functions of the controller apparatus 30 may be provided by means of one or more data processors. Figure 8 shows an example for the control apparatus comprising at least one memory 31, at least one data processing unit 32, 33 and an input/output interface 34. The control apparatus 30 can be configured to execute an appropriate software code to provide the control functions. The control functions may be provided by separate processors or by an integrated processor. The data processors may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs), application specific integrated circuits (ASIC), gate level circuits and processors based on multi core processor architecture, as non-limiting examples. The data processing may be distributed across several data processing modules. A data processor may be provided by means of, for example, at least one chip. Appropriate memory capacity can also be provided in the relevant devices. The memory or memories may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory.

[0048] The heat exchanger can be manufactured by welding it in entirety. Thus the shell, the heat transfer plates, and the electrode elements such as electrode plates can be welded together, as shown in figure 5. A welded structure can withstand high pressures. A welded circular structure may withstand higher pressures than a rectangular structure.

[0049] The heat exchanger may be manufactured from modular components, for example from component including a pair of heat transfer plates and an electrode element, for example an electrode plate resembling or identical to the heat transfer plates there between as describes above. Modularity can be used to ease designing and production of appropriately sized heat exchangers based on the requirements of the application.

[0050] The surface of a heat transfer plate can be kept clean by causing short duration gas formations and/or controlled corrosion effects by means of appropriate current densities. The polarity can be switched by the control apparatus so that anodic mode can be used for oxidation and cathodic for reduction.

[0051] An appropriately adapted computer program code product or products may be used for implementing the embodiments, when loaded or otherwise provided on an appropriate data processing apparatus, for example for controlling current levels and/or switching between the circuits and/or control of polarizations of the different circuits and/or switching on and off different circuits and other control operations. The program code product for providing the operation may be stored on, provided and embodied by means of an appropriate carrier medium. An appropriate computer program can be embodied on a computer readable record medium. A possibility is to download the program code product via a data network. In general, the various embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Embodiments of the inventions may thus be practiced in various components such as integrated circuit modules. The design of integrated circuits is by and large a highly automated process. Complex and powerful software tools are available for converting a logic level design into a semiconductor circuit design ready to be etched and formed on a semiconductor substrate.

[0052] The embodiment can provide advantage in that the current is applied uniformly to the adjacent heat transfer elements. Furthermore, for example in plate exchangers similar potential can be applied to the heat transfer plates on both sides of the electrode plate. Manufacture and assembly of a plate heat exchanger with integrated cleaning and/or protection system can be made easier and more economically viable. In tube exchangers a round electrode within a tube provides similarly even treatment on the entire heat transfer surface around it. The embodiment enables use of more controlled and optimized application of currents and potentials to the heat transfer elements. The separated electrode and the adjacent heat transfer surfaces can be polarized in controlled and optimal manner. This is mainly so because the limitations of use of a heat transfer element in a dual function as an electrode can be avoided. An advantage provided by division of electrodes into smaller circuits is the improved controllability of the process. For example, more accurate control of temporary or short duration formation of gases may be provided. This can be of particular importance in systems where polarizations can be changed, for example in view of reduction of formed gases and power consumption.

[0053] It is noted herein that while the above describes exemplifying embodiments of the invention, there are several variations and modifications which may be made to the herein disclosed examples without departing from the scope of the appended claims.

Claims

1. An apparatus for electrochemically protecting and/or cleaning surfaces of a heat exchanger, the apparatus comprising:

    heat transfer plates forming at least one flow channel there between,
    at least one electrode plate arranged in the flow channel between the heat transfer plates, the at least one electrode plate substantially resembling from the size and shape thereof the adjacent heat transfer plates;
    insulating means for providing electrical isolation between the at least one electrode plate and the heat transfer plates; and
    at least one conductive element for conducting current to the at least one electrode plate.

2. An apparatus according to claim 1, wherein each plate has at least one side provided with formations and the plates are arranged in groups of three such that each group forming a flow channel has no abutting formations within the flow channel.

3. An apparatus according to claim 2, wherein plates in a first group are arranged in one direction and plates in the adjacent second group are arranged such that the formation thereof are turned 180 degrees relative to the formations of the plates of the first group.

4. An apparatus according to any preceding claim, wherein the at least two heat transfer plates form there between at least one primary flow channel and/or at least one secondary flow channel of the heat exchanger, the electrode plates being arranged within at least one of the channels.

5. An apparatus according to claim 4, wherein the electrode plates are arranged within the primary flow channels or secondary flow channels of the heat exchanger, the channels with the electrode plates being wider than the channels without the electrode plates.

6. An apparatus according to any preceding claims, wherein the at least one electrode plate comprises at least one of corrugations, recesses, bosses, dimples, grooves, vanes, openings, stripes and coating.

7. An apparatus according to any preceding claims, wherein the at least one electrode plate comprises a free flow plate.

8. An apparatus according to any preceding claim, comprising at least two electrode plates, wherein the at least two electrode plates are connected to different control circuits.

9. An apparatus according to claim 8, wherein each of the circuits is provided with at least one circuit specific conductive element.

10. An apparatus according to claim 8 or 9, comprising a controller apparatus adapted to control the circuits such that at least one of the circuits can be operated at a different current and/or different polarity and/or independently switched on and off.

11. An apparatus according to any preceding claim, comprising separating elements between the at least one electrode plate and the heat transfer plates.

12. A heat exchanger assembly comprising the apparatus according to any of the preceding claims.

13. A method for assembling a heat exchanger provided with an integral arrangement for electrochemical protection and/or cleaning of surfaces of heat transfer plates forming flow channels there between, the method comprising:

   assembling at least one electrode plate in a flow channel between two heat transfer plates, the at least one electrode plate substantially resembling from the size and shape thereof the adjacent heat transfer plates, and
   providing electrical isolation means between the at least one electrode plate and the heat transfer plates.

14. A method for controlling electrochemical protection and/or cleaning of surfaces of a heat exchanger comprising heat transfer element forming flow channels, at least one electrode element arranged in a flow channel, and means for providing electrical isolation between the at least one electrode element and the heat transfer element, the method comprising controlling electrode elements arranged into at least two circuits.

15. A computer program comprising program code means adapted to perform the steps of claim 14 when the program is run on a data processing apparatus.

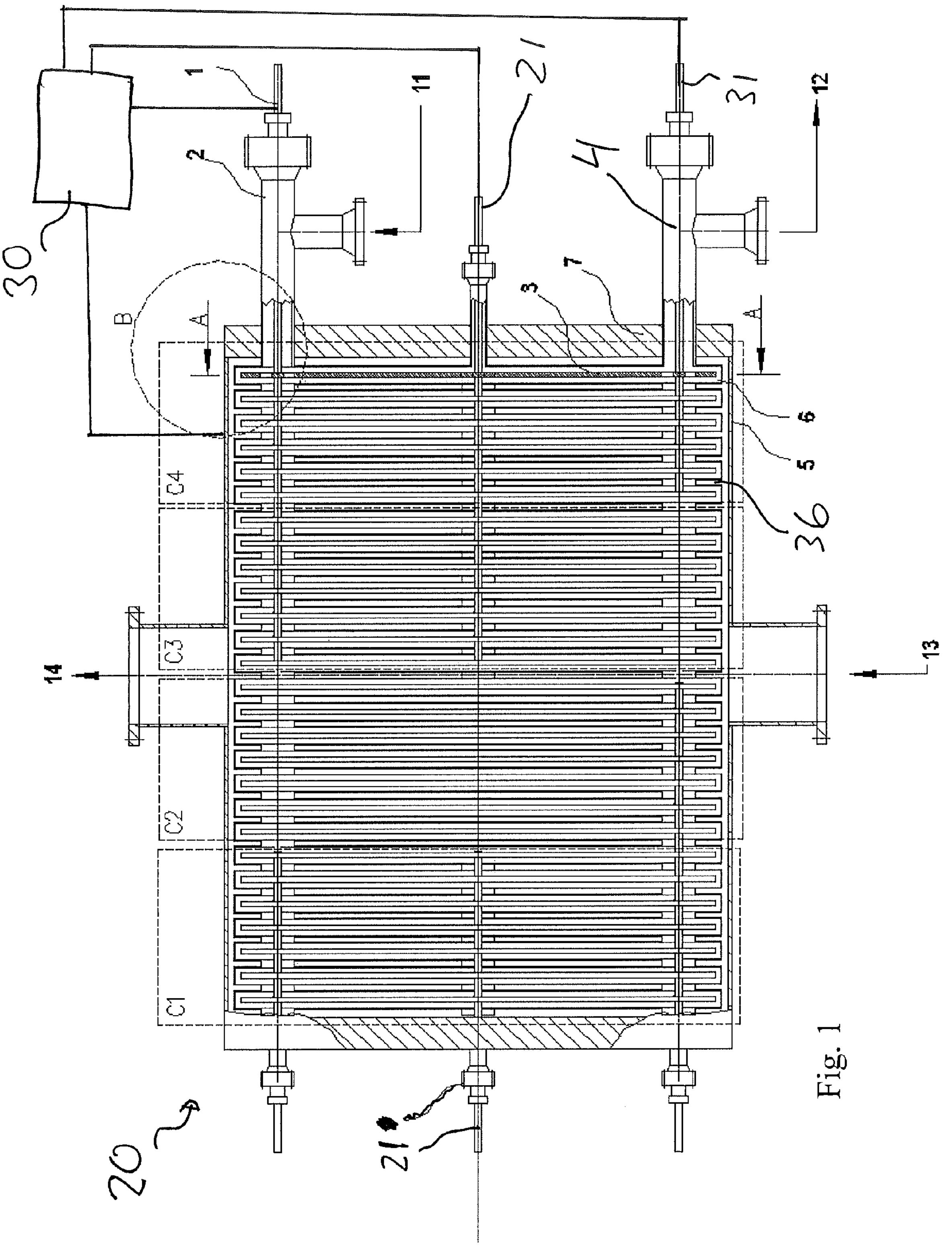

Fig. 1

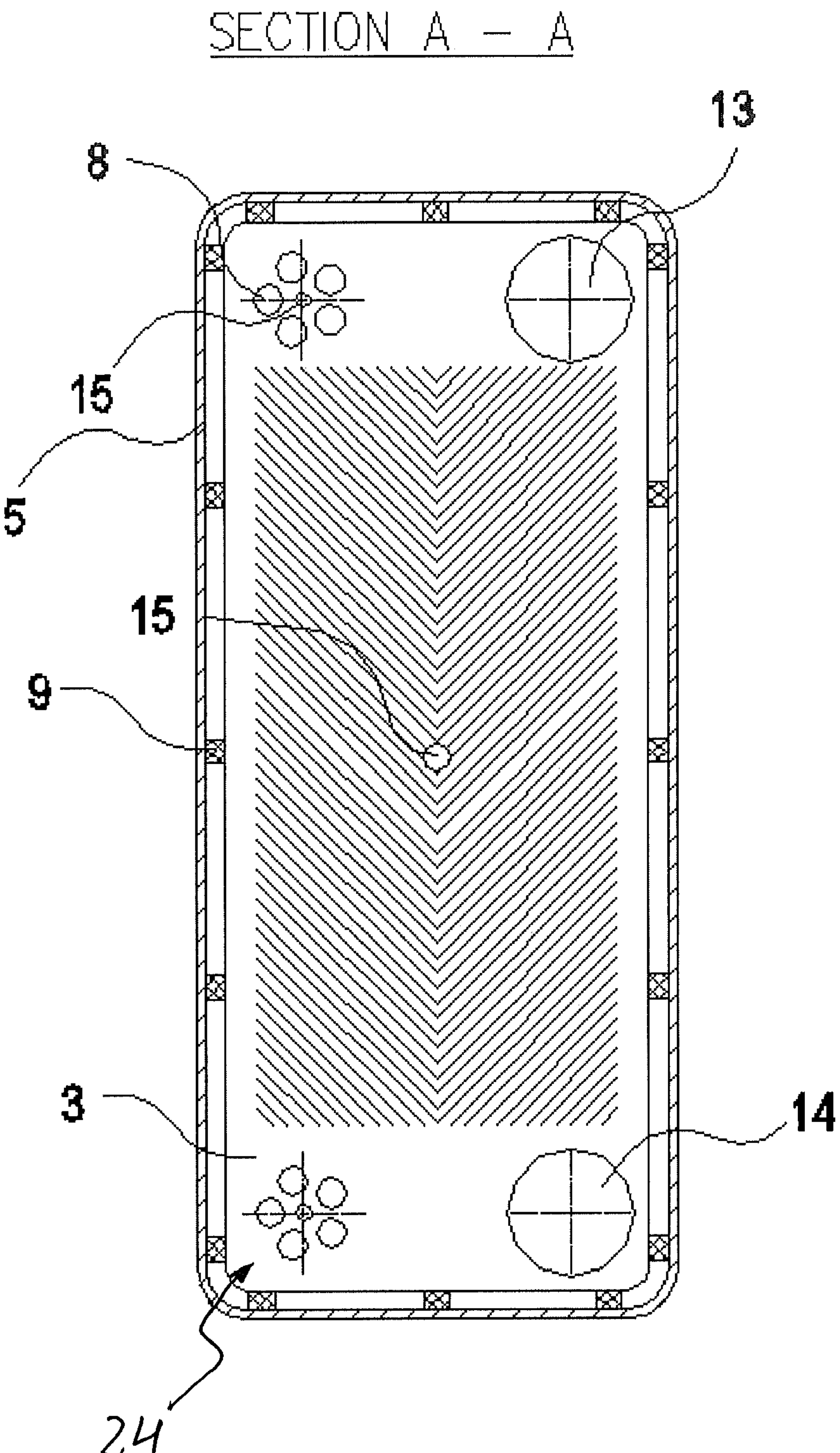

Fig. 2

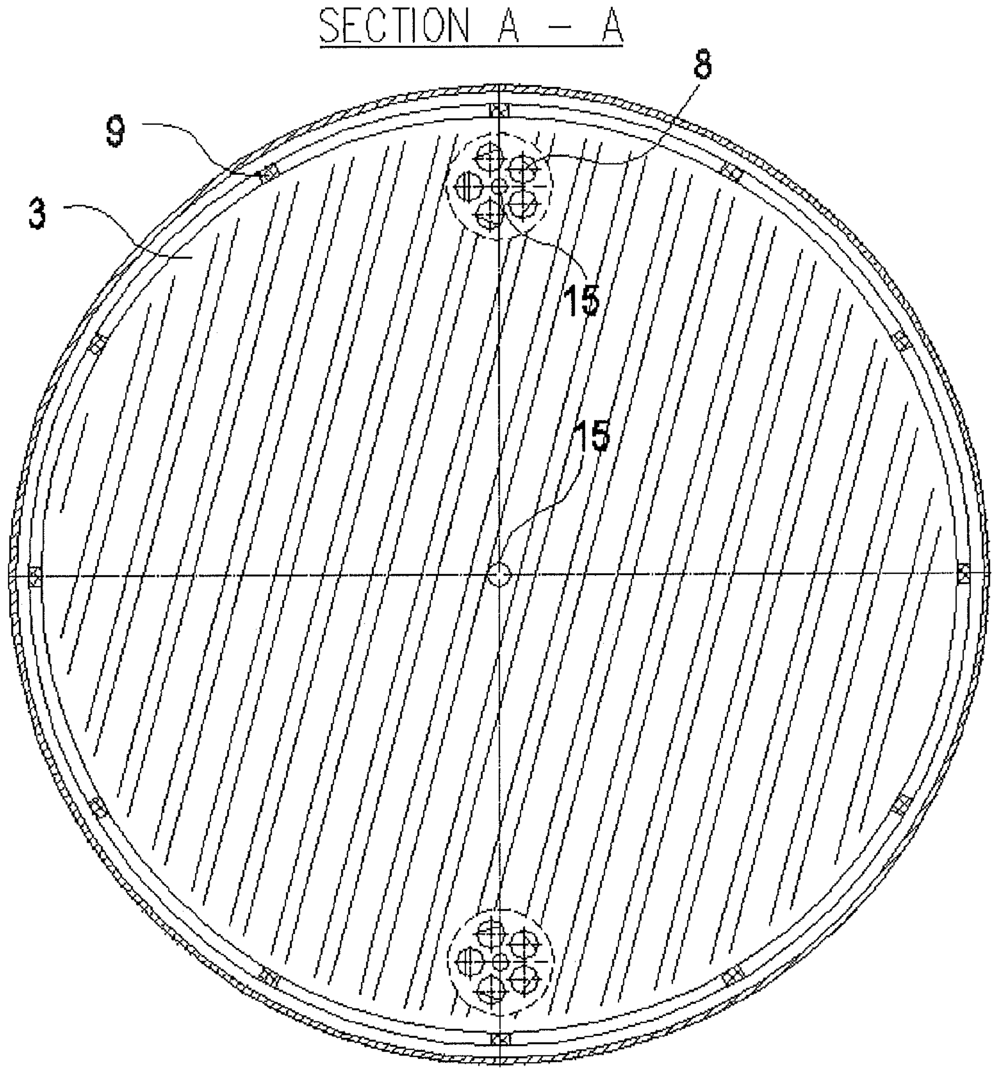

Fig. 3

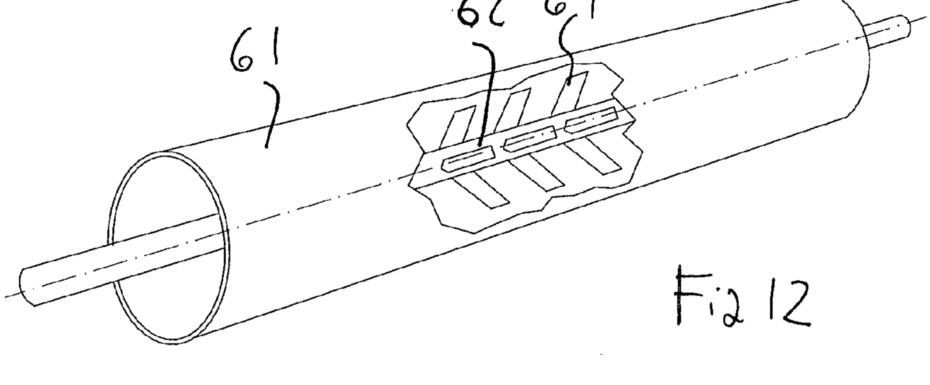

Fig 12

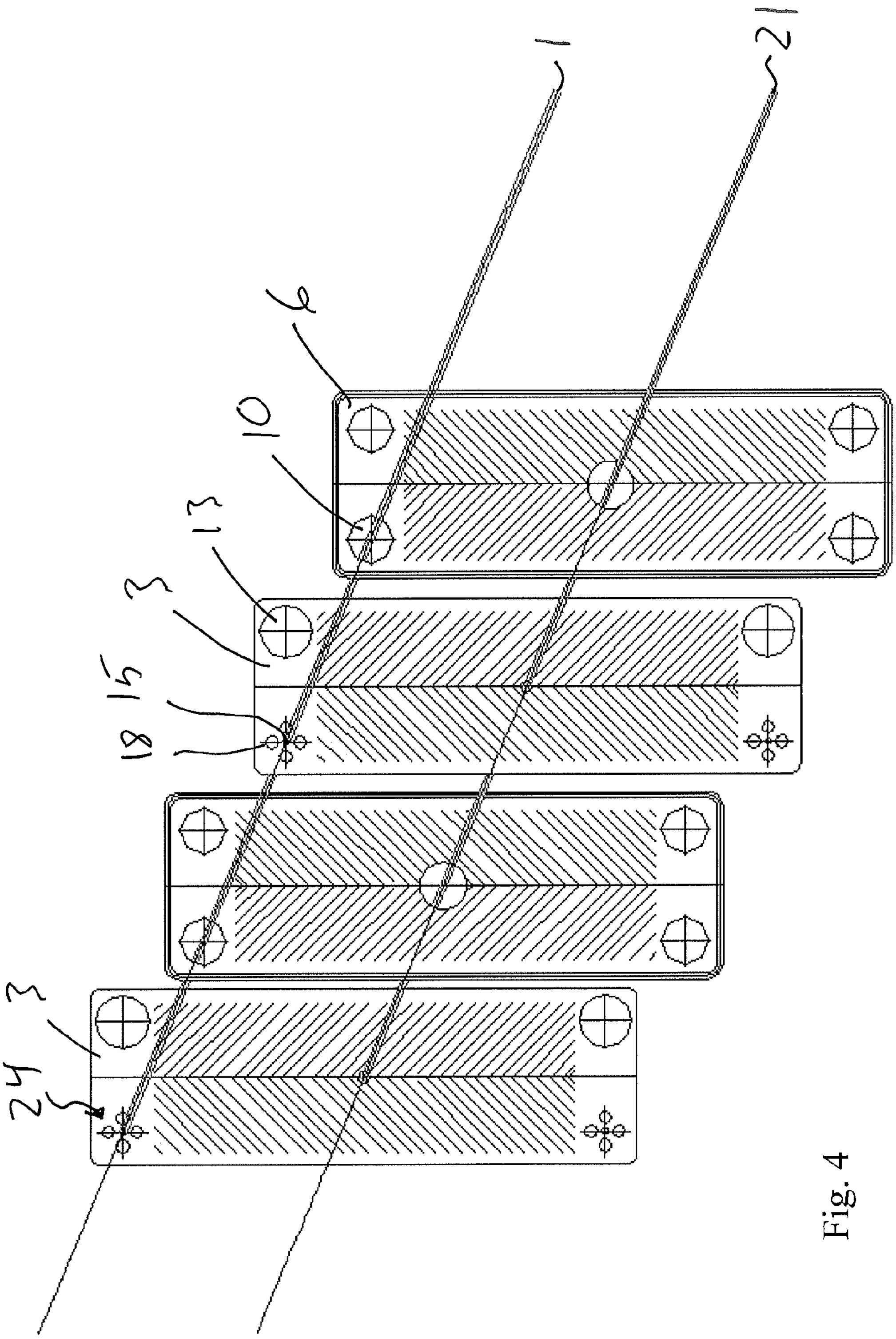

Fig. 4

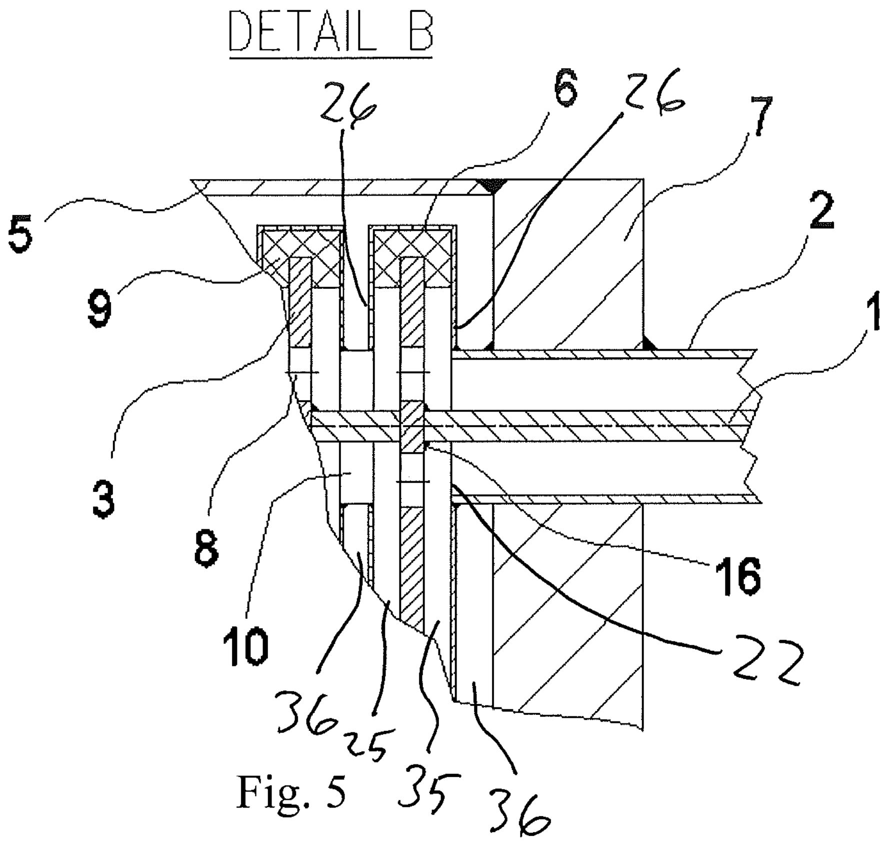

Fig. 5

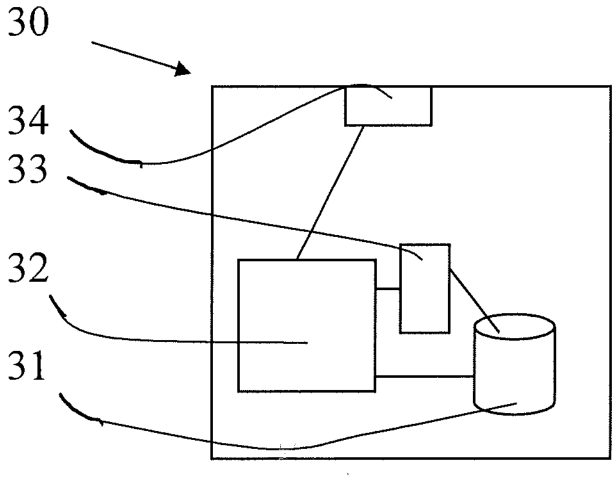

Fig. 8

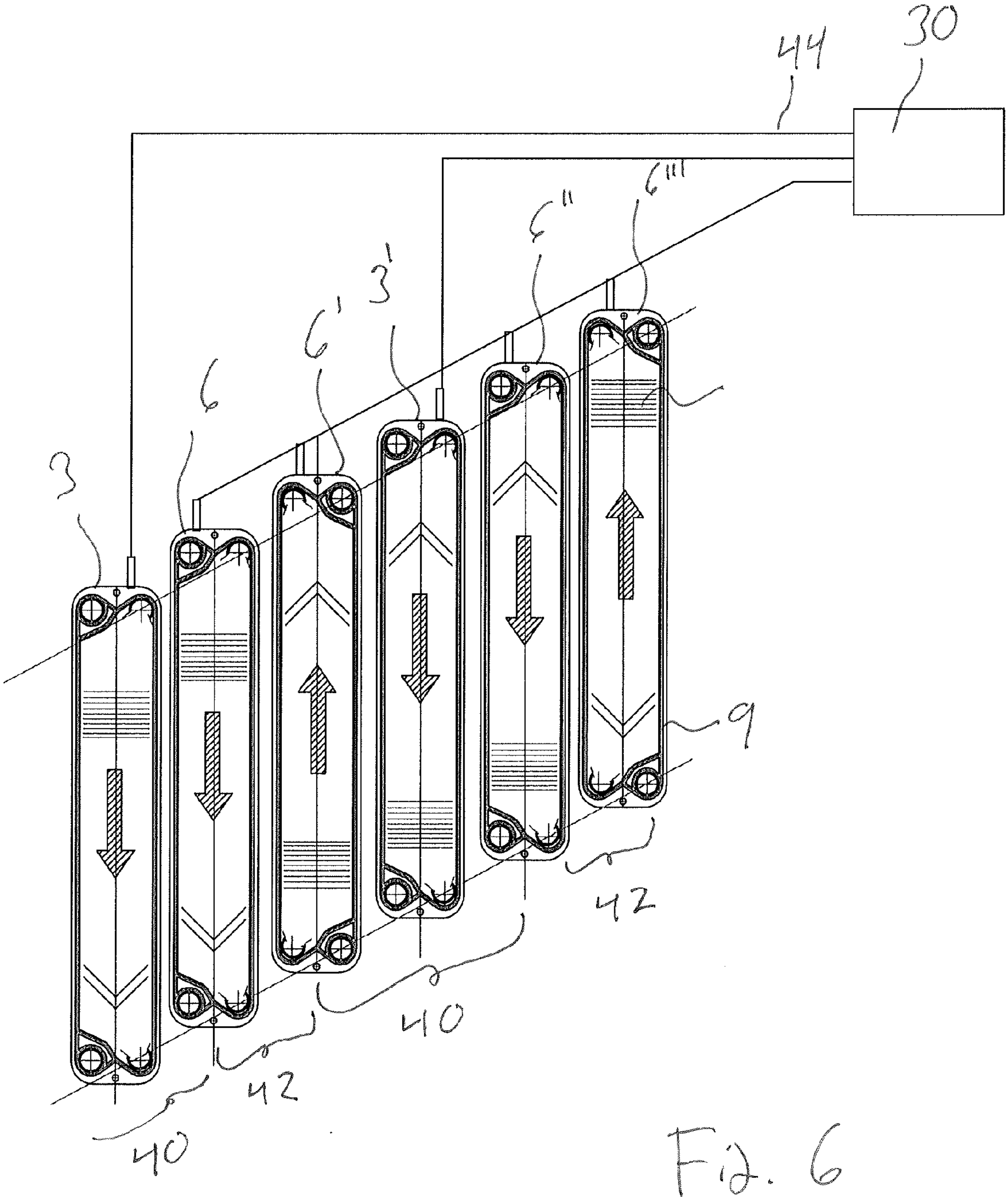

Fig. 6

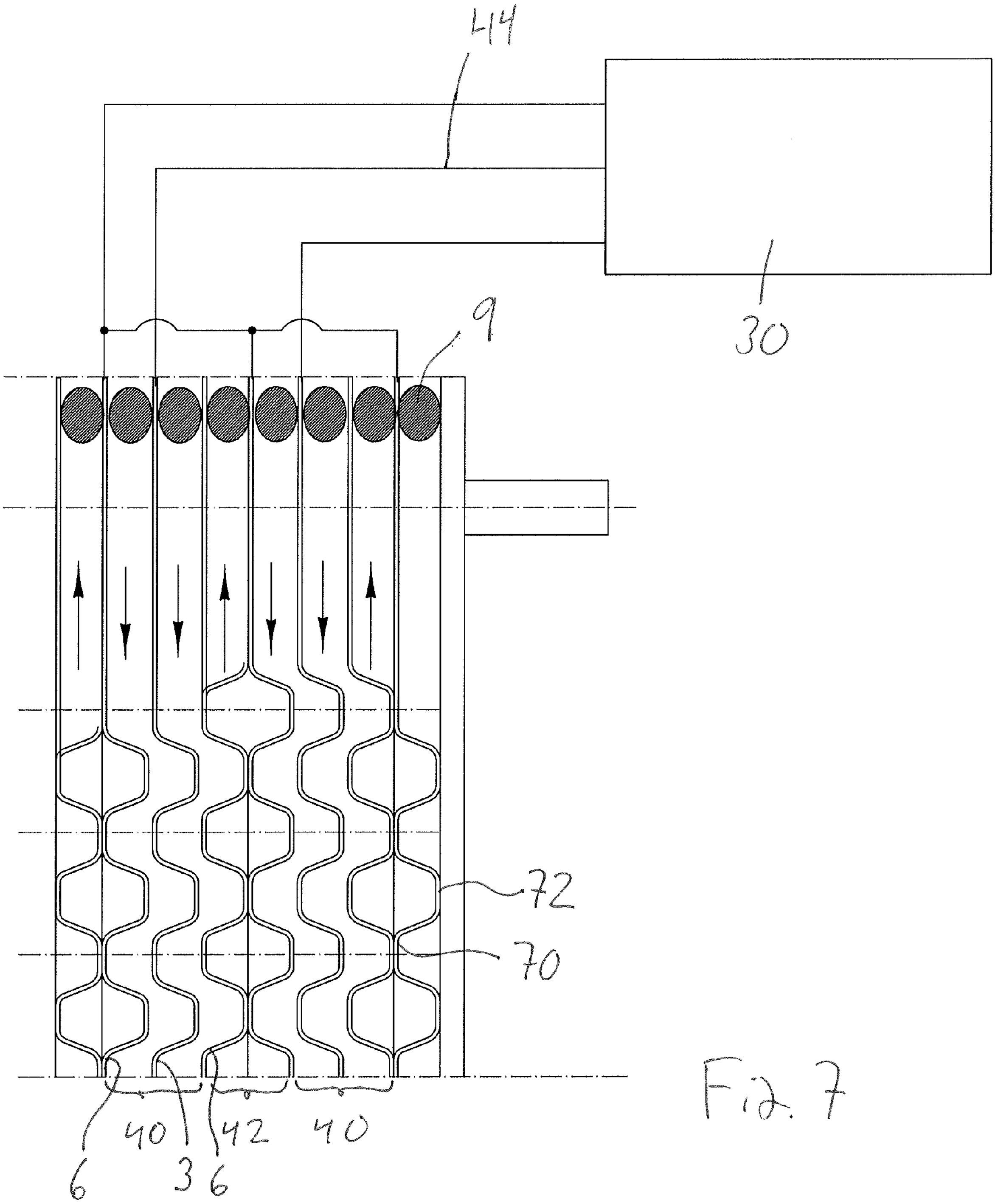

Fig. 7

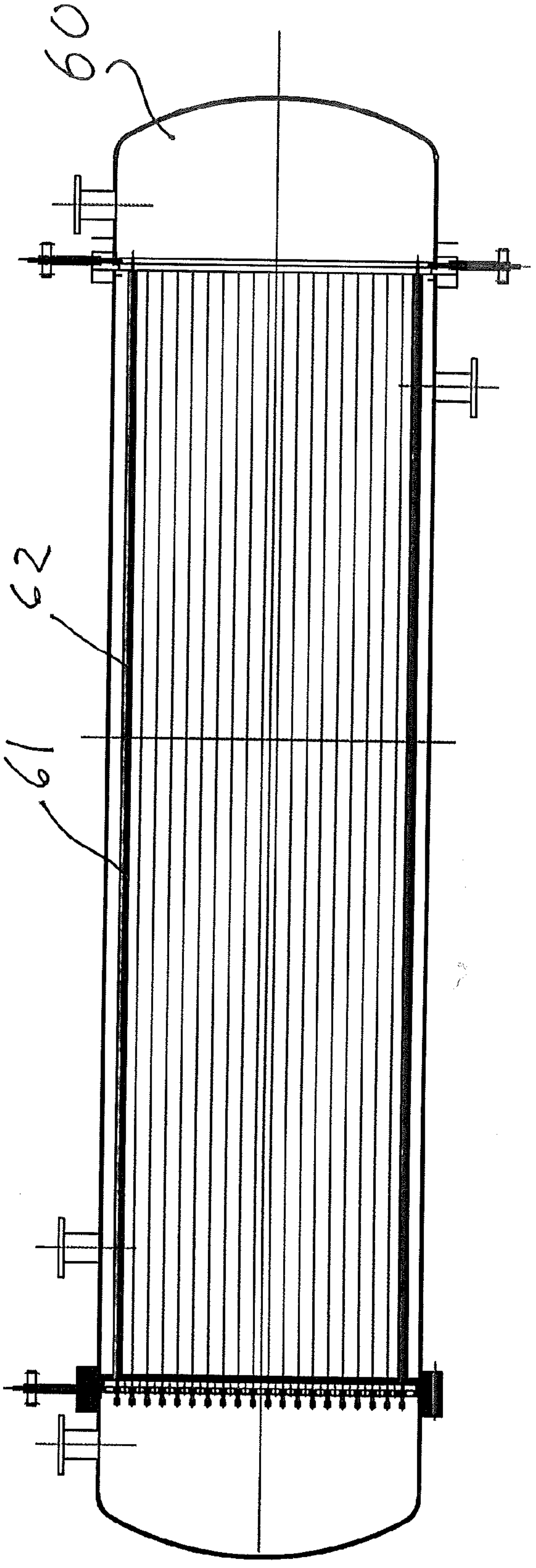

Fig. 9A

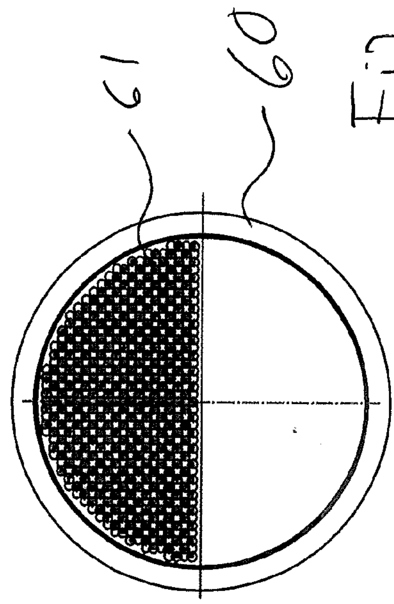

Fig. 9B

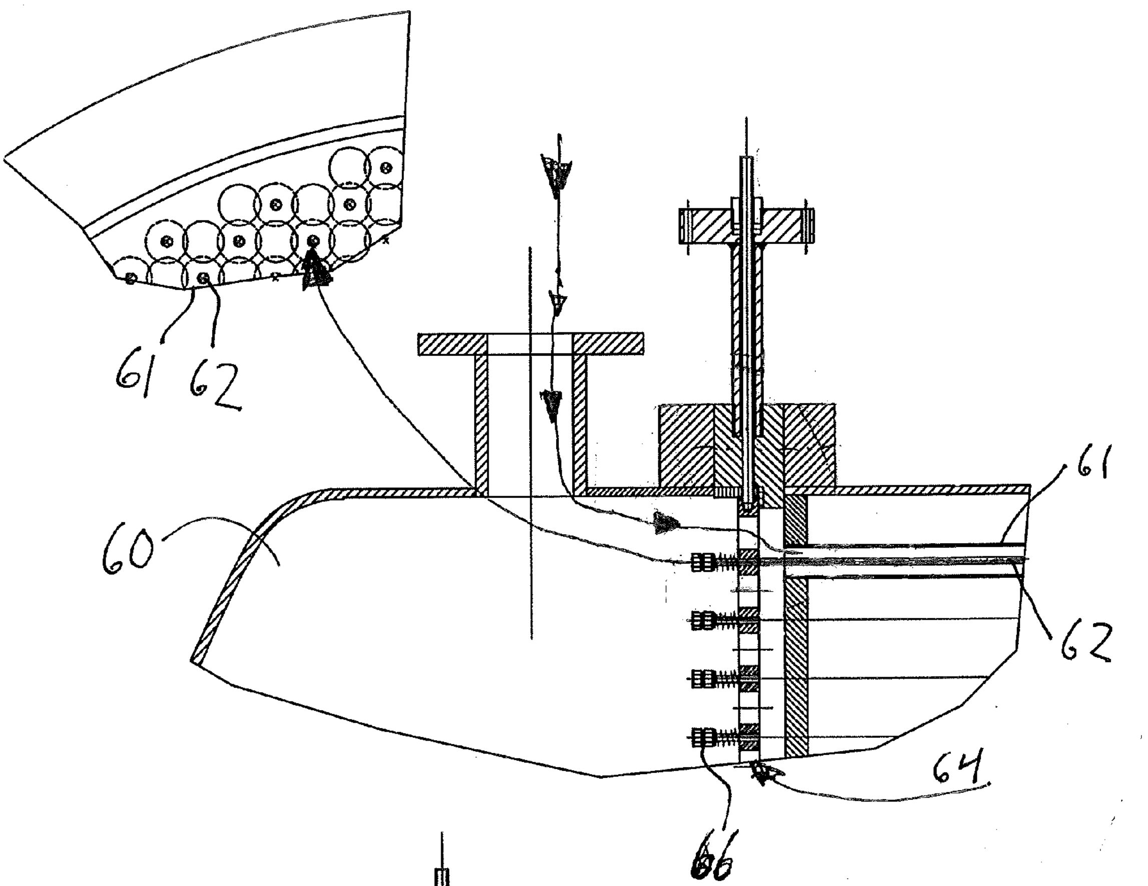

Fig 10

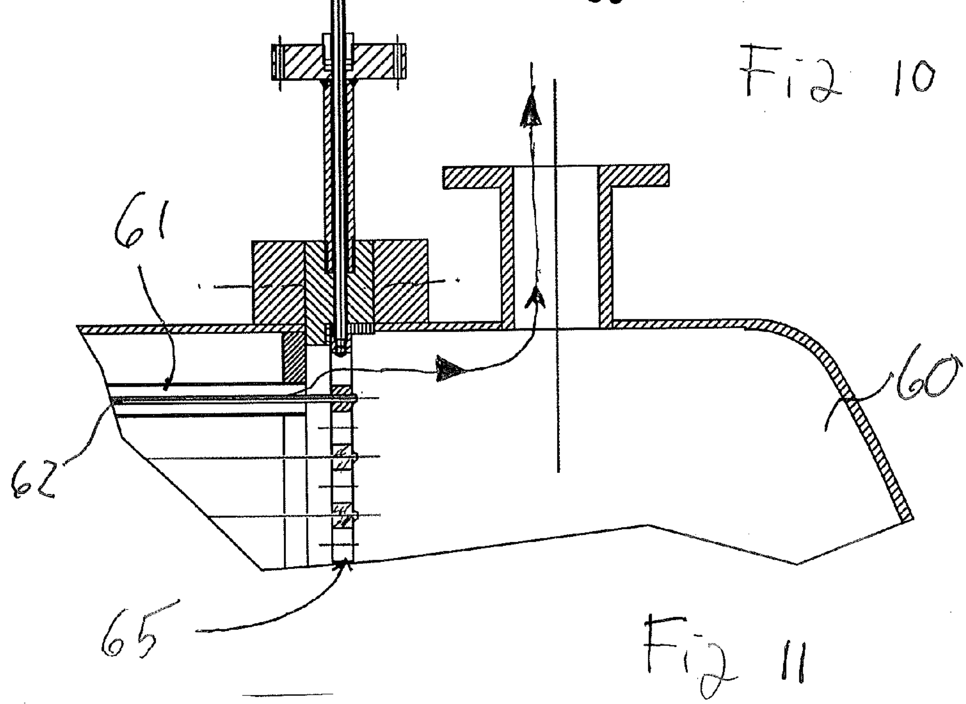

Fig 11

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 4586562 A **[0005]**
- US 7225863 B **[0005]**
- US 4800007 A **[0005]**
- US 6357516 B **[0005]**
- US 4588022 A **[0006]**
- US 5515913 A **[0006]**
- US 5513694 A **[0006]**