



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) Publication number:

0 451 416 A1

(12)

EUROPEAN PATENT APPLICATION

(21) Application number: **90314168.7**

(51) Int. Cl.⁵: **F24H 1/10**

(22) Date of filing: **21.12.90**

(30) Priority: **10.04.90 GB 9008095**

(43) Date of publication of application:
16.10.91 Bulletin 91/42

(54) Designated Contracting States:
AT BE CH DE DK ES FR GB IT LI LU NL SE

(71) Applicant: **Electricity Association Services Limited**
30 Millbank
London SW1P 4RD(GB)

(72) Inventor: **Simpson, David Preston, Dr.**
Enderby House, Enderby Road
Chester CH1 4AH(GB)
Inventor: **Stirling, Robert, Dr.**
Robin Hey, 9 Station Road
Heswall, Wirral L60 8PN(GB)

(74) Representative: **Cross, Rupert Edward Blount et al**
BOULT, WADE & TENNANT 27 Furnival Street
London EC4A 1PQ(GB)

(54) **An ohmic heater.**

(57) An ohmic heater comprises at least two electrodes 1 contained within a vessel 2 such that the electrodes lie along the length of the vessel 2. The vessel 2 has inlet and outlet ports 4 and 12 in the top and bottom through which a fluid to be heated flows, passing through the vessel 2 along the length of the vessel 2. The electrodes 1 are equally spaced about the axis of the vessel 2 and when in use, are connected to a power supply, such that the total voltage at any point in time at the electrodes is near or at zero. Hence, when in use, a current passes perpendicular to the flow of the fluid, but the electric potential on the axis is near to zero, and hence the leakage current from the ohmic heater is substantially reduced.

EP 0 451 416 A1

This invention relates to an ohmic heater, which heats a fluid by passing an electric current through the fluid. This type of heater is used for fluids which require heating but which might foul or block conventional heaters.

Arrangements are known where the current is passed longitudinally or in the direction of flow of the fluid. However, in these systems, due to the uneven flow of the fluid in the container, there is uneven heating of the fluid.

Also known are transverse ohmic heaters in which the current is passed between electrodes transversely, or perpendicular to the flow of the fluid. However, in such arrangements, some of the current may flow to earthed components in the apparatus such as the ends of the connecting pipes to and from the heater. This is termed a leakage current, and can give rise to unacceptably high levels of electrolytic corrosion or fouling of the pipe ends which carry these currents.

The present invention provides an ohmic heater for heating a fluid comprising a vessel having inlet and outlet ports between which said fluid flows when in use, along an axis, at least two electrodes arranged to be spaced about said axis of flow and contained within said vessel, and means to supply electric power to said electrodes such that the electric potential at any time on said axis is substantially zero relative to earth.

This arrangement has the advantage in that the fluid along the axis of flow is maintained at or near earth potential, so that current leakage to pipe ends is significantly reduced.

Preferably, the vessel is electrically insulating and said electrodes are adjacent to the walls of the vessel. Said electrodes may be arranged to extend parallel to said axis of said fluid flow where electrical conductivity of the fluid remains relatively constant along the length of the electrodes, in the flow direction, in order to provide a uniform current density over the length.

Alternatively said electrodes may be arranged such that their separation transverse to said axis increases along said axis in the direction of flow of said fluid. This arrangement compensates for the linear increase in conductivity with temperature by increasing the separation of the electrodes, thus maintaining a uniform current density over the length.

Examples of the invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 is a longitudinal sectional view of an ohmic heater according to one embodiment of the present invention;

Figure 2 is a cross-sectional view of an ohmic heater according to the embodiment illustrated in Figure 1;

Figure 3 is a longitudinal sectional view of an ohmic heater according to another embodiment of the present invention; and

Figure 4 is a longitudinal sectional view of an ohmic heater according to a further embodiment of the present invention.

Figure 5 is a longitudinal sectional view of an ohmic heater according to a still further embodiment of the present invention.

Figure 6 is a cross-sectional view of an ohmic heater according to another embodiment of the invention.

Referring now to Figures 1 and 2, these drawings illustrate an embodiment of the present invention in which electrodes 1 are arranged to be parallel to the flow of the fluid to be heated.

The vessel 2 comprises three parts:- a cylindrical main body 2a, a top end plate 2b and a bottom end plate 2c. The top end plate 2b has a flange 3a which is connected to an upper flange 3b of the cylindrical main body 2a, by bolts. The bottom end plate 2c has a flange 3d that is connected to a lower flange 3c of the cylindrical main body 2a, also by bolts. The three parts are thus joined together to form the watertight vessel 2.

The vessel 2 is constructed from a suitable electrically-insulating material and of such wall thickness as to adequately withstand the internal pressures applied or generated in the heater - for example by any tendency for the heated fluid to boil.

The top end plate 2b has a outlet port 4 in the centre. The internal surface of the top end plate 2b tapers from the internal diameter of the cylindrical main body 2a to the diameter of the outlet port 4. The outlet port 4 is arranged to form a connection with an output pipe 5 by the coupling of flanges 6 and 7 of the outlet port 4 and the output pipe 5 respectively.

Surrounding the outlet pipe 4 within the flange 6, there is a guard ring 8 which is electrically connected to earth by a metallic gasket 9.

At regular spacings around the upper surface of the top end plate 2b, upper ends of three rod shaped electrodes 1 project through the top end plate 2b into the vessel 2. The electrodes 1 and the top end plate 2b are sealed to prevent fluid loss from the vessel 2 by seals 17. The electrodes 1 extend parallel to the axis of the vessel 2 and have opposite ends located in bores drilled in the interior face of the bottom end plate 2c. When in use, the electrodes 1 are electrically connected by wires 10 to a three-phase power supply (not shown). The electrodes 1 are equally spaced and in Figure 2, they can be seen to lie at the apices of an equilateral triangle, wherein the centroid of the equilateral triangle falls at the axis of the vessel 2, which is also the axis of flow of the fluid to be heated.

The bottom end plate 2c, is of similar shape to the top end plate 2a and comprises an inlet port 12 with a guard ring 13, a metallic gasket 14 and a flange 15. The inlet port 12 is connected to an input pipe 11 by the connection of flanges 15 and 16 of the inlet port 12 and input pipe 11 respectively.

When in operation, a fluid to be heated is passed into the input pipe 11 and flows through the vessel 2 to the output pipe 5. The direction of flow of the fluid is indicated in the drawings by arrows. In order to heat the fluid uniformly, the electrical conductivity of the fluid must be relatively uniform over the length of the electrodes 1. This can be achieved either by selecting a fluid to be heated for which the electrical conductivity does not change very much over a wide temperature variation or by limiting the temperature range over which the fluid is heated, such that the change in electrical conductivity is small.

Whilst the fluid is passing the electrodes 1, the electrodes 1 are energised by connection to a three-phase power supply (not shown).

A convenient voltage to use may be 415 V. Given that the electrical conductivity of the fluid to be heated is substantially constant over any planar section of the heated volume taken at right angles to the axis of the vessel 2, equal phase to phase electrical currents will be maintained between these three electrodes 1 since they are disposed at equal separations. This provides balanced phase currents as required for a three-phase power supply.

A major advantage of this geometry, is that the centroid of the equilateral triangle formed by the three electrodes 1 will always be maintained at or very near the common electrically neutral voltage level of the three electrical phase voltages applied to the electrodes 1, if a current balance is maintained between them, in the manner explained above. The input and output pipes 11 and 5 are provided at each end of the vessel 2, co-axial with the vessel 2 and the centroid of the electrodes 1 and hence the axes of these pipes 5 and 11 will also lie along lines of zero net voltage or electrical potential relative to earth

Although any conventional method of measuring and controlling the temperature of the fluid may be used, since the axis of the pipes 5 and 11 are maintained at or near earth potential, an earthed metal-clad thermocouple can be used in the outlet stream.

The dimensions of the apparatus are such that the mutual separation of the electrodes 1 in their triangular disposition is substantially greater than the diameters of the input and output pipes 11 and 5 and hence it is apparent that the voltage level corresponding to the periphery of these pipes 5 and 11 will be very low compared to the electrode

voltages, and may, by suitable choice of dimensions, be reduced to an insignificant value. Thus, a small or even negligible leakage current could be constrained to flow to the pipes 5 and 11 in the end plates 2b and 2c of the vessel 2 from each electrode 1 as its voltage varies sinusoidally in time about a mean (zero) level corresponding to the axial voltage value of the vessel 2.

In practice such leakage currents, even if very small in proportion to the main ohmic heater current might give rise to unacceptably high levels of electrolytic corrosion or fouling of the pipes 11 and 5 which would carry these currents. To still further reduce the levels of these leakage currents, the metallic or conducting portion of the ends of the pipes 11 and 5 are connected to the end plates 2b and 2c at a suitable distance from the electrodes 1 thus increasing the current path length to this electrically-neutral region, and reducing the leakage current flowing in proportion. In addition, guard rings 8 and 13 of suitable material - which may be the same material used to form the electrodes of the heater - may be mounted over the end of each pipe 5 and 11 in such a way as to shield or screen the pipe material from carrying any current at all; all the leakage current flowing to the guard rings 8 and 13. It must be appreciated that with perfect phase-balance between the three main electrodes 1 of the ohmic heater and identical electrode 1 to guard ring 8 and 13 distances, achieved by suitable ohmic heater geometry, any leakage current from each electrode 1 to the guard rings 8 and 13 at either end of the vessel 2 will be exactly equal in peak amplitude to that from any other electrode 1. Under these circumstances, it is a well-known feature of the balanced three-phase system that the net current flowing (to the guard rings 8 and 13) will be zero - the incoming current from any electrode 1 will be exactly balanced by the sum of the outgoing current to the other two electrodes at any instant of time. There is thus no absolute requirement to connect either guard ring 8 or 13 to an earth or neutral point of the electrical supply to the ohmic heater, although it would be good practice to connect such guard rings 8 and 13 to the system neutral, and desirable for safety reasons for the mutual guard ring/neutral connection to be the main earthing point of the ohmic heater. In any case if metallic pipe connections were to be used to the vessel 2, these would require to be earthed, and it would follow that the guard rings 8 and 13 would be electrically connected to these pipes and to earth.

The electrodes 1 and guard rings 8 and 13 may be made from any suitable material which is compatible with the chemical and electrochemical properties of the fluid to be heated. In general there will be an upper limit to the current density

which any particular electrode material/working fluid will withstand without either damaging the current-carrying portion of the electrode or causing the fluid to decompose or otherwise react at the electrode surface and form a fouling deposit on the surface thus adversely affecting the operation of the ohmic heater. The dimensions of the ohmic heater, and in particular the mutual electrode 1 spacings and the electrode 1 to guard rings 8 and 13 distances will need to be chosen in such a way as to limit the currents flowing to levels which the electrode/fluid combination will withstand. Suitable electrode materials which will operate successfully with wide range of industrial fluids have been found to be platinized titanium and various graphite-based materials.

For fluids having electrical conductivities similar to those of standard tap water, suitable dimensions for the ohmic heater components may be electrode diameters of approximately 50 mm, at a mutual spacing of 100 mm between centres. The electrodes 1 might be contained in a tubular insulating housing some 200 mm in diameter and 1000mm long. Pipes 5 and 11 to the ends of the heater of 25 mm diameter might be used, recessed approximately 50 mm into the insulating end plates 2b and 2c of the ohmic heater to reduce leakage currents. Such an ohmic heater would draw a balanced three-phase power totalling some 10 kW.

It has been found that a convenient method of adjusting the current flowing between the electrodes in this type of heater when the electrical conductivity of the heated fluid proves to be higher than expected is to apply an appropriate length of heat-shrinkable or other close-fitting insulating tubing to cover a defined length of each electrode. No deleterious effect on either the electrodes or the tubing material has been found in tests and the currents drawn from each phase of the supply can be adjusted easily and accurately. Such insulating tubing 46 is shown in figure 5 at the upper ends of the electrodes.

It has been found to be convenient to mount the vessel 2 of the ohmic heater with its axis vertical, so that any gases evolved in the heated volume may be easily swept out through the outlet port 4 of the vessel 2. Similarly, any solid particulates which may pass into the vessel 2 will tend to fall to the lower end of the vessel chamber, clear of the 415 V electrodes 1, thus obviating any tendency for such particulates to short out or reduce the resistance of the main current paths which provide the heating effect in the apparatus. In addition it is advantageous if the upper and lower end plates 2b and 2c of the vessel 2 are sloping as shown in Figure 1, so the gas may more easily be swept out of the outlet port 4 and solids will tend to settle on the axis of the vessel 2 near

the inlet port 12. The guard rings 8 and 13 at either end of the vessel 2 may be simply connected to earth by means of suitably shaped metallic gasket 9 and 14 interposed between the guard rings 8 and 13 and the pipe flanges 6, 7, 15 and 16 at either end of the vessel. The three parts forming the vessel 2 may be constructed from suitable plastic material which will withstand the temperature and pressure conditions within the vessel, as well as any corrosive action of the heated fluid, or alternatively they may be constructed from glass or enamel lined steel in the case of particularly arduous operating conditions.

An example of another embodiment of the present invention is shown in Figure 3. Many of the components of this embodiment are similar to those already described herein above for the previous embodiment. However, the vessel 20 comprises only two parts, an upper end plate 20a and a tapered main body 20b, joined together by bolts through flanges 22 and 23. In this embodiment, the separation of the three electrodes is increased as the heated fluid passes through the vessel 20 from bottom to top. In this way the current density at any point along the length of each electrode 21 can be maintained at the constant desired level even if the electrical conductivity of the heated fluid increases during its passage through the heater. The ratio of the pitch circle diameters of the upper and lower ends of the electrodes 21 should generally be equal to the ratio of the initial and final conductivities of the heated fluid, it being understood that the conductivity of fluids generally increases linearly with temperature so that the linearly-increasing spacing of the electrodes exactly compensates for this effect. The temperature of the heated fluid increases more or less linearly with distance during its passage along the length of the vessel 20.

A further embodiment of the present invention, where the conductivity changes significantly during the heating cycle is shown in Figure 4. Here two vessels 30 and 31 of the same general type as shown in Figure 1 but of different diameters to cope with the change in conductivity, are connected together by means of an adaptor plate 32 constructed from some suitable insulating material. If the geometrically correlating electrodes 33a and 33b in the two parts of the ohmic heater are connected to the same phase of the electrical supply, there will be no need to provide a guard ring at the adaptor plate 32, since the current densities flowing in each part of the ohmic heater will be largely unaffected by the electrical conditions in the other part. In addition, Figure 4 shows alternative means 34 and 35 of making the electrical connection to the lower electrodes 33b, and of sealing these connections against fluid leakage.

Connecting pins 34 penetrate the bottom end plate 37 to connect perpendicularly with the lower end of the electrodes 33b. The head of the connecting pin 34 is connected to wires 36 to provide electrical continuity between the wires 36 and the electrodes 33b. The connecting pins 34 and the lower end plate 37 are sealed to prevent fluid loss by seal 35.

If more than two heating stages or chambers are required, they can be added in series in a similar manner, with the electrical connections to the intermediate chambers being made radially through the appropriate adaptor plates. The surfaces of the adaptor plates 32 may also be shaped as described above in such a manner as to promote the egress of evolved gases or prevent the accumulation of solids at these plates 32.

Figure 5 shows a still further embodiment of the present invention. In this embodiment the versatility of the invention is illustrated in that the heater is used as a heater for tanks of liquid, as used in plating or phosphating baths. Conventionally heat exchangers are used for this application but these are subject to considerable fouling.

The vessel 42 is composed of a vessel body 42a and a vessel top plate 42b, and is suspended in a tank 49 of liquid. The electrodes 41 project through the top plate 42b into the vessel 42, and are connected to a three phase power supply (not shown) by wires 45.

There is no outlet port provided in the top plate 42b as in the previous embodiments. Instead there is an outlet pipe 48 provided within the vessel 42 to allow fluid at the top of the vessel 42 to be output through the wall of the vessel body 42a.

In the outlet pipe 48 and the inlet port 50 two sets of guard rings are provided 43 and 44. The guard rings nearest the electrodes are the neutral guard rings 43 whilst those furthest away are the earth guard rings. The provision of two sets of guard rings allows for the leakage current to be measured and hence monitored by subtracting the neutral return current from the sum of the line phase currents in a sensitive transformer. With a heater 50mm diameter electrodes 1,000mm long at 100mm centres which dissipate approximately 20kw at 415v phase voltage, the total leakage current was found to be well below 1mA, thereby supporting the claim that the leakage current to the earthed parts of the equipment via the heater fluid is negligible using the design.

In this embodiment of the invention circulation of the fluid is provided for by thermal siphoning, in that the circulation occurs due to the decrease in density of the fluid as its temperature rises. Therefore as the temperature of the fluid in the vessel increases it rises up to the outlet pipe 48 and is replaced at the inlet port 50 by cooler fluid.

A further feature is also illustrated in this em-

bodiment. An earthed metal clad thermocouple 47 is used to measure the temperature of the fluid leaving the heater. The use of this is possible since the axis at the outlet pipe 48 is maintained at or near earth potential as hereinbefore mentioned.

Figure 5 also shows that electrode current adjusting insulating sleeves 46 as hereinbefore mentioned. The movement of these sleeves up or down the length of the electrodes 41 varies the electrode currents.

Although in all of the embodiments hereinbefore mentioned the electrodes have been shown to lie within the vessel cavity, where viscous fluids are to be heated it may be advantageous to mount the electrodes against the insulating wall of the vessel. This is advantageous in that no area is provided behind the electrodes in which particulate matter in the fluid can be trapped.

Figure 6 illustrates such an arrangement using a cross-sectional view similar to Figure 2. The cross-section of the electrodes 54 is shaped such that their back face lies flush with the vessel wall 52. 53 denotes the input port. With this arrangement it may be more convenient to make electrical connections to the electrodes to the back face of the electrodes through the vessel wall; with suitable sealing arrangements. This allows for a smoother surface transition between the inlet and outlet ports and reduces the possibility of solids in suspension lodging around the electrodes. This is clearly of paramount importance with viscous or solid-bearing fluids.

Claims

1. An ohmic heater for heating a fluid comprising a vessel having inlet and outlet ports between which said fluid flows when in use, along an axis, at least two electrodes arranged to be spaced about said axis of flow and contained within said vessel, and means to supply electric power to said electrodes such that the electric potential at any time on said axis is substantially zero relative to earth.
2. An ohmic heater as claimed in Claim 1 wherein said vessel is electrically insulating.
3. An ohmic heater as claimed in Claim 1 or Claim 2 wherein said electrodes are arranged to extend parallel to said axis of flow.
4. An ohmic heater as claimed in Claim 1 or Claim 2 wherein said electrodes are arranged such that their separation transverse to said axis increases along said axis in the direction of flow of said fluid.

5. An ohmic heater as claimed in Claim 2, Claim 3 or Claim 4 wherein each said electrode has a back surface adjacent to the wall of said vessel.
5
6. An ohmic heater as claimed in any preceding claim comprising three said electrodes wherein each of said electrodes receives a single phase of a three-phase supply, when in use.
10
7. An ohmic heater as claimed in any preceding claim wherein said inlet and outlet ports are positioned at opposite ends of said vessel, said ports being substantially smaller in area than the cross-sectional area of said vessel.
15
8. An ohmic heater as claimed in any preceding claim further comprising an electrically conductive guard ring positioned to lie around the periphery of each of said ports.
20
9. An ohmic heater as claimed in any preceding claim wherein the surface of part of each of the electrodes is covered with a movable insulating material.
25
10. An ohmic heater as claimed in any preceding claim wherein said vessel is arranged such that the flow of fluid is against gravity.
30
11. An ohmic heater as claimed in any preceding claim comprising at least two said vessels coaxially coupled wherein the spacing of said electrodes is greater in successive said vessels along the direction of flow of said fluid.
35
12. An ohmic heater as claimed in Claim 11 wherein electrodes in geometrically equivalent positions in each said vessel are electrically connected together.
40
13. A method of operating an ohmic heater comprising the steps of passing a fluid to be heated along a flow axis through a vessel and energising electrodes, spaced about said axis such that the electric potential at any time on said axis is substantially zero relative to earth.
45
14. A method of operating an ohmic heater as claimed in Claim 13 wherein current between said electrodes can be varied by the adjustment of the position of an insulating material partially covering the surface of said electrodes.
50
55

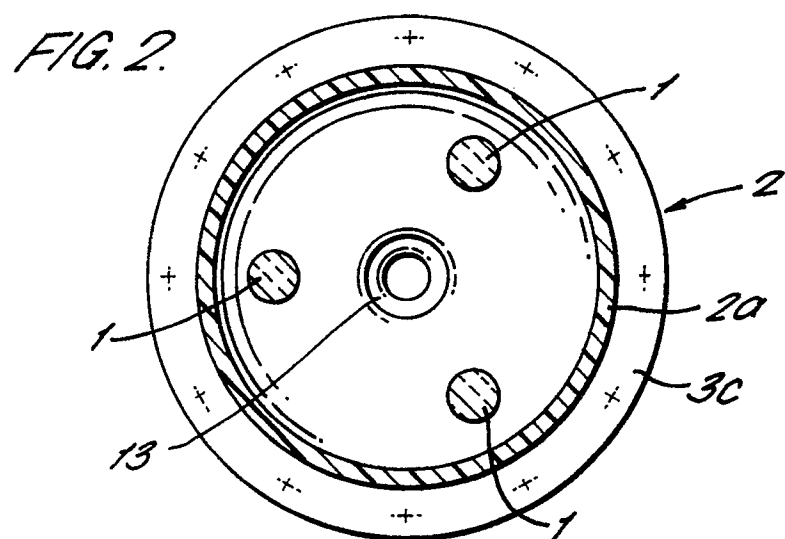
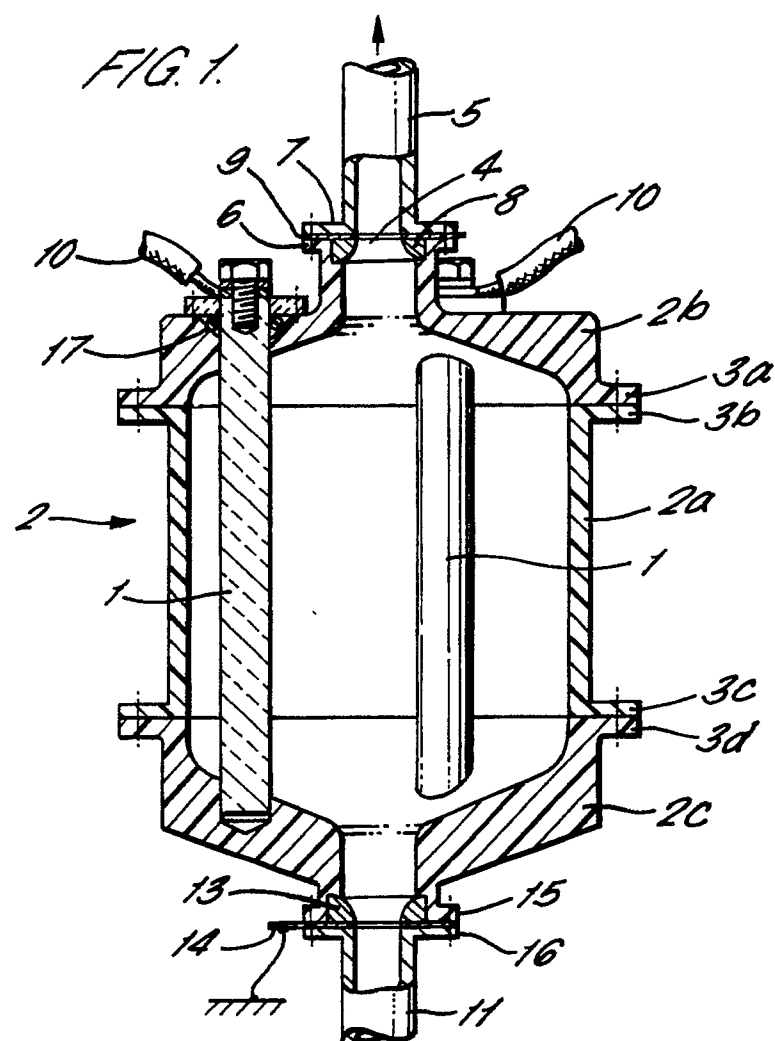


FIG. 3.

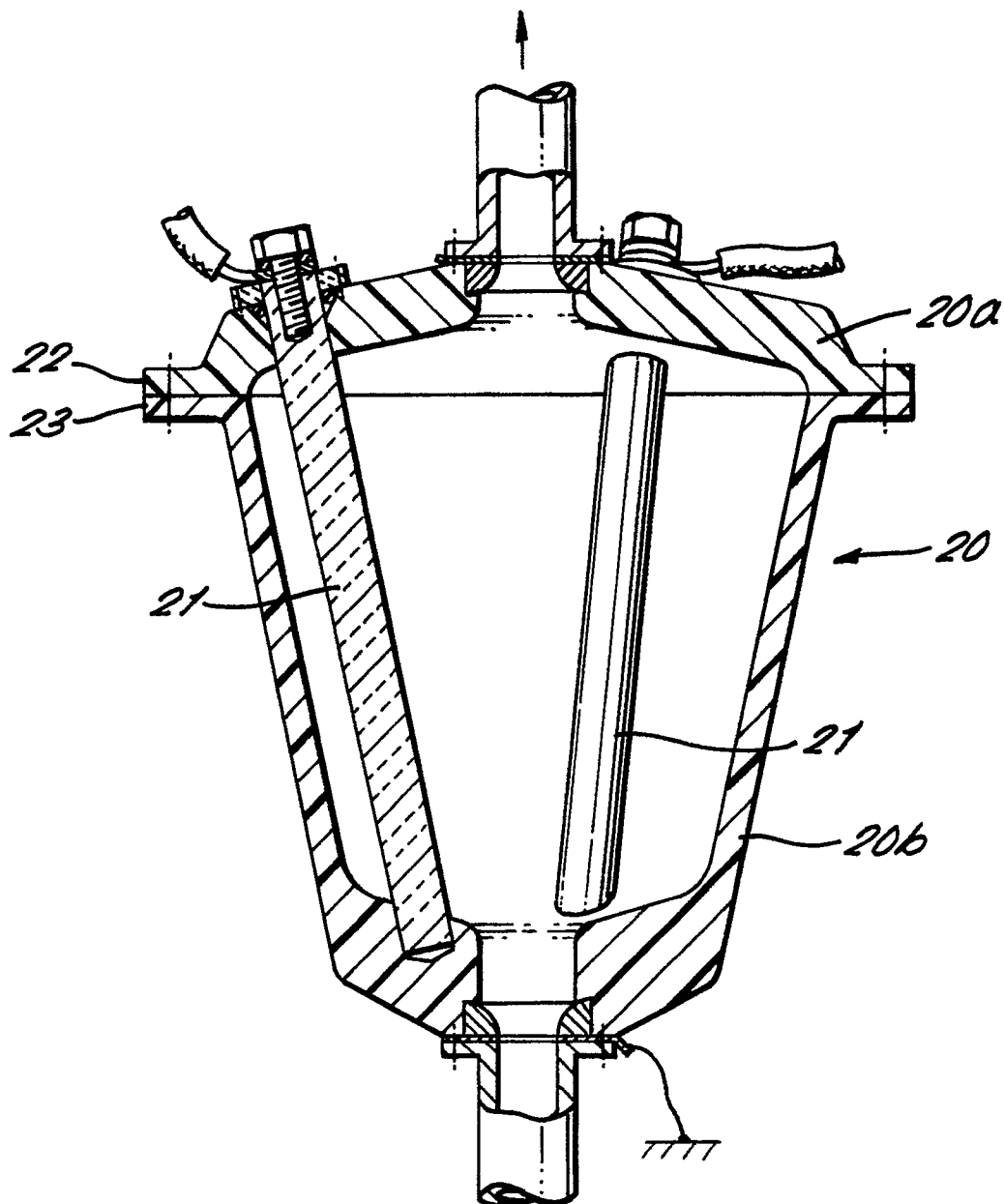


FIG. 4.

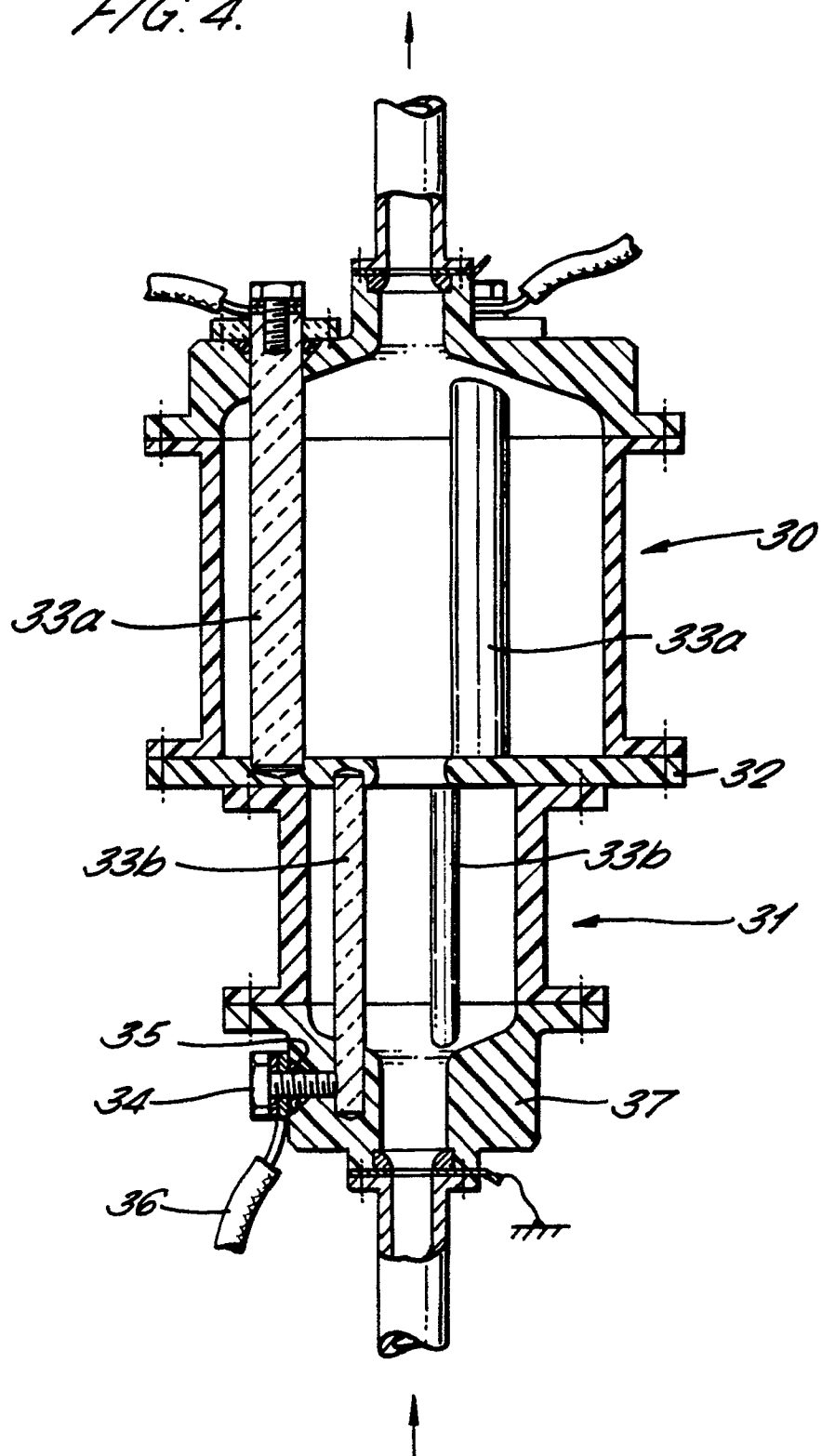


FIG. 5.

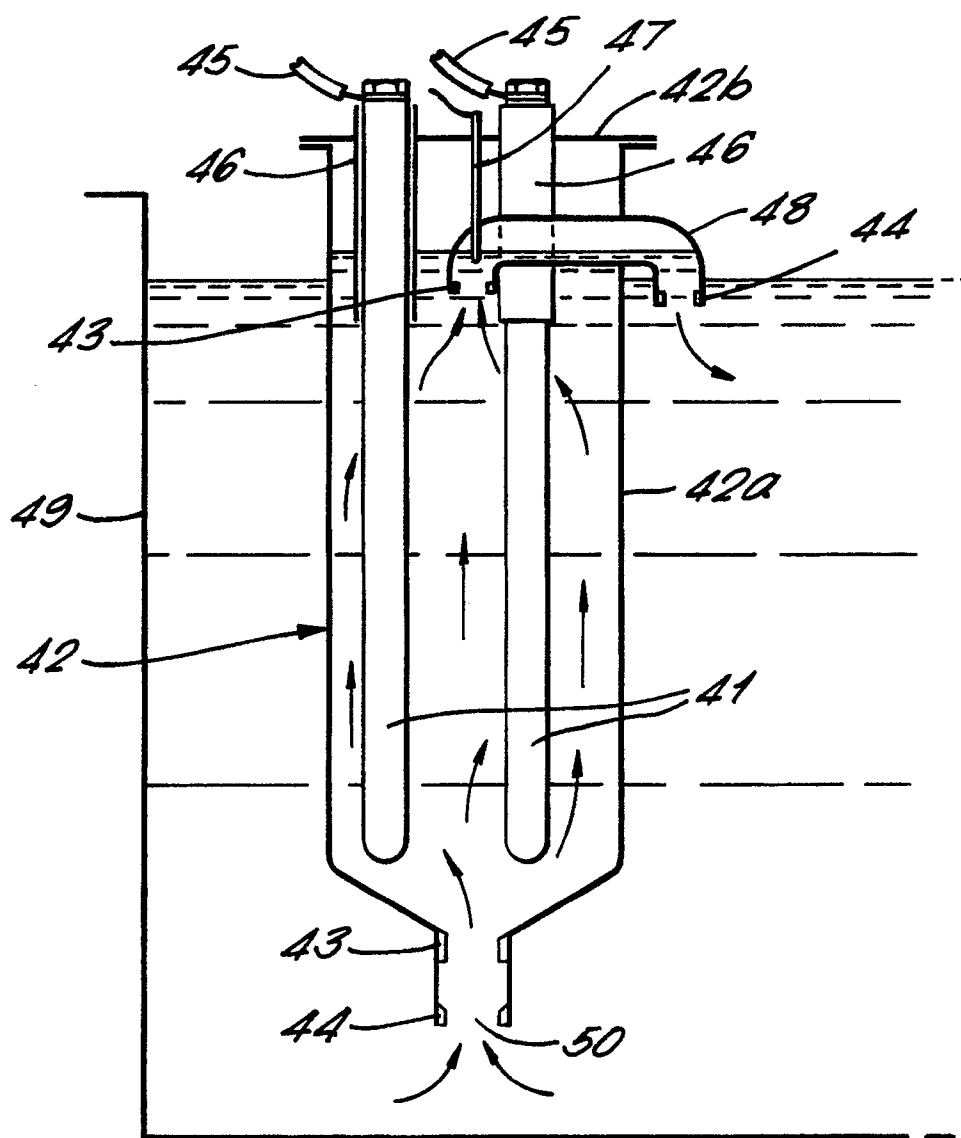
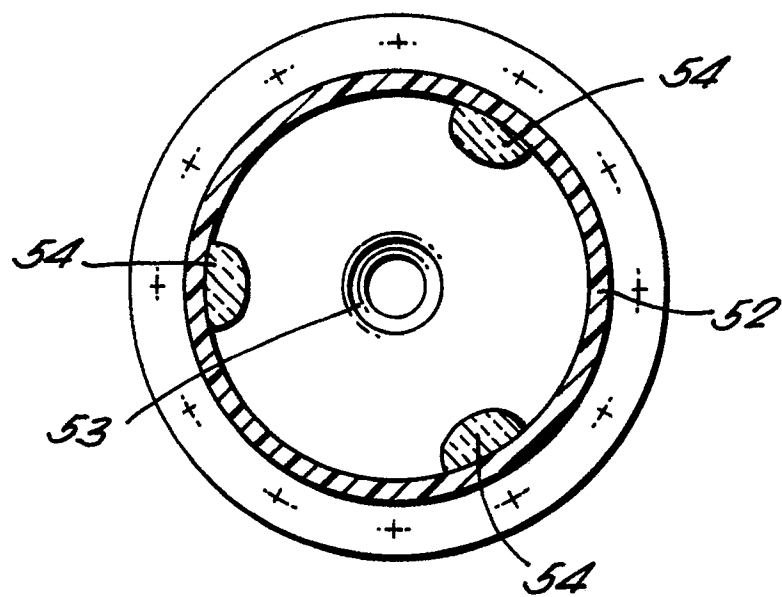


FIG. 6.





European
Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 31 4168

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	FR-A-9 647 33 (BERNARD) * the whole document * -- -- --	1,3,6,7, 10,13	F 24 H 1/10
X	AU-A-2 321 3 (BRITISH RAILWAYS BOARD) * page 4, paragraph 4 - page 5, paragraph 2; figures 2,3 * -- -- --	1,2,3,4,6, 7,13	
A	US-A-2 663 788 (TATEM) * the whole document * -- -- --	9,14	
A	DE-A-9 093 79 (RHEINISCH-WESTFÄLISCHES ELEC- TRIZITÄTSWERK AG) * the whole document * -- -- --	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			F 24 H H 05 B
The present search report has been drawn up for all claims			
Place of search		Date of completion of search	Examiner
The Hague		21 June 91	VAN GESTEL H.M.
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			