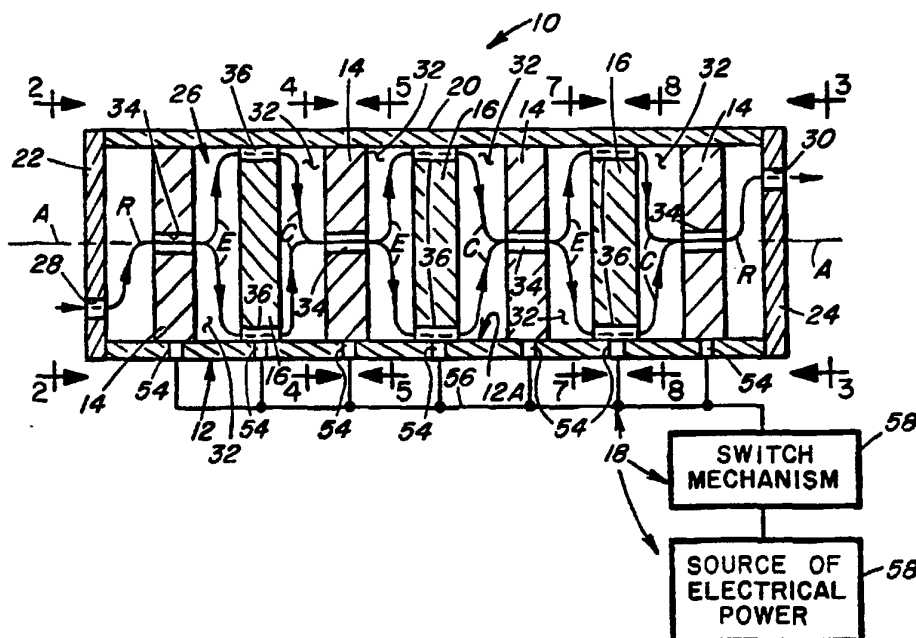




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

| | | |
|---|--|---|
| (51) International Patent Classification ⁵ : B01D 17/06, B03C 5/02, C25B 9/00, 15/08 | A1 | (11) International Publication Number: WO 94/17891 (43) International Publication Date: 18 August 1994 (18.08.94) |
| (21) International Application Number: PCT/US94/01312 (22) International Filing Date: 4 February 1994 (04.02.94) (30) Priority Data: 08/015,376 8 February 1993 (08.02.93) US (71)(72) Applicant and Inventor: KEMMERER, Terry, L. [US/US]; 1835 West Union, Unit 5, Englewood, CO 80110 (US). (74) Agent: FLANAGAN, John, R.; P.O. Box 4309, Boulder, CO 80306 (US). | (81) Designated States: AT, AU, BB, BG, BR, BY, CA, CH, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, KZ, LK, LU, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SK, UA, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> | |

(54) Title: INDUCED IONIC REACTION DEVICE WITH RADIAL FLOW



(57) Abstract

An induced ionic reaction device (12) includes a hollow transport tube (12) having a chamber (26) with a central longitudinal axis (A) and inlet (28) and outlet (30) in opposite ends of the transport tube (12) for entry of fluid to be treated into the chamber (26) and for exit of fluid treated from the chamber (26), a plurality of center-flow and peripheral-flow disc-shaped elements (14, 16) stationarily disposed in the chamber (26) and being spaced from one another along the longitudinal axis (A) of the chamber (26), the disc-shaped elements (14, 16) and the transport tube (12) defining a radial path of fluid flow through the chamber (26) thereof, and an electrical control (18) connected to the disc-shaped elements (14, 16) for electrically charging preselected ones of the disc-shaped elements (14, 16) to induce ionic reactions in the fluid flowing through the chamber (26) and thereby precipitate out substances carried by the fluid into large complex molecular clumps.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

| | | | | | |
|----|--------------------------|----|--|----|--------------------------|
| AT | Austria | GB | United Kingdom | MR | Mauritania |
| AU | Australia | GE | Georgia | MW | Malawi |
| BB | Barbados | GN | Guinea | NE | Niger |
| BE | Belgium | GR | Greece | NL | Netherlands |
| BF | Burkina Faso | HU | Hungary | NO | Norway |
| BG | Bulgaria | IE | Ireland | NZ | New Zealand |
| BJ | Benin | IT | Italy | PL | Poland |
| BR | Brazil | JP | Japan | PT | Portugal |
| BY | Belarus | KE | Kenya | RO | Romania |
| CA | Canada | KG | Kyrgyzstan | RU | Russian Federation |
| CF | Central African Republic | KP | Democratic People's Republic of Korea | SD | Sudan |
| CG | Congo | KR | Republic of Korea | SE | Sweden |
| CH | Switzerland | KZ | Kazakhstan | SI | Slovenia |
| CI | Côte d'Ivoire | LI | Liechtenstein | SK | Slovakia |
| CM | Cameroon | LK | Sri Lanka | SN | Senegal |
| CN | China | LU | Luxembourg | TD | Chad |
| CS | Czechoslovakia | LV | Latvia | TG | Togo |
| CZ | Czech Republic | MC | Monaco | TJ | Tajikistan |
| DE | Germany | MD | Republic of Moldova | TT | Trinidad and Tobago |
| DK | Denmark | MG | Madagascar | UA | Ukraine |
| ES | Spain | ML | Mali | US | United States of America |
| FI | Finland | MN | Mongolia | UZ | Uzbekistan |
| FR | France | | | VN | Viet Nam |
| GA | Gabon | | | | |

DescriptionINDUCED IONIC REACTION DEVICE
WITH RADIAL FLOWTechnical Field

5 The present invention generally relates to techniques for removal of contaminants dissolved in a fluid, such as water, and, more particularly, is concerned with an induced ionic reaction device for producing a radial flow of fluid through a chamber of
10 the ion reaction device to cause precipitation of contaminants dissolved in fluids, such as water.

Background Art

 The development of an effective method for flocculating contaminants in waste waters and liquids by
15 creating insoluble compounds or complexes and then precipitating them so as to make them easily filterable subsequently is a highly desired objective. Prior art methods in the electrochemical field, and specifically ones which take the electrocoagulative approach, have
20 sought to achieve these effects.

 However, these prior art methods are inefficient in both treatment and cost because, in the perception of the inventors herein, of preconceived assumptions and misunderstandings of the true nature and actions of the
25 laws of chemistry, physics, and basic electricity theory when applied to the realm of the contaminated liquid medium. Each of these sciences adheres strictly to its own model of the universe. Such adherence to purity of scientific viewpoint often leaves wide cracks between
30 the sciences and results in an inability to adequately conceptualize the processes occurring in contaminated liquid mediums.

As a result of these preconceived assumptions and misunderstandings, linear flow designs have been developed which result in low turbulence, low exposure or incorrect exposure to electric field flow and frequency proximity, and lack of proper agitation and mixing of the liquid. Instead, these linear flow designs have created counter productive clogging, resistant foaming actions, and unnecessary rises in temperature and excessive energy expenditures, all of which, further hamper the desired level of contaminant precipitate and result in the necessity to back flush the devices. This also seems to have caused the future corrective research and design evolutionary path of these devices to stray further from peak efficiency and validity. In other words, the designs themselves become self-defeating.

Also, spiral flow designs have been developed which actually sacrifice much of the potential and true and actual treatment area due to the need to transport the liquid and achieve the spiral flow prescribed in these designs. Where a large percentage of the potential electrode surface is exposed to the liquid, it is not possible to achieve the maximum effect needed to accomplish the intended purpose of the devices because the design itself cuts down the actual exposure of the liquid to treatment. Furthermore, worse still, water likes to flow in a spiral path. The spinning of the earth promotes a certain amount of spiral movement. The mere spiral movement of water does not cause any mixing to take place whatsoever. Therefore, producing a spiral flow effect by itself is a waste of effort.

Consequently, a need still exists for an effective technique for flocculating contaminants in waste water and liquids.

Disclosure of Invention

The present invention provides an induced ionic reaction device designed to satisfy the aforementioned need. The ionic reaction device of the present invention achieves flocculating of contaminants in waste waters and liquids by creating insoluble compounds or complexes and then precipitating them so as to make them easily filterable subsequently. The present invention operates on and effectively treats, but is not limited to, hazardous wastewaters, non-hazardous wastewaters, process wastewaters, waters containing heavy metals, waters possessing bacteria and viruses, waters containing dissolved solids and suspended solids, and waters containing oil and grease or other emulsions. Also, the present invention sterilizes biologically hazardous or infested liquids and precipitates many dissolved radioactives from water or liquids. These liquid wastes are produced by our global society as a necessary by-product of manufactured goods and service activities.

Accordingly, the present invention is directed to an induced ionic reaction device which comprises: (a) an elongated hollow transport tube having an elongated chamber with a longitudinal axis and an inlet and an outlet in opposite end portions of the transport tube for entry of fluid to be treated into the chamber of the transport tube and for exit of fluid treated from the chamber of the transport tube; (b) means disposed in the chamber of the transport tube for defining a radial path of fluid flow through the chamber of the transport tube; and (c) control means connected to the radial path defining means for imposing a predetermined electron field in the chamber of the transport tube to induce ionic reactions in the fluid flowing through the chamber of the transport tube and thereby precipitate out

substances carried by the fluid into large complex molecular clumps.

More particularly, the means for defining a radial path of fluid flow through the chamber of the transport tube are a plurality of disc-shaped elements. The disc-shaped elements are stationarily disposed in the chamber of the transport tube and spaced from one another along the longitudinal axis of the chamber of the transport tube. The disc-shaped elements and an interior surface of the hollow transport tube together define the radial path of fluid flow through the chamber of the transport tube.

A first group of the disc-shaped elements are center-flow elements sealed about their peripheral edges with the interior surface of the transport tube. Each of the disc-shaped elements in the first group has a flow passage through approximately a central portion of the center-flow element. A second group of the disc-shaped elements are peripheral-flow elements. Each of the disc-shaped elements of the second group has a plurality of flow passages through approximately the peripheral portion of the peripheral-flow element. The peripheral-flow disc-shaped elements of the second group are located in alternating relation with the center-flow disc-shaped elements of the first group.

The radial path of fluid flow through the chamber of the transport tube, as defined by the disc-shaped elements of the first and second groups together with the interior surface of the transport tube, has alternating expanding and contracting path segments. In the expanding path segments, the flow is directed radially outwardly from the central flow passages of the disc-shaped elements of the first plurality toward the peripheral passages of the disc-shaped elements of the second plurality. In the contracting path segments,

which interconnect the expanding path segments, the flow is directed radially inwardly from the peripheral passages of the disc-shaped elements of the second plurality toward the central flow passages of the disc-shaped elements of the first plurality. The flow of fluid proceeds along the radially-outwardly directed expanding path segments at a slower speed than along the radially-inwardly directed contracting path segments.

These and other features and advantages of the present invention will become apparent to those skilled in the art upon a reading of the following detailed description when taken in conjunction with the drawings wherein there is shown and described an illustrative embodiment of the invention.

15 Brief Description of Drawings

In the following detailed description, reference will be made to the attached drawings in which:

Fig. 1 is a longitudinal axial sectional view of an induced ionic reaction device of the present invention, showing a transport tube and a plurality of center-flow and peripheral-flow disc-shaped elements of a first configuration disposed in the transport tube.

Fig. 2 is a front end view of the device as seen along line 2--2 of Fig. 1.

25 Fig. 3 is a rear end view of the device as seen along line 3--3 of Fig. 1.

Fig. 4 is an enlarged front end elevational view of one of the center-flow disc-shaped elements as seen along line 4--4 of Fig. 1, showing also the transport tube in cross-section.

Fig. 5 is an enlarged rear end elevational view of the same one of center-flow disc-shaped elements as seen along line 5--5 of Fig. 1.

Fig. 6 is an enlarged side elevational view of the

center-flow disc-shaped element of Figs. 4 and 5.

Fig. 7 is an enlarged front end elevational view of one of the peripheral-flow disc-shaped elements as seen along line 7--7 of Fig. 1, showing also the transport tube in cross-section.

Fig. 8 is an enlarged rear end elevational view of the same one of peripheral-flow disc-shaped elements as seen along line 8--8 of Fig. 1.

Fig. 9 is an enlarged side elevational view of the peripheral-flow disc-shaped element of Figs. 7 and 8.

Fig. 10 is an end elevational view of a peripheral-flow disc-shaped element having a configuration slightly modified from that of the element of Figs. 7 and 8.

Fig. 11 is a side elevational view of the peripheral-flow disc-shaped element of Fig. 10.

Fig. 12 is a longitudinal axial sectional view of an induced ionic reaction device of the present invention, showing a transport tube and a plurality of center-flow and peripheral-flow disc-shaped elements of a second configuration disposed in the transport tube.

Fig. 13 is an enlarged end elevational view of one of the center-flow disc-shaped elements of the second configuration of Fig. 12.

Fig. 14 is an enlarged side elevational view of the center-flow disc-shaped element of Fig. 13.

Fig. 15 is an enlarged end elevational view of one of the peripheral-flow disc-shaped elements of a third configuration of Fig. 12.

Fig. 16 is an enlarged side elevational view of the peripheral-flow disc-shaped element of Fig. 15.

Best Mode for Carrying Out the Invention

Referring to the drawings and particularly to Figs. 1 and 12, there is illustrated an ionic reaction device, generally designated 10, of the present invention. The

ionic reaction device 10 basically includes an elongated hollow transport tube 12, a plurality of center-flow and peripheral-flow disc-shaped elements 14, 16, and an electrical control means 18 for imposing a predetermined electron field in the transport tube 12.

Referring to Figs. 1-3 and 12, the transport tube 12 of the ionic reaction device 10 has an elongated rigid cylindrical wall 20 and a pair of planar rigid front and rear end plates or walls 22, 24 suitably fitted and attached, such as by threaded connections, to the open opposite ends of the cylindrical wall 20. The cylindrical wall 20 and the front and rear end walls 22, 24 together define an elongated enclosed internal chamber 26 which has a central longitudinal axis A. The transport tube 12 also has an inlet port 28 defined through the front end wall 22 and an outlet port 30 defined through the rear end wall 24. The inlet port 28 permits the entry of a flow of fluid to be treated into the chamber 26, and the outlet port 30 permits the exit of the flow of fluid after treatment from the chamber 26. Typically, flow tubes or pipes (not shown) are threaded into the inlet and outlet portions 28, 30 for supplying and removing the fluid flow to and from the transport tube 12. The transport tube 12 can be constructed of a suitable metallic material, but is preferably constructed of a suitable non-metallic, electrically non-conductive, material.

As shown in Figs. 1 and 12, the center-flow and peripheral-flow disc-shaped elements 14, 16 of the ionic reaction device 10 are stationarily disposed in the chamber 26 of the transport tube 12 and are spaced from one another along the longitudinal axis A of the transport tube 12 so as to define respective gaps 32 between the elements 14, 16 such that the elements 14, 16 do not directly contact one another. The peripheral-

flow disc-shaped elements 16 are located in alternating relation with the center-flow disc-shaped elements 14. The center-flow elements 14 constitute a first group of the disc-shaped elements, while the peripheral-flow disc-shaped elements 16 constitute a second group of the elements. The center-flow and peripheral-flow elements 14, 16 are preferably made of suitable electrically conductive materials.

As seen in Figs. 1-3, each of the center-flow elements 14 of the first group is sealed about its peripheral edge portion 14A with a cylindrical interior surface 12A of the transport tube 12 such that no fluid can flow past the center-flow elements 14 between the peripheral edge portions 14A thereof and the interior surface 12A of the transport tube 12. Also, each of the center-flow elements 14 has a flow passage 34 through approximately a central portion 14B of the center-flow element 14, permitting fluid to flow through the center-flow elements 14 solely via the central flow passage 34.

As seen in Figs. 1, 7 and 8, each of the peripheral-flow elements 16 of the second group has a plurality of flow passages 36 through approximately the peripheral portion 16A of the peripheral-flow element 16. Peripheral segments of the peripheral-flow elements 16 between the peripheral flow passages 36 engage the interior surface 12A of the transport tube 12. As depicted by the arrows in Figs. 1, 3, 4, 7 and 8, the center-flow and peripheral-flow disc-shaped elements 14, 16 and the hollow transport tube 12 together define an overall radial path R of fluid flow through the chamber 26 of the transport tube 12, the flow proceeding through the central flow passages 34 of the center-flow elements 14, through the gaps 32 between the alternating center-flow and peripheral-flow elements 14, 16, and through the peripheral passages 36 of the peripheral-flow

elements 16.

The radial path R of fluid flow through the chamber 26 of the transport tube 12 has alternating expanding and contracting flow path segments E, C. Along the
5 expanding path segments E, the expanding flow is directed radially outwardly from the central flow passages 34 of the center-flow elements 14 toward the peripheral flow passages 36 of the peripheral-flow elements 16. Along the contracting path segments C,
10 which interconnect the expanding path segments E, the contracting flow is directed radially inwardly from the peripheral passages 36 of the peripheral-flow elements 16 toward the central flow passages 34 of the center-flow elements 14. The speed of fluid flow along the
15 radially-outwardly directed expanding path segments E increases, while the speed of fluid flow along the radially-inwardly directed contracting path segments C decreases. Thus, the speed of fluid flow along expanding path segments E is faster than the speed of
20 fluid flow along contracting path segments C. The expanding and contracting radial path of fluid flow results in constant changes the fluid's pressure, density, speed, velocity, direction, temperature, liquid mix, turbulence and exposure to treatment.

25 Several different configurations of the center-flow and peripheral-flow disc-shaped elements 14, 16 are disclosed. Regardless of respective configurations, the center-flow elements 14 always block the flow of fluid at or near their peripheries past the elements 14 and
30 adjacent to the interior surface 12A of the transport tube 12 and thereby redirect the flow radially inwardly toward the central portion 14A thereof. Regardless of respective configurations, the peripheral-flow elements 16 always block the flow of fluid through the elements
35 16 at or near central portions 16B of the elements 16

and thereby redirect the flow radially outwardly toward the peripheral portion 16A thereof.

In the first configuration shown in Figs. 1 and 4-6, each of center-flow disc-shaped elements 14 of the first group has an exterior cylindrical shape and a pair of parallel face surfaces 38, 40 defined on the opposite ends of the center-flow element 14. In the second configuration shown in Figs. 12-14, each of the center-flow disc-shaped elements 14 of the first group has an exterior cylindrical shape and a pair of conical concave face surfaces 42, 44 defined on the opposite ends of the center-flow element 14.

In a first configuration shown in Figs. 1 and 7-9, each of the peripheral-flow disc-shaped elements 16 of the second group has an exterior cylindrical shape and a pair of parallel face surfaces 46, 48 defined on the opposite ends of the peripheral-flow element 16. The peripheral flow passages 36 are in the form of semi-cylindrical grooves made in the peripheral portion 16A of the peripheral-flow element 16 which merge with the interior surface 12A of the transport tube 12. In a modification of the first configuration shown in Figs. 10 and 11, the peripheral flow passages 38 are in the form of cylindrical holes made through the peripheral portion 16A of each peripheral-flow element 16 in spaced relation from the interior surface 12A of the transport tube 12. In a second configuration shown in Figs. 12, 15 and 16, each of the peripheral-flow elements 16 has an exterior cylindrical shape and a pair of conical convex face surfaces 50, 52 defined on opposite ends of the peripheral-flow element 16. Other shapes besides conical are possible. Also, either spiral grooves or guide planes can be etched or attached to the face surfaces of the elements 14, 16 to achieve a further spiraling action in the flow of fluid which adds to the

other dynamic actions occurring therein as described above.

The electrical control means 18 of the device 10 includes electrical contacts 54 spaced axially along and
5 being fixed into and extending through the cylindrical wall 20 of the transport tube 12 so as to make contact with the respective center-flow and peripheral-flow disc-shaped elements 14, 16 within the transport tube 12. The control means 18 also includes conductors 56
10 connecting the various electrical contacts 54 to a switch mechanism 56 and a source of electrical power 58, either AC or DC, connected to the switch mechanism 56. The switch mechanism 56 can be manually set or automatically set by computer control to supply
15 predetermined electrical charges or pulses to the preselected ones of the disc-shaped elements 14, 16 so that the elements will act as either electrical electrodes or emitters in order to induce ionic reactions in the fluid flowing through the chamber 26 of
20 the transport tube 12 and thereby precipitate out substances, being carried by the flow of fluid along the radial path R through the transport tube 12, into large complex molecular clumps.

The operation of the ionic reaction device 10 of
25 the present invention can be understood with reference to a particular application, such as upon wastewater containing dissolved metals. The dissolved metals in wastewater are held as ions, often as metal associated with hydroxides or phosphates depending on the source.
30 The inflowing stream of water bound with dissolved metals enters the reaction chamber 26 through the inlet port 28 and the water bonds are instantly disrupted and continue to be disrupted throughout the following process. Often selected metal ion seeds are made
35 available and other already present materials and

substances in the wastewater also become available which combine with the freed target metals to form or begin to form insoluble complexes. Oxygen and hydrogen ions are also available to replace the water receptor sites in the newly forming complexes. For example, oxygen ions are extremely reactive and they quickly react with the available metal ions to produce metal oxides. Metal oxides are usually completely insoluble. Consequently, these newly formed metal oxides begin to precipitate out of the solution immediately. The precipitates can then be filtered after exiting the tube 12 by the applicable method best suited to the collection characteristics of the floc. An interesting consequence and added bonus of this process is that as the hydroxide ion is reduced to water, the pH of the resulting water stream is often moved toward neutral.

From the above description, it can be realized that the radial flow of a fluid through an electron field and/or a specifically set frequency via an emitter is a more efficient and effective way to achieve induced ionic reactions within some fluids. An electro-chemical action is produced which enhances, effects, supports, or starts an ionic reaction or free radical reaction in various effluent streams. The consequence of this ionic binding produces, in most cases, a stable fallout of matter which in many cases may pass the EPA's Toxicity Characteristic Leaching Procedure (TCLP) which means that if the matter meets TCLP requirements it may then be de-listed and thus not be considered a toxic or hazardous waste.

The unique design of the device 10 of the present invention allows induced ionic reactions to occur within fluids containing reactable material flowing radially, as described above, through electron fields and focused frequency treatment originating from various types of

metals or conductors used to make the elements. The design creates a radial flow of the fluid such that a constant change in direction, pressure, density, speed of flow, velocity, temperature, liquid mix, turbulence, and exposure to treatment results. All of these actions are beneficial, helpful, and desirable during the treatment process described herein.

Also, this design contains no self-defeating attributes as may be found in other electrochemical or electrolytical designs. The resulting fluid turbulence achieves superior mixing and superior exposure to treatment and thus a far more efficient induced ionic reaction, and additionally, achieves self-cleaning of the electrodes and emitters and achieves a large reduction in resistant foaming. Further, the amount of energy consumed in treatment or to start the induced ionic reaction or any induced free radical reactions has been greatly reduced and thereby the temperature gain in the liquid has also been significantly reduced.

The design also allows maximum treatment area to be achieved in the reaction chamber 26 and, therefore, attains new levels of precipitation to be achieved. Thus, significant increases in levels of contaminant reduction after proper filtration over other designs are realized.

Examples

Two examples are given below in Table I of laboratory scale treatment runs using the device 10 of the present invention. Actual plant wastewater from a chromate conversion process was treated. One example is treatment of chromium contamination which was the primary problem and the target substance for the reaction chamber setup. The other example is for treatment of total dissolved solids in the wastewater.

Table I

| Test | Before Treatment | After Treatment | Units |
|-----------------------------|---------------------|--------------------|-------|
| 5 Total Dissolved Solids | 215.0 | 120.0 | mg/l |
| Chromium (total) | 22.0 | 0.52 | mg/l |

Comparison of "before treatment" levels with "after
10 treatment" levels of Total Dissolved Solids and Chromium
shows substantial reductions for both after one pass
through the device 10, and especially for Chromium which
was the target substance in a normally treatment-
resistive water.

15 It is thought that the present invention and its
advantages will be understood from the foregoing
description and it will be apparent that various changes
may be made thereto without departing from its spirit
and scope of the invention or sacrificing all of its
20 material advantages, the form hereinbefore described
being merely preferred or exemplary embodiment thereof.

Claims

1. An induced ionic reaction device, comprising:

(a) an elongated hollow transport tube having an elongated chamber with a longitudinal axis and an inlet and outlet in opposite end portions of said transport tube for entry of fluid to be treated into said chamber of said transport tube and for exit of fluid treated from said chamber of said transport tube;

(b) means disposed in said chamber of said transport tube for defining a radial path of fluid flow through said chamber of said transport tube, said means for defining a radial path of fluid flow through said chamber of said transport tube including a plurality of disc-shaped elements stationarily disposed in said chamber of said transport tube and being spaced from one another along said longitudinal axis of said chamber of said transport tube, said disc-shaped elements and an interior surface of said hollow transport tube together defining said radial path of fluid flow through said chamber of said transport tube, said plurality of disc-shaped elements including a first group of said elements being sealed about their peripheral edges with said interior surface of the transport tube, each of said elements of said first group having a flow passage formed through substantially a central portion of said element, each of said disc-shaped elements of said first group having an exterior cylindrical shape and a pair of concave face surfaces defined on opposite ends of said element; and

(c) control means connected to said radial path defining means for imposing a predetermined electron field in said chamber of said transport tube to induce ionic reactions in the fluid flowing through said chamber of the transport tube and thereby precipitate

out substances carried by the fluid into large complex
35 molecular clumps.

2. The device of claim 1 wherein selected ones of
said plurality of disc-shaped elements each has a
plurality of passages formed through substantially a
peripheral portion of said element adjacent to said
5 interior surface of said transport tube.

3. The device of claim 1 wherein said peripheral
flow passages through each of said selected elements
merge with said interior surface of said transport tube.

4. The device of claim 1 wherein said peripheral
flow passages through each of said selected elements
are spaced from said interior surface of said transport
tube.

5. The device of claim 1 wherein said radial path
of fluid flow through said chamber of said transport
tube has expanding and contracting path segments.

6. The device of claim 5 wherein said expanding
path segments provide fluid flow directed radially
outwardly from said longitudinal axis toward said
interior surface of said transport tube.

7. The device of claim 6 wherein said contracting
path segments provide fluid flow directed radially
inwardly from said inside surface of said transport tube
toward said longitudinal axis of said chamber of said
5 transport tube.

8. The device of claim 7 wherein said flow of
fluid proceeds along said expanding path segments at a

slower speed than along said contracting path segments.

9. The device of claim 1 wherein said disc-shaped elements of said second group are located in alternating relation with said disc-shaped elements of said first group.

10. An induced ionic reaction device, comprising:

(a) an elongated hollow transport tube having an elongated chamber with a longitudinal axis and an inlet and outlet in opposite end portions of said transport
5 tube for entry of fluid to be treated into said chamber of said transport tube and for exit of fluid treated from said chamber of said transport tube;

(b) means disposed in said chamber of said transport tube for defining a radial path of fluid flow
10 through said chamber of said transport tube, said means for defining a radial path of fluid flow through said chamber of said transport tube including a plurality of disc-shaped elements stationarily disposed in said chamber of said transport tube and being spaced from one
15 another along said longitudinal axis of said chamber of said transport tube, said disc-shaped elements and an interior surface of said hollow transport tube together defining said radial path of fluid flow through said chamber of said transport tube, said plurality of disc-
20 shaped elements including a first group of said elements being sealed about their peripheral edges with said interior surface of the transport tube, each of said elements of said first group having a flow passage formed through substantially a central portion of said
25 element, said plurality of disc-shaped elements including a second group of said elements each having a plurality of passages formed through substantially a peripheral portion of said element adjacent to said

interior surface of said transport tube; and

- 30 (c) control means connected to said radial path
defining means for imposing a predetermined electron
field in said chamber of said transport tube to induce
ionic reactions in the fluid flowing through said
chamber of the transport tube and thereby precipitate
35 out substances carried by the fluid into large complex
molecular clumps.

11. The device of claim 10 wherein said peripheral
flow passages through each of said disc-shaped elements
of said second group merge with said interior surface of
said transport tube.

12. The device of claim 10 wherein said peripheral
flow passages through each of said disc-shaped elements
of said second group are spaced from said interior
surface of said transport tube.

13. The device of claim 10 wherein said disc-
shaped elements of said second group are located in
alternating relation with said disc-shaped elements of
said first group.

14. The device of claim 10 wherein each of said
disc-shaped elements of said second group has an
exterior cylindrical shape and a pair of parallel face
surfaces defined on opposite ends of said element.

15. The device of claim 10 wherein each of said
disc-shaped elements of said second group has an
exterior cylindrical shape and a pair of convex face
surfaces defined on opposite ends of said element.

16. The device of claim 10 wherein said peripheral

passages of each of said disc-shaped elements of said second group are defined by a plurality of grooves being spaced apart circumferentially and defined about said peripheral portion of said element.

17. The device of claim 10 wherein said radial path of fluid flow through said chamber of said transport tube defined by said disc-shaped elements of said first and second groups have expanding and contracting path segments.

18. The device of claim 17 wherein said expanding path segments provide fluid flow directed radially outwardly from said central flow passages of said elements of said first group toward said peripheral flow passages of said elements of said second group.

19. The device of claim 18 wherein said contracting path segments interconnect said expanding path segments and provide fluid flow directed radially inwardly from said peripheral flow passages of said elements of said second group toward said central flow passages of said elements of said first group.

20. The device of claim 19 wherein said flow of fluid proceeds along said radially-outwardly directed expanding path segments at a slower speed than along said radially-inwardly directed contracting path segments.

21. An induced ionic reaction chamber, comprising:
(a) an elongated hollow transport tube having an elongated chamber with a central longitudinal axis and an inlet port and an outlet port in opposite end portions of said transport tube for entry of fluid to be

treated into said chamber of said transport tube and for exit of fluid treated from said chamber of said transport tube;

(b) a plurality of center-flow and peripheral flow disc-shaped elements stationarily disposed in said chamber of said transport tube and being spaced from one another along said longitudinal axis of said chamber of said transport tube, said center-flow and peripheral-flow disc-shaped elements and an interior surface of said hollow transport tube together defining a radial path of fluid flow through said chamber of said transport tube, each of said peripheral-flow disc-shaped elements having a plurality of passages formed through substantially a peripheral portion of said element adjacent to said interior surface of said transport tube; and

(c) control means connected to said selected ones of said center-flow and peripheral-flow disc-shaped elements for electrically charging preselected ones of said disc-shaped elements to establish said disc-shaped elements as electrical electrodes and emitters for inducing ionic reactions in the fluid flowing through said chamber of said transport tube and thereby precipitate out substances carried by the fluid into large complex molecular clumps.

22. The device of claim 21 wherein said plurality of center-flow disc-shaped elements are sealed about their peripheral edges with said interior surface of said transport tube.

23. The device of claim 21 wherein each of said center-flow disc-shaped elements has a flow passage formed through substantially a central portion of said element.

21

24. The device of claim 21 wherein said peripheral flow passages through each of said peripheral-flow disc-shaped elements merge with said interior surface of said transport tube.

25. The device of claim 21 wherein said peripheral flow passages through each of said peripheral-flow disc-shaped elements are spaced from said interior surface of said transport tube.

26. The device of claim 21 wherein said peripheral flow passages of each peripheral-flow element are defined by a plurality of grooves circumferentially spaced apart and defined about said peripheral portion
5 of said element.

27. The device of claim 21 wherein said peripheral-flow disc-shaped elements are located in alternating relation with said center-flow disc-shaped elements.

28. The device of claim 21 wherein said radial path of fluid flow through said chamber of said transport tube defined by said center-flow and peripheral-flow disc-shaped elements have expanding and
5 contracting path segments.

29. The device of claim 28 wherein said expanding path segments provide fluid flow directed radially outwardly from said central flow openings of said center-flow disc-shaped elements toward said peripheral
5 flow passages of said peripheral-flow disc-shaped elements.

30. The device of claim 29 wherein said

contracting path segments interconnect said expanding path segments and provide fluid flow directed radially inwardly from said peripheral flow passages of said peripheral-flow disc-shaped elements toward said
5 central flow openings of said center-flow disc-shaped elements.

31. An induced ionic reaction chamber, comprising:

(a) an elongated hollow transport tube having an elongated chamber with a central longitudinal axis and an inlet port and an outlet port in opposite end portions of said transport tube for entry of fluid to be treated into said chamber of said transport tube and for exit of fluid treated from said chamber of said transport tube;

(b) a plurality of center-flow and peripheral flow disc-shaped elements stationarily disposed in said chamber of said transport tube and being spaced from one another along said longitudinal axis of said chamber of said transport tube, said center-flow and peripheral-flow disc-shaped elements and an interior surface of said hollow transport tube together defining a radial path of fluid flow through said chamber of said transport tube, each of said center-flow disc-shaped elements having an exterior cylindrical shape and a pair of parallel face surfaces defined on opposite ends of said element; and

(c) control means connected to said selected ones of said center-flow and peripheral-flow disc-shaped elements for electrically charging preselected ones of said disc-shaped elements to establish said disc-shaped elements as electrical electrodes and emitters for inducing ionic reactions in the fluid flowing through said chamber of said transport tube and thereby precipitate out substances carried by the fluid into

large complex molecular clumps.

32. An induced ionic reaction chamber, comprising:

- (a) an elongated hollow transport tube having an elongated chamber with a central longitudinal axis and an inlet port and an outlet port in opposite end portions of said transport tube for entry of fluid to be treated into said chamber of said transport tube and for exit of fluid treated from said chamber of said transport tube;
- (b) a plurality of center-flow and peripheral flow disc-shaped elements stationarily disposed in said chamber of said transport tube and being spaced from one another along said longitudinal axis of said chamber of said transport tube, said center-flow and peripheral-flow disc-shaped elements and an interior surface of said hollow transport tube together defining a radial path of fluid flow through said chamber of said transport tube, each of said center-flow disc-shaped elements having an exterior cylindrical shape and a pair of concave face surfaces defined on opposite ends of said element; and
- (c) control means connected to said selected ones of said center-flow and peripheral-flow disc-shaped elements for electrically charging preselected ones of said disc-shaped elements to establish said disc-shaped elements as electrical electrodes and emitters for inducing ionic reactions in the fluid flowing through said chamber of said transport tube and thereby precipitate out substances carried by the fluid into large complex molecular clumps.

33. An induced ionic reaction chamber, comprising:

- (a) an elongated hollow transport tube having an elongated chamber with a central longitudinal axis and

an inlet port and an outlet port in opposite end
5 portions of said transport tube for entry of fluid to be
treated into said chamber of said transport tube and for
exit of fluid treated from said chamber of said
transport tube;

(b) a plurality of center-flow and peripheral flow
10 disc-shaped elements stationarily disposed in said
chamber of said transport tube and being spaced from one
another along said longitudinal axis of said chamber of
said transport tube, said center-flow and peripheral-
flow disc-shaped elements and an interior surface of
15 said hollow transport tube together defining a radial
path of fluid flow through said chamber of said
transport tube, each of said peripheral-flow disc-shaped
elements having an exterior cylindrical shape and a pair
of parallel face surfaces defined on opposite ends of
20 said element; and

(c) control means connected to said selected ones
of said center-flow and peripheral-flow disc-shaped
elements for electrically charging preselected ones of
said disc-shaped elements to establish said disc-shaped
25 elements as electrical electrodes and emitters for
inducing ionic reactions in the fluid flowing through
said chamber of said transport tube and thereby
precipitate out substances carried by the fluid into
large complex molecular clumps.

34. An induced ionic reaction chamber, comprising:

(a) an elongated hollow transport tube having an
elongated chamber with a central longitudinal axis and
an inlet port and an outlet port in opposite end
5 portions of said transport tube for entry of fluid to be
treated into said chamber of said transport tube and for
exit of fluid treated from said chamber of said
transport tube;

(b) a plurality of center-flow and peripheral flow
10 disc-shaped elements stationarily disposed in said
chamber of said transport tube and being spaced from one
another along said longitudinal axis of said chamber of
said transport tube, said center-flow and peripheral-
flow disc-shaped elements and an interior surface of
15 said hollow transport tube together defining a radial
path of fluid flow through said chamber of said
transport tube, each of said peripheral-flow disc-shaped
elements having an exterior cylindrical shape and a pair
of convex face surfaces defined on opposite ends of said
20 element; and

(c) control means connected to said selected ones
of said center-flow and peripheral-flow disc-shaped
elements for electrically charging preselected ones of
said disc-shaped elements to establish said disc-shaped
elements as electrical electrodes and emitters for
inducing ionic reactions in the fluid flowing through
said chamber of said transport tube and thereby
precipitate out substances carried by the fluid into
large complex molecular clumps.

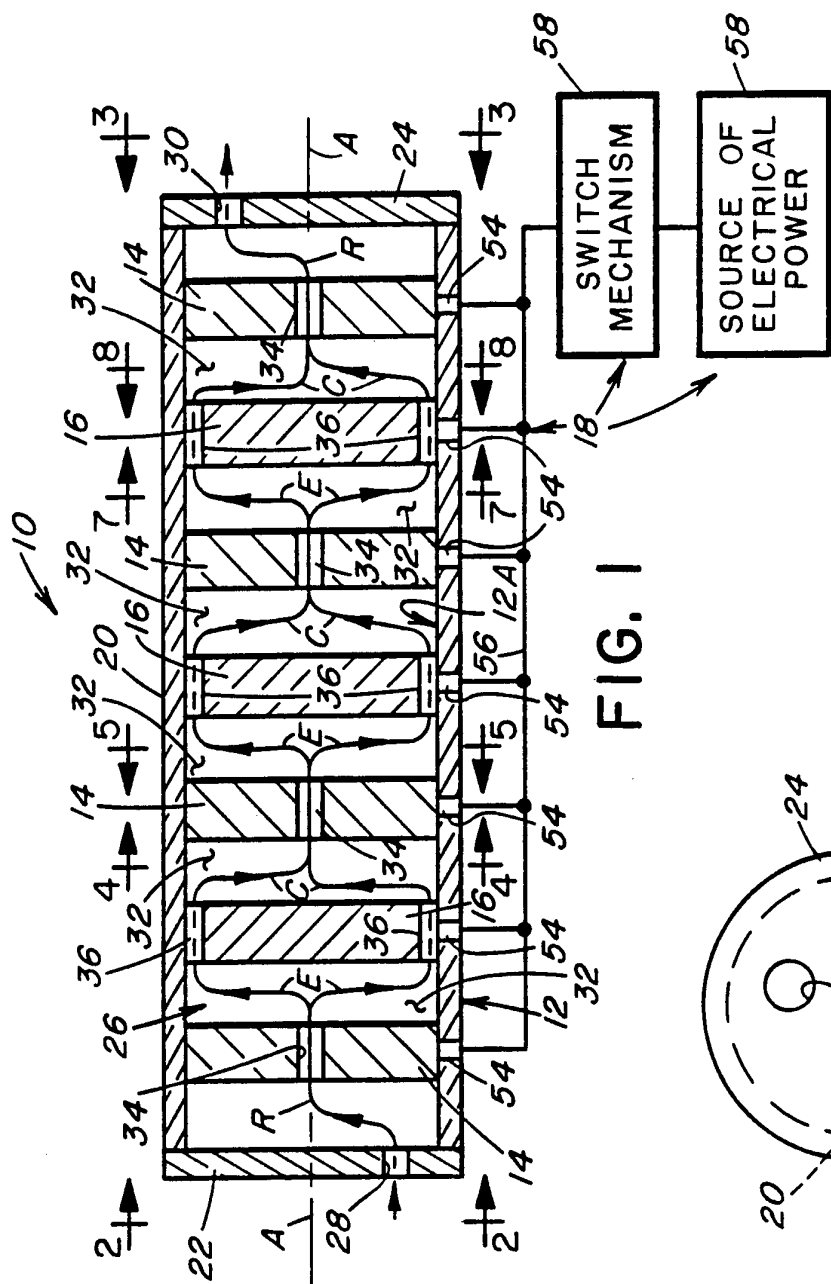


FIG. 1

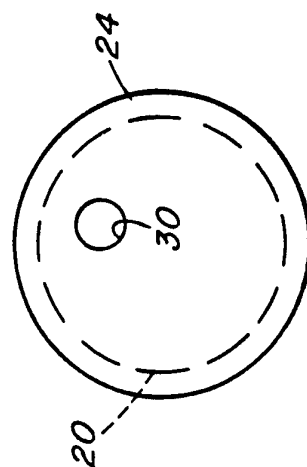


FIG. 2

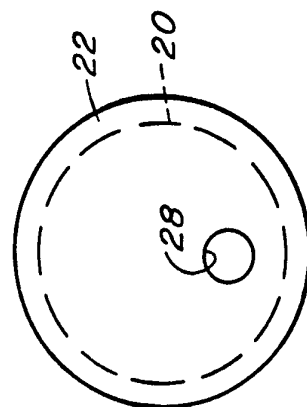


FIG. 3

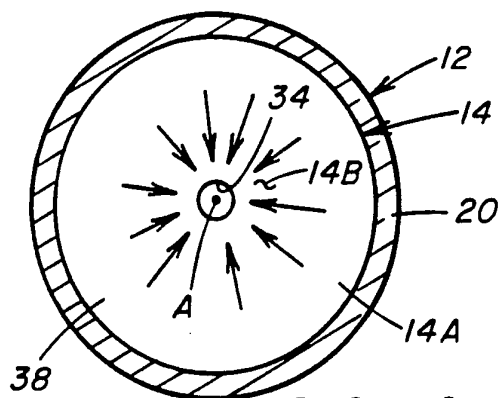


FIG. 4

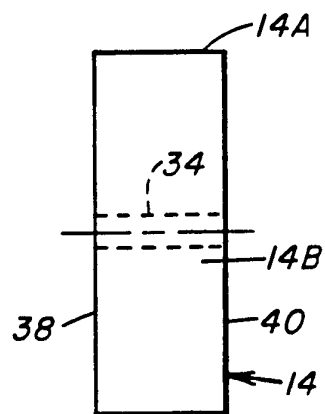


FIG. 6

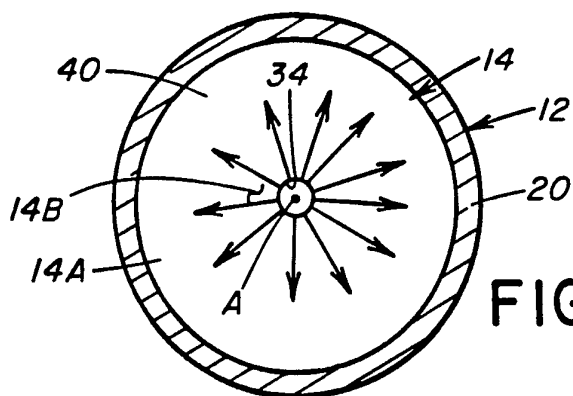


FIG. 5

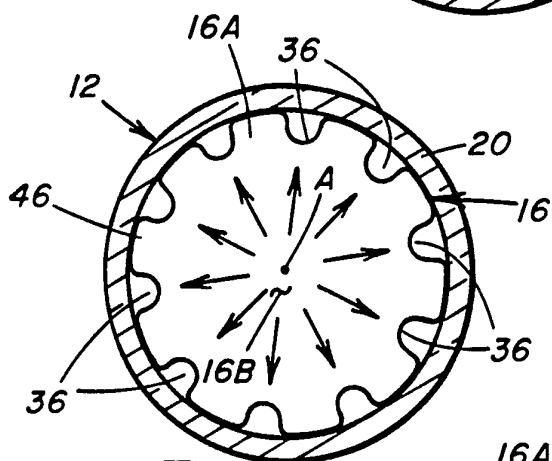


FIG. 7

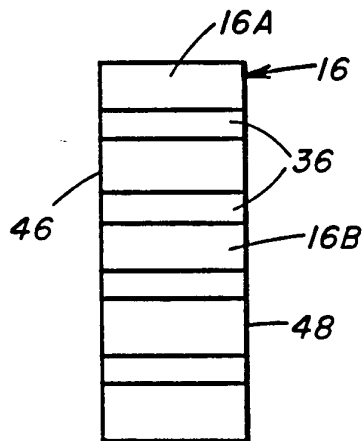


FIG. 9

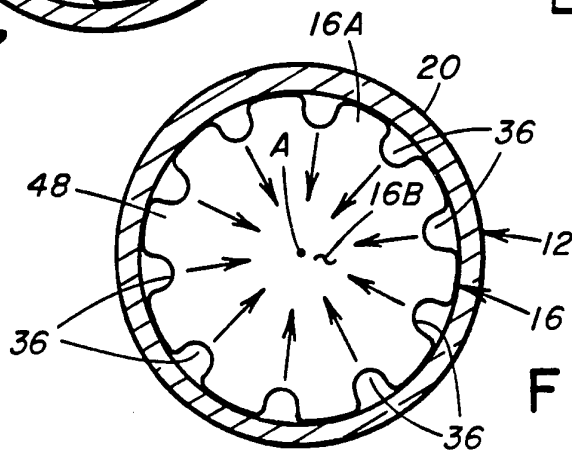


FIG. 8

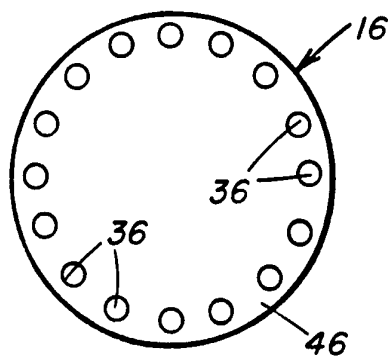


FIG. 10

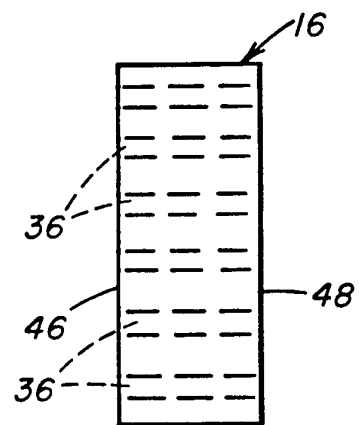


FIG. 11

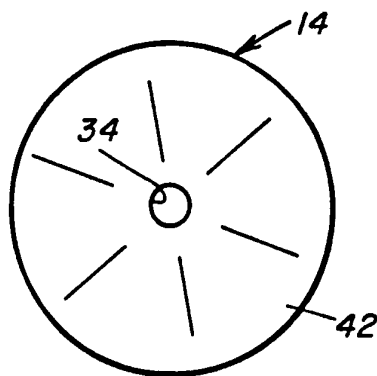


FIG. 13

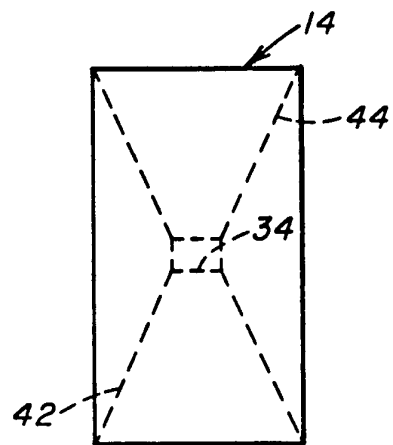


FIG. 14

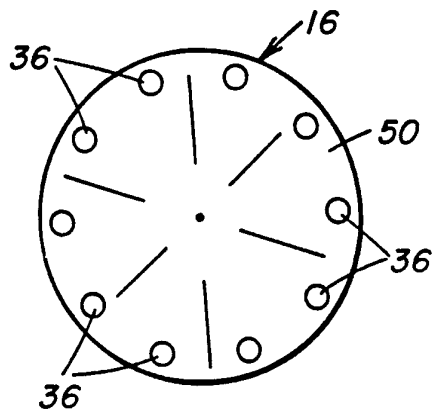


FIG. 15

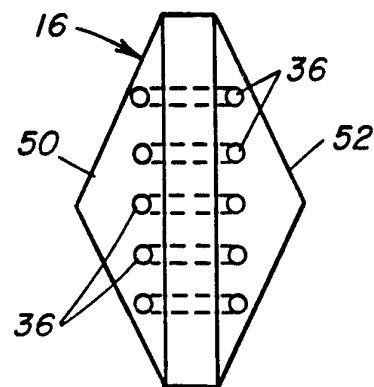


FIG. 16

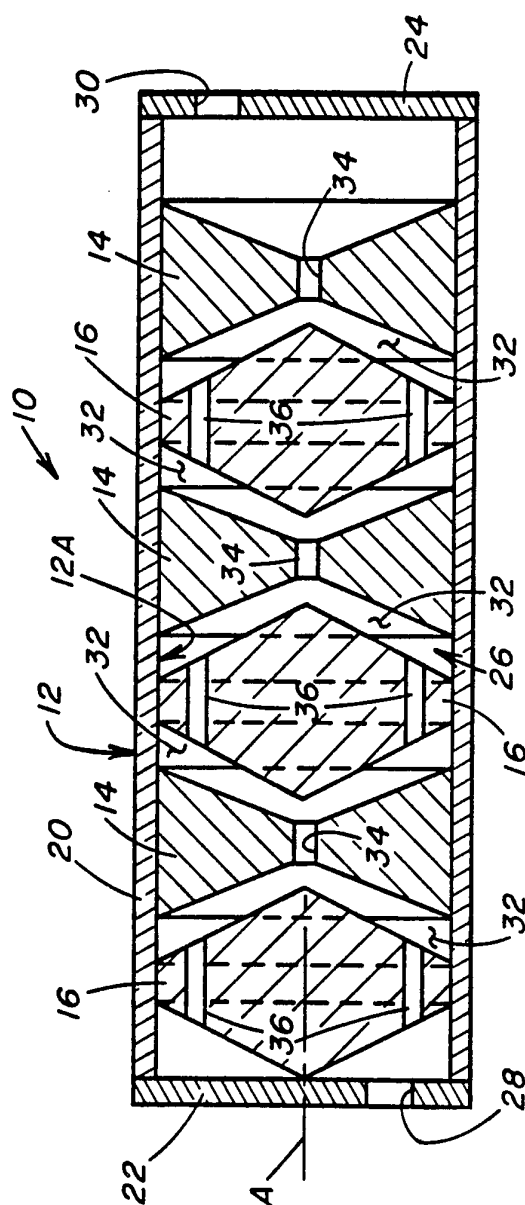


FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/01312**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(5) : B01D 17/06; B03C 5/02; C25B 9/00, 15/08

US CL : 204/228, 269, 270, 275, 276, 277, 278, 305

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 204/228, 269, 270, 275, 276, 277, 278, 305

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

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

APS

search terms: Radial and fluid and flow and path with electrodes or device or coagulat? or clumps

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|-----------------------|
| Y | US, A, 4,710,282 (Chak et al) 01 December 1987, col. 2, lines 32-68, col. 3, lines 21-29, and Figs. 3, 4a, 7. | 1-14, 16-34 |
| Y | US, A, 3,324,026 (Waterman et al) 06 June 1967, col. 5, lines 4-10 and 30-44 col. 8, lines 14-15, col. 9, lines 65-71 and figs 6-7. | 1-14, 16-34 |
| A | US, A, 4,048,047 (Beck et al) 13 September 1977 | 1-34 |
| A | US, A, 3,919, 062 , (Lundquist, Jr. et al) 11 November 1975 | 1-34 |
| A | US, A, 3,915,822 (Veltman) 28 October 1975 | 1-34 |



Further documents are listed in the continuation of Box C.



See patent family annex.

| | | |
|---|-----|--|
| * Special categories of cited documents: | "T" | later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention |
| "A" document defining the general state of the art which is not considered to be of particular relevance | | |
| "E" earlier document published on or after the international filing date | "X" | document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone |
| "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) | "Y" | document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art |
| "O" document referring to an oral disclosure, use, exhibition or other means | | |
| "P" document published prior to the international filing date but later than the priority date claimed | "G" | document member of the same patent family |

Date of the actual completion of the international search :

11 MARCH 1994

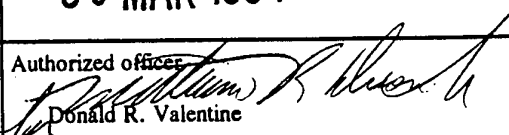
Date of mailing of the international search report

30 MAR 1994

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231

Facsimile No. (703) 305 - 3230

Authorized officer


Donald R. Valentine

Telephone No. (703) 308 - 3327