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(54) **Title:** Convection Elution

(57) **Abstract:** An apparatus and method for elution by convection of an adsorbed material, such as gold adsorbed in activated carbon. The convection elution apparatus comprises a vessel (26) provided with a top screen (28) and a bottom screen (30) defining a compartment (32) therebetween within which the activated carbon is retained during the elution process. A plurality of heating elements (36) mounted in the bottom of vessel (26), are provided to heat the fluid contained in the vessel so as to produce a convection current therein. A centrally located convection passageway or chimney (40) is arranged to direct the flow of fluid driven upwards by convection in a substantially vertical direction parallel to the walls of the vessel (26). Convection chimney (40) extends through the carbon compartment (32), and is provided with a plurality of openings (42), adjacent its lower end allowing the flow of eluent fluid in a heating chamber (44). As the fluid contained in the heating chamber (44) is heated, it is driven up the chimney (40) by convection, flows over the edges of the chimney outlet (46) through an electrowinning cell (50) and down through carbon compartment (32), where it leaches through the carbon to effect the process of gold elution. The electrowinning cell (50) comprises an anode (52) and cathode (54) housed within the vessel (26) for recovering the gold and/or other adsorbed substances from the eluent fluid. The vessel (26) is preferably pressurized and a solution reservoir (26) provided external to the vessel controls the pressure within the vessel.

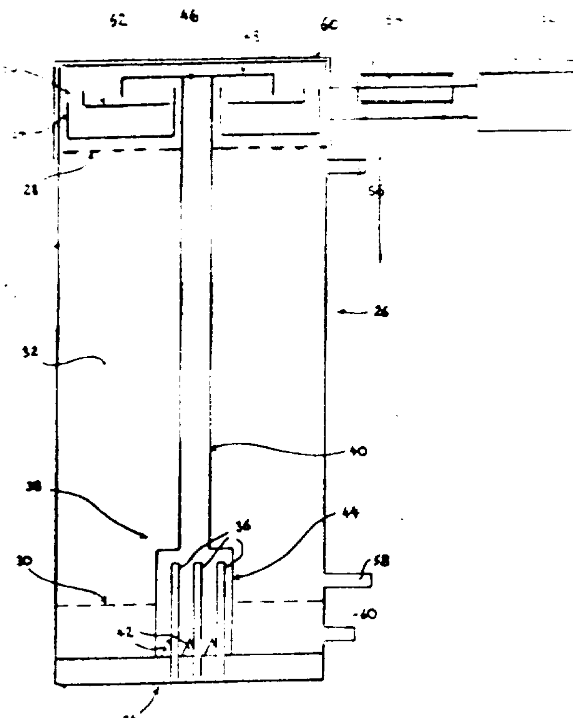

FIG. 2

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CONVECTION ELUTION

FIELD OF THE INVENTION

The present invention relates to a convection elution apparatus and method for removing an adsorbed substance from adsorbent material and relates particularly, but not exclusively, to such an apparatus and method for removing gold from activated carbon.

DISCUSSION OF PRIOR ART

The ability of carbon to adsorb relatively large quantities of gold from solution is well known and is used extensively in the gold mining industry to recover gold from gold-bearing ore. The ore is reduced to a slurry and a cyanide solution is added to extract the gold, and then activated carbon pellets are added to the gold-enriched cyanide solution to separate the gold from other unwanted components in the solution. Due to the large surface area of the activated carbon pellets, a significant quantity of gold is adsorbed by the carbon by bonding to the surface. Quantities of silver are also adsorbed by the carbon.

The process of desorption, or elution of the gold from the carbon, can be achieved by washing with hot aqueous solution, and the gold can then be recovered from the solution by electrowinning.

In the early 1950's, Zadra developed a procedure for desorption of gold from activated carbon. In the Zadra elution plant, a column of loaded carbon is treated with a hot aqueous solution containing 1% sodium hydroxide (NaOH) and 2% sodium cyanide (NaCn). In the Zadra system, the hot solution is pumped through the carbon column to an electrowinning cell containing a stainless steel mesh anode and a steelwool cathode for recovering the gold from the eluent solution. The eluent solution is then recycled to a solution tank, and through a reheat system directly back to the carbon column. Recycling is continued until the concentration of gold in the eluent solution is reduced to a predetermined minimum. When operating at atmospheric pressure and approximately 100°C, the Zadra elution cycle typically takes between 30 and 50 hours. Pressurized versions have achieved shorter elution times. However, the main disadvantage with the Zadra procedure is the relatively long elution time, resulting in a high energy input to maintain the eluent solution at operating temperatures, and longer delays in the recycling of the desorbed carbon.

An alternative elution procedure was developed at the Anglo American Elution Procedure Laboratories (AARL) in South Africa, known as the Anglo American Elution Procedure, which is able to achieve faster elution times (see more detailed description below).

The principal disadvantages of these prior art systems is that they require a relatively large capital expenditure to set up the elution plant comprising a separate carbon column, storage tanks, electrowinning cell, heat exchangers, pumps and piping to carry the eluent solution through the processing plant. The pumps, heat exchangers and piping require constant maintenance as they are prone to blockages and corrosion from contaminants in the eluent solution. Thus, in addition to the initial capital expenditure, there are significant on-going running costs to keep the systems operating at maximum efficiency.

SUMMARY OF THE INVENTION

The present invention was developed with a view to providing an improved elution procedure based on convection, and which therefore can operate without a pump and which can achieve significant reductions in on-going operating costs.

According to one aspect of the present invention there is provided a convection elution apparatus comprising:

a vessel for containing an adsorbent material in a fluid;

means for heating the fluid so as to produce a convection current within the vessel; and,

means provided within the vessel for channelling a flow of said fluid driven by convection whereby, in use, said fluid can be directed to flow via the channelling means and to leach through the adsorbent material to facilitate the removal of an adsorbed substance therefrom.

Preferably, said channelling means comprises a centrally located convection passageway for directing the flow of said fluid in an upwards direction, and wherein the adsorbent material is inhibited from entering said passageway.

In a preferred embodiment, said vessel includes a compartment for containing said adsorbent material, said compartment having means for retaining said adsorbent material therein, whilst allowing the flow of said fluid therethrough. Most preferably, the vessel can be pressurized and said heating means comprises an electric heating element provided towards a lower end of said convection passageway.

The convection elution apparatus typically further comprises an electrowinning cell housed within the vessel for recovering from solution said removed substance.

Preferably the electrowinning cell comprises a cell vessel adapted to pass the flow of eluent fluid therethrough in a horizontal direction.

Typically, the cell vessel is a rectangular vessel provided with a plurality of anodes and cathodes alternately arranged in a vertical orientation within the cell vessel.

In the preferred embodiment an upper portion of the convection passageway comprises a diverter for directing the flow of said eluent fluid into one end of the electrowinning cell.

Preferably exposed surfaces of the vessel of the convection elution plant are coated with an acid-resistant coating. Typically the coating is a polymer coating, preferably a fluoropolymer coating.

According to another aspect of the present invention there is provided a method of convection elution, the method comprising:

containing an adsorbent material held in a fluid in a vessel;

heating the fluid to produce a convection current within the vessel; and,

directing the flow of said fluid whereby, in use, said fluid can leach through the adsorbent material to facilitate the removal of an adsorbed substance therefrom.

Preferably, the method further comprises pressurizing the vessel in order to increase the speed of elution by convection.

Most preferably, the method also includes the step of recovering from solution the removed substance, by electrowinning.

In order to facilitate a better understanding of the apparatus and method of the invention, a preferred embodiment of the convection elution apparatus will now be described in detail, by way of example only, with reference to the accompanying drawings. Although the following description is given with reference primarily to gold elution, it should be understood from the outset that the invention has wider application to the elution of other metals and substances.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

Figure 1 illustrates schematically a prior art gold elution process and plant;

Figure 2 illustrates schematically a first preferred embodiment of the convection elution apparatus of the invention;

Figure 3 illustrates schematically an electrowinning cell employed in the apparatus of Figure 2;

Figure 4 illustrates a second preferred embodiment of the convection elution plant;

Figure 5 illustrates in greater detail the convection elution unit of Figure 4;

Figure 6 illustrates a preferred form of the electrowinning cell employed in the convection elution unit of Figure 5;

Figure 7(a) and (b) illustrate an anode and cathode respectively employed in the electrowinning cell of Figure 6;

Figure 8 illustrates in side elevation another form of electrowinning cell;

Figure 9 illustrates the electrowinning cell of Figure 8 in plan view; and,

Figure 10 illustrates a convection elution apparatus incorporating the electrowinning cell of Figure 8.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to Figure 1, a prior art gold elution plant, known as the Anglo American (Anglo) Elution Plant, is illustrated schematically. The Anglo Elution Plant typically includes a tank 10 for storing an aqueous solution of sodium cyanide and sodium hydroxide, a pump 12 for pumping the solution through heat exchangers 14 to a vessel 16 containing a column of activated carbon. The Anglo procedure involves pre-treatment of the loaded carbon with the above solution suitably heated, followed by elution with pure water. The gold-enriched eluate passes out of the vessel 16 into a storage tank 18 from where it is pumped by pump 22 through an electrowinning cell 20 back into tank 18. The stripped eluate is not recycled through the elution plant, and after electrowinning can be re-used in the aqueous cyanide pretreatment. The Anglo Elution process can be operated at atmospheric pressure, at temperatures of 95 - 98°C, but elution at 110°C at slight pressurization, increases the elution rate. Elution can usually be completed within 8 to 10 hours.

From this brief description, it will be apparent that the Anglo Gold Elution Plant requires a significant length of piping and several pumps for transporting the fluid through the elution circuit and the electrowinning circuit respectively. Considerable expenditure is involved in maintaining these pumps and piping in operating condition, and in removing blockages, corrosion and malfunctions in order to keep the plant operating at maximum efficiency. In addition, the Anglo Elution Plant requires a significant capital expenditure in setting up the plant with two water tanks 10 and 18, heat exchangers 14, pumps 12 and 22 and electrowinning cell 20, all apart from the vessel 16 for the carbon column. Furthermore, both the Zadra and the Anglo Gold Elution Plants require a separate high security "gold room" 24, for enclosing the electrowinning cell to discourage unauthorized removal of gold recovered in the cell.

In the following description of a convection elution apparatus, the many advantages of the present invention over the prior art Zadra and Anglo Gold Elution Plant will become self-evident.

A first preferred embodiment of the convection elution apparatus illustrated schematically in Figure 2, **comprises a vessel 26 for containing an adsorbent material,** such as activated carbon, in a fluid. The vessel 26 is in the form of a steel columnar shell which is effectively a boiler, within which the elution fluid can be heated to elevated temperatures. The boiler is provided with a top screen 28 and a bottom screen 30 defining a compartment 32 therebetween within which the activated carbon is retained during the elution process. Screens 28 and 30 are heavy duty wire screens of sufficiently fine mesh to prevent the carbon pellets from escaping from the carbon compartment 32. Heating means 34, in the form of a plurality of heating elements 36 mounted in the bottom of vessel 26, are provided to heat the fluid contained in the vessel so as to produce a convection current therein.

Also provided within vessel 26, is a means 38 for channelling the flow of fluid driven by convection so that the fluid flows upwards through the channelling means 38 and leaches down through the activated carbon within the compartment 32 to facilitate the removal of an adsorbed substance, such as gold, from the loaded carbon. In the illustrated embodiments, channelling means 38 comprises a centrally located convection passageway or chimney 40 arranged to direct the flow of fluid driven upwards by convection in a substantially vertical direction parallel to the walls of the vessel 26. Convection chimney 40 extends through the carbon compartment 32, and is provided with a plurality of openings 42, adjacent its lower end allowing the flow of fluid into a heating chamber 44, where it is heated by the electrical heating elements 36 before being driven up the chimney 40 by convection. As the fluid contained in vessel 26 is heated, it is driven up the chimney 40 by convection and bubbles over the edges of chimney outlet 46, back down into the body of the vessel 26 to percolate through carbon compartment 32 in a manner analogous to the operation of a coffee percolator. The fluid is preferably an aqueous solution of sodium cyanide and sodium hydroxide which leaches through the loaded carbon to effect the process of gold elution. The eluate fluid passes through the bottom screen 30 and re-enters the heating chamber 44, where it is driven by convection up chimney 40 to complete the cycle. A splash plate or deflection cap 48 is provided above the outlet 46 of the chimney to deflect the fluid downwards.

Before re-entering the carbon compartment 32 through the top screen 28, the eluate fluid must pass through an electrowinning cell 50, comprising an anode 52 and cathode 54, housed within the vessel 26 for recovering the gold and/or other adsorbed substances from the eluate fluid. The structure and function of the electrowinning cell 50 will be described in greater detail below with reference to Figure 3.

Vessel 26 is further provided with an inlet 56 for charging the carbon compartment 32 with loaded carbon, and an outlet 58 for emptying the compartment 32 of the stripped carbon. Vessel 26 is also provided with a drain 60 for draining the used solution from the vessel. A solution reservoir 62 is preferably provided external to the vessel 26 and controls the pressure within the vessel by maintaining a temperature differential between the fluid in the upper and the lower end respectively of the vessel. Reservoir 62 is connected to the vessel 26 by two pipes as shown in Figure 2, the upper pipe being provided with heat exchange means in the form of a condenser 64 for condensing steam transported from the vessel 26 to the reservoir 62, and the lower pipe allowing the cooled fluid to return to the vessel 26 to leach through the carbon compartment 32. Maintaining a temperature differential within the vessel 26 also helps to drive the convection current within the fluid during pressurization. Reservoir 62 is provided with a safety pressure relief valve for releasing excess pressure generated by the continuous heating of the solution by heating elements 36. Typically, the pressure within the vessel 26 is maintained at approximately 100 to 150 kPa (gauge) at 120°C. In a 280 kg convection elution unit (280 kg weight of carbon) the elution time for recovering 90% of the gold is typically between 12 to 24 hours. A convection elution unit of this size would typically contain 5 electrical heating elements consuming 2 to 3.6 kw of electrical power.

Also illustrated in Figure 2, is the provision of a high-security cover 66 enclosing the top end of the vessel 26 where the electrowinning cell is housed. As the only access to the interior of vessel 26 is through the top end, other than by rupturing the shell, the high-security cover 66 provides an effective means of preventing unauthorized access to the electrowinning cell 50.

Referring to Figure 3, an enlarged perspective view of the electrowinning cell 50 is illustrated in section view. The cell 50 comprises a dish-shaped anode 52 made of stainless steel, and having a perforated planar base extending in a substantially horizontal plane perpendicular to the convection chimney 40. The anode 52 is of circular construction and is provided with a central aperture thereof enabling it to be received over the top of the chimney 40. The cathode 54 is also of circular dish-shaped construction similar to that of the anode 52, except that the diameter of the cathode 54 is substantially larger than that of the anode 52. Furthermore, the cathode 54, does not have perforations in the base thereof, so that fluid flowing therein must overflow the side wall of the cathode in order to escape. Cathode 54 is also provided with a centrally located aperture, having a sleeve member 68 provided therein sized to fit snugly over the top of the convection chimney 40. Sleeve 68 passes upwards through the anode aperture and is of sufficient height to ensure that the eluate solution flows through the cell rather than down the sides of the chimney 40. Deflecting cap 48 deflects the solution down onto the anode 52, as previously described. Between anode 52 and cathode 54, a significant quantity of steelwool 70 is sandwiched, to increase the effective surface area of the cathode 54. The potential difference applied to the electrowinning cell is typically in the order of 3 to 4 volts dc with a charging current of 80 to 100 amperes. Electrowinning of the gold onto the steelwool occurs in a known manner so that substantially all of the gold in the eluate solution is recovered. At the completion of the elution, the electroplated steelwool can be removed from the cell for smelting to form ingots.

The convection elution unit described above operates highly successfully with up to 280kg weight of activated carbon in the carbon compartment 32. However, if the volume of activated carbon in carbon compartment 32 is increased significantly, the elution time becomes considerably longer in order to achieve the same level of gold recovery. The principal limitation of the previously described convection elution plant is the rate at which gold can be recovered from the eluent fluid in the electrowinning cell 50. The electrowinning cell 50 is not efficient enough to recover the increased volume of gold dissolved in the eluent fluid from the greater volume of carbon.

A second preferred embodiment of a convection elution plant will now be described which can provide increased capacity without a significant increase in the elution time. Like reference numerals refer to corresponding parts and elements as appear in Figures 2 and 3 of the first embodiment, and their description will not be repeated below.

The second embodiment of the convection elution apparatus illustrated in Figure 4, comprises a vessel 26 similar in construction and operation as that of the first embodiment, provided with a carbon inlet 56, a carbon outlet 58 and a solution drain 60. One significant difference between the vessel 26 of the second embodiment compared to the first embodiment is the increased dimensions of the vessel designed to accommodate an increased volume of activated carbon. This

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embodiment of the convection elution apparatus is designed to accommodate from 500kg up to approximately 1.0 tonne of activated carbon within its carbon compartment 32 (see Figure 5). A further significant difference is the provision of a header tank 72 on top of the vessel 26.

Header tank 72 is part of the convection elution unit and forms together with the vessel 26 an enlarged boiler within which the convection elution process takes place. The vessel 26 is typically constructed with a stainless steel cylindrical shell, as previously described, whereas the header tank 72 is of rectangular construction also typically of stainless steel. The header tank 72 is positioned off-centre of the vessel 26 for reasons which will become apparent below, and is supported by support brackets 74. A solution reservoir 62, in the form of a pressure vessel is connected to the header tank 72 by two pipes, the upper pipe being provided with a condenser 64 for condensing steam transported from the header tank 72 to the reservoir 62, and the lower pipe allowing the cooled fluid to return to the header tank 72. The vessel 26 and header tank 72 are typically filled with eluent solution to a level midway between the upper and lower pipes connecting the header tank to the pressure vessel 62. As with the previous embodiment, a high security cover 66 may be provided to prevent unauthorised access to the header tank 72 housing the electrowinning cell.

Referring to Figure 5, the position of the electrowinning cell 80 within header tank 72 can be clearly seen. The structure of the electrowinning cell 80 will be described in greater detail below with reference to Figures 6 and 7. However, from Figure 5 it becomes immediately apparent why the header tank 72 is positioned off-centre on the vessel 26. The off-centre position of the header tank 72 is necessitated by the need to locate the electrowinning cell 80 in such a position that eluent fluid, driven by convection, can still be directed through the cell 80 by the channelling means 38. In this embodiment, means 38 for channelling the flow of eluent fluid driven by convection is similar to that of the previous embodiment, and comprises a convection chimney 40 provided with a plurality of openings 42 adjacent its lower end, allowing the flow of fluid into a heating chamber 44 where it is heated by electrical heating elements 36. However, at its upper end, the chimney 40 is provided with a goosenecked section 84 connected to the vertical chimney 40 by an angled section 86. Together the angled section 86 and goosenecked section 84 form a diverter for diverting the flow of fluid driven by convection upwards through chimney 40 into the top of the electrowinning cell 80 adjacent one end.

In order to direct the flow of eluent fluid into the top of the cell 80 the convection passageway must pass between the end wall 87 of the cell vessel 82 and a vertical wall of the header tank 72. Of course, the electrowinning cell 80 could have been positioned to one side of the centrally located **chimney 40, and thus the need for a diverter would have been** obviated. however, with the cell 80 thus positioned, it is much more difficult to construct the header tank 72 together with the vessel 26 as a single self-contained unit, since the header tank 72 would be positioned even further off-centre on the vessel 26. On the other hand, if the electrowinning cell 80 were located centrally over the convection chimney 40, so that the header tank 72 could also be centrally located on the vessel 26, the angle of inclination of the angled section 86 would have been such that the flow of the eluent fluid driven up the chimney 40 by convection would be significantly retarded before it could reach the goosenecked section 84. Thus, the angled section 86 preferably extends at approximately 45^0 to the vertical from the top of the vertically extending chimney 40.

Eluent fluid heated in the heating chamber 44 is driven upwards by convection through the channelling means 38, to exit from the goosenecked section 84 in sufficient volume to generate a convection current within the vessel 26 and header tank 72. In view of the increased volume of eluent solution eight heating elements 36 are provided in the heating chamber 44, compared with the five elements of the previous embodiment.

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The electrowinning cell 80 will now be described in greater detail with reference to Figure 6, in which the cell is illustrated schematically in perspective view. The electrowinning cell 80 comprises a cell vessel 82 for containing the eluent solution as it flows through the cell in a horizontal direction in the sense of arrow A. The solution enters the cell at one end via the goosenecked section 84 of the convection passageway, and flows through the cell to exit from the outlet 88. A plurality of anode trays and cathode frames are arranged vertically in the cell vessel 82, so that the solution flows through a series of alternate anodes and cathodes before exiting from the outlet 88. The cell vessel 82 typically houses nine anode trays 90 arranged alternately with eight cathode frames 92.

As can be seen more clearly in Figure 7(a) each anode tray 90 comprises a perforated stainless steel rectangular plate approximately 500mm deep and 700mm wide. Each cathode frame 92 comprises a U-shaped frame, as illustrated in Figure 7(b), and a brace 94 extending horizontally between the arms of the frame. Each cathode frame is provided with steelwool wound around the brace 94 and the lower horizontal bar of the U-shaped frame across the full width of the brace 94. Both the cathode frame 92 and brace 94 are made of stainless steel and thus there is both excellent electrical and thermal contact between the steelwool and the cathode frame ensuring improved electrical conductivity and heat dissipation. Furthermore, the brace 94 is positioned so that when the cathode frame is inserted in the cell vessel 82, the whole of the steelwool is submerged within the eluent solution flowing through the cell.

The cell vessel 82 is provided with a plurality of slots on its inner walls within which the cathode frames 92 and anode trays 90 are received. A potential difference is applied between each of the series of alternate cathodes and anodes of the electrowinning cell to produce an electroplating current which flows in the same direction as the eluent solution. This arrangement provides increased gold recovery and improved efficiency of the electrowinning cell 80. The cell vessel 82 is preferably constructed of non-conductive material such as, for example, a rigid plastics material. When the electrowinning cell 80 is housed within the header tank 72, the cell vessel 82 is itself partly submerged in the solution contained in the header tank 72.

Whilst the above described electrowinning cell 80 is particularly advantageous for the convection elution unit described, a conventional multi-electrode electrowinning cell could also be employed if desired. The provision of header tank 72 and the modifications to the convection chimney enable the installation of a more efficient electrowinning cell within the convection elution unit, which in turn enables a greater volume of activated carbon to be used in the unit due to the increased rate at which gold can be electrowon from the solution. The carbon compartment 32 of the second embodiment can be charged with up to one tonne of activated carbon and 90% of the gold can still be recovered with an elution time of between 12 to 24 hours.

In the first embodiment of the correction elution plant 5 heating elements 36 are provided for heating the eluent fluid in heating chamber 44. In the second embodiment 8 electrical heating elements 36 are typically provided for heating the increased volume of eluent fluid circulating within the vessel 26 by convection. Obviously, alternative heat sources may be employed such as for example, gas burners for heating the fluid contained in the vessel 26.

In Figures 8, 9 and 10 a still further embodiment of an electrowinning cell that can be employed in the convection elution unit of the present invention is illustrated. In this embodiment the cell vessel 100 is of circular shape to facilitate the flow of eluent fluid in a circular direction, as indicated by arrows C in Figure 9. Eluent fluid enters the cell vessel via fluid inlet 102 and exits from the vessel via a fluid outlet 104. Conveniently, fluid inlet 102 may be connected to the convection chimney 40, which passes upwards through the centre of the cell vessel 40, by a connecting pipe 106. The inlet 102 takes the form of a plurality of spreader holes provided longitudinally of the pipe 106 for spreading the incoming fluid evenly across the width of the cell vessel.

In an alternative arrangement, (not illustrated) the top of the convection chimney 40 is provided with a gooseneck extension which opens into the top of the cell vessel 100, in approximately the same position as inlet 102. The outlet 104 takes the form of an elongate conduit that extends upwards from the floor of the cell vessel 100.

As can be seen most clearly in Figure 8, the inlet 102 is positioned adjacent to and slightly above the outlet 104 but is separated from the outlet by a fluid barrier 108. Thus fluid entering the cell vessel via inlet 102 is forced to flow around the cell vessel to exit via outlet 104. A plurality of cathodes 110 are alternately arranged in the flow path of the eluent fluid and extend radially in a vertical orientation. The construction of the cathodes 110 are similar to that illustrated in Figures 7(b), and will not be described again here. A plurality of slots 114 are provided on the inner wall 113 of the cell vessel for receiving the cathodes 110 radially therein. The outer wall 112 of the cell vessel forms the anode of the electrowinning cell and is separated from the inner wall 113 by an electrically insulating layer 115. A potential difference is applied between each of the series of cathodes 110 and the anode wall 112 to produce an electroplating current.

A distribution tray 116 is provided below the cell vessel 100 and has a perforated base designed to distribute the fluid flowing out of the outlet 104 more evenly over the top of the carbon compartment 32.

This embodiment of the electrowinning cell is particularly advantageous since it provides a relatively long flow path for the eluent fluid through the cell, but still within the confines of the cylindrical vessel 26. Obviously the cell vessel 100 need not be hexagonal, but could also be octagonal or indeed simply annular if a convenient method for arranging the anodes and cathodes radially within the flow path is devised.

In the above described embodiments of the convection elution plant, the vessel 26 is in the form of an elongate cylindrical boiler having a length/diameter ratio in the range of 3 to 5. However, any shaped vessel can be employed for containing the adsorbent material in a fluid in such a manner that the eluent driven by convection can leach through the adsorbent material to facilitate removal of an adsorbed substance therefrom. In this connection, it is not necessary for the channelling means 38 to take the form of a single centrally located chimney, as the channelling means may be a plurality of passageways, or indeed an annular shaped passageway extending around the outside diameter of the carbon compartment, to enable the flow of fluid driven by convection. Furthermore, whilst it is advantageous to have the electrowinning cell housed within the vessel 26, this is not essential to the present invention and the cell may also be housed separately from the vessel, although this would necessitate building a separate security enclosure.

In the above described embodiments, before the carbon compartment 32 can be charged with loaded carbon, the loaded carbon must be subjected to an acid wash in a separate acid wash vessel. In order to eliminate the need for this additional acid wash vessel, it would be desirable to be able to subject the loaded carbon to the required acid wash after it has been pumped into the carbon compartment 32 of the convection elution unit. In the above described embodiments it would not be possible to use the carbon column vessel 26 for the acid wash, since the hydrochloric acid would corrode the stainless steel materials of the vessel 26 and channelling means 38. However, this problem may be overcome by coating the exposed surfaces of the vessel 26 and the chimney 40, heating chamber 44 and heating elements 36 with a suitable acid resistant coating. A suitable coating may be a polymer coating such as, for example, a coating made of PTFE or FEP polymers.

Particularly suitable for the present application is a fluoropolymer coating of the kind supplied by Unasco Pty. Ltd., with the product name UNASCOFLON (trade mark). This fluoropolymer coating is similar to teflon and has excellent resistance to most chemicals including hydrochloric acid. The fluoropolymer also has remarkable radiation resistance, weathering resistance, stress cracking resistance and high temperature stability. The unique chemical and mechanical properties of this fluoropolymer make it particularly well suited to the present application. An alternative coating which may perform equally satisfactorily is a resin coating, typically a fibre-glass resin coating which has excellent resistance to abrasion caused by the carbon particles.

By coating the exposed inside surfaces of the vessel 26 and the exposed surfaces of the chimney 40 and heating chamber 44 with an acid-resistant coating, the vessel 26 of the convection elution unit can also be used for the acid wash. Thus, the need for a separate acid-wash vessel is eliminated from the elution plant. One of the advantages of the convection elution unit described herein is the relative ease with which it may be transported to the site of use. Elimination of one more vessel further improves the portability of the unit.

It will be apparent from the above description that the convection elution plant has significant advantages over the Zadra and Anglo Gold Elution Plants. In particular, there is a significant reduction in capital outlay as most of the plant can be manufactured and purchased in a single unit. Furthermore, most of the piping is eliminated and no pumps are required as the elution process can be driven entirely by convection. The plant can be readily modified to accommodate various weights of activated carbon.

It will be apparent to those skilled in the relevant arts, that numerous variations and modifications may be made to the preferred embodiment of the convection elution plant, other than those already described, without departing from the basic inventive concepts. For example, the goosenecked section 84 of the second embodiment need not be of the shape illustrated and could be replaced by a manifold that connected the convection passageway to one end 87 of the cell vessel 82. All such variations and modifications are to be considered within the scope of the invention, the nature of which is to be determined from the foregoing description and the appended claims.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A convection elution apparatus comprising:

a vessel for containing an adsorbent material in a fluid;

means for heating the fluid so as to produce a convection current within the vessel; and,

means provided within the vessel for channelling a flow of said fluid driven by convection whereby, in use, said fluid can be directed to flow via the channelling means and to leach through the adsorbent material to facilitate the removal of an adsorbed substance therefrom.

2. A convection elution apparatus as claimed in claim 1, wherein said channelling means comprises a centrally located convection passageway for directing the flow of said fluid in an upwards direction, and wherein the adsorbent material is inhibited from entering said passageway.

3. A convection elution apparatus as claimed in claim 2, wherein said vessel includes a compartment for containing said adsorbent material, said compartment having means for retaining said adsorbent material therein, whilst allowing the flow of said fluid therethrough.

4. A convection elution apparatus as claimed in claim 3, further comprising an electrowinning cell housed within the vessel above said compartment for recovering from solution said removed substance.

5. A convection elution apparatus as claimed in claim 4, wherein said electrowinning cell comprises an anode and a cathode arranged one above the other to facilitate the flow of eluent fluid through the cell whereby, in use, a potential difference applied to the cell causes said removed substance to be deposited onto an electroplating surface provided in electrical connection with said cathode.

6. A convection elution apparatus as claimed in claim 5, wherein said anode and cathode are both in the form of a dish-shaped tray, said anode having a perforated base to facilitate the flow of eluent fluid therethrough, said cathode being arranged below said anode and having a quantity of steelwool therein to provide said electroplating surface.

7. A convection elution apparatus as claimed in claim 6, wherein said anode and cathode a both provided with a central aperture through which said convection passageway extends vertically, and wherein there is further provided a deflecting means for deflecting the fluid driven upwards through the passageway down onto said anode.

8. A convection elution apparatus as claimed in claim 4, wherein said electrowinning cell comprises a cell vessel adapted to pass the flow of eluent fluid therethrough in a horizontal direction.

9. A convection elution apparatus as claimed in claim 8, wherein the cell vessel is a rectangular vessel provided with a plurality of anodes and cathodes alternately arranged in a vertical orientation within the cell vessel.

10. A convection elution apparatus as claimed in claim 9, wherein an upper portion of the convection passageway comprises a diverter for directing the flow of said eluent fluid into one end of the cell vessel.

11. A convection elution apparatus as claimed in claim 10, further comprising a header tank, provided above and in communication with the vessel, for housing the electrowinning cell.

12. A convection elution apparatus as claimed in claim 8, wherein said cell vessel is adapted to pass the flow of fluid in a circular direction, and is provided with a plurality

of anodes and cathodes extending radially and arranged alternately therein in a vertical orientation.

13. A convection elution apparatus as claimed in claim 12, wherein said cell vessel is provided with an inlet, and an outlet adjacent said inlet but separated from the inlet by a fluid barrier whereby, in use, the fluid entering via the inlet must flow around the cell vessel and pass through said plurality of anodes and cathodes to reach the outlet.

14. A convection elution apparatus as claimed in claim 13, wherein the cell vessel is provided with a distribution means arranged below the cell vessel for distributing the flow of fluid from the outlet evenly over the top of the compartment containing said adsorbent material.

15. A convection elution apparatus as claimed in any one of the preceding claims, wherein said vessel can be pressurized and wherein there is further provided a separate fluid reservoir with heat exchange means in fluid communication with said vessel for maintaining a temperature differential in the fluid within the vessel.

16. A convection elution apparatus as claimed in claim 15, further comprising a fluid reservoir in fluid communication with said vessel for controlling the pressure within the vessel by maintaining a temperature differential between the fluid in an upper and a lower end respectively of the vessel.

17. A method of convection elution, the method comprising:

containing an adsorbent material held in a fluid in a vessel;

heating the fluid to produce a convection current within the vessel; and,

directing the flow of said fluid whereby, in use, said fluid can leach through the adsorbent material to facilitate the removal of an adsorbed substance therefrom.

18. A method of convection elution as claimed in claim 17, further comprising the step of recovering from solution the removed substance, by electrowinning.

19. A method of convection elution as claimed in claim 18, wherein fluid driven by convection is driven vertically upwards through the vessel, before passing consecutively through said steps of electrowinning and leaching to return to a lower region of the vessel in a continuous cycle.

20. A method of convection elution as claimed in any one of claims 17 to 19, further comprising pressurizing the vessel in order to increase the speed of elution.

PATENT AGENT

Dated this 9TH day of OCTOBER 1990.

PETER GOOSEN and INTERNATIONAL CONSOLIDATED RESOURCES N.V.
By Their Patent Attorneys:

GRIFFITH HACK & CO.
Fellows Institute of Patent
Attorneys of Australia.

ABSTRACT

An apparatus and method for elution by convection of an adsorbed material, such as gold adsorbed in activated carbon. The convection elution apparatus comprises a vessel (26) provided with a top screen (28) and a bottom screen (30) defining a compartment (32) therebetween within which the activated carbon is retained during the elution process. A plurality of heating elements (36) mounted in the bottom of vessel (26), are provided to heat the fluid contained in the vessel so as to produce a convection current therein. A centrally located convection passageway or chimney (40) is arranged to direct the flow of fluid driven upwards by convection in a substantially vertical direction parallel to the walls of the vessel (26). Convection chimney (40) extends through the carbon compartment (32), and is provided with a plurality of openings (42), adjacent its lower end allowing the flow of eluent fluid in a heating chamber (44). As the fluid contained in the heating chamber (44) is heated, it is driven up the chimney (40) by convection, flows over the edges of the chimney outlet (46) through an electrowinning cell (50) and down through carbon compartment (32), where it leaches through the carbon to effect the process of gold elution. The electrowinning cell (50) comprises an anode (52) and cathode (54) housed within the vessel (26) for recovering the gold and/or other adsorbed substances from the eluent fluid. The vessel (26) is preferably pressurized and a solution reservoir (26) provided external to the vessel controls the pressure within the vessel.

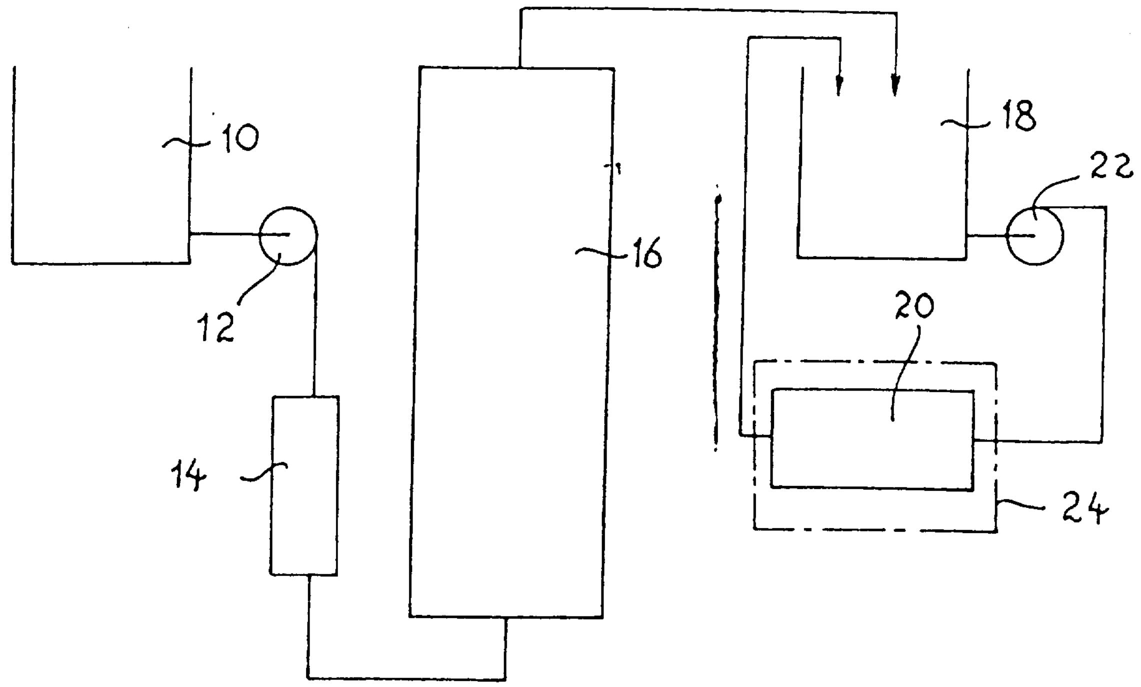

FIG. 1.

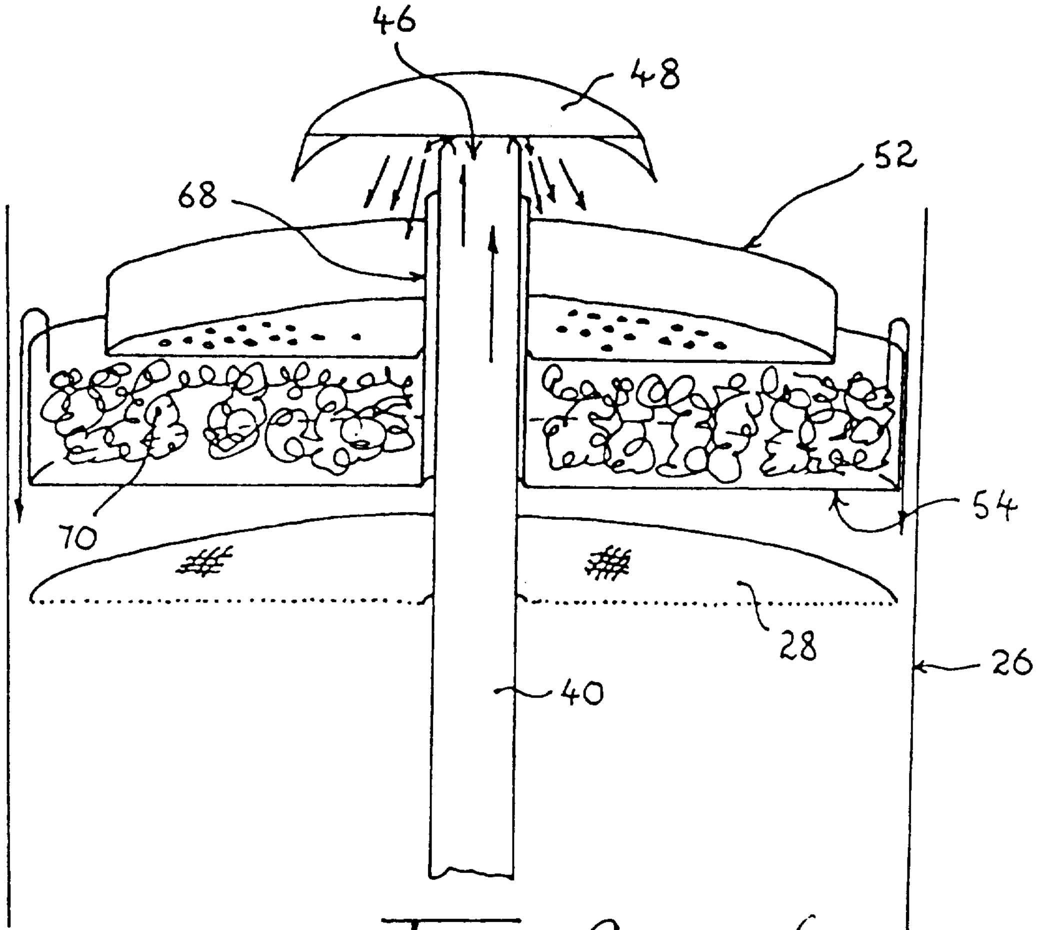

FIG. 3.

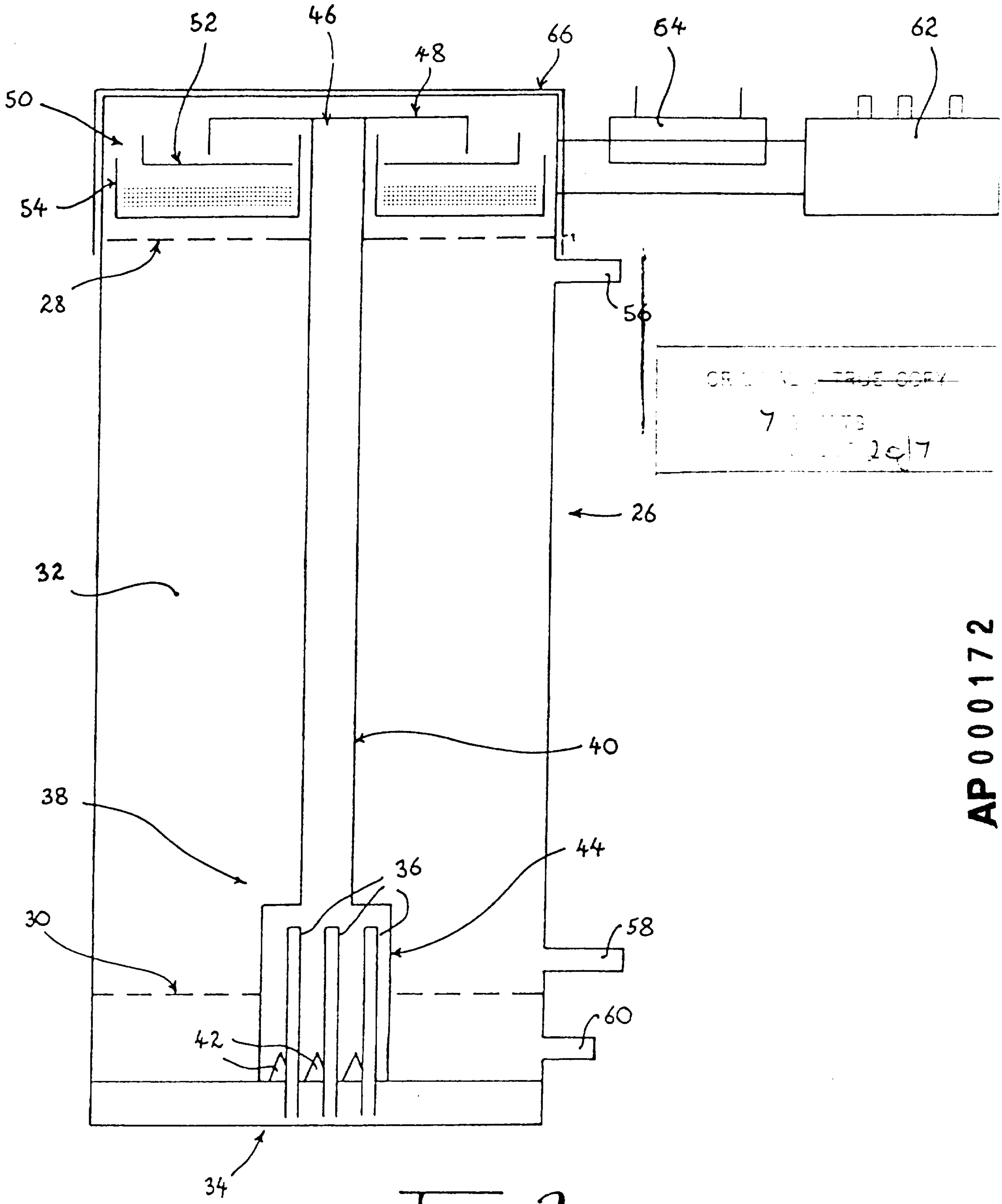

FIG. 2

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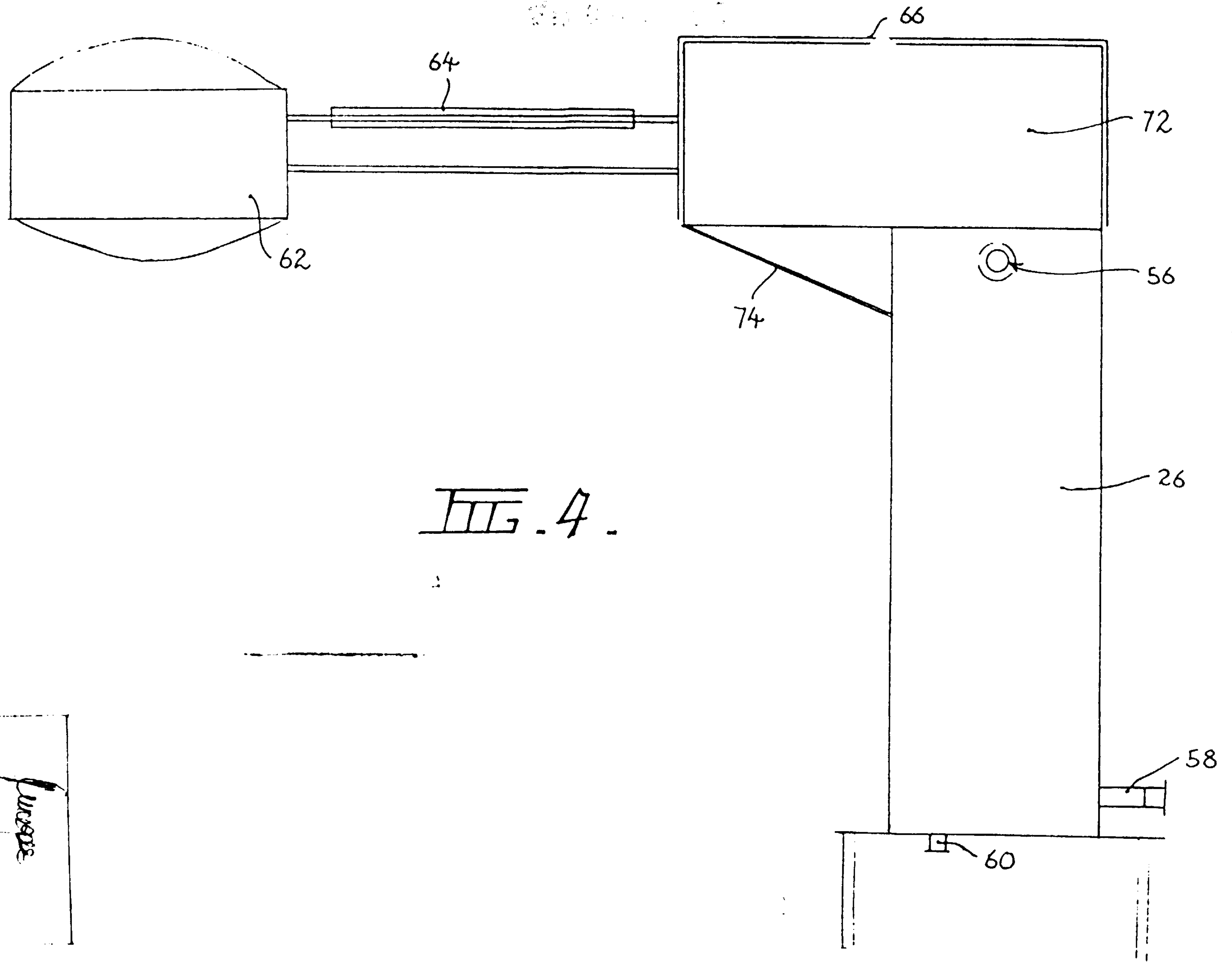

FIG. 4.

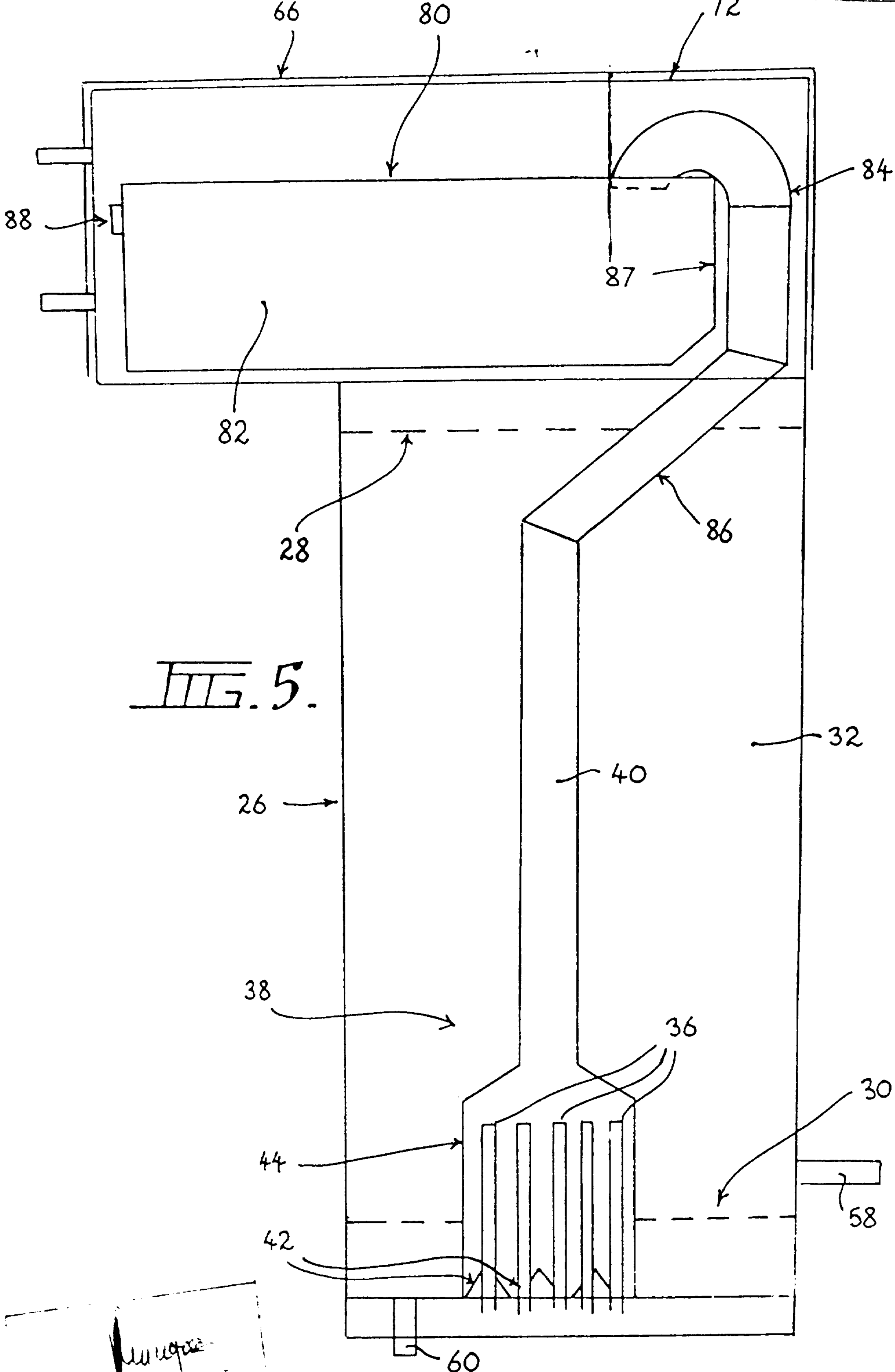

FIG. 5.

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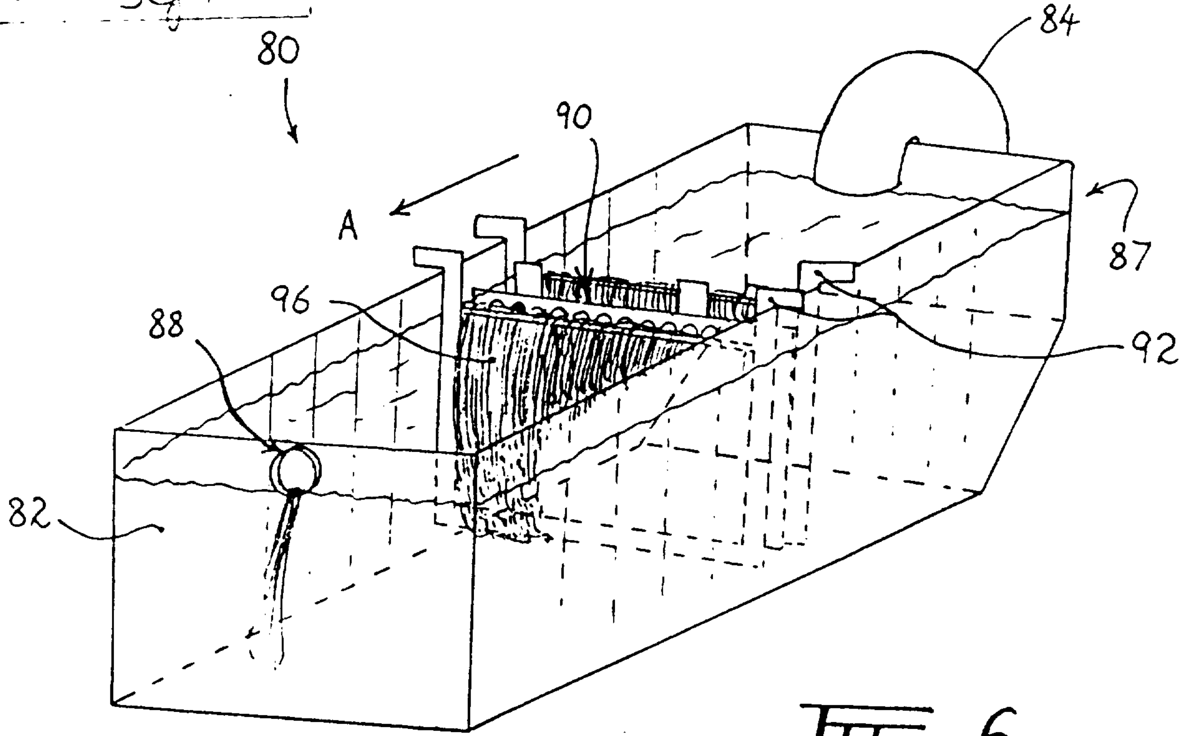
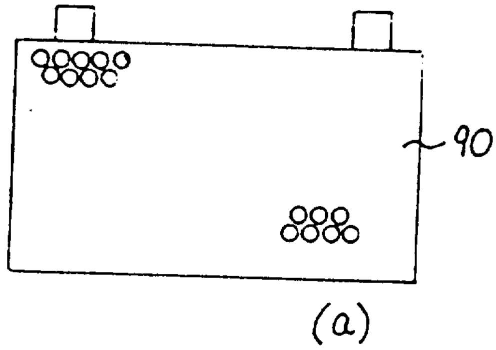


FIG. 6.



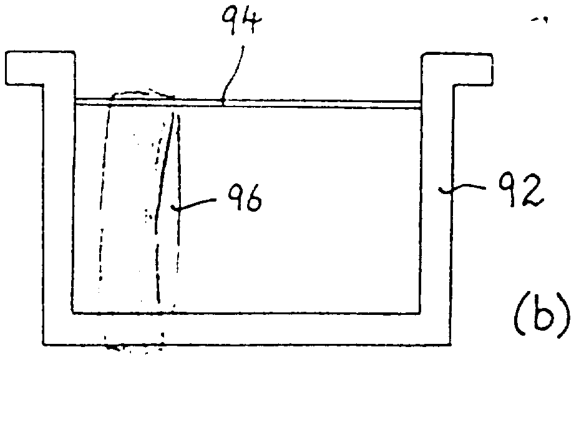
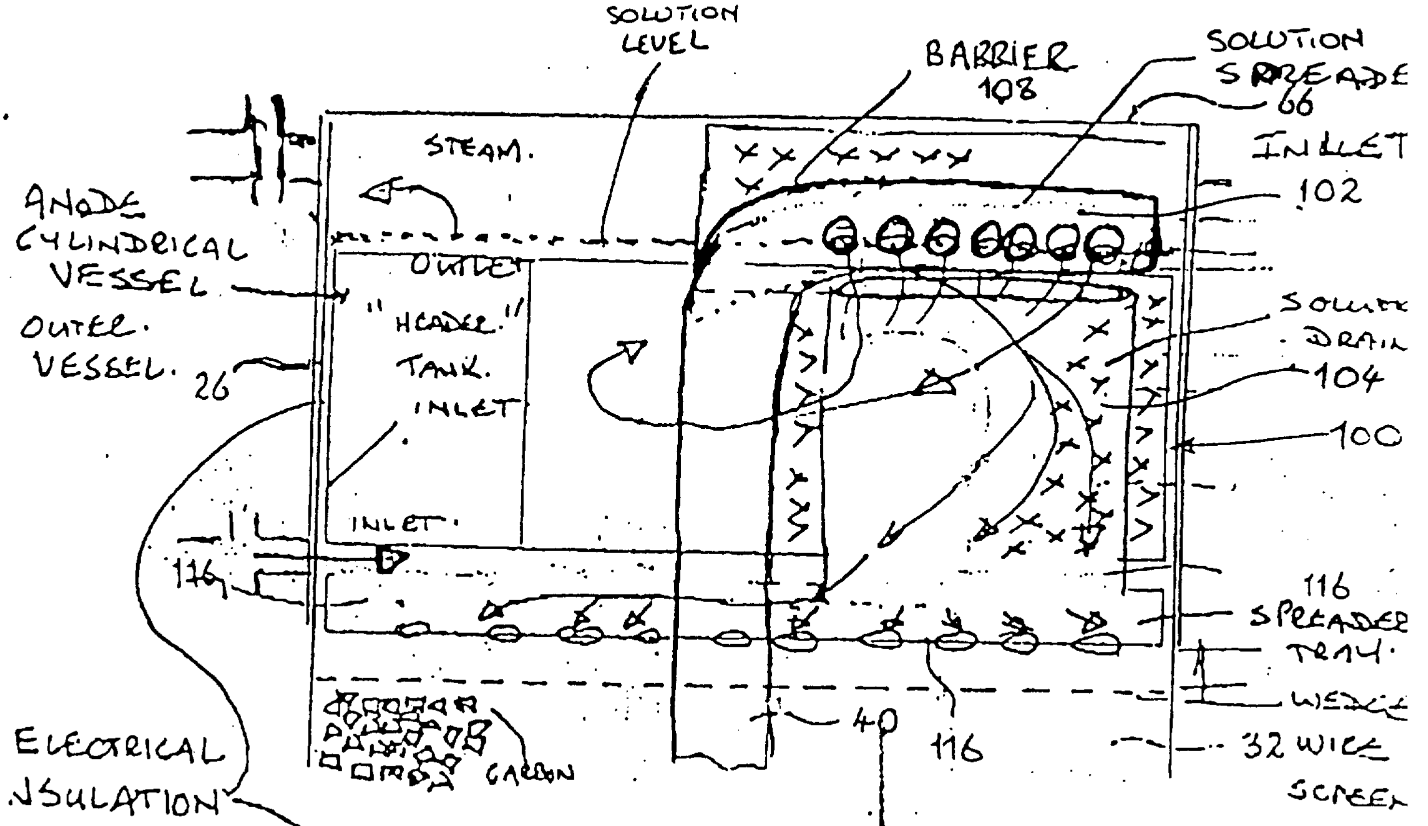


FIG. 7.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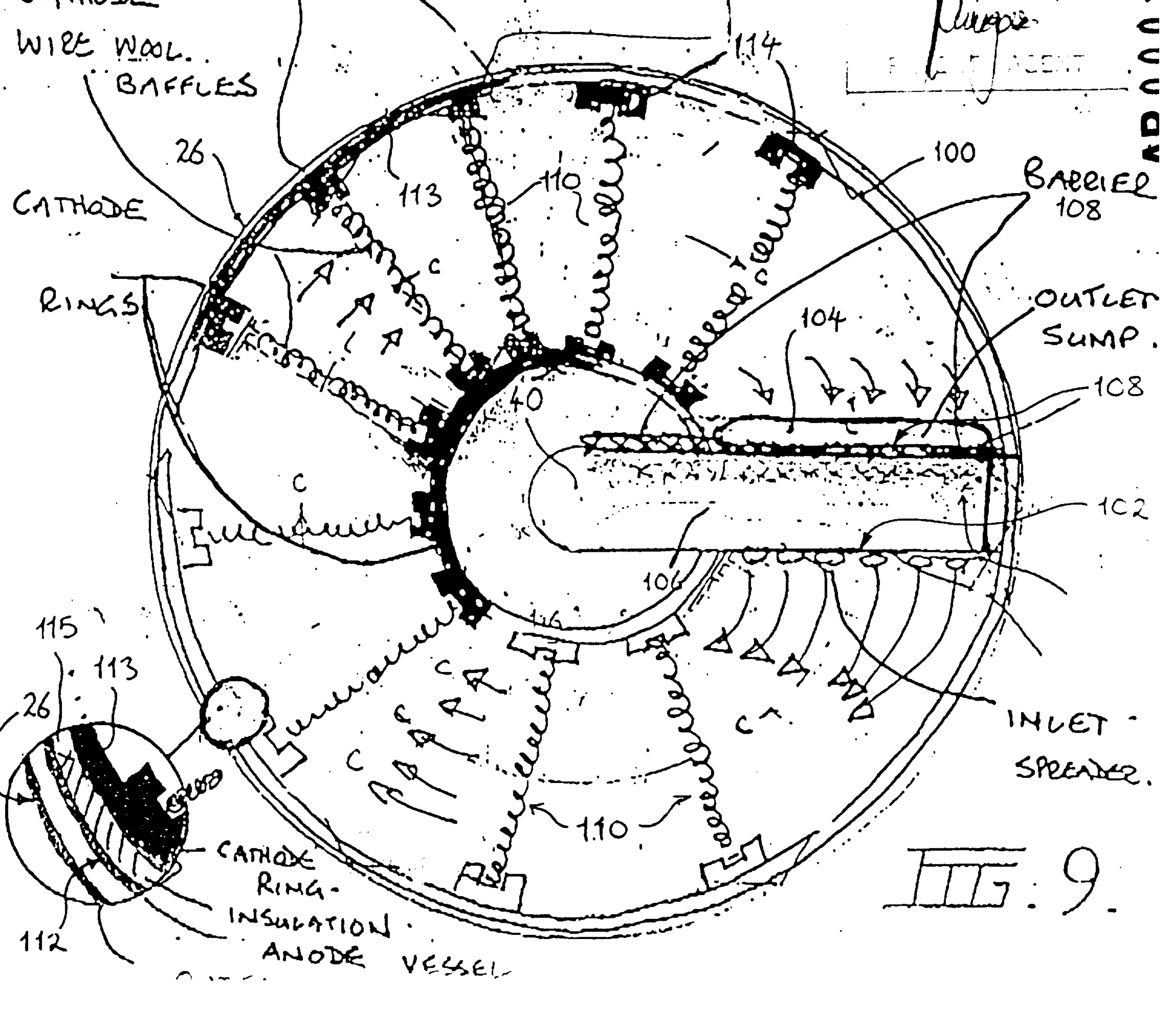
STEAM.
102
ANODE CYLINDRICAL VESSEL
OUTLET
"HEADER"
TANK.
INLET
OUTER VESSEL.
26
104
100
INLET
116
116
SPREADER TRAY
40
116
CARBON
ELECTRICAL INSULATION

FIG. 8.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BAFFLES
114
26
113
110
100
BARRIER 108
CATHODE
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C
104
OUTLET SUMP.
108
40
102
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INLET SPREADER.
115
113
26
110
CATHODE RING
INSULATION
ANODE VESSEL
112

FIG. 9.

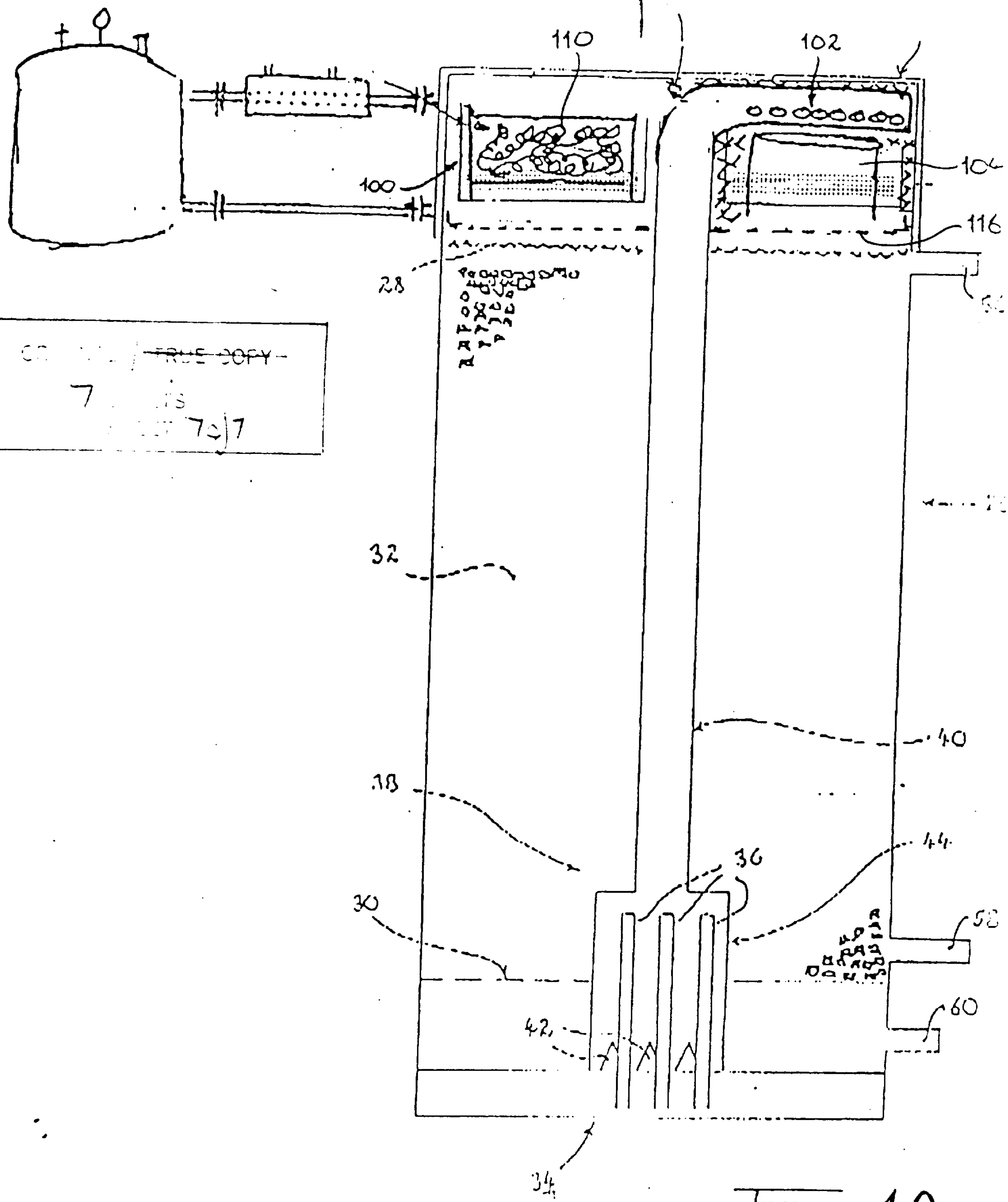

FIG. 10.