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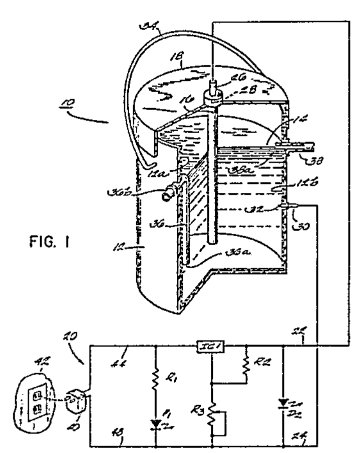
(54) Disposable cell for recovering conductive metal and method of use.

(57) An apparatus and method for recovering a conductive metal from a liquid which contains that metal, and a method for recovering that metal using that apparatus. The apparatus includes a generally closed non-metallic recovery container (12) defining a cavity, for containing the liquid. A first electrode (16) is supported and affixed within the cavity. A second electrode is composed of a thin film (12b) applied to the inside surface of the recovery container (12), the film including as its main constituent the same metal as that to be recovered from the solution. Finally, a power supply (20) is electrically connected, positive to the first electrode and negative to the second electrode, thus causing the metal from the solution to be deposited on the film electrode, lining the inside surface of the recovery container with the metal to be recovered. In one embodiment the apparatus includes a separate holding container for holding the solution, and the recovery container is placed in liquid communication with the holding container. During the reaction, solution is circulated from the holding container into the recovery container and back by a pump. The recovery container may be mounted above the holding container, and the center electrode tubular, to be used as part of the return path of the solution to the holding container.

FIG. I



EP 0 342 969 A1

Description

DISPOSABLE CELL FOR RECOVERING CONDUCTIVE METAL AND METHOD OF USE

This invention relates to methods and apparatus for recovering metals from liquid solutions, and in particular to methods and apparatus facilitating the recovery of silver from bleach fix solutions used in photo processing, by disposable cells, with high efficiency.

Up to the present time, recovery of conductive metals from solution, and particularly recovery of silver from fixer solutions, has been a relatively expensive process, requiring substantial mechanism and moving parts, as well as close supervision or complex computer controls, to accomplish. This is because the recovery process is electrolytic in nature, and the reaction if not closely monitored can cause sulfiding, damage to the solution and loss of silver. Hence continuous agitation is required as well as close control of the current being supplied to the reaction.

For instance, X-Rite Company offers a number of silver recovery systems, all of which include some type of device provided specifically for agitating the solution. Further, most of the systems offered by X-Rite have a cathode which is coiled, thus having a relatively small surface area.

Similarly, Roconex Corporation manufactures a number of lines of silver recovery systems and markets them under the "Rotex" trademark. All of these systems include some devices specifically devoted to agitation, generally with a rotating cathode which must then be removed from the recovery unit and cleaned, and later reinstalled and reused.

Moreover, all of the systems referred to above are relatively expensive, and there is a need in the marketplace for systems which are less expensive and mechanically simpler, since mechanical simplicity brings with it a high degree of reliability.

This invention relates to improvements to the apparatus described above and to solutions to some of the problems raised thereby.

The invention relates to an apparatus for recovering a conductive metal from a liquid which contains that metal, and to a method for recovering that metal using that apparatus. The invention is particularly well suited for recovery of silver from photographic fixer solutions. The apparatus includes a generally closed non-metallic recovery container defining a cavity, for containing the liquid. A first electrode is supported and affixed within the cavity. A second electrode is composed of a thin film applied to the inside surface of the container, the film including as its main constituent the same metal as that to be recovered from the solution. Finally, power supply means are electrically connected to the electrodes so as to result in the first electrode being an anode and the second electrode being a cathode, thus causing the metal from the solution to be deposited on the second, film electrode, lining the inside surface of the container with the metal to be recovered.

The invention further includes means for circulating metal laden liquid, that is, liquid containing the metal in solution, into the container and for removing demetalized solution from the container.

The method of the invention includes providing a disposable, electrically insulating container for containing metal-containing solution and applying a thin film of the metal to the inside surface of the container. An electrode is affixed within the container so that it is immersed in the liquid and insulated from film on the inside surface of the container. The voltage potential of the electrode over that of the thin film is then raised to about 1.5 volts, thereby causing the metal in the solution to be electrolytically deposited on the film and to build up thereon. This voltage causes a current density between the electrode and the film of about 1.5 milliamperes per square inch.

In one embodiment the apparatus includes a holding container for holding the solution. The recovery container is placed in liquid communication with the holding container. The first electrode in this embodiment is tubular to provide liquid communication between the two containers. This embodiment further includes a pump for circulating the metal laden liquid from the holding container into the recovery container. The recovery container is mounted on the top of the holding container, and recovered solution drains down from the recovery container via the liquid communication means. The pump therefore has an inlet in the holding container and an outlet in the recovery container. The pump outlet is positioned within the recovery container so as to provide agita tion of the solution in the recovery container merely by the discharge of solution from the pump outlet.

In each embodiment the recovery operation is facilitated by the fact that the recovered metal is not required to be removed from the cathode, because the recovery container itself is disposable, constructed from materials such as plastic or glass which can be added to the smelting furnace without contaminating the smelting operation.

Other objects and advantages of the invention will become apparent hereinafter.

Fig. 1 is a cross sectional view, partially schematic, especially with respect to the electrical control circuit, of a metal recovery apparatus constructed according to one embodiment of the invention.

Fig. 2 is a cross sectional view, also partially schematic, of a metal recovery apparatus constructed according to an alternative embodiment of the invention.

Fig. 3 is a cross sectional view, also partially schematic, of ametal recovery apparatus constructed according to yet another embodiment of the invention.

While the invention is applicable to removal of any type of conductive ionic metal in solution, it is particularly well suited to an application wherein silver is removed from photographic fixer or bleach-fix solutions. The following description will refer to that silver removal application as exemplary, but it should not be considered as limiting the intended scope of the invention.

Single Container Embodiment

Referring now to Fig. 1, an apparatus 10 constructed according to one embodiment of the invention includes a recovery container 12, containing an amount of fixer solution 14. The fixer solution 14 is a solution in which a ionic silver is dissolved. The entire inner surface 12a of the container 12 is coated with a very thin film 12b of silver, the metal to be removed from the solution, such as by spray painting. The actual thickness of the film 12b as applied is not critical, as will be shown presently, as long as the interior surface of the container 12 is evenly coated sufficiently thick to conduct electricity. The thickness is commonly on the order of 1 mil. The material of the film may be generally any type of paint or other sprayable film containing silver, such as Acrylic 1, Part No. 73-00025, from Tecknit EMI Shielding Products, or E-Kote 3040 from ACME Conductive Coatings. Alternatively, the film 12b may be some other conductive material. For instance, the film 12b may be a thin layer of stainless steel or gold, applied by means of tape or sheeting to the inside surface of container 12.

An electrode 16 is suspended near the center of the container 12, reaching substantially into the solution 14. This electrode 16 can be of any suitable and readily available material for such an electrode, such as carbon/graphite rod material. For ease of assembly and mounting of the electrode 16 to the container, the electrode can be mounted in the center of a cover 18, which is attached to the top of and closes the container 12. Preferably the cover 18 is formed of insulative material so as to insulate the electrode from the thin film 12b. The electrode 16 thus mounted reaches downward into the solution 14 for the majority of its length.

The apparatus 10 further includes a power supply 20 for providing energy for an electrolytic reaction to plate the ionic silver out of the fixer solution 14. This power supply 20 is preferably a 1.5 to 2.2 volt DC power supply, having a positive pole 22 and a negative pole 24. The electrode 16 is electrically connected to the positive pole 22 of the power supply 20, preferably by a positive connector 26, which fits into a receptacle 28 provided for that purpose at the top of electrode 16. Similarly, the thin film 12b coating the inside surface 12a of the container 12 is preferably electrically connected to the negative pole 24 by a negative connector 30 which fits into a receptacle 32 provided for that purpose. Hence the electrode 16, being connected to the positive pole of the power supply 20, is the anode for the electrolytic reaction, while the thin film 12b in effect acts as another electrode, becoming the cathode for the electrolytic reaction because of its connection to the negative pole of the power supply.

In the simplest mode of operation of the apparatus 10, then, an amount of fixer liquid 14 is placed in the container 12, and the cover 18 carrying the electrode rod 16 is placed on top of the container to close it. The electrode 16 and the film 12b are then connected to the power supply 20 and the electrolytic reaction begins. During the electrolytic reaction, silver from the solution 14 is deposited on the silver film 12b until all or a suitable amount of the silver is plated out of the solution. As the silver builds up on the film 12b, the cathode in effect increases in thickness, improving its performance. This is the reason that the original thickness of the film 12b is not critical, since it increases as the reaction progresses. Because of the relatively large surface area of the cathode film 12b with re spect to the anode electrode 16, the current density will be extremely low, on the order of 1.5 milliamperes per square inch. Hence the apparatus 10 may run relatively unattended, since it is clear that the danger of sulfiding and/or damage to the solution, which problem is carefully and expensively controlled and guarded against in the prior art, is very remote at this low current density level. When a sufficient amount of silver has plated out, the power supply 20 may be disconnected and the electrode 16 and the liquid 14 removed.

The used container 12 may then be placed in its entirety, including the cover 18, in a silver smelting furnace (not shown) to refine the silver for reuse. This is a major advantage of the present invention. In most presently existing silver recovery devices, the deposited silver must be somehow removed from the cathode before smelting, whether by scraping or some other physical means or process. This can be a difficult, expensive and dangerous job. Moreover, some silver is inevitably lost in the process. In order that the container 12 may accompany its contained silver into the smelting furnace, it is required to be made entirely of some material that easily refines out of the molten silver in the smelting process, such as a common plastic pail. Of course a handle 34 may be provided for ease of handling the container 12, but if it is of a metal containing copper, such as stainless steel, or some other metal which does not easily refine out of silver, it must be removably attached to the container, so that it can he removed prior to placement of the container in the smelting furnace, and even reused, as is the electrode 16. Preferably, however, it is simply conventional iron or zinc-plated (galvanized iron, for low cost.

In the preferred embodiment as shown in the Fig. 1, the silver-containing solution may be continuously introduced into the container 12 by means of a liquid introduction tube 36 which has its outlet 36a near the bottom of the container. As silver is removed from the solution, the solution becomes lighter, rising to the top of the liquid 14 in the container 12 in a naturally occurring phenomenon referred to as "stratified transport". The solution at the top of the liquid, then, will be relatively more de-silvered compared to that at the bottom of the liquid. This relatively de-silvered solution at the top may be continuously removed from the container 12 by a liquid drain tube 38, the inlet 38a of which is located in the sidewall of the container at the level of the top of the liquid. By proper relative placement of the source of the silver-containing solution, above the container 12, and of the reservoir of relatively de-silvered solution, below the container 12, any necessity for pumps or other mechanically powered devices to move the solution is avoided, since the solution will move by siphoning. Further, since the relatively de-silvered solution may not be completely de-silvered from one pass through the apparatus 10, it may be desirable to connect a number of such apparatus together serially, so as to achieve the greatest possible silver extraction rate.

Both tubes 36 and 38 are preferred to be of plastic in order to be consistent with the objective, referred to above, that the entire container 12 may be placed in the smelting furnace when sufficient silver has been deposited.

The power supply 20 may be a generally conventional plug-in module type, as shown. As an additional aid in controlling and ensuring the integ rity of the de-silvering reaction, the power supply 20 may also include certain additional features. In particular, in one embodiment of the present invention, the power supply 20 first includes a generally conventional transformer module 40, which plugs into a conventional 110 volt or 220 volt electrical outlet 42 and outputs 5 volts DC, up to one amp, via a positive lead 44 and a negative lead 46. A calculator-type transformer module with these characteristics may be particularly well suited for this application. Connected between the two leads are a current limiting resistor R1 and a light emitting diode D1 connected in series. The purpose of the diode D1 is to indicate that the transformer module 40 is indeed receiving power from the outlet 42. Hence, whenever the outlet 42 is supplying power, the diode D1 is lit. Also connected to the positive lead 44 is a first lead of a voltage regulator IC1. The anode, or electrode 16, of the apparatus 10 is connected to a second lead of IC1. Finally, a third lead of IC1 is connected to the second lead by a resistor R2 and, via a potentiometer R3, to the negative lead 46 of the power supply transformer module 40. The purpose of the described arrangement of the voltage regulator IC1 and resistors R2 and R3 is to ensure that the current passing to the electrode 16 remains extremely low as described above. The potentiometer R3 allows adjustment of the circuit for tolerances of the components and for various sizes of containers 12. Preferably potentiometer R3 would be adjusted so as to provide 1.5 volts DC to the electrodes 12b and 16, resulting in the extremely low current density set forth above. Finally, flashing light emitting diode D2 is connected between the anode and cathode of the electrolysis circuit, that is, between the positive connector 26 and the negative connector 30. This diode D2 will flash if there is no current passing between the electrode 16 and the film 12b, thus acting as an indicator of the integrity of the electrolysis circuit.

While it is possible to use the apparatus 10 as described above in a "batch mode", it is more efficient to use it in "continuous" mode, as will now be described mainly in reference to Fig. 2. In continuous mode, as shown there, fixer solution 14 is constantly being circulated into the container 12, and de-silvered solution is constantly being removed. In the preferred embodiment as shown in the figure, the fixer solution 14 is continuously introduced into the container 12 by means of a pump 48, which is preferably an existing recirculating pump of an existing, conventional, film processing machine solution tank 50, which is normally connected to a film processing machine 52 via the recirculating pump and appropriate tubing 54. In general, tank 50 serves as a holding tank for the film processing solution 14, which is thereby continually recirculated to the film processing machine 52. This solution 14 builds up silver content with use, however, so that it has been conventional procedure to periodically replace the solution, and to attempt to recover the silver from solution because of the intrinsic value of the silver. The advantage of the embodiment shown in Fig. 2 is that the solution 14 does not need to be replaced, at least not as often, if the silver can be removed and recovered from the solution without removal or replacement, by use of the apparatus shown there.

The embodiment shown in Fig. 2 includes valve means 58 for, in one position, permitting normal flow of solution 14 from the pump 48 to the film processing machine 52, while in the other position diverting the flow to container 12. While one valve 60 is shown to accomplish the function of valve means 58, the same effect can be achieved by use of a plurality of valves. Valve means 58 includes one outlet 58a to which is attached an inlet 62 of the container 12. Inlet 62 of Fig. 2 corresponds to liquid introduction tube 36 of the embodiment shown in Fig. 1, although of slightly different configuration because of the pressure supplied by the pump 48. This inlet 62 terminates inside the container 12, at the bottom thereof, in a deflecting means 64. Thus when the valve means 58 is in its "divert" position, solution 14 is pumped by pump 48 into container 12, where deflecting means 64 deflects the flow of the solution, causing substantial and desirable agitation. The solution then returns to tubing 54 via an outlet 66, which again corresponds to liquid drain tube 38 of the embodiment shown in Fig 1, with minor changes because of the pressurization of the system. Outlet 66 is preferably connected to and returns the solution 14 to valve means 58.

The power supply 20 is basically the same as that shown in Fig. 1. Because of the agitation referred to above provided by the pump 48 and deflecting means 64, the voltage may be adjusted to be higher, resulting in higher current density and faster recovery of the silver from the solution.

Two-Container Embodiment

Referring now to Fig. 3, an apparatus 110 is shown constructed according to another alternative embodiment of the invention, which in a sense combines the first two embodiments shown. Apparatus 110 includes a holding container 112, holding an amount of fixer solution 14. This solution 14 may be circulated into and out of holding container 112 by conventional means via an inlet 116 and an outlet 118, so as to make sure that the solution in the holding container 12 at all times contains some dissolved silver. The top of holding container 112 is covered by a suitable cover 120.

The apparatus 110 further includes a cell or recovery container 122, constructed of a material such as plastic or glass, similar to container 12 of the earlier disclosed embodiments, which material is easily separated from the recovered silver during smelting. It may be advantageous that the recovery container 122 be constructed of a clear plastic or glass so as to allow the viewing of the progress of the deposition operation as will be described presently. The entire inner surface 122a of recovery container 122 is coated with film 12b, as referred to above with respect to the first two disclosed embodiments. If recovery container 122 is clear as indicated above, then just the side surface 122a should be covered with the bottom surface 122c left uncovered so as to allow observation of the progress of the plating operation within the recovery container.

Advantageously, recovery container 122 is provided with a cap 124, which is sized to fit in sealing engagement over the sole opening 122d of the recovery container. An electrode 126 is affixed near the center of the cap 124, for ease of assembly and mounting of the electrode to the recovery container 122. Electrode 126 reaches substantially into the recovery container 122 for the majority of the length of the electrode, when the cap 124 is placed thereon. Electrode 126 may also, however, protrude slightly beyond cap 124, outside of recovery container 122. This electrode 126 can be formed of any suitable and readily available material for an electrode in such an application, such as stainless steel, since the solutions to be handled thereby can be corrosive. Preferably the cap 124 is formed of insulative material so as to insulate the electrode 126 from the film 12b. The cap 124 also includes an opening for a pump outlet 130, for reasons to be set forth presently. The recovery container 122 is then mounted on the holding container 112 by inverting the recovery container and mounting the cap 124 onto the cover 120, with the openings of the cap mating with similar openings provided for that purpose in the cover.

The apparatus 110 further includes a pump 128 for pumping the solution 114 from the holding container 112 up into the recovery container 122, via pump outlet 130, already disclosed to be positioned inside the recovery container. This pump outlet 130 is positioned so that the output of the pump 128 causes substantial agitation of the solution 14 within the recovery container 122. That is, the pump outlet 130 directs the movement of the solution 14 at an angle, so that the solution in recovery container 122 is agitated by the solution being pumped into the recovery container, merely by the force of the pump action. By this means, agitation of the solution 14 is provided without any apparatus devoted solely to the agitation function, resulting in a substantial economy of parts and mechanism, in turn improving the reliability and efficiency of the apparatus 110.

In the embodiment shown in Fig. 3, the recovery container 122 is inverted and placed on top of holding container 112. The solution 14 pumped into the recovery container 122 is allowed to drain back into the holding container 112 via up to two routes. The first route is a higher volume route, and must at least equal the flow of the pump outlet 130. Elec trode 126 can be provided in a tubular configuration, to provide the necessary liquid communication means. Alternatively, electrode 126 could be solid and a separate liquid return tube 132 (in phantom) provided. In either case, the topmost opening 126a of electrode 126 or the separate liquid return tube 132 inside recovery container 122 is substantially above cap 124 when the recovery container is in its installed, inverted position, a substantial amount of solution 14 remains in recovery container 122, as shown in the figure. The level of the solution 14 within recovery container 122 is, thus, determined by the location of opening 126a of electrode 12b, or the separate liquid return tube 132, above the opening of the recovery container. The second route by which solution drains back into holding container 112 is via a drain opening 134 formed in the cap 124 and the cover 120. This drain opening 134 is always open, but the amount of the flow allowed by this drain opening is substantially less than the output of the pump 128. The purpose of drain opening 134 is to allow the solution 14 remaining in recovery container 122 after pump 128 is turned off to drain back into holding container 112, thereby preventing the recovered metal from redissolving back into the solution. Hence this apparatus has particular application to recovery of silver from bleach fix solutions used in photo processing, since this type of solution is particularly susceptible to re-dissolution when power is not applied.

The apparatus 110 further includes a power supply 20 similar to that provided for the single container embodiment shown in Figs. 1 and 2.

In operation, an amount of solution 14 is placed in holding container 112, which has already been closed by cover 120, pump 128 having previously been placed in the holding container 112 with pump outlet 130 protruding through the top of the cover. The cap 124 carrying tubular electrode 126 is then installed on the recovery container 122, and that assembly is placed, inverted, on top of the cover 120, with the pump outlet 130 reaching just into the recovery container and the electrode reaching just into holding container 112. Pump 128 is then turned on and electrode 126 and film 122b are connected to the power supply 20, and the metal recovery reaction begins. During the reaction, silver from the solution 14 is deposited on the silver film 12b until a suitable amount of the silver is deposited thereon. As with the embodiments shown above, as the silver builds up on the film 12b, the cathode in effect increases in thickness, so again the original thickness of film 12b is not critical.

When a sufficient amount of silver has plated onto the cathode 12b, pump 128 may be turned off and power supply 20 disconnected. The solution remaining in recovery container 122 will drain back into holding container 112 via drain opening 134. The recovery container 122 is then removed from the holding container 112 and placed wholly in a smelter, where the silver is separated from the material of the container by conventional means.

While the apparatus hereinbefore set forth is effectively adapted to fulfill the aforesaid objects, it is to be understood that the invention is not intended to be limited to the specific preferred embodiment of disposable cell for recovering conductive metal and method of using set forth above. Rather, it is to be taken as including all reasonable equivalents within the scope of the following claims.

Claims

1. An apparatus for recovering a conductive metal from a liquid containing said metal in solution, said apparatus comprising:
a generally closed non-metallic recovery container defining a cavity, for containing said liquid, and constructed of a material which is easily refinable when smelted with said metal;
a first electrode supported and removably affixed within said cavity;
a second electrode comprising a thin film applied to the inside surface of said cavity, said film including said metal to be recovered;
power supply means electrically connected to said electrodes so as to result in said first electrode being an anode and said second electrode being a cathode, thus causing said metal to be deposited on said second electrode, lining the inside surface of said cavity with said metal.

2. An apparatus as recited in claim 1 further comprising means for circulating said liquid into and out of said cavity.

3. An apparatus as recited in claim 2 wherein said circulating means includes:
a liquid introduction tube having an inlet outside said recovery container and an outlet within said recovery container near the bottom of said recovery container; and
a liquid drain tube having an inlet inside said recovery container at about the level of said liquid in said recovery container, and an outlet outside said recovery container.

4. An apparatus as recited in claim 3, wherein said inlet includes means for connecting to a reservoir of relatively unrecovered liquid, and wherein said outlet includes means for connecting to a reservoir of relatively recovered liquid.

5. An apparatus as recited in claim 1 wherein said power supply supplies a current density of about 1.5 milliamperes per square inch.

6. An apparatus as recited in claim 1 further comprising current regulator means, electrically connected between said power supply means and said electrodes, for regulating the amount of current passing from said power supply means to said electrodes.

7. An apparatus as recited in claim 6 wherein said current regulator means comprises indicator means for indicating that power is being supplied by said power supply and indicator means for indicating that current is not flowing between said electrodes.

8. An apparatus as recited in claim 1 further comprising:
a holding container in liquid communication with said recovery container; and
a pump having an outlet in said recovery container, for pumping said liquid from said holding container into said recovery container, said liquid returning to said holding container via return means.

9. An apparatus as recited in claim 8 wherein said recovery container is mounted above said holding container, and wherein said first electrode comprises a tube connecting said cavity with said holding container, for providing liquid communication between said holding container and said recovery container.

10. An apparatus as recited in claim 9 wherein said pump is positioned within said holding container, and has an outlet in said recovery contain er, for pumping said liquid from said holding container into said recovery container, said liquid returning to said recovery container via said tube of said first electrode.

11. An apparatus as recited in claim 9 wherein said pump has a predefined flow rate, and further comprising a drain for allowing said liquid to drain back into said holding container from said recovery container when said pump is not running, said drain having a flow rate substantially less than that of said pump.

12. An apparatus as recited in claim 9 wherein said recovery container is substantially smaller than said holding container.

13. An apparatus as recited in claim 8 wherein said pump outlet is positioned to cause substantial agitation of said liquid within said cavity.

14. A method for recovering a conductive metal from a solution containing said metal, comprising the steps of:
providing a disposable, electrically insulating recovery container, constructed of a material which is easily refinable when smelted with said metal;
applying a thin film of said metal to the inside surface of said recovery container;
removably affixing an electrode within said recovery container so that said electrode is immersed in said liquid and insulated from said thin film;
raising the voltage potential of said electrode over that of said thin film, thereby causing said metal in said solution to be deposited on said film and build up thereon;
removing said electrode from said recovery container; and
placing said recovery container, including said deposited metal, in a smelting furnace and smelting said metal.

15. A method as recited in claim 14 wherein said potential of said electrode is raised over that of said film sufficiently to cause a current density between said electrode and said film of

about 1.5 milliamperes per square inch.

16. A method as recited in claim 15 wherein said potential of said electrode is raised over that of said film by about 1.5 volts.

17. A method as recited in claim 14 further comprising the step of:
circulating said liquid by introducing said liquid near the bottom of said recovery container and withdrawing said liquid near the top of said recovery container.

18. A method as recited in claim 14 further comprising the step of:
circulating said liquid through said recovery container by means of stratified transport.

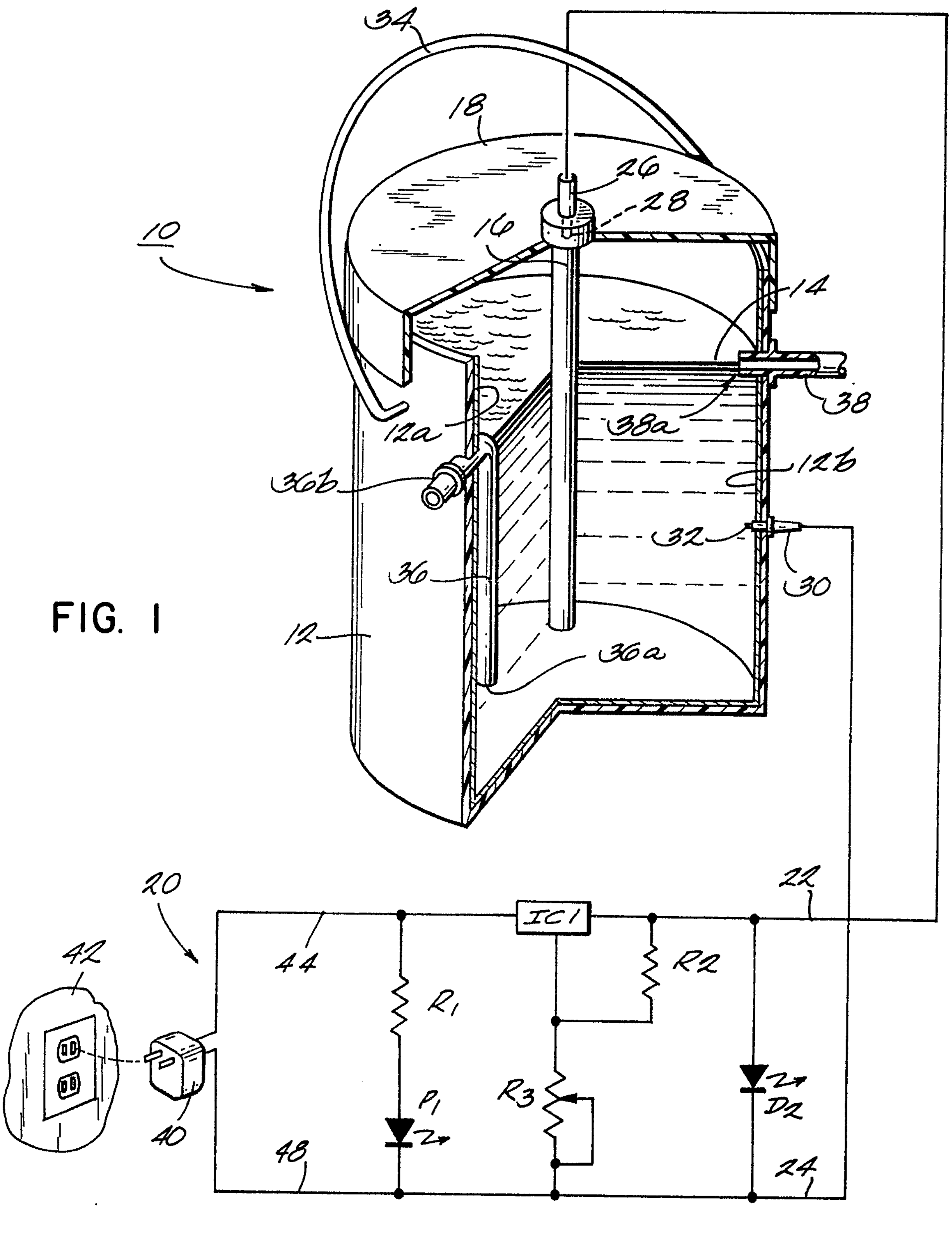
19. A method as recited in claim 14 further comprising the steps of:
placing a holding container in liquid communication with said recovery container; and
circulating said liquid from said holding container into said recovery container and back.

20. A method as recited in claim 19 wherein said electrode is tubular and constructed of a conductive metal different from the metal to be recovered from said solution.

21. A method as recited in claim 19 wherein said electrode is tubular and further comprising positioning said recovery container, opening down, above said holding container such that said electrode is in fluid communication with both containers; and
permitting said solution to begin to return to said holding container via said electrode after the level of the liquid in said recovery container has reached a predetermined level.

22. A method as recited in claim 19 wherein said circulating is done at a predetermined rate, and
further comprising the step of preventing the collected metal from being re-dissolved into the solution, by allowing said solution to constantly drain from said recovery container into said holding container at a rate substantially lower than said circulating rate.

23. A method as recited in claim 19 further comprising the step of agitating the solution in said recovery container by directing said circulating within said recovery container so as to cause agitation within said recovery container.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R1
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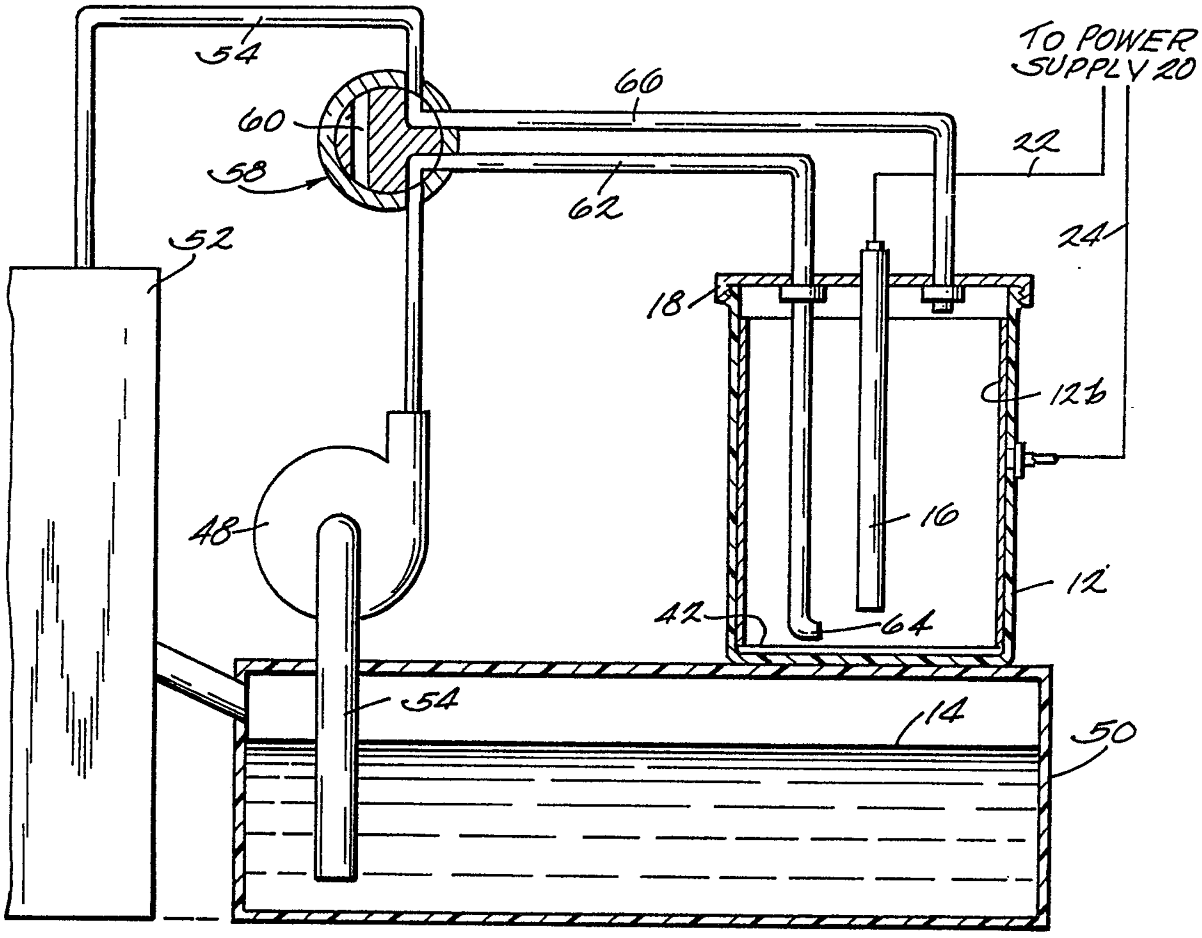
FIG. 1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TO POWER
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12b
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14
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FIG. 2

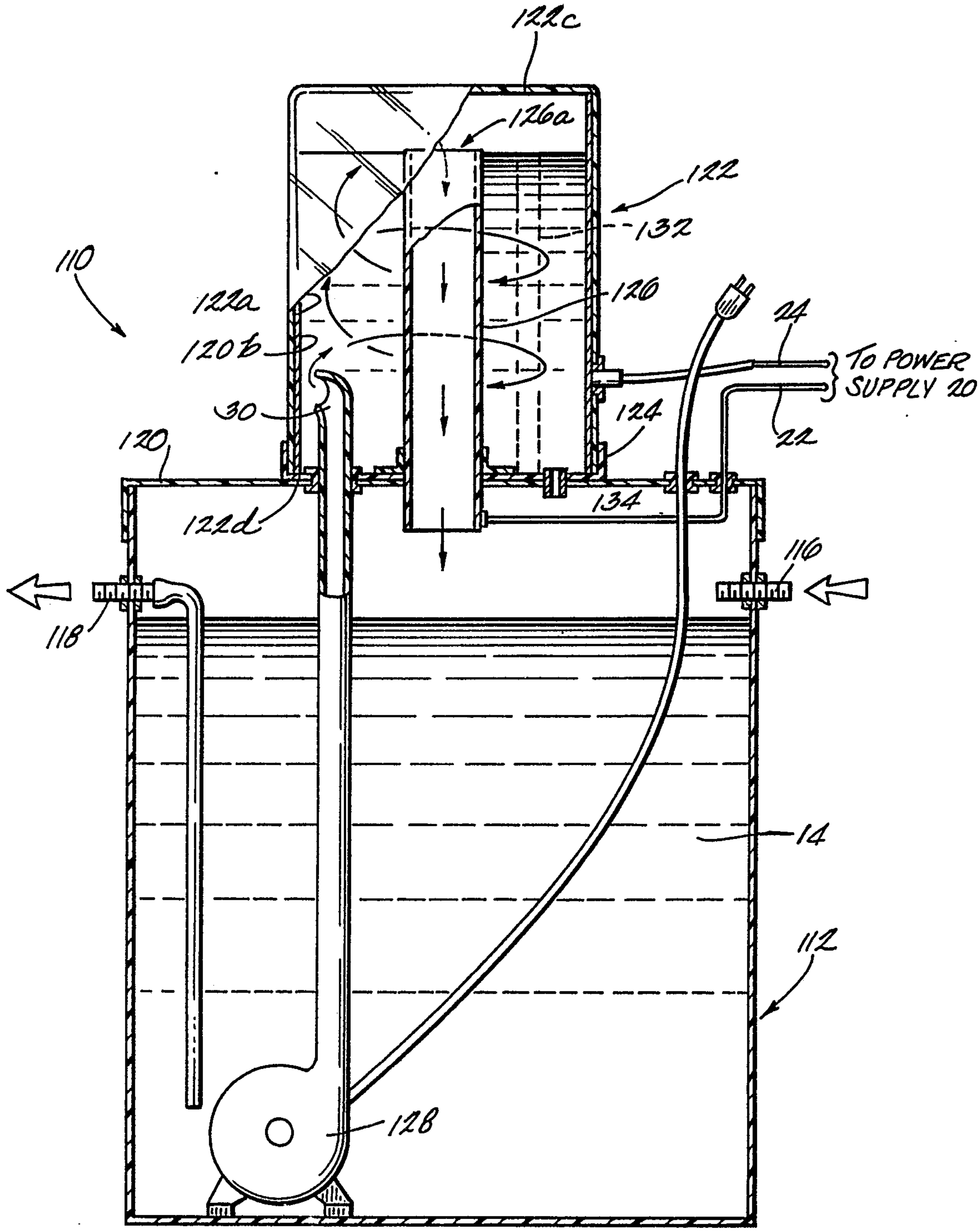
122c
126a
122
132
110
122a
126
120b
24
TO POWER SUPPLY 20
30
124
22
120
122d
134
116
118
14
112
128

FIG. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 30 5012

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	US-A-4 028 212 (W.L. BOWEN) * Column 9, lines 24-32; claims *	1,2,14, 19,20, 23	C 25 C 7/00 C 25 C 1/20
Y		5,8,15	
Y	GB-A-1 202 688 (COMPTOIR LYON-ALEMAND) * Column 2, lines 42-48; column 4, claim 1 *	5,8,15, 16	
A	US-A-4 440 616 (K.R. HOUSEMAN) * Whole document *	1-4,9, 14,17, 20,23	
A	US-A-3 985 634 (K.R. LARSON) * Column 3, lines 28-41 *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

C 25 C 7
C 25 C 1

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	11-08-1989	GROSEILLER PH.A.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P0401)