



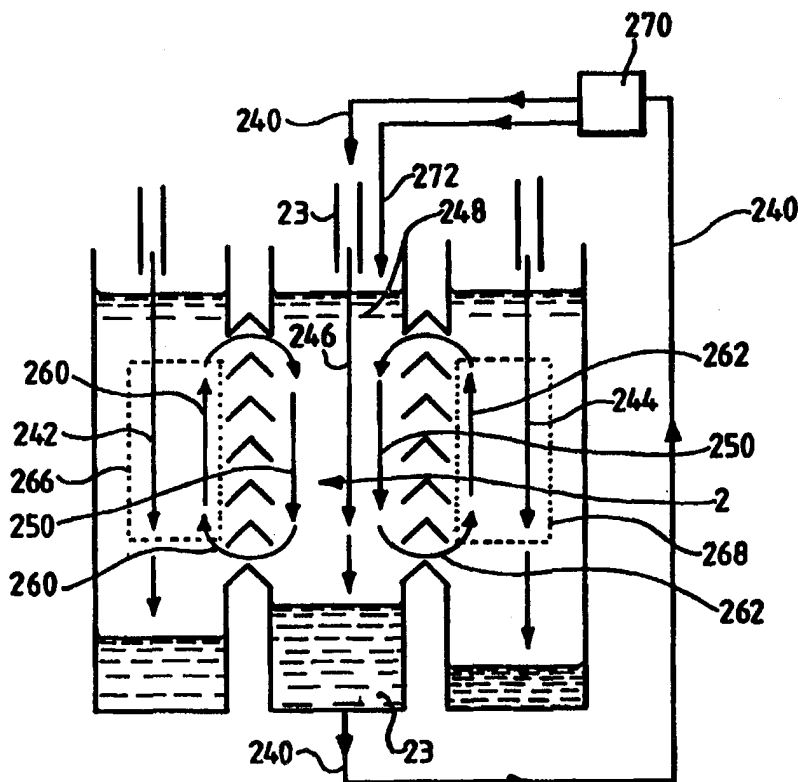
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(21) International Application Number: PCT/GB98/00967 (22) International Filing Date: 1 April 1998 (01.04.98) (30) Priority Data: 9707188.0 8 April 1997 (08.04.97) GB (71) Applicant (for all designated States except US): BRITISH NUCLEAR FUELS PLC [GB/GB]; Risley, Warrington, Cheshire WA3 6AS (GB). (72) Inventor; and (75) Inventor/Applicant (for US only): BROAN, Christopher, John [GB/GB]; British Nuclear Fuels plc, Company Research Laboratory, B516 Springfields Works, Salwick, Preston, Lancs. PR4 0XJ (GB). (74) Agents: GODDARD, David, John; Harrison Goddard Foote, Vine House, 22 Hollins Lane, Marple Bridge, Stockport SK6 5BB (GB) et al.		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, 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 With international search report.

(54) Title: EXTRACTION METHOD AND APPARATUS

(57) Abstract

A method and apparatus for the extraction of a solute from an aqueous feed solution (242) into an aqueous stripping solution (244) are described. The method comprises the steps of providing at least one stream of each of said feed solution (242) and said stripping solution (244) passing through a continuous phase of a non-polar carrier liquid (248); said carrier liquid (248) having therein a chemical having an affinity for ions of at least two species in said solute in said feed solution (242); each of said at least one streams of feed (242) and stripping (244) solutions being under the influence of a high voltage electrostatic field for at least a part of their passage time through said carrier liquid (248) so as to break up said streams into a multiplicity of droplets of each of said solutions; and, providing mutually separated receiving means (212, 214) to collect the streams of said feed (242) and said stripping (244) solutions after they pass out of said high voltage electrostatic field; said method being characterised by providing means (236) to supply a third aqueous scrubbing solution (246) falling through said carrier liquid (248); means to disperse said aqueous scrubbing solution into small droplets; said chemical and said species migrating through said aqueous scrubbing stream (246) where at least some of one of said at least two species are extracted into said scrubbing stream (246).



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EXTRACTION METHOD AND APPARATUS

The present invention relates to improvements to the so-called "electrostatic pseudo liquid membrane" (ESPLIM) method of separation of metal ions from aqueous solutions.

Chinese patent application number CN 86101730A describes a separation technique which enables the purification of aqueous solutions and concentration of solutes in aqueous solutions.

The technique includes the steps of passing droplets of an aqueous feed solution which it is desired to purify and/or from which it is desired to extract metal ions for example, under the influence of gravity, through a first region of a non-polar carrier liquid in which is dissolved a chemical having high affinity for the metal ion or ions to be removed whilst simultaneously subjecting the droplets to a high voltage electrostatic field so as to break up the droplets into a multiplicity of much smaller droplets in order to increase their surface area to volume ratio. The metal ions are complexed by the dissolved chemical into the carrier liquid and are driven, principally by the concentration gradient so formed, to a second region in the non-polar carrier liquid through which is passing under the influence of gravity a stream of droplets of an aqueous "stripping" solution which has a chemically higher affinity for the metal ion than the complexing chemical in the carrier liquid. The stripping solution droplets are also simultaneously subjected to a high voltage electrostatic field so as to break them up into a multiplicity of much smaller droplets and thus to increase their surface area to volume ratio. The metal

ions are thus concentrated into the stripping solution and the aqueous feed solution is largely purified of the metal ions. As the very small droplets of the purified feed solution and the stripping solution, the former now having
5 a lower concentration of the metal ions and the latter now having a high concentration of the required metal ions, pass out of the high voltage electrostatic field, they coalesce and fall under gravity into mutually separated first and second collecting vessels, respectively, and
10 from which they can be removed.

The first and second regions of the carrier liquid are separated by a barrier or baffle which is intended to allow substantially uninterrupted flow and passage of the
15 carrier liquid to and from the first and second regions but, is also intended to physically impede or prevent the passage of the aqueous feed solution from the first region into the second region and, the passage of the stripping solution from the second region to the first region.

20

One problem with the conventional form of ESPLIM apparatus and method as described above is difficulty where it is desired to achieve a product in the stripping cell which comprises a concentrate of one particular species.
25 However, where there are two or more species in the feed solution which are naturally extracted by the ligand, a product is formed in the stripping cell which is contaminated by one or more of the unwanted species naturally extracted from the feed solution.

30

Furthermore, we have now found an additional problem in that contrary to the flow direction of the carrier liquid being governed by the concentration gradient therein of

- the species being extracted as previously believed, the flow of the organic carrier liquid is more strongly influenced by the physical flows of the aqueous phases passing through. Furthermore, since the flow rate of the aqueous feed solution is usually far greater than that of the stripping solution, the flow pattern of the organic carrier phase within the cell is dominated by the flow of the feed solution.
- 10 This flow pattern imposed on the carrier phase by the aqueous feed solution has the undesirable effect of producing flow directions in the carrier liquid phase which is non-optimum with regard to the most efficient extraction of the desired species in the feed solution by the organic carrier phase.

According to a first aspect of the present invention, there is provided a method for the extraction of a solute from an aqueous feed solution into an aqueous stripping solution, the method comprising the steps of providing at least one stream of each of said feed solution and said stripping solution passing through a continuous phase of a non-polar carrier liquid; said carrier liquid having therein a chemical having an affinity for ions of at least two species in said solute in said feed solution; each of said at least one streams of feed and stripping solutions being under the influence of a high voltage electrostatic field for at least a part of their passage time through said carrier liquid so as to break up said streams into a multiplicity of droplets of each of said solutions; and, providing mutually separated receiving means to collect the streams of said feed and said stripping solutions after they pass out of said high voltage electrostatic

field; said method being characterised by providing means to supply a third aqueous scrubbing solution falling through said carrier liquid; means to disperse said aqueous scrubbing solution into a plurality of droplets;
5 said chemical and said species migrating through said aqueous scrubbing stream where at least some of one of said at least two species are extracted into said scrubbing stream.

10 The third aqueous scrubbing stream may be provided in a region substantially between the feed and stripping streams such that the complexed ligand containing the two or more species must pass through the scrubbing stream on its way to the stripping stream.

15

The third aqueous scrubbing stream may be dispersed into droplets in a similar manner to the feed and stripping streams by the provision of a high voltage electrostatic field through which the scrubbing stream may be falling
20 under the influence of gravity.

The aqueous scrubbing stream may, for example, be of a different pH to that of the stripping stream such that the species which is unwanted in the final concentrated
25 product resulting in the stripping stream is preferentially extracted from the ligand in the carrier liquid by the scrubbing stream and leaving the desired species in the carrier.

30 The region in which the scrubbing stream is disposed may be situated between baffles so as to minimise leakage of feed solution into the scrubbing stream and vice versa and

leakage of the stripping solution stream into the scrubbing stream and vice versa.

Additional benefits of the provision of a scrubbing stream
5 between the feed and stripping streams is that due to
their increased separation, the feed stream raffinate is
less contaminated by the species required in the product
and the stripping stream product is less contaminated by
raw feed solution due to leakage across the baffle in each
10 direction. One effect of the scrubbing stream is to
entrain and remove aqueous droplets of the feed and strip
streams into the scrubbing stream.

The scrubbing stream may also be provided with its own
15 unique receiving means from which it may be extracted by,
for example, conduit and pump means and refluxed through
the carrier liquid.

For maximum extraction efficiency, it is desirable for the
20 flow directions of both the aqueous feed and stripping
solutions to be generally opposed to the flow direction of
the carrier liquid within the cell.

In this specification the word "flow" is to be construed
25 broadly. Alternative words may include "movement",
"migration" and are to be interpreted as meaning a
transfer of the carrier liquid in a general desired
direction, from one region to another, rather than, for
example, the easily demonstrable unidirectional "flow" of
30 liquid through a system of pipes.

It has been found that in a conventional ESPLIM cell which
is being operated to concentrate up a dilute feed

solution, the feed solution flow rate is much greater than the flow rate of the stripping solution. The effect of this on the flow direction of the carrier phase is to cause circulation within the cell which is cocurrent on the feed side and countercurrent on the strip side. Whilst this situation is efficient for the strip side, it is not the most efficient for the feed side. It is possible to operate the strip side at high levels of reflux so as to increase the apparent overall flow rate on that side so as to equate to that on the feed side. However, where the flow rates are changed in this manner, the overall effect is to cause both the feed and strip flows to be cocurrent which is even less efficient on both sides. If the flow rate of the strip side is altered so as to be greater than that of the feed side, the effect is to cause circulation of the carrier liquid within the cell which is cocurrent on the strip side and countercurrent on the feed side. The mechanism causing the carrier liquid flows is believed to be liquid entrainment or viscous drag of the carrier liquid by the aqueous solutions on each side; generally, the side having the greater volume flow rate has the dominant effect.

The method of the present invention is most advantageous where the distribution coefficient of the desired solute species between the aqueous feed solution and the organic carrier liquid is less than 100. Preferably the distribution coefficient may be less than 10.

In one advantageous embodiment of the method of the present invention the aqueous scrubbing stream is used as a means for generating a suitable carrier liquid flow pattern within the cell. Where the aqueous scrubbing

stream is falling under the influence of gravity and which may advantageously be at a rate greater than that of either the feed or stripping solutions, the effect is to cause two essentially separate modes of carrier liquid circulation which results in the carrier liquid flowing
5 countercurrent to the aqueous solutions in both the feed and stripping sides.

10 The aqueous liquid may be drawn off from its receiving means and recycled back through the carrier liquid in order to minimise the volume of liquid employed.

According to a second aspect of the present invention,
15 there is provided an apparatus for the extraction of a desired solute from an aqueous feed solution into an aqueous stripping solution to form a concentrated aqueous product of the desired species, the apparatus comprising vessel means for containing a continuous non-polar carrier
20 liquid, the carrier liquid having therein a chemical having an affinity for ions of at least two species in said solute in said feed solution; means for providing at least one stream of each of said feed and stripping solutions through said carrier liquid in said vessel
25 means; electrode means for applying a high voltage electrostatic field to each of said feed and stripping solution streams so as to cause said streams to break up into a multiplicity of small droplets; mutually separate receiving means for collecting said feed and stripping
30 solutions after they have passed through said high voltage electrostatic fields, the apparatus being characterised by further including means to supply a third aqueous scrubbing solution through said carrier liquid; means to

disperse said aqueous scrubbing solution into small droplets; and means to receive and collect said third aqueous scrubbing stream.

5 The means for supplying the third aqueous scrubbing stream may be one or a plurality of nozzles supplying the aqueous liquid to a central region disposed between the feed and stripping sides of the cell.

10 The cell of the method of the present invention also includes at least one region disposed between the feed and strip sides of the cell. This region may comprise two generally vertical baffle arrangements with an intervening space in which the aqueous scrubbing stream is falling and
15 which is as free as possible of the feed and stripping solution streams by virtue of the baffles and provides a region where the loaded and stripped carrier liquid may migrate to and from the feed and strip regions, respectively.

20

A multi-cell apparatus according to the present invention may be produced comprising a plurality of pairs of feed and strip cells, each feed and strip cell having a central scrubbing region lying therebetween and able to generate
25 the appropriate flow directions under the appropriate flow rate conditions as described above.

In order that the present invention may be more fully understood, examples will now be described by way of
30 illustration only with reference to the accompanying drawings, of which:

Figure 1 shows a schematic arrangement of apparatus showing the basic operation of a prior art ESPLIM cell;

Figure 2 shows a schematic arrangement of a prior art
5 ESPLIM cell similar to that shown in Figure 1 indicating a normal flow pattern of the carrier liquid therein;

Figure 3 shows a schematic arrangement of a first
embodiment of an apparatus according to the present
10 invention; and

Figure 4 which shows the schematic apparatus of Figure 3
indicating the flow pattern of carrier liquid engendered
by the method of the present invention under appropriate
15 flow conditions.

Referring now to the drawings and where Figure 1 shows a
schematic cross section through an apparatus 10 for
carrying out the ESPLIM method of separation according to
20 the prior art. The apparatus 10 comprises a reaction tank
or vessel 12 which is divided at its upper portion by a
wall 14 into an extraction cell 16 and a stripping cell
18. At the lower end of the tank 12 there is a wall 20
which divides the tank into two receiving vessels or
25 settling tanks 22, 24 for the purified feed solution or
raffinate and, for the concentrated extractant in the
stripping solution, respectively. Situated between the
upper wall 14 and the lower wall 20 is a baffle 26 which
allows an organic carrier liquid 28, in this case
30 kerosene, to move freely throughout the tank 12.
Electrodes 30, 32 are situated in the extraction cell side
16, between which a first high voltage AC electrostatic
field may be applied. Electrodes 34, 36 are situated in

the stripping cell side 18, between which a second high voltage AC electrostatic field may be applied. In each of the cells 16, 18 at least one of the electrodes is insulated with, for example, a coating of polytetrafluoroethylene (PTFE) to prevent short circuiting within each cell. A controllable high tension AC supply 80 is provided for the electrodes so as to establish a desired potential therebetween. A conduit 40 is provided above the extraction cell 16 to supply a stream of feed solution 42 which is to be purified, into the carrier liquid 28. The conduit 40 has connected thereto pump means (not shown) and a reservoir tank (not shown) to provide a continuous supply of aqueous feed solution at a controlled rate. Another conduit 44 is provided above the stripping cell 18 to supply a stream 46 of aqueous stripping solution into the carrier liquid 28. The conduit 44 also has connected thereto pump means (not shown) and a reservoir tank (not shown) to provide a continuous supply of stripping solution at a controlled rate. Each of the receiving vessels 22, 24 have conduits 50, 52 to enable the raffinate 54 and the concentrate 56 to be drawn off as the level in each vessel rises or as required. The raffinate and concentrate are pumped to collection vessels (not shown) for disposal or further processing as required.

In operation, the apparatus 10 functions as follows and using as an example the extraction of cobalt metal ions from the feed solution 42 in which the Co ions are present at a concentration of 1000ppm in a 0.1M aqueous sodium acetate solution, the feed solution being supplied at a flow rate of 200 ml/hr into the carrier liquid. The stripping solution comprises a 1.0M solution of sulphuric

acid which is supplied at a flow rate of 10 ml/hr into the carrier liquid. The diluent kerosene carrier liquid 28 has dissolved therein 10 volume% of di-(2-ethyl-hexyl)phosphoric acid (D2EHPA) extractant. An AC electrostatic field of 3KV supplied via a transformer from the mains supply is applied between the electrodes 30, 32 and 34, 36 to establish the first and second electrostatic fields. As the relatively large droplets of the feed solution 42 and stripping solution 46 fall into the extraction cell 16, they are subjected to the electrostatic fields between the electrodes 30, 32 and 34, 36 which have the effect of causing the relatively large droplets to break up into a multiplicity of microdroplets 60, 62 thereby greatly increasing the surface area to volume ratio of the two aqueous phases. In the extraction cell 16, the Co ions are extracted from the aqueous solution droplets due to the affinity of the D2EHPA thus causing the concentration of the Co-complex to rise in the extraction cell in the kerosene phase. Due to the concentration gradient so formed, the Co-complex diffuses through the kerosene through the baffle 26 towards the stripping cell 18 where the Co-complex reacts with the microdroplets 62 of the stripping solution where the Co-complex reacts with the sulphuric acid to free the D2EHPA, the Co ions reacting with the sulphuric acid and being concentrated therein. The D2EHPA then migrates back through the baffles 26 to the extraction cell 16 to establish a continuous chemical process. As the reacted droplets 60, 62 pass through the electrostatic fields under the influence of gravity, they eventually pass out of the electrostatic fields and begin to coalesce into larger droplets 70, 72 which fall into the receiving vessels 22, 24 as appropriate.

In experiments under the conditions described above, an initial feed solution of a Co concentration of 1000 ppm was purified to a concentration of 10 ppm in the raffinate 5 54, whilst the concentrate 56 had a concentration of 19,750 ppm of Co ions.

Therefore, it will be seen that the method makes it possible to concentrate metal ions to a level where it is 10 both practicable and economic to extract the concentrated metal ions so as to recover and reuse the metal per se. An example of this may be uranium. It is also clear that the feed solution may be so purified as to make disposal easier and/or less hazardous. However, as noted 15 hereinabove, in some cases the feed solution may contain more than one species which may be extracted by the D2EHPA into the carrier liquid and which serves to contaminate the product concentrate 56 and would be desirable to remove prior to the stripping stream.

20

Figure 2 shows a simplified version of the apparatus of Figure 1 for the sake of clarity. The feed and stripping streams are indicated generally by the arrows 90, 92 respectively rather than droplets as in Figure 1. Since 25 the feed stream 90 has a substantially higher flow rate than the stripping stream 92, it tends to dominate in its effect on flow of the carrier liquid 28 within the cell 12. The effect of the feed stream 90 is to cause the carrier liquid to flow or move in a generally downwardly 30 direction as indicated by the arrow 98, mainly due to entrainment and viscous drag by the aqueous feed droplets. In the absence of the feed stream, the stripping stream 92 would tend to have the same effect on the carrier liquid

but due to the much higher flow rate of the feed stream in this case, the overall effect is to promote an anticlockwise flow in the carrier liquid as indicated by the arrows 98, 100, 102 and 104. Therefore, flow of the feed and carrier liquids in the feed region subject to the electrostatic field and indicated by the dotted box 106 are cocurrent whereas flow of the stripping and carrier liquids in the stripping region indicated by the dotted box 108 are countercurrent which is a much more efficient regime of operation with regard to the extraction of the required solute species from the ligand in the carrier liquid.

A further advantageous benefit of the present invention, under the appropriate circumstances, is to promote countercurrent flow simultaneously in both the feed and stripping sides of the cell apparatus as will be described below.

Figure 3 shows a schematic cell 200 according to the apparatus of the present invention. As with the cell 12 of Figures 1 and 2, the cell 200 comprises a feed side 202; a stripping side 204; appropriate aqueous solution supply means 206, 208; receiving vessels 212, 214; electrodes 216, 218, 220, 222 in the feed and stripping cells respectively for establishing electrostatic fields and which may be connected to a power supply similar to that described with reference to 80 in Figure 1; and, a central region 226 situated between the feed and stripping sides 202, 204. The central region 226 is separated from the feed and strip by two separate baffle arrangements 228, 230, respectively which are disposed on either side of the central region 226. The central region 226 is also

provided with electrodes 232, 234 to provide a high voltage electrostatic field therebetween to disperse a stream of aqueous scrubbing liquid from a supply conduit 236 into a plurality of smaller droplets, as in the feed and stripping sides described above, before falling into a receiving vessel 238. Conduit/pump means 240 are also provided to extract the aqueous liquid from the receiving vessel 238.

10 In operation, the apparatus 200 of Figure 4 is supplied with feed and stripping streams 242, 244 respectively. However, a third aqueous scrubbing liquid stream 246 from the supply nozzle 236 is fed into the carrier liquid 248 in the central region 226. The stream 246 is dispersed by
15 the high voltage electrostatic field between the electrodes 232, 234 into a plurality of droplets which react with the complexed ligand in the carrier liquid 248 to remove the species which is unwanted in the product captured in the receiving vessel 214. However, the flow
20 rate of the scrubbing stream 246 is such that it causes the flow direction of the carrier liquid 248 to be in a downward direction as indicated by the arrows 250. At least the flow rate of the stream 246 is such that it dominates the effects produced by the streams 242, 244 and
25 causes two circulation patterns to be established: a clockwise circulation about the baffle 228 in the feed side/central region indicated by the arrows 260; and, an anticlockwise circulation about the baffle 230 in the stripping side/central region indicated by the arrows 262.

30 In the central region the flow directions of both circulation patterns coincide, as indeed they must, since both flow patterns originate from the stream 246 in the central region 226. However, the important aspect is that

the flow directions in the feed region indicated by the dotted box 266 and in the stripping region indicated by the dotted box 268 are both countercurrent to the streams 242 and 244, respectively. Thus, extraction of the required species from the feed stream 242 and extraction of the species from the carrier liquid 248 by the stripping stream 244 are both effected in a more efficient countercurrent regime. The aqueous scrubbing liquid from the stream 246 falls into the receiving vessel 238 and is removed by suitable conduit and pump means indicated by the arrowed line 240 to be recirculated back to the supply nozzle 236. If required, separator means 270 may be placed in the circuit so as to separate aqueous liquid 246 from carrier liquid 248, the latter being fed back to the carrier liquid 248 in the cell by a conduit indicated by the arrow 272.

The central region 226 provides a volume where the loaded carrier liquid moving from the feed side to the stripping side via the baffle 228 and the carrier liquid denuded of the required species by the stripping stream moving back towards the feed side via the baffle 230 may join the appropriate flows and be treated by the scrubbing liquid 246 to remove unwanted species prior to the final concentrated product of the desired species in the vessel 214.

The chemical requirements of the carrier liquid, ligand, feed, scrubbing and stripping liquids will be apparent to those skilled in the art of solvent extraction and need not be elaborated on in this specification.

CLAIMS

1. A method for the extraction of a solute from an aqueous feed solution into an aqueous stripping solution, the method comprising the steps of providing at least one stream of each of said feed solution and said stripping solution passing through a continuous phase of a non-polar carrier liquid; said carrier liquid having therein a chemical having an affinity for ions of at least two species in said solute in said feed solution; each of said at least one streams of feed and stripping solutions being under the influence of a high voltage electrostatic field for at least a part of their passage time through said carrier liquid so as to break up said streams into a multiplicity of droplets of each of said solutions; and, providing mutually separated receiving means to collect the streams of said feed and said stripping solutions after they pass out of said high voltage electrostatic field; said method being characterised by providing means to supply a third aqueous scrubbing solution falling through said carrier liquid; means to disperse said aqueous scrubbing solution into a plurality of droplets; said chemical and said species migrating through said aqueous scrubbing stream where at least some of one of said at least two species are extracted into said scrubbing stream.

2. A method according to claim 2 wherein the third aqueous scrubbing stream is provided in a region substantially between the feed and stripping streams.

3. A method according either claim 1 or 2 wherein the third aqueous scrubbing stream is dispersed into droplets

by the provision of a high voltage electrostatic field through which the scrubbing stream is falling.

4. A method according to any one preceding claim wherein the aqueous scrubbing liquid is chemically different from the stripping liquid.

5. A method according to any one preceding claim wherein baffle arrangements are provided between the feed and scrubbing streams and between the scrubbing and stripping streams.

6. A method according to any one preceding claim wherein the flow rate of the aqueous scrubbing stream is greater than the flow rates of the feed and stripping streams.

7. A method according to any one of preceding claim wherein the aqueous scrubbing liquid is recycled back through the carrier liquid in order to minimise the volume of liquid employed.

8. An apparatus for the extraction of a solute from an aqueous feed solution into an aqueous stripping solution to form a concentrated aqueous product of the desired species, the apparatus comprising vessel means for containing a continuous non-polar carrier liquid, the carrier liquid having therein a chemical having an affinity for ions of at least two species in said solute in said feed solution; means for providing at least one stream of each of said feed and stripping solutions through said carrier liquid in said vessel means; electrode means for applying a high voltage electrostatic field to each of said feed and stripping solution streams so as to cause said streams to break up into a

multiplicity of small droplets; mutually separate receiving means for collecting said feed and stripping solutions after they have passed through said high voltage electrostatic fields, the apparatus being characterised by
5 further including means to supply a third aqueous scrubbing solution through said carrier liquid; means to disperse said aqueous scrubbing solution into small droplets; and means to receive and collect said third aqueous scrubbing stream.

10

9. Apparatus according to claim 8 wherein the means for supplying the third aqueous scrubbing stream is one or a plurality of nozzles.

15

10. Apparatus according to either claim 8 or 9 further including a central region disposed between the feed and strip sides of the cell into which region said third aqueous liquid is introduced.

20

11. Apparatus according to claim 10 wherein the central region is situated between generally vertical baffle arrangements, the baffle arrangements separating the feed and central regions and the central and stripping regions respectively.

25

12. Apparatus according to any one of preceding claims 8 to 11 comprising a plurality of pairs of feed and strip cells, each feed and strip cell having a central scrubbing region lying therebetween.

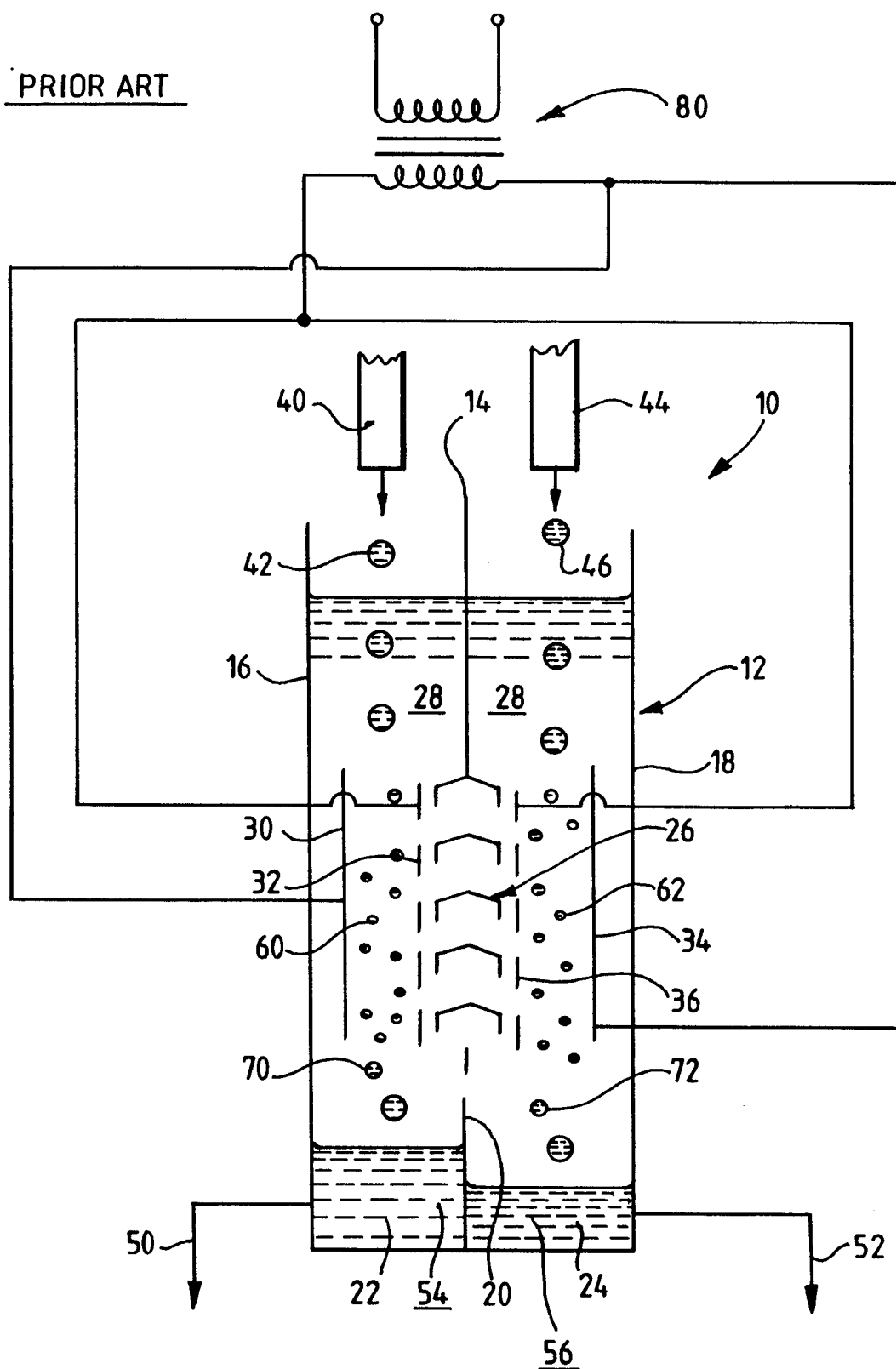
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13. Apparatus according to any one of preceding claims 8 to 12 further including means to extract from and recycle said aqueous scrubbing liquid through said carrier liquid

14. A method for the extraction of a solute from an aqueous feed solution into an aqueous stripping solution substantially as hereinbefore described with reference to
5 the accompanying description and Figures 3 and 4 of the drawings.

15. Apparatus for the extraction of a solute from an aqueous feed solution into an aqueous stripping solution
10 substantially as hereinbefore described with reference to the accompanying description and Figures 3 and 4 of the drawings.

1/3



PRIOR ART

2 / 3

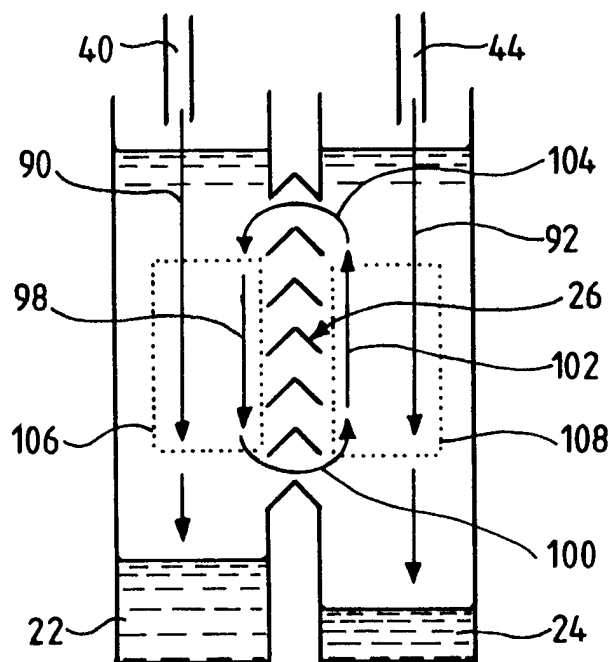


Fig.2.

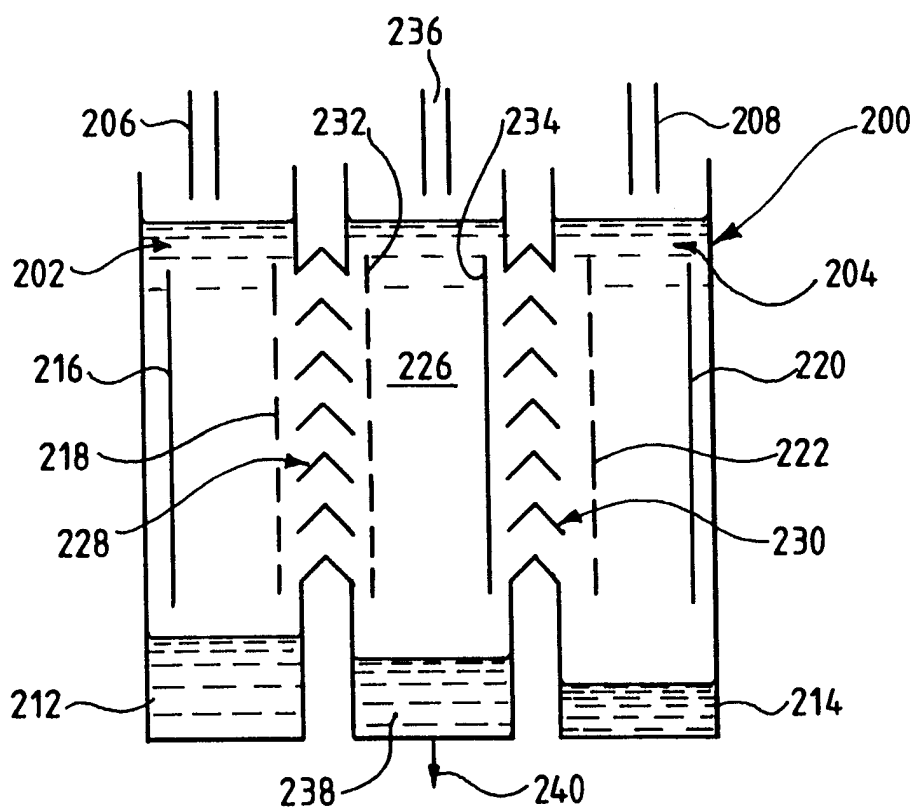


Fig.3.

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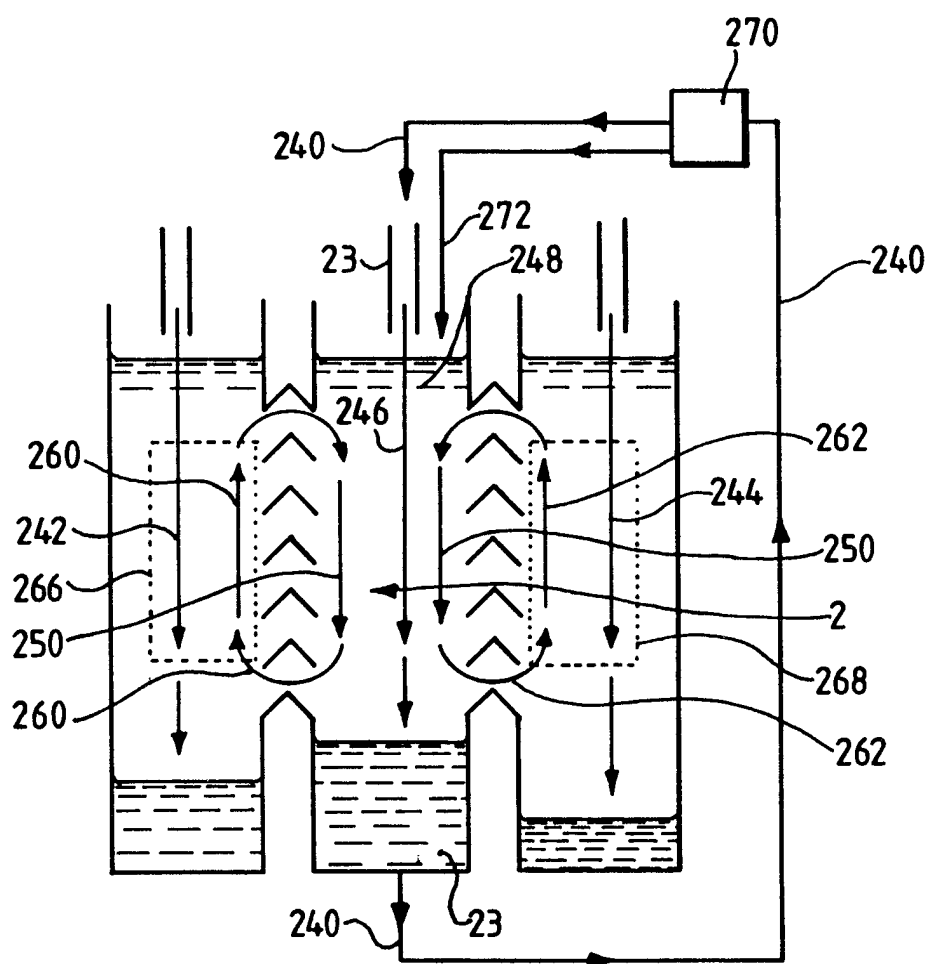


Fig.4.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 98/00967

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 B01D11/04 B01D61/40

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)

IPC 6 B01D

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 practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	YANG X -J ET AL: "EXTRACTION AND SEPARATION OF SCANDIUM FROM RARE EARTHS BY ELECTROSTATIC PSEUDO LIQUID MEMBRANE" JOURNAL OF MEMBRANE SCIENCE, vol. 106, no. 1/02, 13 October 1995, pages 131-145, XP000586952 see abstract; figures 1-4,10; tables 4,6-8 see page 132, column 1, last paragraph - page 135, column 2, paragraph 2 see page 137, column 2, paragraph 3 - page 141, column 1, line 1 see page 141, column 2, last paragraph - page 144, column 1, last line --- -/--	1,8,14,15



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Date of the actual completion of the international search

14 July 1998

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 98/00967

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication where appropriate, of the relevant passages	Relevant to claim No.
A	ZHONGMAO GU ET AL: "LABORATORY AND PILOT PLANT TEST OF YTTRIUM RECOVERY FROM WASTEWATERBY ELECTROSTATIC PSEUDO LIQUID MEMBRANE" JOURNAL OF MEMBRANE SCIENCE, vol. 93, no. 2, 22 August 1994, pages 137-147, XP000488171 see abstract; figures 1-5; table 2 see page 139, column 1, paragraph 2 - page 140, column 2, last line see page 142, column 2, last paragraph - page 143, column 2, line 4 see page 146 ----	1-3,5, 8-12,14, 15
A	ZHONG-MAO GU: "A NEW LIQUID MEMBRANE TECHNOLOGY-ELECTROSTATIC PSEUDO LIQUID MEMBRANE" JOURNAL OF MEMBRANE SCIENCE, vol. 52, no. 1, 15 August 1990, pages 77-88, XP000172713 see abstract; figures 1,2; tables 1,4 see page 78, line 5 - page 86, last line -----	1,8,14, 15