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(54) Title: EXTRACTION OF METAL FROM METAL ORE

(57) Abstract: A settler tank for a solution used as part of a process to extract metal from metal ore, the settler tank being dimensioned such that it may be transported by a conventional truck and trailer. A settler tank for an ore extraction process, the settler tank being provided with a plurality of receiving means arranged to receive one or more flow regulators or flow distributors at different locations within the settler tank.

EXTRACTION OF METAL FROM METAL ORE

The present invention relates to an apparatus and a method which may be used as part of the process of the extraction of metal from metal ore.

Electrowinning has been used for many years to extract metal from metal ore. A liquid leach solution containing the metal to be extracted is obtained by passing a suitable acid over the metal ore. The liquid leach solution may then be subjected to a purification process. An electrical current is then passed through the liquid leach solution. The current passes from an inert anode through the liquid leach solution and onto a cathode. As a result of the electric current, metal from the liquid leach solution is deposited on to the cathode. Over time a layer of the metal builds up on the cathode. The cathode is then removed from the liquid leach solution, and the metal is removed from the cathode.

Electrowinning (sometimes referred to as electroextraction) is commonly used to extract copper from copper ore. When a sufficiently large deposit of copper ore is found, it is conventional to build a bespoke copper extraction plant adjacent to the copper ore deposit. A typical bespoke copper extraction plant will include tanks which are the size of substantial buildings (e.g. with a capacity of more than 1 million litres. Such tanks may be used for example to store liquid leach solution, or to form part of a chemical process used to increase the concentration of copper ore in the liquid leach solution. In addition, such plants typically comprise many tens or hundreds of electrowinning cells, which may for example measure several metres along each side. The investment required to build such a plant is typically of the order of tens or even hundreds of millions of US dollars. For this reason, a copper ore deposit must include a substantial volume of copper ore in order for it to be economically viable to build such a plant. Smaller deposits of ore do not contain sufficient ore for it to be economically viable for a bespoke plant to be built. So called tailings dumps may exist at locations where copper extraction has previously been performed. The concentration of copper in tailings dumps may not be high enough for it to be economically viable for a bespoke plant to be built.

It is an object of the present invention to overcome or mitigate the above disadvantage.

According to a first aspect of the present invention there is provided a settler tank for a solution used as part of an ore extraction process, the settler tank being dimensioned such that it may be transported by a conventional truck and trailer.

Preferably, the settler tank is preassembled.

The settler tank may be less than 13.7 metres long, less than 2.5 metres wide and less than 2.9 metres high. The settler tank may be less than 12.2 metres long, less than 2.5 metres wide and less than 2.6 metres high. The settler tank may be less than 6.1 metres long, less than 2.5 metres wide and less than 2.6 metres high. The settler tank may be up to 18 metres long. The settler tank may have a volume of 6 m^3 or less.

According to a second aspect of the invention, there is provided settler tank for an ore extraction process, the settler tank being provided with a plurality of receiving means arranged to receive one or more flow regulators or flow distributors at different locations within the settler tank.

The receiving means may be arranged to allow a flow regulator or flow distributor to be removed from a first location within the settler tank and positioned at a second location within the settler tank. The receiving means may comprise slots arranged to receive the flow regulators or flow distributors. The slots may be provided in walls of the settler tank. The slots may be defined by flanges which extend from walls of the settler tank. The receiving means may comprise a bore which passes partway into the tank, the bore being configured to receive a post such that the post extends upwardly in the settler tank.

According to a third aspect of the invention, there is provided a settler tank for an ore extraction process, the settler tank comprising one or more flow regulators or flow distributors held by receiving means within the settler tank, the receiving means comprising slots which allow the one or more flow regulators or flow distributors to be removed from the settler tank or moved to different locations within the settler tank as desired. The settler tank may further comprise a weir which may be removed from the settler tank or moved to different locations within the settler tank as desired.

The settler tank according to the second or third aspect of the invention may have dimensions according to the first aspect of the invention.

According to a fourth aspect of the invention there is provided a modular ore extraction plant comprising a plurality of settler tanks connected to one another. The modular ore extraction plant may comprise at least three settler tanks. The settler tanks may have the same or similar dimensions. At least one of the settler tanks may be an extraction tank and at least one of the settler tanks may be a stripping tank.

According to a fifth aspect of the invention there is provided a settler tank for use in a solvent extraction process, said tank comprising at least two connectors for operably connecting a mixing vessel for mixing material prior to discharging mixed material into said tank, said connectors being provided at spaced locations around the periphery of the tank such that a mixing vessel can be operably connected at one of said at least two spaced locations.

According to a sixth aspect of the invention there is provided a settler tank for use in a solvent extraction process, said tank comprising connectors for connection to a fluid flow regulator and a weir member, wherein said connectors are configured to facilitate selective positioning of one of said fluid flow regulator and weir member such that said one is positioned closer to an end wall of the tank than the other of said fluid flow regulator and weir member.

Specific embodiments of the invention will be described by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic illustration of a process for extracting metal from metal ore which may include an embodiment of the invention;

Figures 2 to 4 are diagrams of a plurality of settler tanks according to an embodiment of the invention which are used as part of the metal extraction process;

Figures 5 and 6 are diagrams of a single extraction tank according to an embodiment of the invention which is used by the metal extraction process;

Figure 7 is a diagram which shows connections between the plurality of tanks; and

Figure 8 is a diagram of a plurality of electrowinning cells which are used as part of the metal extraction process.

Figure 1 schematically shows a process for extracting metal from metal ore. The process is generally known from the prior art, but may incorporate an embodiment of the invention (as is described in relation to subsequent figures). A heap of copper ore 2 rests upon a high density polyethylene liner 4. The liner 4 and copper ore heap 2 lie on a slope. A trench 6 is located at a bottom end of the slope. Dilute sulphuric acid is sprayed from a spray head 8 onto the copper ore heap 2. Although the spray head 8 is shown as applying spray to only a small portion of the copper heap 2, this is merely schematic. A plurality of spray heads may be used to apply the dilute sulphuric acid onto the copper ore heap 2 such that the majority of the copper ore heap 2 receives dilute sulphuric acid. Alternatively or additionally drippers, hoses and the like may be used to direct sulphuric acid onto the copper ore 2.

The dilute sulphuric acid passes through the copper ore heap 2, and dissolves copper out of the copper ore. The resulting solution, which is referred to as pregnant leach solution, flows down over the sloped high density polyethylene liner 4 into the trench 6. The pregnant leach solution then flows from the trench 6 into a pregnant leach solution tank 10. The pregnant leach solution may for example comprise 8 grams per litre of copper. The pregnant leach solution is pumped by a pump 12 to a

solvent extraction plant 14 where the concentration of the copper in the solution is increased from 8 grams per litre to approximately 45 grams per litre (this solution is referred to as rich electrolyte). The solvent extraction plant 14 is described further below. In general terms, the solvent extraction plant 14 operates by extracting copper ions from the initial pregnant leach solution using an organic phase extractant and then transferring the copper ions back into aqueous solution in the rich electrolyte.

The rich electrolyte is pumped using a pump 16 from the solvent extraction plant 14 to a rich electrolyte storage tank 18. The rich electrolyte is then pumped using a pump 20 to an electrolyte concentration adjustment plant 22. The electrolyte concentration adjustment plant 22 comprises a rich electrolyte tank 24 and a lean electrolyte tank 26. The rich electrolyte is received in the rich electrolyte tank 24. Lean electrolyte, which is received from electrowinning cells, is delivered to the lean electrolyte tank 26. A proportion of the lean electrolyte, which may for example have a copper concentration of 30 grams per litre, passes into the rich electrolyte tank 24. This reduces the copper concentration of the rich electrolyte solution from 45 grams per litre to 33 grams per litre.

Electrolyte is pumped from the rich electrolyte tank 24 using a pump 28 into a plurality of electrowinning cells 30. Each electrowinning cell comprises a tank into which electrolyte is pumped, and is provided with an anode and a cathode. A DC electrical current is passed between the anode and the cathode. This causes copper to be drawn out of the electrolyte and to be deposited on the cathode. Over a period of time copper builds up on the cathode. The cathode is then removed from the tank to allow the copper to be removed and sold.

Electrolyte with a copper concentration of 30 grams per litre passes from each electrowinning cell 30 into the lean electrolyte tank 26. A pump may not be required to achieve this, if the electrowinning cells 30 are positioned higher than the lean electrolyte tank 26, since gravity may be used to maintain the flow of the electrolyte from the electrowinning cells into the lean electrolyte tank 26. A proportion of the

lean electrolyte is pumped using a pump 32 from the lean electrolyte tank 26 into the solvent extraction plant 14.

As can be seen from Figure 1, the process illustrated is a continuous process, and fluids are reused by the process. Dilute sulphuric acid which is output from the solvent extraction plant 14 is pumped using a pump 34 to the spray head 8, from which it is sprayed onto the copper ore heap 2.

Over time the concentration of copper ore in the copper ore heap 2 is depleted to a level at which no significant further copper is extracted from the copper ore heap 2. At this time the spray of dilute sulphuric acid from the spray head 8 is switched off, and the dilute sulphuric acid is instead passed to another copper ore heap (not illustrated). In practice, several copper ore heaps may be processed at any given time. A copper ore heap for which processing has been completed may be treated to extract any remaining sulphuric acid, for example by washing the copper ore using lime.

In the illustrated process 560 litres per minute of electrolyte are passed through the electrowinning cells 30. The solvent extraction plant 14 delivers rich electrolyte at a rate of 37.3 litres per minute. Dilute sulphuric acid is delivered to the copper ore heap 2 at a rate of 74.7 litres per minute.

The concentrations of copper per litre indicated in the description of figure 1 are intended as examples only, and the scope of the invention is not limited to these concentrations.

Figures 2 to 4 are diagrams which show settler tanks according to an embodiment of the invention, that comprise the solvent extraction plant 14. The solvent extraction plant 14 comprises three extraction tanks 40a-c, and a stripping tank 42 (these may all be considered to be settler tanks). Each extraction tank 40a-c is connected to a mixer 44a-c. The stripping tank 42 is also connected to a mixer 46.

The extraction tanks 40a-c and stripping tank 42 each have the same shape and dimensions. This means that only a single design of tank is required, thereby making manufacture of the tanks simpler. Tanks with different designs may be used however. The dimensions of the tanks are shown in Figure 4 (all dimensions being indicated in millimetres). As indicated by Figure 4, each tank internally measures 4,200 mm by 2000 mm, and has a depth of approximately 700 mm. The external dimensions of the tanks are slightly larger than this. The external dimensions of the tanks 40a-c, 42 are such that they may be transported using a conventional truck. That is to say that they are less than the standard exterior dimensions of one of the shipping containers specified by the International Organisation for Standardisation (i.e. less than 6.1 x 2.5 x 2.6 metres).

Although specific dimensions are shown in figure 4, these are by way of example only, and other dimensions may be used. However, it is preferable that the tanks are sufficiently small that they can be transported using conventional vehicles (i.e. without requiring specialist transport vehicles). The tanks may be dimensioned such that they are not larger than a shipping container, for example less than 6.1 x 2.5 x 2.6 metres). The tanks may be dimensioned so that they fit inside a shipping container, for example the most commonly occurring shipping container (e.g. 5.7 x 2.3 x 2.3 metres or less).

Although in general shipping containers have the same height and width, they may have different lengths. For example, some shipping containers are 12.2 metres long and some are 13.7 metres long. In some instances, shipping containers may be 2.9 metres high. The tanks may be dimensioned such that they may are not larger than these shipping containers (i.e. be up to 13.7 metres long and up to 2.9 metres high). In this way, the tanks are transportable using a truck and trailer which is dimensioned to transport a shipping container.

The settler tank may for example be up to 18 metres long – this is often the maximum length that is permitted to travel by road according to government transport regulations.

As mentioned, the extraction tanks 40a-c and the stripping tank 42 are the same. This means that when a new plant is being assembled, only one design of tank needs to be provided (rather than the conventional two designs). Due to the small size of the tanks (compared with conventionally used tanks), the tanks may be easily transported to the site of the new plant using conventional trucks and trailers. It is not essential that the stripping tank is the same as the extraction tanks, and there may be differences in their dimensions or other aspects of their design. The tanks may have the same or similar dimensions (the term "similar dimensions" is intended to mean that the dimensions vary by less than 20% between tanks, and for example vary by less than 10% between tanks).

Each of the mixers 44a-c, 46 is approximately 1,400 mm in height, and has a diameter of 1,200 mm. The mixers are sufficiently small that they be conveniently transported to the site of a new plant using conventional trucks and trailers.

Each mixer 44a-c, 46 is provided with a channel 50a-c, 52 which opens into a slot provided at an upper end of each mixer 44a-c, 46. The channel 50a-c, 52 is dimensioned to fit together with a corresponding channel 54a-c, 56 provided in each tank 40a-c, 42. The channels 50a-c, 52 may be provided with flanges which may be bolted together to connect each tank 40a-c, 42 to an adjacent mixer 44a-c, 46.

Each of the tanks 40a-c, 42 is provided with internal components, some of which are shown in figure 2. These internal components are described further below in relation to figure 5.

Each tank 40a-c, 42 has a height which is significantly less than the height of each mixer 44a-c, 46. For this reason, the tanks 40a-c, 42 are supported on plinths 60, which may for example be formed from concrete. Each plinth 60 may for example have a height of 700 mm. In order to provide good stability, each mixer 44a-c, 46 may also be provided on a plinth 62. In order to ensure that the heights of the

channels 50a-c, 52, 54a-c, 56 correspond, the height of these plinths 62 are substantially less, in this case being 100 mm.

Based on the above internal dimensions, the volume of each tank 40a-c, 42 is around 5.9 m^3. The tanks may be constructed for example to provide a volume of 6 m^3 or less. The volume of a given tank may be increased by extending upwards the sidewalls of that tank. This may be achieved by adding pre-made walls, which may be connected for example using flanges provided on the walls and corresponding flanges provided on the tank.

Figure 3 shows the tanks 40a-c, 42 and mixers 44a-c, 46 from the same perspective, but with covers provided on each of them, and pipes provided between the tanks 40a-c, 42 and mixers 44a-c, 46 shown. The pipes carry fluid between the tanks 40a-c, 42 and mixers 44a-c, 46. This is described in more detail in relation to figure 7.

Figure 5a shows a perspective view of an extraction tank 40a and mixer 44a. Figure 5b shows a view from above of the same extraction tank 40a and mixer 44a. A first flow regulator or distributor 70 comprising a plurality of spaced baffles (which may be referred to as a "picket fence"), a second picket fence 72, a weir 74, and a wall 76 are releasably received in the tank 40a.

The first picket fence 70 is located near to an end of the extraction tank 40a which is adjacent to the mixer 44a. The first picket fence is formed from four pieces 70a-d. Each piece comprises a series of upright baffles separated from one another and held together by cross-pieces. Slots 78 provided in the walls of the tank 40a are positioned to receive ends of the picket fence pieces 70a-d. A post 80 extends upwardly in a position which is between the slots 78 but displaced slightly along the length of the tank. The post 80 is provided with slots 82 which receive the picket fence pieces 70a-d.

The picket fence pieces 70a-d are received in the slots 78, 80 such that they extend across the extraction tank 40a. The picket fence pieces 70a-d are arranged in pairs 70a,d, 70b,c, one behind the other, such that fluid flowing through the tank 40a must pass through one picket fence piece 70a,b of each pair and then through the other picket fence piece 70c,d of each pair. The position of the post 80 is such that the first picket fence 70 does not extend in a straight line across the tank 40a, but instead forms an open v-shape. That is to say, the middle of the first picket fence 70 is further from the adjacent end of the extraction tank 40a than edges of the picket fence 70.

The second picket fence 72 is provided towards the centre of the extraction tank 40a. The second picket fence 72 extends in a straight line across the extraction tank 40a. The second picket fence 72 is held in slots 84 provided in the walls of the extraction tank 40a.

Although the slots 84 shown in figure 5 are formed in the walls of the extraction tank 40a, in an alternative arrangement they may be defined by flanges which project from walls of the extraction tank. Where this is the case, it is not necessary for the slots to extend fully from the top to the bottom of the extraction tank. Instead, a plurality of flanges may define a plurality of slots which are vertically separated from one another and which receive a picket fence.

The weir 74 may be seen more clearly in figure 6, which is a cross-sectional view of the extraction tank 40a and mixer 44a viewed from one side. Loaded organic phase L containing copper and raffinate R, i.e. the fluid remaining after extraction of copper, are also shown in figure 6. The weir 74 does not extend to the top of the extraction tank 40a, and neither does it extend to the bottom of the extraction tank 40a. The weir 74 forms part of a liquid separation component 85, which is substantially u-shaped in cross-section. The u-shape of the liquid separation component 85 is arranged to hold liquid prior to that liquid being removed from the extraction tank 40a, and is referred to here as the liquid storage area 86.

The wall 76 extends from an upper end of the extraction tank 40a into the liquid storage area 86, dividing the liquid storage area 86 in two areas. A first of these areas 86a receives loaded organic phase L, and is therefore referred to here as the loaded organic phase storage area 86a. The second area 86b receives raffinate R, and is therefore referred to here as the raffinate storage area 86b.

A first outlet 87 is provided partway up the wall of the extraction tank 40a, and is positioned to allow loaded organic phase L to be removed from the loaded organic phase storage area 86a. A second outlet 88 is connected beneath the loaded organic phase storage area 86a, and thus also allows loaded organic phase L to be removed from the loaded organic phase storage area.

A one way valve system 90 is located adjacent to the liquid separation component 85, and is arranged to direct raffinate R which has flowed underneath the liquid separation component 85 into the raffinate storage area 86b. A third outlet 92 is provided partway up the wall of the extraction tank 40a, and is positioned to allow raffinate R to be removed from the raffinate storage area 86b. A fourth outlet 94 is connected beneath the raffinate storage area 86b, and thus also allows raffinate R to be removed from the raffinate storage area 86b.

Although a particular configuration of picket fences 70, 72, liquid separation component 85 (including weir 74), wall 76 and one way valves 90 has been shown, other configurations may be used. For example, only a single picket fence may be used. The picket fence may be in a location which is different from the locations shown in figures 5 and 6. Alternatively two or more picket fences may be provided, some or all of which may be in positions which differ from those shown in figures 5 and 6. The extraction tank 40a may be provided with a plurality of slots at different locations, the slots being arranged to receive ends of picket fences. In this way, flexibility regarding the positioning of the picket fences is achieved. Similarly, the extraction tank may include a plurality of threaded bores (or other receiving means) arranged to receive posts which receive ends of the picket fences.

The liquid separation component 85 may be removable from the extraction tank 40a. For example, the liquid separation component may be held in place by the use of protrusions which protrude from the walls of the extraction tank such that the liquid separation component may rest upon them. Similar protrusions (or other holding means) may be provided at other locations in the extraction tank, to allow the liquid separation component to be positioned at other locations in the extraction tank. Corresponding outlets may also be provided. The outlets may include valves which allow them to be closed in the event that they are not being used.

The wall 76 may be held in slots provided in walls of the extraction tank 40a. Similar slots may be provided at other locations in the extraction tank 40a, to allow the wall to be positioned at other locations in the extraction tank.

As explained above, each of the components, i.e. fence 70,72, weir 74 and wall 76, provided within the extraction tank 40a may be moved to different positions. This provides a high degree of configurability of the extraction tank. The configuration of the extraction tank may be adjusted for example if a different rate of flow of liquid is desired, or if a different number of extraction tanks is to be used.

Each internal component, i.e. fence 70,72, weir 74 and wall 76, can be secured in the correct position within the tank 40a to suit a particular application and then, if desired, removed and repositioned for a subsequent application. It is anticipated that in some applications it will be desirable to provide the components 70,72,74,76 in a first orientation, for example, as shown in Figure 5a, and then, after using the tank 40a, to reverse the order of some or all of the components 70,72,74,76. In this way, the same tank 40a can be used in many different applications with its internal components 70,72,74,76 arranged to suit the particular application in hand. Tank 40a in accordance with a preferred embodiment of an aspect of the present invention is therefore significantly more adaptable to a range of different applications than prior art settler tanks.

In a further embodiment of the settler tank according to an aspect of the present invention not depicted in the accompanying drawings, the settler tank is provided with suitable connectors to enable a mixer to be connected at two or more locations around the periphery of the tank. By way of example, as shown in Figure 2, the tank 40a incorporates a first channel 54a for connection to a corresponding channel 50a connected to its respective mixer 44a. In accordance with the further embodiment, tank 40a may be modified to incorporate at least one further channel (not shown) extending from an upper portion of the opposite end wall of the tank 40a. In this way, the mixer 44a could be disconnected from the channel 54a to which it is shown connected in Figure 5a, moved to the opposite end of the tank 40a, and then connected to the further channel (not shown) which extends from the opposite end wall to which it is now adjacent. This further embodiment thus enables the orientation of a mixer relative to its respective tank to be reversed to suit a particular application.

It will be appreciated from the foregoing that a tank according to an aspect of the present invention, incorporating both means to releasably receive internal components, such as flow regulators, weirs, walls etc, and two or more means for connection to a dedicated mixer at different locations around the periphery of the tank, affords the user with significantly more freedom to configure the tank and its components in the most appropriate manner to suit a specific application than prior art settler tanks. The relatively small size of tanks according to aspects of the present invention further enhances this flexibility in that it allows a modular system of multiple tanks to be established at a particular site in which the configuration of each tank, and therefore the overall system, can be optimised to suit the current application and then easily modified, if necessary, to take account of changes in the processing requirements of the system.

The number of tanks which are used for a given application may be selected in order to provide a desired capacity for that application. This provides desirable flexibility of configuration. In the illustrated example, one stripping tank and three extraction tanks are used. However, two extraction tanks, four extraction tanks, or

any other number of extraction tanks may be used. Similarly, any number of stripping tanks may be used.

Referring to figure 6, in use pregnant leach solution is delivered to the mixer 44a. An extractant is also introduced into the mixer 44a. Any suitable extractant may be used, such as an oxime in an organic solvent, for example kerosene. The pregnant leach solution and extractant are mixed by rotating blades 96 which are driven by a motor 97. The mixture overflows via the channel 50a, 54a into the extraction tank 40a. Typically mixture which overflows in this manner has been mixed for around 3 minutes.

In the extraction tank 40a the mixture M separates into the loaded organic phase L and the aqueous raffinate R as mentioned above. The mixture M is shown in the extraction tank 40a in dark grey, and can be seen to separate into the loaded organic phase L and aqueous raffinate R as the liquid flows through the extraction tank 40a (moving from right to left in figure 6). The loaded organic phase L is less dense than the aqueous raffinate R, and so settles above the aqueous raffinate R. The first and second picket fences 70, 72 reduce the amount of turbulence present in the liquid as it flows through the extraction tank 40a, thereby allowing improved separation of the loaded organic phase L and aqueous raffinate R to occur.

Since the loaded organic phase L floats above the aqueous raffinate R, only loaded organic phase L passes over the weir 74 and into the loaded organic phase storage area 86a. The loaded organic phase L is removed from the extraction tank 40a via the first and second outlets 87, 88.

The aqueous raffinate R flows underneath the liquid separation component 85, and is delivered by the one way valve system 90 into the aqueous phase storage area 86b. The aqueous raffinate R is removed from the extraction tank 40a via the third and fourth outlets 92, 94.

The efficiency of the extraction process may be improved by having more than one extraction tank (the organic phase has a limited loading capacity). Thus, more than one extraction tank, and associated mixers, may be provided together as a solvent extraction plant (labelled 14 in figure 1). An example of a solvent extraction plant comprising one stripping tank 42 and three extraction tanks 40a-c has been shown in figures 2 to 4. The operation of the tanks will now be described in relation to figure 7.

A stripping tank 42, outputs extractant (labelled E in figure 7). The extractant comprises reagent dissolved in a solvent (i.e. organic phase which has not been loaded). The extractant E passes to an input of a first mixer 44c associated with a first extraction tank 40c. The extractant also E passes to an input of a second mixer 44b associated with a second extraction tank 40b. The first mixer 44c also receives pregnant leach solution from the pregnant leach solution tank 10 (see figure 1). The mixer 44c mixes the extractant and the pregnant leach solution, and passes the mixture to the first extraction tank 40c. The mixture is separated by the first extraction tank 40c, with loaded organic phase (containing copper) on top and decopperised solution (raffinate) on the bottom. The majority of the raffinate (labelled R in figure 7) passes from the first extraction tank 40c to the spray head 8 (optionally via a pond or reservoir in which the raffinate can be conditioned ready for use) and onto the copper ore heap 2 (figure 1). The raffinate may for example be the dilute sulphuric acid which is mentioned above in the description of figure 1. A smaller proportion of the aqueous raffinate R passes back to the first mixer 44c. The majority of the loaded organic phase (labelled L in figure 7) passes to the mixer 46 which is associated with the stripping tank 42. A smaller proportion of the loaded organic phase L passes back to the first mixer 44c. Recirculating a small amount of raffinate R and loaded organic phase L back to the first mixer 44c is optional. Recycling of fluids R and L can be carried out in the present preferred embodiment of the invention because each tank 40a,c,b and 42 has the same pipe connectors and so tank 40c is already provided with suitable connectors to facilitate piping of fluids R and L back from the tank 40c to its respective mixer 44c. It will be appreciated that provision of suitable connectors on tank 40c does not necessitate pumping of fluid R or fluid L back to the mixer 44c. Rather, the modular nature of the inventive tanks

forming part of the system depicted in Figure 7 affords the user the flexibility to chose whether or not to recycle an amount of fluid R and/or fluid L back to the mixer 44c to improve the efficiency and/or performance of the solvent extraction process.

The second mixer 44b associated with the second extraction tank 40b receives extractant E from the stripping tank 42. In addition, it receives aqueous raffinate R from the third extraction tank 40a. The second mixer 44b mixes these fluids and passes them to the second extraction tank 40b. The mixture is separated into raffinate R and loaded organic phase by gravity in the second extraction tank 40b. The majority of the aqueous raffinate R passes onto the copper ore heap 2. A smaller proportion of the aqueous raffinate R passes back to the second mixer 44b. The majority of the loaded organic phase L passes to the third mixer 44a. A smaller proportion of the loaded organic phase L passes back to the second mixer 44b. Recirculating a small amount of fluids R and L from the second tank 40b to the second mixer 44b is optional, but may be preferred in certain applications where is increases the efficiency and/or performance of the solvent extraction process. As mentioned above in respect of the first tank 40c and mixer 44c, the ability to recirculated fluids R and L is derived from the provision of suitable connectors resulting from the modular nature of the tanks 40a-c, 42, and increases the adaptability of the solvent extraction process and its components to suit a particular application.

The third mixer 44a associated with the third extraction tank 40a receives pregnant leach solution from the pregnant leach solution tank 10, and receives loaded organic phase L from the second extraction tank 40b. The third mixer 44a mixes these fluids and passes them to the third extraction tank 40a. The mixture is separated into raffinate R and loaded organic phase by gravity in the third extraction tank 40a. The majority of the aqueous raffinate R passes to the second mixer 44b. A smaller proportion of the aqueous raffinate R passes back to the third mixer 44a. This step is again optional and is available to the user due to the modular nature of the third tank 40a. The majority of the loaded organic phase L passes to the mixer 46 which is associated with the stripping tank 42. A smaller proportion of the loaded organic

phase L passes back to the third mixer 44a. This step is also optional and is available in view of the modular nature of the third tank 40a.

The mixer 46 associated with the stripping tank 42 receives loaded organic phase L (i.e. loaded with copper) from the first and third extraction tanks 40a,c. The mixer 46 also receives lean electrolyte LE from the lean electrolyte supply 26 (see figure 1). The mixer 46 mixes the loaded organic phase L and the lean electrolyte LE, and passes the mixture to the stripping tank 42. The copper transfers from the organic phase to the electrolyte; that is to say the electrolyte becomes rich electrolyte. The organic phase is stripped of copper (this is the origin of the name 'stripping tank'). This stripped organic phase comprises regenerated extractant which can then be reused as described below. The majority of the rich electrolyte RE passes to the rich electrolyte tank 24 (see figure 1), from which it passes to the electrowinning cells 30. A smaller proportion of the rich electrolyte RE passes back to the mixer 46. The majority of the regenerated extractant E passes to the first mixer 44c associated with the first extraction tank 40c, and to the second mixer 44b associated with the second extraction tank 40b. A smaller proportion of the extractant E passes back to the mixer 46 associated with the stripping tank 42.

Figure 8 is a drawing which shows in more detail the electrowinning cells 30 of figure 1. Ten electrowinning cells 100 are supported by an elevated platform 120. The elevated platform 120 comprises a frame which supports a timber floor upon which an operator may walk. The floor is provided with openings within which the electrowinning cells 100 may rest. The electrowinning cells 100 extend partway through the platform 120.

A transformer rectifier 130 is provided to one side of the platform 120. Electrical connections 132, 134 connect the transformer rectifier 130 to the electrowinning cells via a metal frame which is provided on the platform 120. Steps 136 are provided at an opposite side of the platform 120 to allow an operator to conveniently access the platform. Although connections of fluid pipes to the electrowinning cells are not shown in Figure 8, these will be as shown in Figure 1.

The platform 120 is approximately 2 metres in height, and is supported on a series of pillars 122. If it is desired to provide additional electrowinning cells, then this may be achieved by providing more pillars and extending the platform 120 as appropriate. An electrical connector 136 connects electrowinning cells 100 at a far end of the platform 120 from the transformer rectifier 130. This electrical connector 136 is provided with conveniently disengageable electrical connection clamps, which allow convenient disconnection and subsequent connection to other electrowinning cells. The number of electrowinning cells may therefore easily be adjusted according to the requirements of the electrowinning process being performed.

Each electrowinning cell in this example is 1620 mm by 1438 mm, and has a depth of 1320 mm. The electrowinning cells are significantly smaller than currently used conventional electrowinning cells. This means that they are more easily transported and installed. The relatively small dimensions of the electrowinning cells also allow finer adjustment of the capacity of an electrowinning process than would previously been available. The dimensions referred to here are examples only, and electrowinning cells having other dimensions may be used. For example, electrowinning cells which measure less than 2m x 2m x 2m may be used.

In use, rich electrolyte is passed through the cells 100. An anode and a cathode are located in each cell, and an electrical current is passed through each cell. The electrical current is a DC current of typically around $300A/m^2$, and is provided by the transformer rectifier 130 (transformed and rectified from mains electricity). The temperature of the electrolyte may be for example 50 to 60 °C. The potential difference may be for example ~2 V. The electrical current causes copper to be deposited on cathodes in the electrowinning cells. Once a desired amount of copper has been deposited on a given cathode, that cathode is lifted out of the cell. The copper is then removed from the cathode to be sold. The cathode may then be replaced in the cell. While any desirable type of cathode may be employed, such as a reticulated or flat plate cathode, it is generally preferred that flat plate cathodes are used as they are relatively easy and quick to clean and reuse.

Copper may be removed from the cathode by using for example a manually operated hydraulic tool. The tool may be arranged to flex the cathode. Since the copper is less flexible than the material of the cathode (which may for example be stainless steel), the copper falls off the cathode when the bending applies a sufficient curvature to the cathode.

The dimensions and copper concentrations referred to in the above description are given as examples only, and are not intended to limit the scope of the invention. Although the invention has been described in terms of coppers extraction, the invention may be used for extraction of other metals, for example cobalt or nickel.

Since the mixers and settler tanks are pre-made (i.e. not fabricated on site) and have suitable dimensions, once all of the commercially viable copper has been removed from ore at a particular site, the mixers and settler tanks may be moved to a new site and used again. The mixers and settler tanks may be moved between sites using conventional trucks. Similarly, the small size of the electrowinning cells allows these to be conveniently moved to a new site. Other parts of the ore extraction plant, such as the transformer rectifier and the hydraulic copper removal tool, are also dimensioned such that they may be conveniently moved to a new site using conventional trucks.

Claims

1. A settler tank for a solution used as part of a process to extract metal from metal ore, the settler tank being dimensioned such that it may be transported by a conventional truck and trailer.

2. The settler tank of claim 1, wherein the settler tank is less than 13.7 metres long, less than 2.5 metres wide and less than 2.9 metres high.

3. The settler tank of claim 1, wherein the settler tanks is less than 12.2 metres long, less than 2.5 metres wide and less than 2.6 metres high.

4. The settler tank of claim 1, wherein the settler tanks is less than 6.1 metres long, less than 2.5 metres wide and less than 2.6 metres high.

5. The settler tank of claim 1, wherein the settler tank has a volume of 6 m^3 or less.

6. A settler tank for an ore extraction process, the settler tank being provided with a plurality of receiving means arranged to receive one or more flow regulators or flow distributors at different locations within the settler tank.

7. The settler tank of claim 6, wherein the receiving means are arranged to allow a flow regulator or flow distributor to be removed from a first location within the settler tank and positioned at a second location within the settler tank.

8. The settler tank of claim 6 or claim 7, wherein the receiving means comprise slots arranged to receive the flow regulators or flow distributors.

9. The settler tank of claim 8, wherein the slots are provided in walls of the settler tank.

10. The settler tank of claim 8, wherein the slots are defined by flanges which extend from walls of the settler tank.

11. The settler tank of any of claims 6 to 10, wherein the receiving means comprises a bore which passes partway into the tank, the bore being configured to receive a post such that the post extends upwardly in the settler tank.

12. A settler tank for an ore extraction process, the settler tank comprising one or more flow regulators or flow distributors held by receiving means within the settler tank, the receiving means comprising slots which allow the one or more flow regulators or flow distributors to be removed from the settler tank or moved to different locations within the settler tank as desired.

13. The settler tank of claim 12, wherein the settler tank further comprises a weir which may be removed from the settler tank or moved to different locations within the settler tank as desired.

14. The settler tank of any of claims 6 to 13, wherein the settler tank has dimensions or a volume according to any of claims 1 to 5.

15. A modular ore extraction plant comprising a plurality of settler tanks connected to one another.

16. The modular ore extraction plant of claim 15, comprising at least three settler tanks.

17. The modular ore extraction plant of claim 15 or claim 16, wherein the settler tanks have the same or similar dimensions.

18. The modular ore extraction plant of any of claims 15 to 17, wherein at least one of the settler tanks is an extraction tank and at least one of the settler tanks is a stripping tank.

19. A settler tank for use in a solvent extraction process, said tank comprising at least two connectors for operably connecting a mixing vessel for mixing material prior to discharging mixed material into said tank, said connectors being provided at spaced locations around the periphery of the tank such that a mixing vessel can be operably connected at one of said at least two spaced locations.

20. A settler tank for use in a solvent extraction process, said tank comprising connectors for connection to a fluid flow regulator and a weir member, wherein said connectors are configured to facilitate selective positioning of one of said fluid flow regulator and weir member such that said one is positioned closer to an end wall of the tank than the other of said fluid flow regulator and weir member.

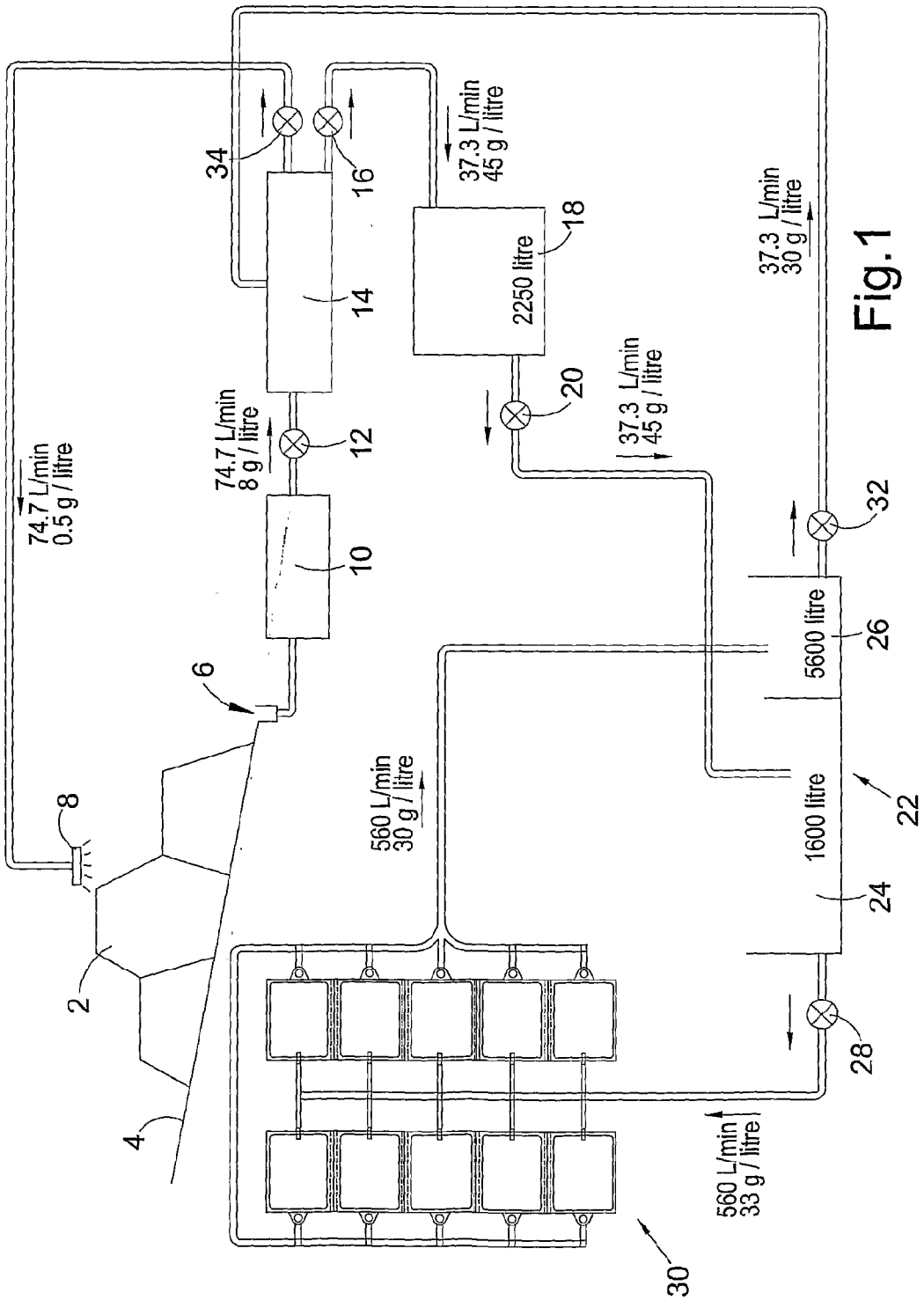

74.7 L/min
0.5 g / litre
74.7 L/min
8 g / litre
37.3 L/min
45 g / litre
37.3 L/min
45 g / litre
37.3 L/min
30 g / litre
37.3 L/min
45 g / litre
560 L/min
30 g / litre
560 L/min
33 g / litre
2250 litre
5600 litre
1600 litre
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34

Fig.1

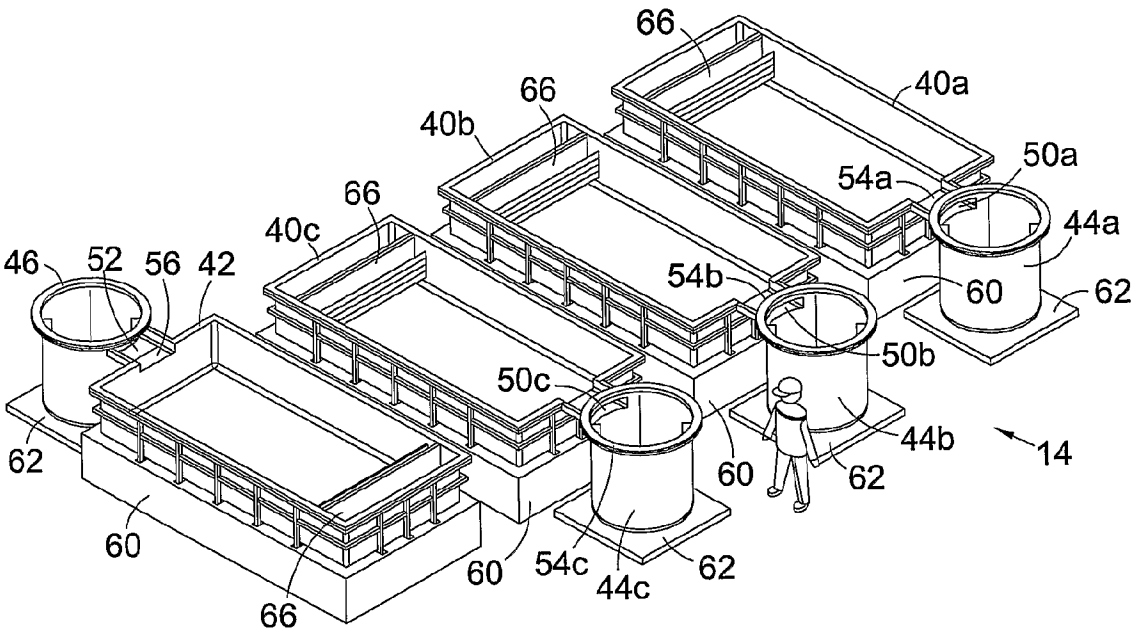

66
66
66
66
40a
40b
40c
50a
54a
44a
46
52
56
42
54b
60
62
50b
50c
44b
14
62
60
62
60
60
54c
44c
62
66

Fig.2

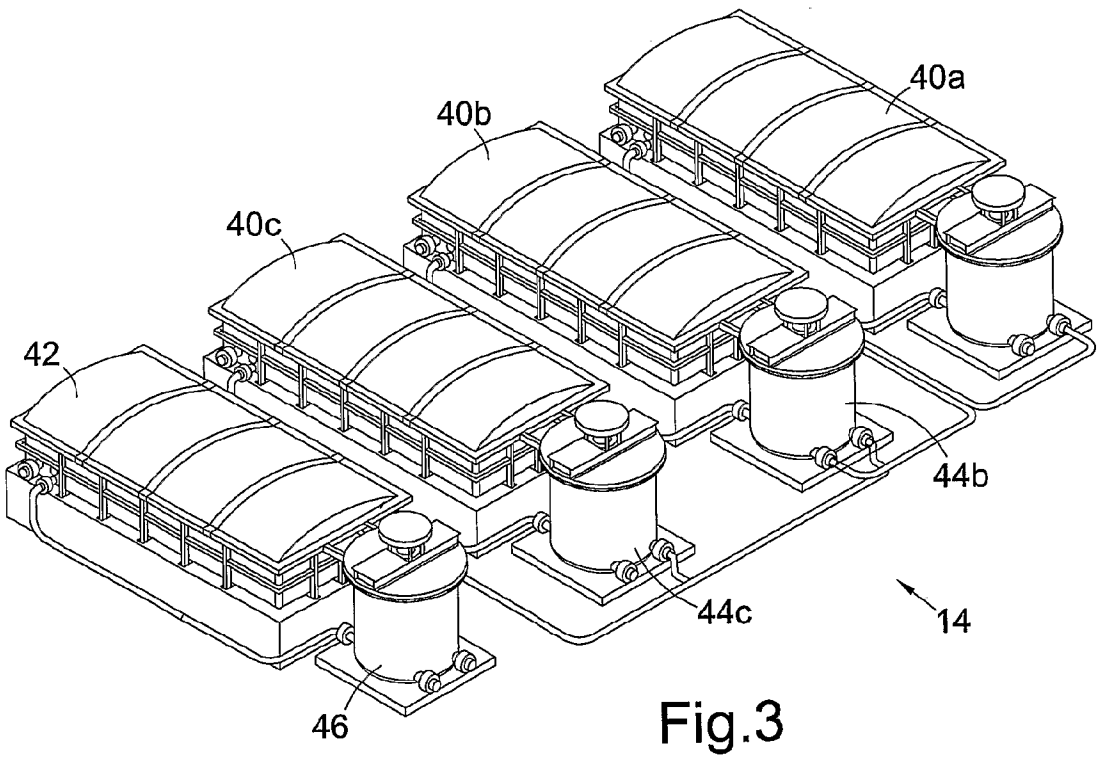

40a
40b
40c
42
44b
44c
14
46

Fig.3

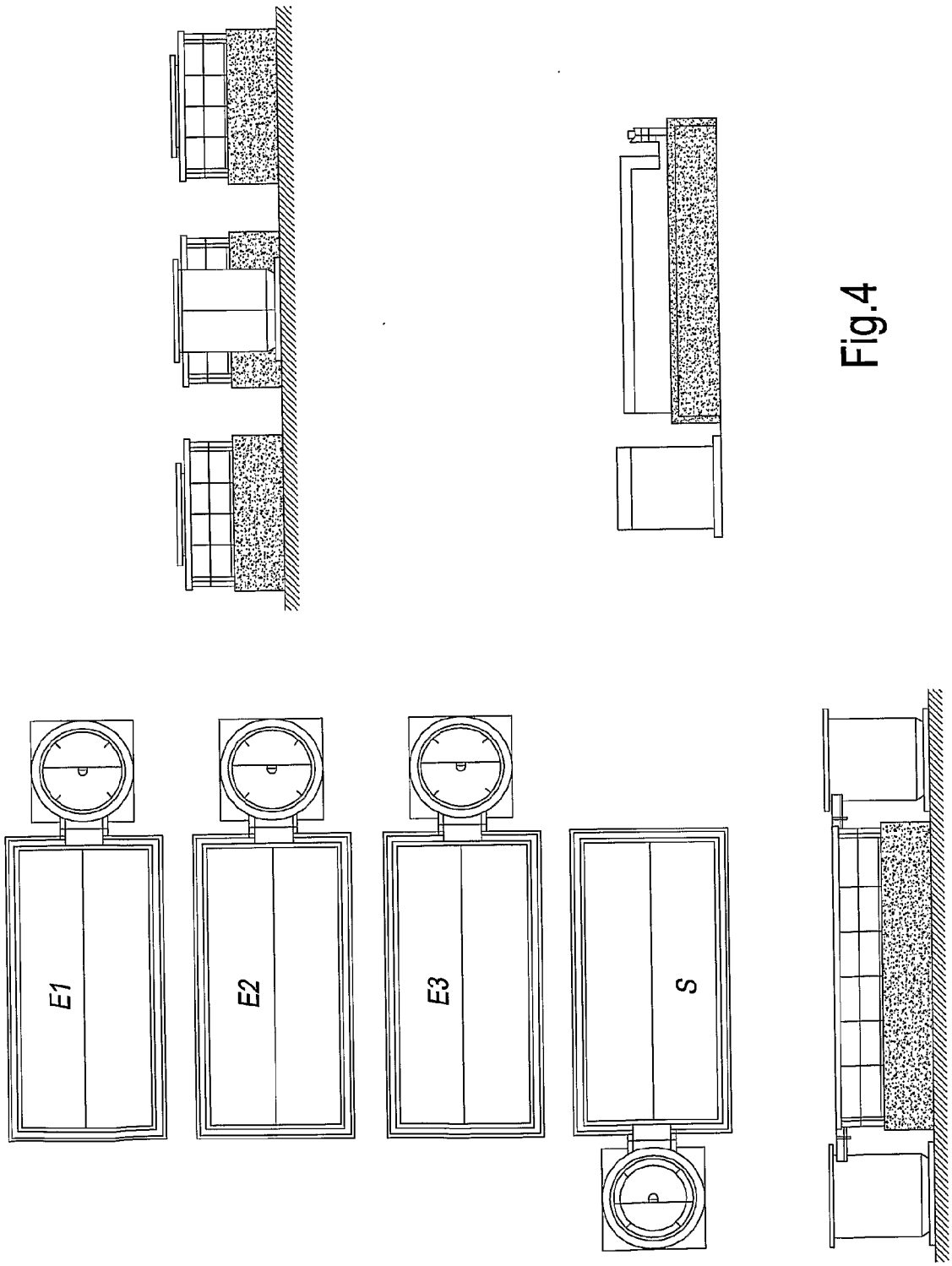


Fig.4

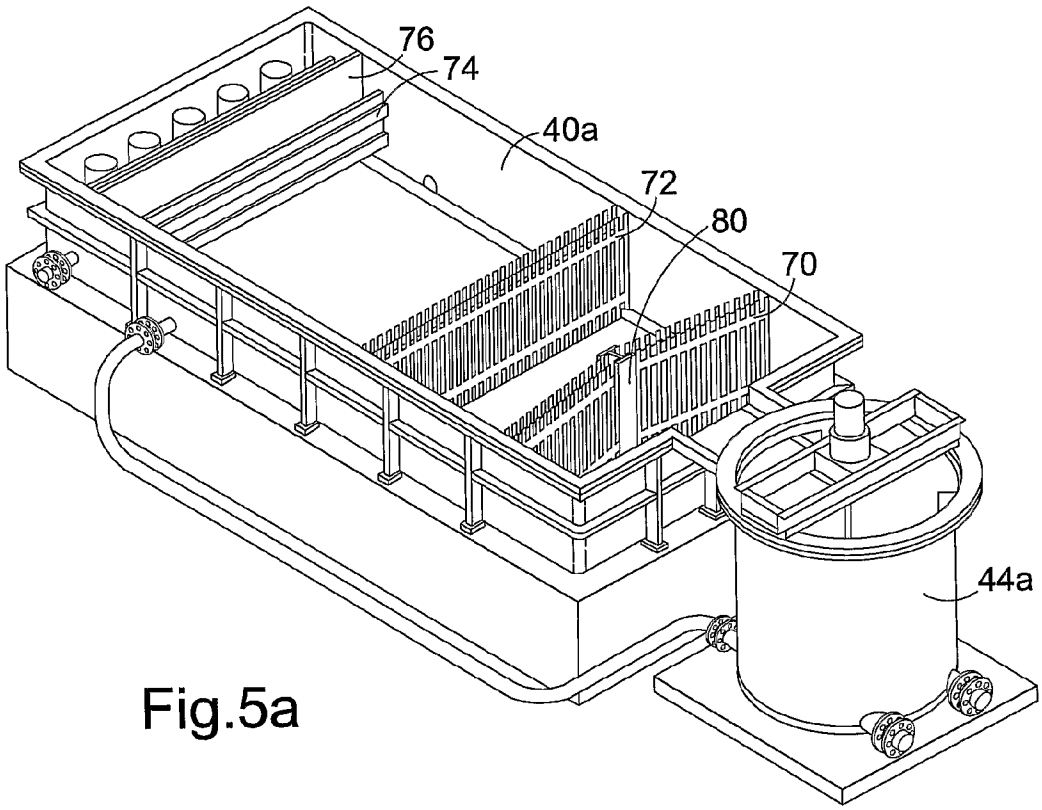

76
74
40a
72
80
70
44a

Fig.5a

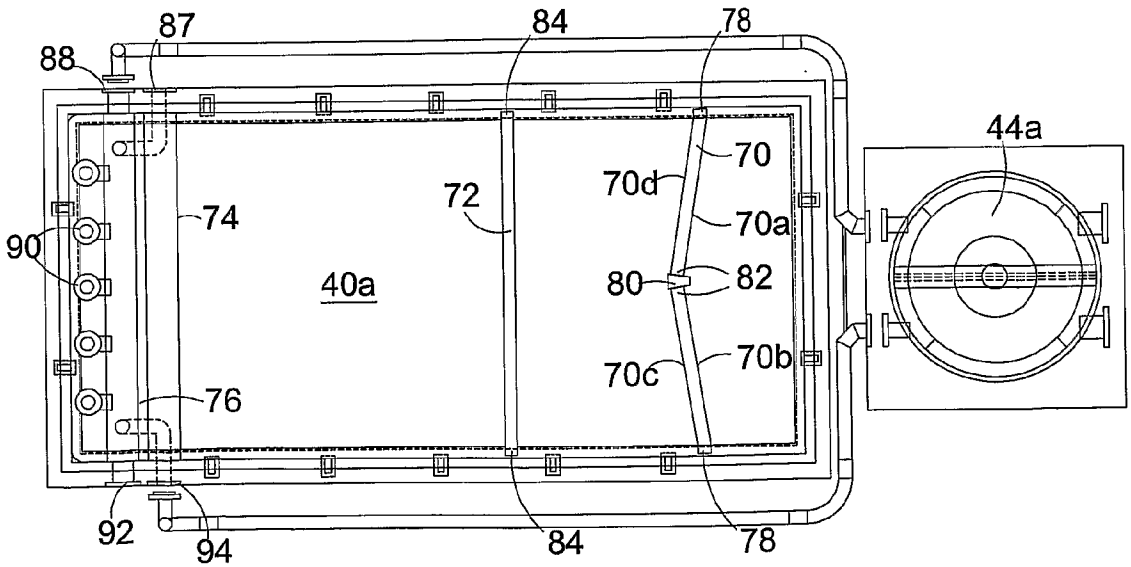

87
84
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88
44a
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70d
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70a
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40a
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70b
70c
76
92
94
84
78

Fig.5b

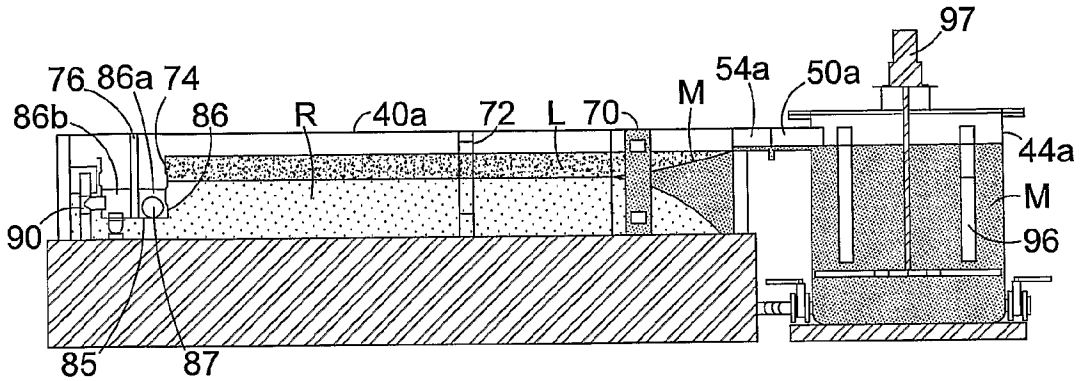

97
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R
40a
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L
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M
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44a
M
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96
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87

Fig. 6

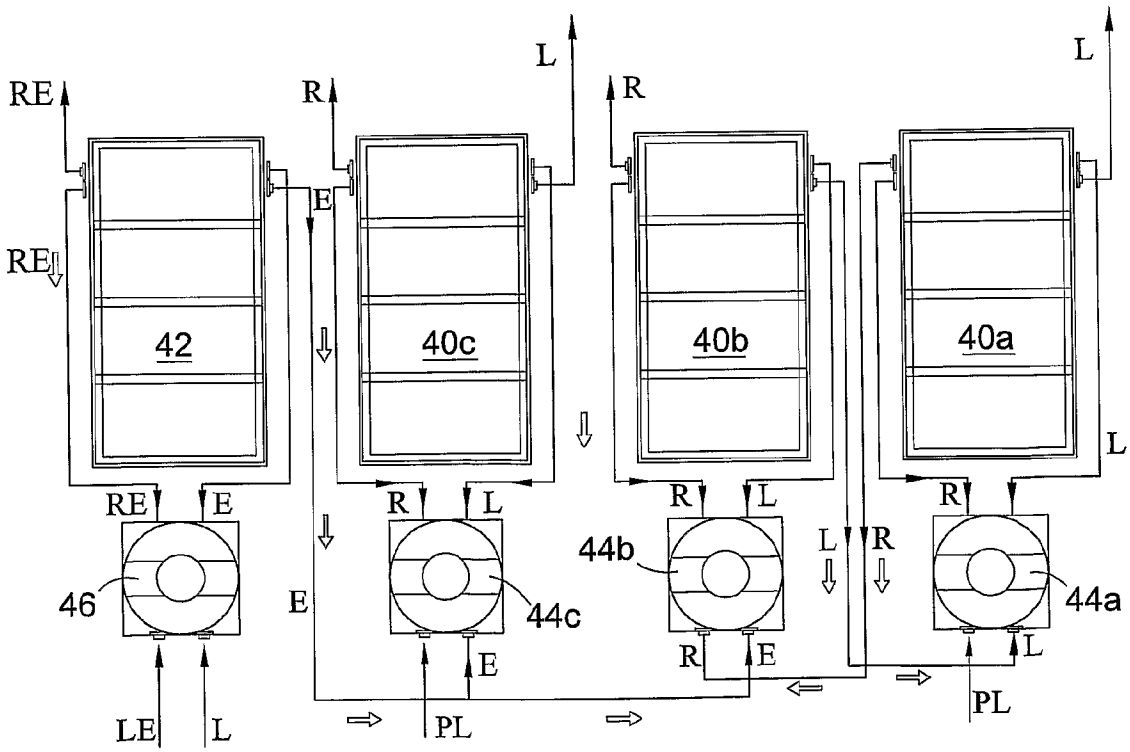

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R
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R
L
RE
E
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40c
40b
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L
RE
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L
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L
R
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44b
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R
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E
44c
44a
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E
L
E
LE
L
PL
PL

Fig. 7

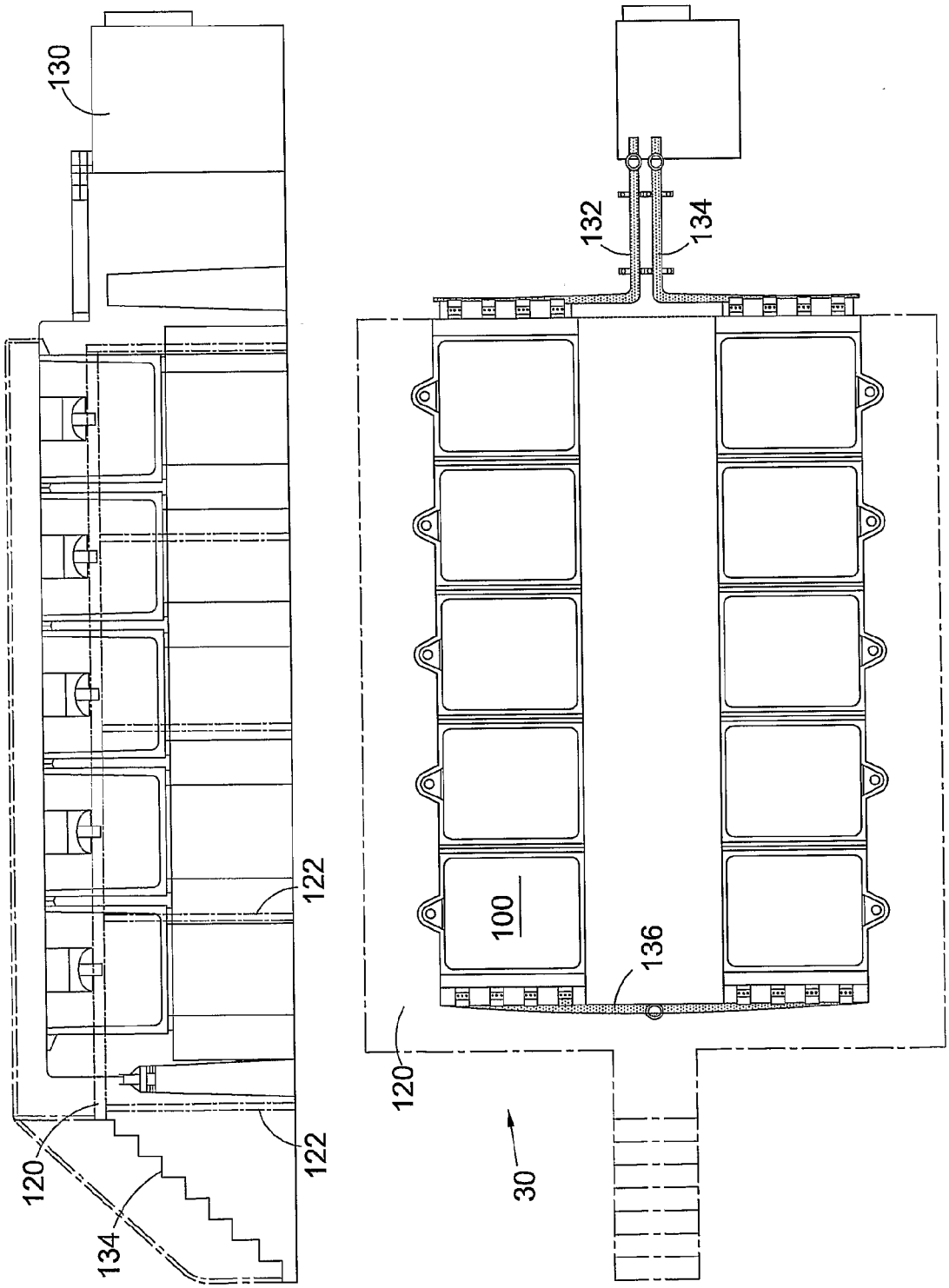


Fig.8