

[54] Title: METAL RECOVERY

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ABSTRACT

The invention provides an installation for recovering metal values from a pulp or leach solution by carbon-in pulp or resin-in-pulp adsorption, comprising a number of adsorption cells. Each cell comprises a container having an inlet and an outlet, a screen disposed between the inlet and the outlet, and an impeller adapted to force liquid entering the container via the inlet through the screen and out of the outlet. The installation includes a conduit for feeding a metal-laden pulp or leach solution to each adsorption cell selectively. The supply of the pulp or leach solution to a selected cell can be interrupted for removal of metal-laden carbon or resin from the cell. The same conduit returns the lean pulp or leach solution from each cell to a further adsorption cell.

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ABSTRACT

The invention provides an installation for recovering metal values from a pulp or leach solution by carbon-in-pulp or resin-in-pulp adsorption, comprising a number of adsorption cells. Each cell comprises a container having an inlet and an outlet, a screen disposed between the inlet and the outlet, and an impeller adapted to force liquid entering the container via the inlet through the screen and out of the outlet. The installation includes a conduit for feeding a metal-laden pulp or leach solution to each adsorption cell selectively. The supply of the pulp or leach solution to a selected cell can be interrupted for removal of metal laden carbon or resin from the cell. The same conduit returns the lean pulp or leach solution from each cell to a further adsorption cell.

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BACKGROUND OF THE INVENTION

This invention relates to a process and installation for recovering metal values from a pulp or leach solution by carbon-in-pulp or resin-in-pulp adsorption.

In existing installations for recovering metal values such as gold by carbon-in-pulp or resin-in-pulp adsorption, a number of adsorption tanks are typically arranged adjacent to one another and staggered vertically so that each tank is lower than the previous tank. Each adsorption tank contains fine carbon particles, and a metal-laden pulp or leach solution is passed through each tank in succession, from the highest to the lowest tank, by gravity feed. Metal is adsorbed on to the carbon or resin particles in each tank, and the leaner pulp or leach solution is then passed to the next tank, where the process is repeated. A screening device in each tank prevents the carbon or resin particles from passing out of their respective tanks.

As the carbon or resin particles in each tank become loaded with metal, it conventionally becomes necessary to transfer a proportion of the carbon or resin upstream counter-current to the flow

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of pulp or leach solution. This is normally
achieved by means of an air lift or pump. This
process can be tedious and gives rise to
inefficiencies due short-circuiting of the carbon or
resin. It is also inconvenient operationally, and
expensive from an installation viewpoint, to build
each adsorption tank on a different level.

SUMMARY OF THE INVENTION

According to the invention, an installation
for recovering metal values from a pulp or leach
solution by carbon in pulp or resin-in-pulp
adsorption comprises a plurality of adsorption
cells, each cell comprising a container having an
inlet and an outlet, a screen disposed between the
inlet and the outlet, and impeller means adapted to
force liquid entering the container via the inlet
through the screen and out of the outlet. The
installation further including means for feeding a
metal-laden pulp or leach solution to each
adsorption cell selectively so that the supply of
the pulp or leach solution to a selected cell can be
interrupted for removal of metal-laden carbon or
resin from the cell, and means for advancing the
lean pulp or leach solution from each cell but the
last to a further adsorption cell.

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The means for feeding the pulp or leach solution to each cell may comprise a conduit interconnecting the inlets of the cells and adapted to be supplied with pulp or leach solution from one or more supply points.

The means for advancing the lean pulp or leach solution from each cell to a further cell may comprise a conduit interconnecting the outlets of the cells and having one or more drain points from which lean pulp or leach solution may be fed to a waste reservoir.

In a preferred embodiment, the conduit interconnecting the inlets of the cells is common with the conduit interconnecting the outlets of the cells.

Further according to the invention a process for recovering metal values from a pulp or leach solution by carbon-in-pulp or resin-in-pulp adsorption includes passing a metal-laden pulp or leach solution successively through each of a plurality of adsorption cells, each cell containing carbon or resin particles onto which metal from the pulp or leach solution is adsorbed, the pulp or leach solution being circulated through each cell to mix with the carbon or resin particles and then

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being passed out of the cell through a screen which prevents the particles from escaping from the cell; and selectively isolating each cell from the others in turn, without interrupting the metal-recovery process, to remove metal-laden carbon or resin particles from the cells.

The pulp or leach solution is preferably passed from one cell to the next via a common conduit which links the cells.

10 **BRIEF DESCRIPTION OF THE DRAWINGS**

Figure 1 is a top view of an installation for recovering gold according to the invention;

Figure 2 is a section on the line X-X to Figure 1;

15 Figure 3 is a partial sectional view of a single adsorption cell; and

Figures 4 and 5 are graphs illustrating the performance of a pilot installation according to the invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

20 The installation as illustrated in Figure 1 comprises two parallel banks of six adsorption cells 10. A centrally disposed conduit in the form of a

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ring-shaped launder 12 interconnects the cells 10.
Each cell 10 has an inlet 14 and an outlet 16
opening into the launder 12. Removable metal gates
72 are located in the launder 12 between each inlet
5 14 and outlet 16, and effectively isolate the inlet
and outlet of each cell when in position in the
launder. A feed pipe 18 is provided which supplies
gold laden pulp or leach solution to the launder 12
via a plurality of valves 20. Each valve 20 is
10 disposed above the launder 12 adjacent to a
respective inlet 14. A plurality of drain openings
22 are provided in the launder 12, between the
inlets and outlets of adjacent cells 10, leading to
a centrally disposed waste conduit 24. The waste
15 conduit 24 empties into a container 26, the contents
of which can be transferred to a waste reservoir by
means of a pair of pumps 28 and 30.

At the bottom of each cell 10 is a drain
opening 32 which is controlled by means of a valve
34 (see Figure 2). The opening 32 is connected by
20 means of a pipe 36 to common drain conduits 38, 40
which lead to a drain pump 42.

The construction of an individual cell 10
is shown more clearly in Figure 3. The cell 10
25 comprises a container 44 which has a square section,

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seen in plan, but a rounded bottom. The inlet 14
and the outlet 16 are connected to a centrally
mounted screening device. The screening device is
similar to that described in South African Patent
Specification No. 68/6324, the disclosure of which
is incorporated herein by reference. An electric
motor 46 is mounted above the container 44 and
drives a vertical shaft 48 at the end of which is an
impeller 50. A hollow screen element 52 is disposed
about the shaft 48, and has a cylindrical outer
surface of fine mesh which is sized to prevent
carbon particles 54 from passing through the screen.
An agitator assembly 56 is mounted on the shaft 48
and has vertically extending agitator members 58
which pass close to the surface of the screen
element 52 and create turbulence in the liquid
adjacent to the screen element when the motor 46 is
operational. Further impeller blades 60 are fitted
to the shaft 48 between the shaft and the inner
surface of the screen element 52. The container 44
is mounted on angle iron legs 68 which are secured
to a concrete base 70.

In operation, pulp or leach solution passes
from the launder 12, through an inlet valve 62, and
through the inlet 14 in the direction of the arrow,
into the interior of the cell 10. The impeller 50

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circulates the solution in the cell, and the
impeller 60 generates a head within the container
44. Pulp or leach solution passes through the
screen element 52 and into an annular space 64 above
the screen element 52, and hence out of the outlet
16 in the direction of the arrow. The pulp or leach
solution passes through an outlet valve 66 and back
into the launder 12. For purposes of clarity, the
inlet 14 and the outlet 16 have been shown in Figure
3 as forming an angle of 180° with one another, so
that there appear to be two separate launders 12.
It will be appreciated that this angle can be varied
as required. In the prototype installation, the
inlet 14 and the outlet 16 form an angle of
approximately 20° or 30° with each other, as shown
in Figure 1, and are connected to a common launder.

In use the adsorption cells are loaded with
a predetermined quantity of carbon particles, and
gold-laden pulp or leach solution is introduced into
the launder 12 via a selected valve 20. For
example, the valve 20 adjacent to the cell 10 at the
upper left-hand side of Figure 1 may be opened. The
pulp or leach solution will flow into the first
adsorption cell 10 via its inlet 14, and operation
of the impeller 60 will generate a head within the
cell which forces the pulp or leach solution through

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the cell and out of the outlet 15, back into the
launder 12. The somewhat leaner pulp or leach
solution will then flow into the inlet 14 of the
next cell 10, and subsequently through the remaining
5 cells, becoming progressively leaner.

Clearly, the carbon particles in the first
cell will be the first to become saturated with
gold. When this occurs, that cell can be isolated
by closing off its inlet and outlet valves 62 and
68. The corresponding valve 20 will be closed and
10 the valve 20 adjacent to the inlet of the subsequent
cell will be opened. The drain valve 22 in the
launder 12 corresponding to the isolated cell will
be opened, to allow barren pulp at the end of the
15 adsorption cascade to leave the circuit via the
conduit 24.

Thus, the saturated cell will be isolated
from the rest of the cells, but operation of the
installation can continue as normal, with the gold-
laden pulp or leach solution being supplied to the
20 inlet of the next cell downstream from the isolated
cell by the respective valve 20. The valve 34 at
the base of the isolated cell can now be opened, and

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the saturated carbon pumped out for further processing. The carbon in the cell is replaced with regenerated carbon, and the carbon in the cell can be brought back into operation, without interruption of the gold recovery process. The reconnected cell will now be part in the cascade of cells.

Should it be necessary to bypass any particular cell for maintenance or other reasons, this can be achieved simply by closing the inlet valve 14 and the outlet valve 16 of the cell in question, and removing the gate 72 in the launder between the valves. Pulp or leach solution will then flow along the launder from the cell preceding the bypassed cell to the cell subsequent thereto.

The described installation has the advantage that it is relatively compact and can be installed on a flat surface. The screening device in each cell performs a dual screening and pumping function, so that it is not necessary to provide external pumps to pump the leach solution from one cell to the next, and it is also not necessary for the cells to be installed on an incline. This reduces the cost of the installation.

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Although a process and installation for the recovery of gold by carbon-in-pulp adsorption has been described, it will be appreciated that other metals, such as uranium, can also be recovered by the process and installation. Instead of carbon-in-pulp adsorption, a resin in pulp process can be used. It will be appreciated that although the expressions "carbon in pulp" or "resin-in-pulp" suggest the recovery of metal from a pulp or slurry only, metal can also be recovered from a leach solution using the method and apparatus of the invention.

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EXAMPLE

The following example relates to the performance of a pilot installation according to the invention. The pilot installation comprised two cells in series, each cell having a volume of 1.8m³. The installation was used to treat a bleed stream of milled and cyanided gold ore from an existing gold recovery operation.

The cells were situated at the same horizontal elevation, and transport of the pulp through the circuit was effected by means of the impeller in each of the cells. A quantity of activated carbon was suspended in each cell to adsorb gold dissolved from the ore.

The pilot circuit was operated to provide a kinetic information which could be incorporated into a dynamic model of the adsorption process, in order to predict the behaviour of the pilot plant if more cells were used. The experimental method used was to operate the two cells under steady state conditions at various applied pulp flowrates, and to observe trends in the gold contents of activated carbon and solution in each cell, with time.

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Tests were carried out at flowrates of $31.6\text{m}^3/\text{h}$, $20.5\text{m}^3/\text{h}$ and $13.7\text{m}^3/\text{h}$, corresponding to cell residence times of 3.4mins, 6.3mins and 7.9mins respectively

By way of example, the process conditions for Test 3 ($13.7\text{m}^3/\text{h}$) are summarized below, and the actual kinetic response is shown plotted in Figure 4.

Test 3 Conditions:

10	Pulp Flowrate	: $13.7\text{m}^3/\text{h}$
	Pulp relative density	: 1.490
	Solids relative density	: 2.700
	Solution Flowrate	: $10.5\text{m}^3/\text{h}$
	Cell Volume	: 1.8m^3
15	Nominal Residence Time	: 7.9 mins
	Cell Carbon Content	: $100\text{kg}/\text{m}^3$
	Feed Solution Gold Content	: Approx. 6.0 to $6.0\text{g Au}/\text{m}^3$

Reference to Figure 4 shows that over the duration of the test (40 hours), the gold loading of the carbon increased steadily to values of $12.35\text{kg Au}/\text{t}$ and $3.6\text{kg Au}/\text{t}$ for cells 1 and 2 respectively.

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solution values increased at a more gradual rate, showing the progressive influence of the loading of gold on the carbon on the adsorption kinetics.

Using average values of gold in solution over the 48 hour period of 5.78 Au/m³ for the feed, 0.878 Au/m³ for Cell 1 and 0.188 Au/m³ for Cell 2, the extractions of gold per stage were 83% and 81% for Cells 1 and 2 respectively. Those skilled in the art will appreciate that these extractions are extremely high, and are particularly remarkable for the fact that the residence time of pulp in each cell was only 7.9 minutes. Typical extractions in a "conventional" carbon-in-pulp process are in the range 60-70%, for pulp residence times of 45-60 mins.

It should be appreciated that in a continuous operating circuit, a point will be reached where the loading of the carbon in each cell is deemed to be optimum, and the feed position will then be moved downwards (i.e. to the next cell) to set up a new set of kinetic conditions in the cascade. Using the¹ amplified example provided by the two cell pilot plant, and assuming that a decision is made that 35 hours constitutes the optimum cycle period, then the carbon in Cell 1 at

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a loading of 11.9kg Au/t would be drained off and go forward as a final adsorption product, and the feed pulp would then be directed to Cell 2 in which the carbon has a loading of 2.1kg Au/t.

5 The pilot plant tests at varying flowrates provided data which enabled the calculation of the adsorption mass transfer coefficients, and these in turn were used in a simulation model to predict the performance of a circuit having a variety of
10 adsorption stages.

The table below shows the predictions for a pilot plant treating 300^l/hour of slurry at a solution feed concentration of 6.5kg Au/t, and a solution residue concentration of 0.201g Au/t:

15	Number of stages	Residence Time (min)	Carbon Concent ⁿ (kg/t)	Carbon Loading (gAu/t)	Carbon Processed (t/day)	Total Carbon Inventory (tons)
	6	3.6	100	18 900	0.180	0.80
	8	3.6	80	21 010	0.144	0.88
20	8	3.6	50	29 100	0.104	0.83

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Again, those skilled in the art will discern the advantages which the described installation has over conventional systems, namely:

- (i) Shorter pulp residence times and hence smaller equipment sizes;
- (ii) Higher carbon loadings and hence reduced costs associated with downstream processing to recover the gold from the carbon;
- (iii) Lower circuit inventories of carbon, and hence lower inventory costs, and
- (iv) No necessity for interstage transfer of carbon, thereby eliminating negative back-mixing effects, and simplifying plant operation.

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WHAT IS CLAIMED IS:

1. An installation for recovering metal values from a pulp or leach solution by carbon-in-pulp or resin-in-pulp adsorption comprising a plurality of adsorption cells, each cell comprising a container having an inlet and an outlet; a screen disposed between the inlet and the outlet; and impeller means adapted to force liquid entering the container via the inlet through the screen and out of the outlet. The installation further including a conduit for feeding a metal-laden pulp or leach solution to each adsorption cell selectively so that the supply of the pulp or leach solution to a selected cell can be interrupted for removal of metal-laden carbon or resin from the cell, the conduit interconnecting the inlets of the cells and being adapted to be supplied with pulp or leach solution from one or more supply points located adjacent to the inlets of respective cells, and a conduit for advancing the lean pulp or leach solution from each cell but the last to a further adsorption cell.

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3. An installation according to claim 1 wherein the conduit for advancing the lean pulp or solution from each cell to a further cell interconnects the outlets of the cells and has a plurality of drain points from which lean pulp or leach solution may be led to a waste reservoir, each drain point being located between the inlet of one cell and the outlet of an adjacent cell.

5. An installation according to claim 1 wherein the conduit for feeding the pulp or leach solution to each cell and the conduit for advancing the lean pulp or leach solution from each cell to a further cell are a common conduit interconnecting the inlets and outlets of the cells.

4. An installation according to claim 3 wherein gate means are provided in the conduit between the inlet and the outlet of each cell to allow the flow of pulp or leach solution in the conduit to be interrupted selectively.

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6. An installation according to claim 5 wherein the common conduit forms a closed loop.

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6. An installation according to claim 1 wherein the inlet and the outlet of each cell are provided with respective shut-off valves to allow any cell to be isolated from other cells of the installation.

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7. An installation according to claim 6 wherein each cell is provided with a drain which is controllable by means of a valve, to allow metal-laden carbon or resin to be drained from the cell when the cell is isolated from the other cells of the installation.

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8. A process for recovering metal values from a pulp or leach solution by carbon-in-pulp or resin-in-pulp adsorption comprising passing a metal-laden pulp or leach solution successively through each of a plurality of adsorption cells, each cell containing carbon or resin particles on to which metal from the pulp or leach solution is adsorbed, the pulp or leach solution being circulated through each cell to mix

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with the carbon or resin particles and then
being passed out of the cell through a
screen which prevents the particles from
escaping from the cell; and selectively
isolating each cell from the others in
turn, without interrupting the metal-
recovery process, to remove metal-laden
carbon or resin particles from the cells,
wherein the pulp or leach solution is
passed from one cell to the next via a
common conduit which links the cells.

A process according to claim 8 wherein the
metal-laden pulp or leach solution to be
processed is supplied to a selected cell
from one of a plurality of supply points
located adjacent to the inlets of
respective cells.

A process according to claim 8 wherein lean
pulp or leach solution is drained from the
conduit via one of a plurality of drain
points each of which is located between the
inlet of one cell and the outlet of an
adjacent cell.

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11. A process according to claim 6 cell through which the metal-leach solution is first passed from the other cells after a delay to allow the metal-laden carbon or resin particles to be removed for further processing, the removed carbon or resin particles being replaced by fresh particles and the cell being reconnected to the other cells without the process being interrupted.

12. A process according to claim 11 wherein the metal-laden pulp or leach solution to be processed is supplied to the next cell downstream from the isolated cell, the isolated cell becoming the last cell to receive the pulp or leach solution when it is reconnected.

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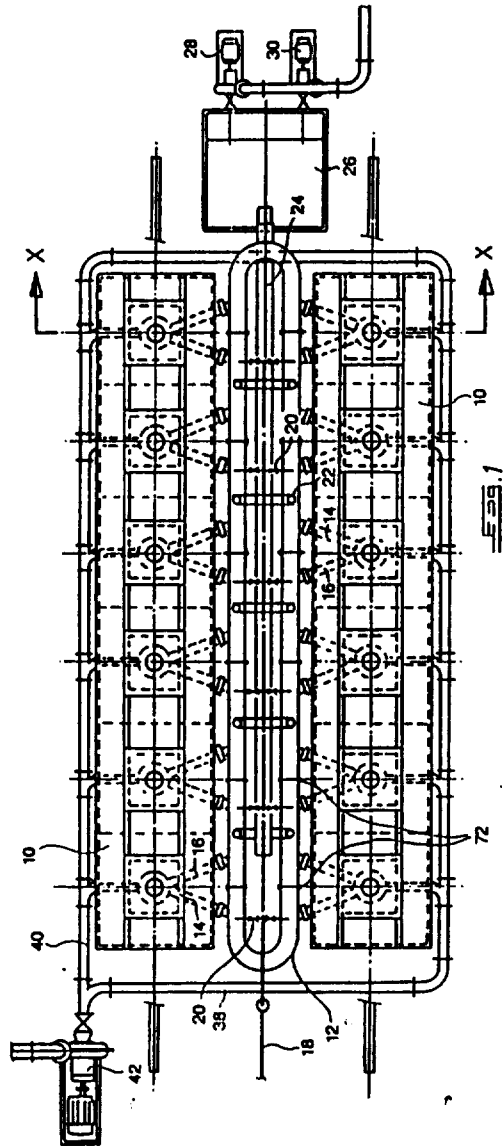
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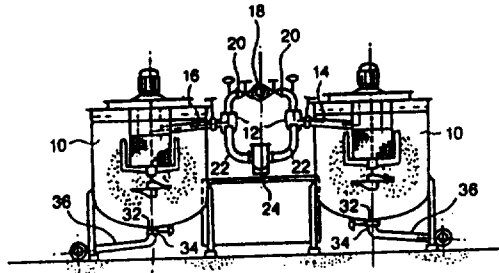
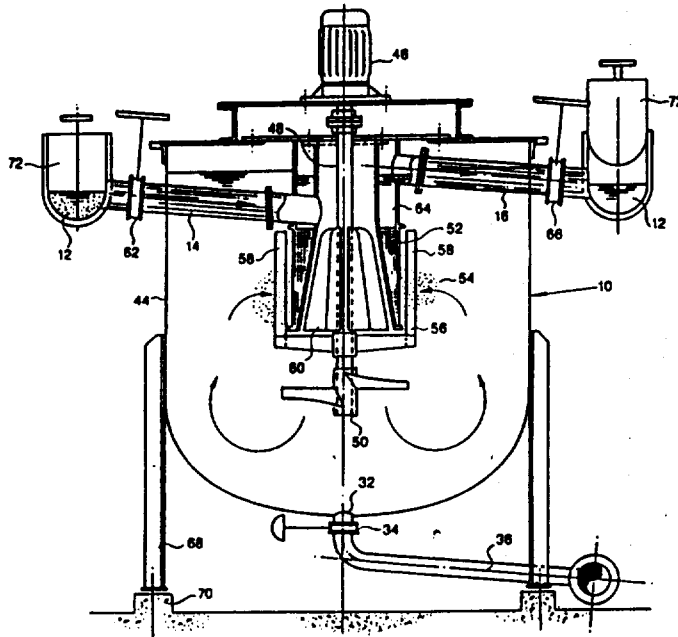


Fig. 2

Fig. 3



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FIG 4

CARBON-LOADING ON CIP-CAROUSEL - TEST 3
DURATION : 36 HRS

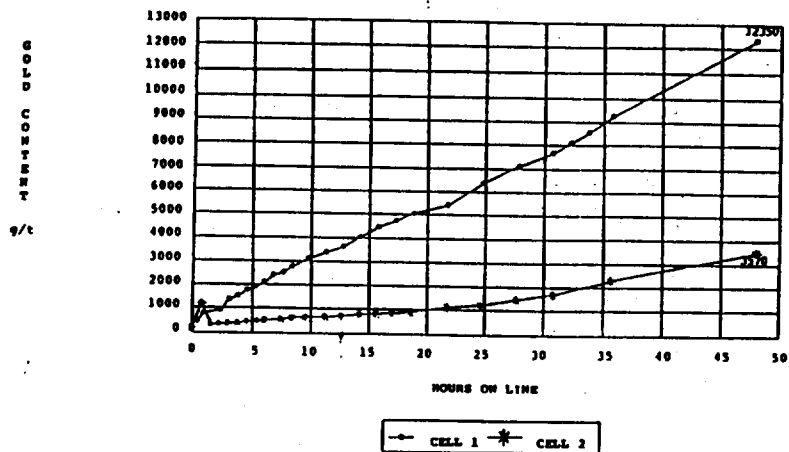
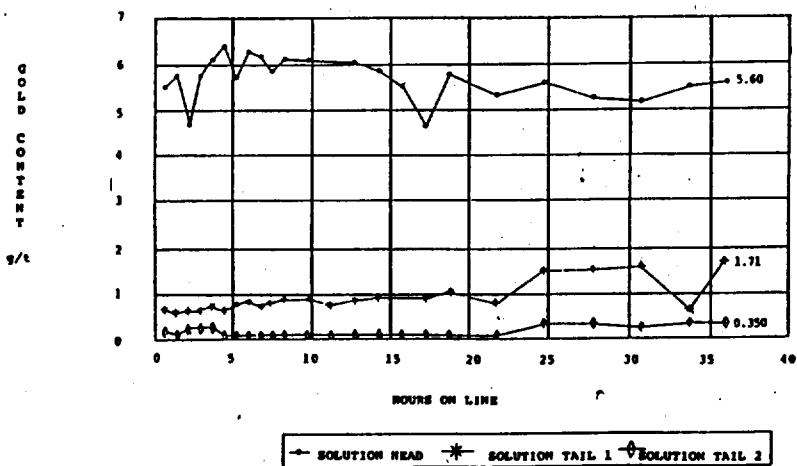


FIG 5

SOLUTION SAMPLES : CIP-CAROUSEL - TEST 3



SLURRY FLOWRATE : 13.7 m³/h

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