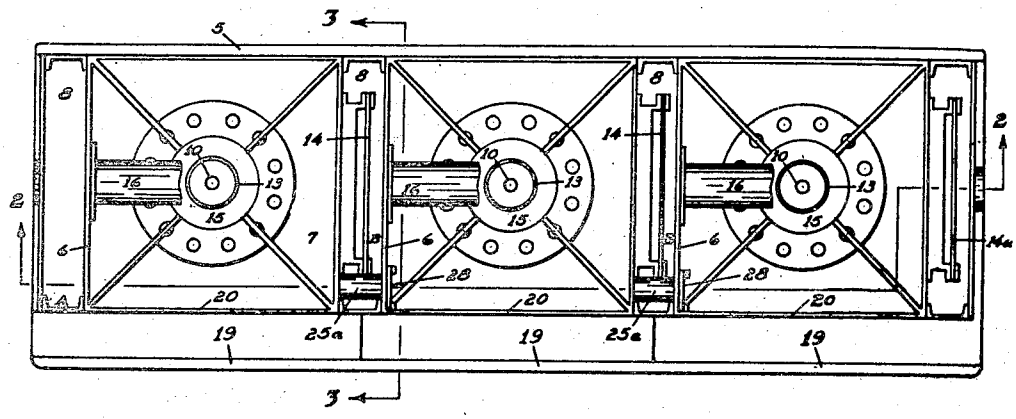
July 8, 1947. L. H. LOGUE 2,423,456

MULTIPLE-STAGE FROTH FLOTATION

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Fig. 1.



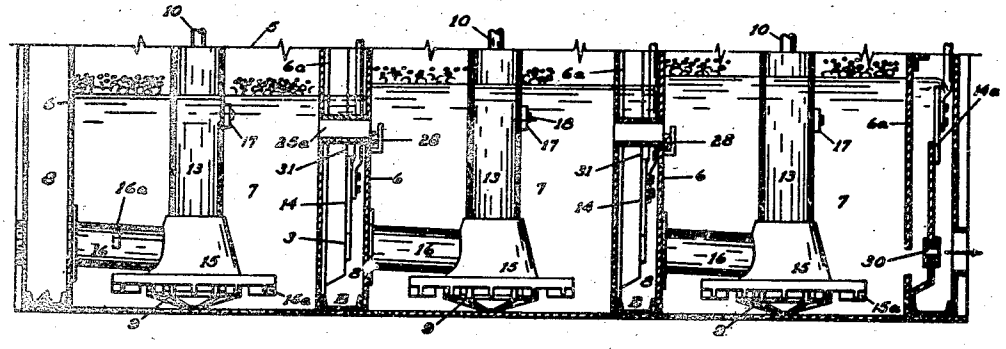


Fig. 2.

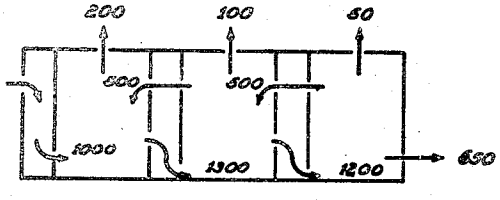


Fig. 4.

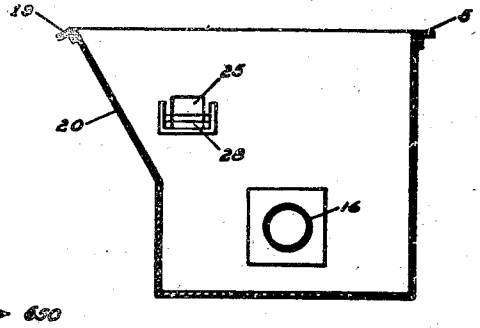


Fig. 3.

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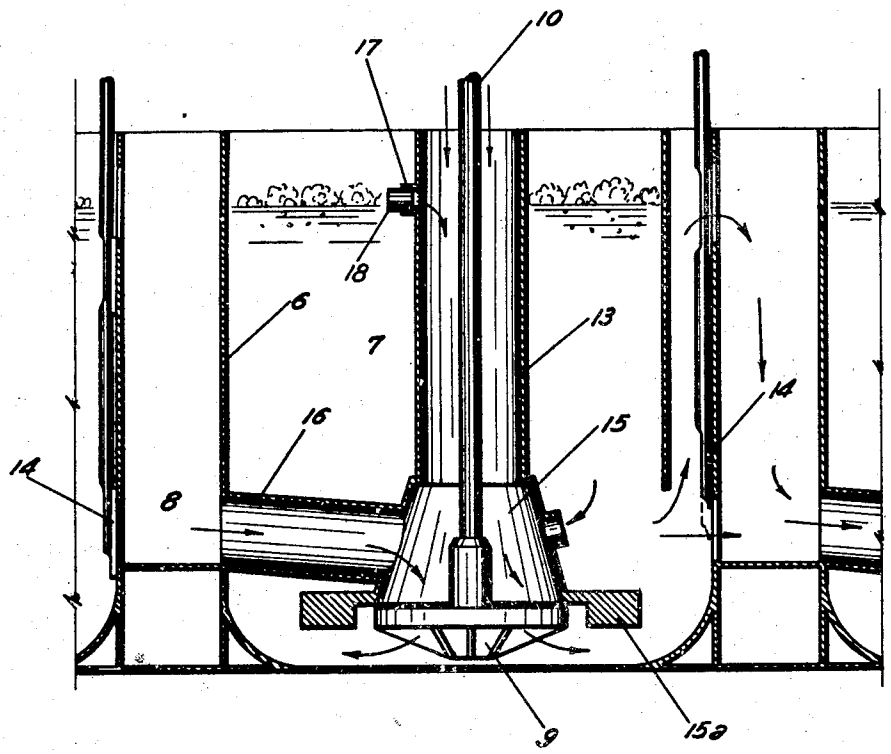


Fig. 5

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Patented July 8, 1947 2,423,456

UNITED STATES PATENT OFFICE

2,423,456

MULTIPLE-STAGE FROTH FLOTATION

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Application April 16, 1943, Serial No. 483,286

15 Claims. (Cl. 209—164)

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This invention relates to improvements in flotation treatments, and more particularly relates to improvements in the operation of froth flotation machines of the mechanical agitation type.

The present invention contains subject matter related to the disclosure in Daman et al., Serial No. 337,420, filed May 27, 1940, Patent No. 2,316,770, issued April 20, 1943, for Froth flotation apparatus and treatments, and has been embodied in a separate application in compliance with a voluntary division of subjects matter entered in the aforesaid application. Features described but not claimed in this application have been made the subject matter of claims in the aforesaid application.

An object of the invention is to provide a hydraulic balance between the respective cells of a multi-cell machine to the end that pulp will be fed to the several impellers in sufficient quantity to maintain proper overflow levels for a progressively decreasing froth bed in successive cells.

Another object of the invention is to provide a control means for maintaining froth beds of varying depth at a substantially uniform relation to a common overflow level.

Other objects reside in novel details of construction and novel combinations and arrangements of parts, all of which will become apparent in the course of the following description.

To afford a better understanding of the invention, reference is made to the accompanying drawings, in the several views of which corresponding parts have been designated similarly and in which:

Figure 1 is a top plan view of a multi-cell flotation machine suited for the practice of the present invention;

Figure 2 is a developed section taken along the line 2—2 of Figure 1;

Figure 3 is a section taken along the line 3—3 of Figure 1;

Figure 4 is a diagrammatic representation of the circulatory system employed in the operation of the machine shown in Figures 1, 2 and 3;

Figure 5 is a vertical central section through the intermediate cell of the series shown in Figure 1 and drawn to an enlarged scale.

Referring first to Figures 1 and 2, the machine illustrated is a three-cell machine, it being understood that any plurality of cells may be similarly arranged. The machine comprises a tank 5 divided by a plurality of partitions 6 and 6a into a series of cells 7, each of which is provided with a feed compartment 8.

A rotary impeller 9 is disposed in the lower portion of each cell on a shaft 10 suitably supported

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in a bearing structure (not shown), and a hollow column 13 surrounds the shaft in spaced relation thereto and extends above the liquid level in the cell determined by an overflow control, in this case an adjustable weir or gate 14, in each cell except the last of the series in which the overflow is controlled by another similar gate 14a.

The column 13 is supported upon a flaring hood 15 terminating at its periphery in a series of downwardly projecting vanes 15a in spaced proximity to the impeller 9.

Features of the impeller and hood construction disclosed but not claimed herein have been claimed in the patent to A. C. Daman and L. H. Logue, No. 2,243,309, issued May 27, 1941, for Flotation apparatus.

A feed intake conduit 16 connects the flaring hood 15 with the feed compartment 8 and preferably is positioned at an inclination as illustrated to permit gravity feeding.

Intermediate the ends of conduit 16, a partition 16a partially closes the passage for purposes that will be explained hereinafter.

In proximity to but slightly below the froth level in the cells, openings 17 are provided in column 13 and preferably are threaded to permit adjustment of flow therethrough by the insertion of suitable bushings 18. A suitable overflow lip 19 extends along one side 20 of the tank 5, and a suitable launder (not shown) extending in front of the overflow lip usually receives froth moved across the same in a manner well known in the art.

As best seen in Figures 2 and 3, the machine of the present invention is provided with a series of openings 25 in the walls 6 and 6a of the respective cells to admit the insertion of conduit members 25a which provide conductive connections between the liquid bodies in the respective cells for purposes that will be explained hereinafter.

Another feature of importance in the present design is the flow regulation through conduits 25a. As best seen in Figures 2 and 3, an adjustment means is provided, such as the gate 28, which varies the area of the opening 25 at the end of the conduit 25a. Preferably, this gate is a slat weir to permit precise adjustments, but it will be understood that any means for varying the flow through the opening 25 will be satisfactory for this purpose.

Each of the feed compartments 8 other than the compartment of the intial cell, designated in Figure 2 by reference letter B, is provided with a regulatable opening 30 in close proximity to the impeller 9 of its associated cell through which heavy solids not readily maintained in suspension

may flow to the succeeding cell in the progressive movement of material through the machine.

The liquid level in each cell is controlled by the adjustable weir 14 movable along a passage-defining member 31 to selective elevations. Movement of the weir in the preferred form is controlled by screw-actuated mechanism (not shown).

In the usual operation of the machine, pulp is fed into compartment A (Figures 1 and 2) and feeds by gravity through conduit 16 into the hood enclosure where it descends upon impeller 9. Gas is introduced to the impeler through the hollow column 13, mixing with the entering pulp and being subjected to the mixing and compressive action of the impeller 9 before discharge therefrom past the vanes 15a.

While in the usual machine of this character a close control of the positioning of the respective gates 14 would be necessary in order to maintain the proper overflow conditions within the respective cells, the provision of the conduit members 25a in the present construction, in association with other parts, provides a novel means of liquid level regulation of great importance to the metallurgical efficiency of the operation.

In the usual flotation machine of this character, the action of the reagent in the first cell of the series produces a voluminous froth, bringing up relatively large quantities of mineral, which are removed by overflow and pass from the treatment. In succeeding cells of the operation, there is a progressive decrease in froth volume and mineral recovery with pronounced differences in this condition in the first cells of the series and a gradual tapering off thereafter.

As such machines are built with a common froth overflow level, it is necessary to so regulate the pulp overflow from cell to cell in order to give proper elevation to the froth bed in such cells that it may be discharged by overflow and removed as a concentrate. In normal operation, there is a progressively decreasing pulp volume coming into the successive cells, due to the removal of a portion of the pulp content from each cell as a concentrate.

The decreasing amount of concentrates to be removed from successive cells, combined with the reduced tonnage passing through the machine, causes a shallower froth bed, necessitating a higher pulp level in each successive cell. These conditions, coupled with feed fluctuations, require much operating control with continual attention to the individual gates to maintain the shallow froth beds at the correct elevation to produce the continuous overflow.

With the present structural arrangement, an initial setting of the gates 14 is made to overflow a volume of feed into the next cell which is in excess of the initial flow of feed to the machine.

Due to the fact that the impellers are operated to accommodate a capacity much in excess of the actual capacities encountered in operation, this does not create an overloaded condition.

The impellers function at all times as pumps in the circulatory movement of the pulp through the machine to force pulp overflowing from the preceding weir into the cell in which the impeller operates and from which it passes into a succeeding cell in the series.

Under operating conditions such as hereinbefore described, the impellers function to deliver to their respective cells a quantity of pulp in excess of the amount normally passing to them from the preceding cells.

Because of the provision of the passages 25a, a quantity of pulp from a given cell will flow back to the preceding cell in an amount sufficient to make up the deficiency of the original feed.

As a hydrostatic head is necessary to cause the reverse flow through the passage 25a, the pulp level in each succeeding cell is maintained at a higher elevation than the pulp level in the preceding cell. As a consequence, the present structural arrangement induces a counterflow in the upper portion of such cells opposed to the normal flow of pulp through the machine.

The gates 28 vary the size of the openings through which this counterflow passes from cell to cell, and are regulated to establish an initial pulp level differential between adjoining cells. Thereafter, the settings are not changed, except when it is desired to establish a new differential. The gate 14a in Figure 1 controls the pulp levels of the preceding group of cells and may be either the final gate control of the machine, or merely a gate control for a given number of cells within a machine.

Feed fluctuations or changes in the rate of flow through the machine only require an operation of the weir or gate setting 14a and such regulation controls the preceding cells as a group, while the differentials in pulp levels between the cells of the group are maintained by reason of the initial setting of the gates 28, coupled with the return flow through the passages 25a between the cells.

Thus, it will be seen that after the initial setting, the control of individual cells is automatic with a progressively higher pulp level provided in successive cells creating a successively shallower froth bed, allowing continuous overflow of froth without attention to the individual gates or weirs 14. In addition, the aforesaid flow regulation simplifies operating procedure and reduces to a large degree the extent of operator control necessary to the maintenance of such a machine in continuous operation.

The conduits 25a perform their equalizing function in conjunction with the action of the impellers to maintain the froth bed at the desired elevation with reference to the overflow level and following the initial setting of the gates 14, regulation of the controls of the individual cells other than the last of the series controlled by gate 14a is not required except in the event of extraordinary circumstances, such as shut-downs and the like.

In the aerating action, various forms of gas delivery may be employed. Where the intake of atmospheric air is sufficient to satisfy aerating requirements, atmospheric air is delivered to the mixing zone through column 13 under the suction influence of the impeller.

However, if additional aeration is required to supplement the intake through column 13, gas under pressure may be introduced in any of the various ways disclosed in related application Serial No. 337,420.

With whatever gas introduction system is employed the gas delivered within the hood is subjected to mixing with pulp and reagent under the beating action of the impeller and subsequent compression, with the result that it is entrained in the fluid body discharging from the impeller in a widely diffused condition promoting greater efficiency of the flotation reaction.

What I claim and desire to secure by Letters Patent is:

1. The improvement in the froth flotation process, in which a body of pulp is subjected to

agitation and aeration in successive stages, subject to continuous feed and discharge at each stage, which comprises delivering a quantity of pulp from a preceding stage to a succeeding stage in excess of the quantity of the initial feed thereby raising the liquid level in said succeeding stage substantially above the level in the preceding stage, and maintaining a hydrostatic balance between such stages by returning pulp to a preceding stage from a succeeding stage and restricting the return flow an amount sufficient to maintain the level differential between cells substantially constant throughout a substantial period of continuous operation.

2. The improvement in the froth flotation process, in which a body of pulp is subjected to agitation and aeration in successive stages, subject to continuous feed and discharge at each stage, which comprises delivering a quantity of pulp from a preceding stage to a succeeding stage in excess of the quantity of the initial feed thereby raising the liquid level in said succeeding stage substantially above the level in the preceding stage, and maintaining a hydrostatic balance between such stages by simultaneously returning pulp to a preceding stage from a succeeding stage and restricting the return flow an amount sufficient to maintain the level differential between cells substantially constant throughout a substantial period of continuous operation.

3. The improvement in the froth flotation process, in which a body of pulp is subjected to agitation and aeration in successive stages, subject to continuous feed and discharge at each stage, which comprises overflowing froth at an elevation common to the succession of stages, pumping a quantity of pulp through a confined zone from a preceding stage to a succeeding stage in excess of the quantity of the initial feed, returning through an orifice from each succeeding stage to the preceding stage a quantity of pulp less than the volume of incoming feed to such cell, and restricting the flow through the orifice between each succession of stages to a sufficient degree to cause a progressively increased pulp level in each successive stage.

4. The improvement in the froth flotation process, in which a body of pulp is subjected to agitation and aeration in successive stages, subject to continuous feed and discharge at each stage, which comprises overflowing froth at an elevation common to the succession of stages, pumping a quantity of pulp through a confined zone from a preceding stage to a succeeding stage in excess of the quantity of initial feed, returning pulp from each succeeding stage to the preceding stage through an orifice in a quantity less than the volume of incoming feed to such stage, restricting the flow through said orifice to a degree sufficient to maintain a higher pulp level in said succeeding stage than in said preceding stage, and changing the degree of such restriction so as to vary the relative pulp levels in at least two adjoining stages.

5. The improvement in the froth flotation process, in which a body of pulp is subjected to agitation and aeration in successive stages, subject to continuous feed and discharge at each stage, which comprises over-flowing froth at an elevation common to the succession of stages, pumping a quantity of pulp through a confined zone from a preceding stage to a succeeding stage in excess of the quantity of initial feed, returning pulp from each succeeding stage to the preceding stage through an orifice in a quantity less than the volume of incoming feed to such stage, restricting the flow through said orifice to a degree sufficient to maintain a higher pulp level in said succeeding stage than in said preceding stage, changing the degree of such restriction so as to vary the relative pulp levels in at least two adjoining stages, and restricting the final discharge of the succession of stages a degree sufficient to prevent a discharge of pulp in substantial excess of the volume required to maintain the level regulation in the preceding stages.

6. In flotation apparatus, inclusive of a series of cells having a feed inlet at one end and a tailings discharge outlet at the opposite end of the series, a rotary impeller in each cell, and a plurality of passages for the progressive movement of a body of pulp from a preceding cell to the impeller of each succeeding cell in the series, the improvement which comprises means for regulating the feed to each impeller positioned to establish a progressive increase in pulp level through a plurality of said cells, conductive means for returning excess pulp from a succeeding cell to each preceding cell, said conductive means having pulp passages which are sufficiently small in relationship to the difference between the discharge capacity of the preceding cell and the final discharge capacity of the series of cells to maintain the level differentials between adjoining cells substantially uniform, means for varying the return flow through said pulp passages, and means for restricting the flow through the tailings discharge outlet so as to maintain the level differentials in said cells.

7. In flotation apparatus, inclusive of a series of cells having a feed inlet at one end and a tailings discharge outlet at the opposite end of the series, a rotary impeller in each cell, and a plurality of passages for the progressive movement of a body of pulp from a preceding cell to the impeller of each succeeding cell in the series, the improvement which comprises means for regulating the feed to each impeller positioned to establish a progressive increase in pulp level through a plurality of said cells, conductive means for returning excess pulp from a succeeding cell to each preceding cell, said conductive means having pulp passages which are sufficiently small in relationship to the difference between the discharge capacity of the preceding cell and the final discharge capacity of the series of cells to maintain the level differentials between adjoining cells substantially uniform, means, including a valve, for varying the return flow through said pulp passages, and means for restricting the flow through the tailings discharge outlet so as to maintain the level differentials in said cells.

8. In flotation apparatus, inclusive of a series of cells having a feed inlet at one end and a tailings discharge outlet at the opposite end of the series, a rotary impeller in each cell, and a plurality of passages for the progressive movement of a body of pulp from a preceding cell to the impeller of each succeeding cell in the series, the improvement which comprises means for regulating the feed to each impeller positioned to establish a progressive increase in pulp level through a plurality of said cells, conductive means for returning excess pulp from a succeeding cell to each preceding cell, said conductive means having pulp passages sufficiently small in relationship to the difference between the discharge capacity of the preceding cell and the

final discharge capacity of the series of cells to maintain the level differentials between adjoining cells substantially uniform, adjustable means cooperative with said conductive means for varying the effective capacity of said conductive means, and means for restricting the flow through the tailings discharge outlet so as to maintain the level differentials in said cells.

9. In flotation apparatus, inclusive of a series of cells having a feed inlet at one end and a tailings discharge outlet at the opposite end of the series, a rotary impeller in each cell, and a plurality of passages for the progressive movement of a body of pulp from a preceding cell to the impeller of each succeeding cell in the series, the improvement which comprises means for regulating the feed to each impeller positioned to establish a progressive increase in pulp level through a plurality of said cells, conductive means for returning excess pulp from a succeeding cell to each preceding cell, said conductive means having pulp passages which are sufficiently small in relationship to the difference between the discharge capacity of the preceding cell and the final discharge capacity of the series of cells to maintain the level differentials between adjoining cells substantially uniform, means for varying the return flow through said pulp passages, means controlling the final pulp discharge from the series of cells in proportion to the quantity of pulp initially fed to said series, and means for restricting the flow through the tailings discharge outlet so as to maintain the level differentials in said cells.

10. A continuous froth flotation process, which comprises maintaining a body of pulp subject to continuous feed at one end and continuous discharge at its opposite end and divided intermediate its ends into a plurality of treatment stages, aerating the pulp in each of said stages, directing the pulp in the lower portion of said body progressively from the feed end to the discharge end, causing a portion of the pulp in the upper portion of said body to flow countercurrent to the progressive movement of pulp in the lower portion from each succeeding stage to the stage immediately preceding, and throttling said countercurrent flow between each adjoining stage to a degree sufficient to limit the quantity of pulp so returned to less than the quantity of the progressive flow and to maintain the pulp levels at each successive stage between the feed end and discharge end of said body at a progressively higher elevation.

11. A continuous froth flotation process, which comprises maintaining a body of pulp subject to continuous feed at one end and continuous discharge at its opposite end and divided intermediate its ends into a plurality of treatment stages, aerating the pulp in each of said stages, directing the pulp in the lower portion of said body progressively from the feed end to the discharge end, causing a portion of the pulp in the upper portion of said body to flow countercurrent to the progressive movement of pulp in the lower portion from each succeeding stage to the stage immediately preceding, throttling said countercurrent flow between each adjoining stage to a degree sufficient to limit the quantity of pulp so returned to less than the quantity of the progressive flow and to maintain the pulp levels at each successive stage between the feed end and discharge end of said body at a progressively

higher elevation, and varying the final end discharge rate in proportion to fluctuations in feed so as to maintain the level differentials in the successive stages substantially constant.

12. A continuous froth flotation process, which comprises maintaining a body of pulp subject to continuous feed at one end and continuous discharge at its opposite end and divided intermediate its ends into a plurality of treatment stages, aerating the pulp in each of said stages, directing the pulp in the lower portion of said body progressively from the free end to the discharge end, causing a portion of the pulp in the upper portion of said body to flow countercurrent to the progressive movement of pulp in the lower portion from each succeeding stage to the stage immediately preceding, throttling said countercurrent flow between each adjoining stage to a degree sufficient to maintain the pulp levels at each successive stage between the feed end and discharge end of said body at a progressively higher elevation, and varying the volume of pulp in said counterflow by changes in the throttling action so as to change pulp level differentials between adjoining stages.

13. In a method of froth floating ores, in which pulp is treated in a series of cells having submerged connecting passages for returning pulp from a succeeding cell to a preceding cell, the improvement which comprises feeding pulp from a preceding cell to a succeeding cell in a volume in excess of the volume of incoming feed to the first cell in the series, inducing a return flow from a succeeding cell to a preceding cell through the passage between adjoining cells, and throttling said return flow between adjoining stages to a degree sufficient to maintain a level differential between the adjoining cells.

14. In a method of froth floating ores, in which pulp is treated in a series of cells having submerged connecting passages for returning pulp from a succeeding cell to a preceding cell, the improvement which comprises feeding pulp from a preceding cell to a succeeding cell in a volume in excess of the volume of incoming feed to the first cell in the series, and providing a hydraulic resistance in the return flow through at least one of said passages sufficient to produce a hydrostatic differential between the associated preceding and succeeding cells.

15. In a method of froth floating ores, in which pulp is treated in a series of cells having submerged connecting passages for returning pulp from a succeeding cell to a preceding cell, the improvement which comprises feeding pulp from a preceding cell to a succeeding cell in a volume in excess of the volume of incoming feed to the first cell in the series, and providing a hydraulic resistance in the return flow through the said passages sufficient to produce hydrostatic differentials between the preceding and succeeding cells of said series.

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Number	Name	Date
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