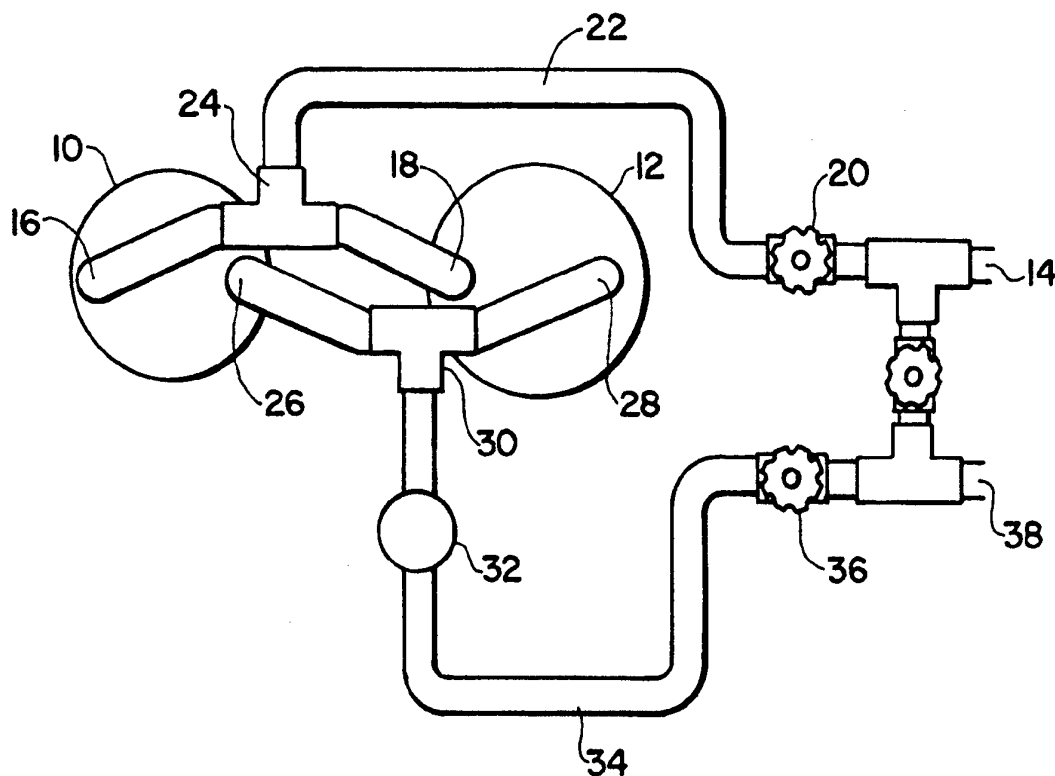




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(54) Title: MULTI-TANK LIQUID TREATMENT METHOD AND APPARATUS



(57) Abstract

A method and apparatus for treating liquid is disclosed utilizing two or more treatment tanks (10, 12) connected in parallel for treating the liquid. The treatment tanks (10, 12) are essentially alike in terms of treatment performance. The tanks (10, 12) each contain a bed of treatment material which may be regenerated. The treatment material in only one of the tanks (10, 12) is regenerated at a time, such that the remaining tank or parallel connected tanks may continue to supply treated liquid.

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MULTI-TANK LIQUID TREATMENT METHOD AND APPARATUS

5

BACKGROUND OF THE INVENTION**FIELD OF THE INVENTION**

The present invention relates to a novel method and apparatus for the treatment of liquid utilizing two or more treatment beds. More particularly, it relates to a treatment method and apparatus wherein two or more treatment tanks, each containing a treatment bed are connected in a parallel arrangement for treating a liquid. Even more particularly, this invention relates to the use of such a method and apparatus in an automatic water softening system.

BACKGROUND INFORMATION

For many uses, it is necessary to treat a liquid such as water prior to its use. Such treatments of water include softening to remove hardness and also filtering to remove solid suspended particles. For instance, it is desirable to soften hard water for many industrial, commercial and household uses. The liquid to be treated customarily flows through a pressurized tank containing a regeneratable treatment material. It is necessary to regenerate the treatment material, wherein its capacity to treat the liquid is lost. For instance, in the process of supplying softened water, typically called the service cycle, ion exchange resin particles acquire hardness inducing ions from hard raw water which is treated in exchange for soft ions. That is, ions which do not induce hardness to the water. After continued contact of the hard water with the resin particles, the ion exchange capacity is considerably diminished and regeneration of the resin particles must be accomplished. The resin particles are regenerated by exposing bathing them in a brine solution, i.e., an aqueous solution of sodium chloride or potassium chloride or the like during a regeneration cycle.

The ion exchange process, which takes place during the regeneration of the ion exchange material, is accomplished in a resin tank of softeners of well-known construction. During the period of time in which the ion exchange material is being regenerated, it cannot be used for providing softened water. Thus, in a typical application of a water softener in a home, the regeneration cycle is conducted during the early morning hours when water is normally not used. When it is necessary to conduct the regeneration at a particular time, such as during the early morning hours, if soft water is to continuously be supplied at other times, it is necessary to regenerate the ion exchange material prior to its being completely exhausted, since otherwise on exhaustion of the ion exchange ability of the resin, hard water would be supplied until the next early morning hour regeneration. It is further desirable to use no more brine than is necessary to completely regenerate the ion exchange material. Therefore, systems provided in the past have attempted to adjust the amount of brine provided during a regeneration to that which is necessary to completely regenerate the ion exchange material.

However, the most efficient regeneration of ion exchange material occurs when it is not regenerated until it is essentially depleted. It is further desirable to provide a water treatment or water softening system wherein the treated or softened water may be continuously provided, i.e., the supply is not interrupted by the need to regenerate the treatment bed.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide a water treatment system and more particularly, a water softening system, wherein the ion exchange resin in a tank may be completely exhausted before it is regenerated. It is a further object of this invention to provide a water treatment or softening system wherein the treated or softened water is continuously supplied without regard to the need to regenerate the treating material, or ion exchange material in the case of a softener. It is still another object of this

invention to provide a water treatment or more particularly, a water softening system which is both efficient and simple to operate. Accordingly, it is an object of this invention to provide a water treatment and more particularly, a water softening system which will maximize the efficient use of the regenerate material to provide for the continuous supply of treated or softened water even during regeneration of a portion of the treatment material which in the case of the softener, is an ion exchange resin. It is a further object of this invention to utilize the treatment or ion exchange material or bed to near its a point of exhaustion, wherein it is most efficiently restored by exposure to a treatment solution, which in the case of a softener, is brine.

In accordance with this invention, a water treatment or water softening system is provided which employs at least two tanks containing treatment beds. The tanks are connected in parallel such that the untreated liquid flows through the treatment bed in either of the tanks, to emerge as a treated liquid. If more than two treatment tanks are utilized, there are as many parallel flow paths as there are treatment tanks. A flow meter is provided to measure the amount of liquid treated, such that by knowing the hardness of the water in the case of a softener, the amount of treatment capacity used in the treatment of the water can be determined. Electronic means are provided for recording the amount of treatment capacity of each of the treatment beds which has been utilized since it was last regenerated.

Insofar as all of the treatment beds are connected in parallel, it is presumed that the flow through each of the treatment beds is equal, such that the total flow is divided by the number of treatment beds to determine the amount of treatment capacity utilized from each bed. In a preferred embodiment, when the total amount of treatment capacity utilized is equal to the treatment capacity of one of the treatment beds, one of the treatment beds is regenerated. Thereafter, treatment of one of the treatment beds is initiated when it reaches a predetermined lower limit of remaining capacity (essentially exhausted) or the regeneration of the one of the parallel connected treatment beds having the

least remaining treatment capacity is initiated when every one of the treatment beds has less than a predetermined minimum amount of remaining capacity. In a preferred embodiment of this invention, the predetermined minimum amount of remaining
5 capacity is equal to the full or total capacity of one of the treatment beds divided by the number of treatment beds connected in parallel. Each time a treatment bed is regenerated, the recording means for that treatment bed is reset to again record the depletion of its treatment ability.

10

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic representation of the liquid flow paths for two treatment tanks connected in accordance with
15 this invention.

FIG. 2 is a schematic diagram of an electrical control circuit for controlling the regeneration of two treatment tanks in accordance with this invention.

FIGS. 3A through 3F are representations of manner in
20 which a two tank system is regenerated in accordance with this invention.

FIG. 4 is a flow diagram for a two resin tank softening system, setting forth the regeneration decisions in accordance with this invention.

FIGS. 5A through 5E are representations of manner in
25 which a three tank system is regenerated in accordance with this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

30

To assist in the understanding of the system and method for supplying treated liquid in accordance with this invention, particularly with respect to a water softening system, a schematic diagram of the liquid flow paths for a two
35 tank system in accordance with this invention is shown in FIG. 1. A pair of tanks containing ion exchange resin particles are represented 10 and 12. A supply of raw water is connected to supply pipe 14 which is connected to the inlets 16 and 18 of the tanks 10 and 12 respectively through a shut-off valve

20, pipe 22, and tee connection 24. The outlets for the discharge of the treated or softened water 26 and 28 of tanks 10 and 12 respectively are connected together through another tee connection 30, a flow measuring device 32, a pipe 34, and
5 a shut-off valve 36 to a treated water outlet pipe 38. If for some reason, such as replace of the softening system, it should be necessary to bypass the treatment tanks 10 and 12, a bypass valve 40 is provided. The bypass valve 40 should only be opened when valves 20 and 36 are closed.

10 The measuring device or means 32 may be in the form of a turbine-type meter which provides an electrical output indicative of the quantity of flow of processed or softened water through outlet pipe 38.

Referring to FIG. 2, a preferred embodiment of an
15 electrical control circuit for controlling the regeneration of two treatment tanks in accordance with this invention will be described. The essence of the control circuit 40 is a microprocessor. The control circuit 40 receives an electrical signal output from the flow measuring device 32 through leads
20 42, so as to enable recording means within the control circuit 40 to maintain a record or register of the use of the capacity of each of the tanks 10 and 12. The microprocessor, in accordance with an algorithm recorded therein, utilizes the recorded use of the capacity of each of the tanks 10 and 12 to
25 develop control signals which control the valve motors 44 and 46 which control the regeneration cycles of each of the tanks 10 and 12 respectively. The various flow cycles necessary for regenerating a water softener resin bed using a brine solution are well known in the art and are not further described
30 herein. The microprocessor 40 is connected to valve motor 44 by the leads 48 and 50, and to the valve motor 46 by the electrical leads 52 and 54. The outlet 26 and 28 from the tanks 10 and 12, as well as the flow measuring device 32 and the outlet pipe 38 are also shown in FIG. 2.

35 Referring to FIGS. 3A through 3F, the manner in which a two tank system is regenerated in accordance with this invention will be described. The two tanks of the system are shown as tanks 1 and 2. The remaining softening capacity of each of the tank is represented by the darkened area of the

tank. While the initial start up conditions could be different, it is preferred that both resin tanks be placed in service at full or 100% capacity, as represented by the fully darkened tanks in FIG. 3A.

5 As service water starts to flow through the softener, the capacity of both tanks is equally depleted. The depletion of the tanks will continue until both of the tanks are depleted to a predetermined minimum amount of remaining capacity, which in the case of a two tank system is preferably
10 50% of the tanks full capacity. Thus, as shown in FIG.3B, tank 1 is taken out of service and regenerated when it is exhausted to 50% of its total capacity. Tank 2 remains in service to provide softened water, such that its remaining capacity drops below 50% if softened water is used while tank
15 1 is being regenerated.

As shown in FIG.3C, tank number 1 has been regenerated to full or 100% capacity, while the remaining capacity of tank 2 has continued to drop during the regeneration of tank 1, due to the use of softened water. Tank 1 will return to the
20 service position and both tanks will remain in service until tank 2 is exhausted to a predetermined lower limit, which is normal close to full exhaustion, and is shown as such in FIG.3D. The capacity of tank 2 having been completely exhausted, it will be taken off line to be regenerated. Tank
25 1 remains in service to handle all the softening requirements until the regeneration of tank 2 is finished. As shown in FIG.3E, the remaining capacity of tank 1 will have continued to drop as tank number 2 is regenerated and restored to full or 100% of capacity. Both tanks will be on line again until
30 tank number 1 has been completely exhausted.

As shown in FIG.3F, tank 1 has become completely exhausted, such that it will be regenerated and tank 2 will handle all of the softening requirements while it is being regenerated. Thereafter, the cyclic regeneration of the tanks
35 will continue as from the condition shown in FIG.3C.

In the preferred embodiment of a twin tank system of this invention, the fundamental decision when to initiate a regeneration of one of the two resin tanks is: Is the capacity used recorded by the softener's electronic control equal to

the set capacity in the control? Or in other terminology, is the capacity remaining in a resin tank at 50% or 0% (completely depleted). If one of the two conditions is true a regeneration will be initiated immediately.

5 The 50% remaining capacity trip point is used to prevent hard water bleed when one tank is on line and the other tank is regenerating. It is also used to insure sufficient softening capacity remains in the tank remaining in service. The softener must be more carefully sized to the installation
10 because sufficient capacity must remain in the tank left in service while the other tank regenerates. The salt or brine dosage used to regenerate a tank in accordance with the system of this invention is always that necessary to fully restore and essentially depleted tank.

15 The advantage of a twin resin tank softener configuration is that a continual source of soft water is available. As the softener softens, water capacity in the two tanks depletes. When the softening capacity has been depleted to a preset level or predetermined minimum amount, one resin
20 tank will regenerate and the other tank will remain on line softening water. The capacity in the resin tank remaining on line must be sufficient to provide soft water during the regeneration. Every time a regeneration occurs, the regeneration will use preselected salt and water efficient
25 settings, for completely regenerating the tank.

The Twin Tank Softener is designed to provide the highest possible salt efficiency and the minimum possible water usage for regeneration. Because two resin tanks are used, the regeneration of one tank can occur at any time of
30 day because there is always capacity available in the opposite tank to provide soft water. Under normal operating conditions, both resin tanks operate simultaneously to provide soft water, each tank processing one half of the water used. The controller directs the valve operation such that the resin
35 tanks are operated in a out-of-phase regeneration sequence so that at least one tank always has water softening capacity available.

The above-described operation of a two tank system in accordance with this invention is also set forth in the flow

diagram of FIG.4. This flow diagram sets forth the regeneration decision made in accordance with this invention.

The present invention not only contemplates two tank systems but also multi-tank systems. Referring to FIGS. 5A through 5E, the manner in which a three tank system is regenerated in accordance with this invention will be described. The three tanks of the system are shown as tanks 1, 2 and 3. The remaining softening capacity of each of the tank is represented by the cross-hatched area of the tank. While the initial start up conditions could be different, it is preferred that all of the resin tanks be placed in service at full or 100% capacity, as represented by the fully cross-hatched tanks in FIG. 5A.

As service water starts to flow through the softener, the capacity of all three tanks will be equally depleted. The depletion of the tanks will continue until all three tanks are depleted to a predetermined minimum amount of remaining capacity, which in the case of a two tank system is preferably two-thirds or 66.7% of the tanks full capacity. Thus, as shown in FIG.5B, tank 1 is taken out of service and regenerated when it is exhausted to 66.7% of its total capacity. Tanks 2 and 3 remain in service to provide softened water, such that their remaining capacities drop below 66.7% if softened water is used while tank 1 is being regenerated.

As shown in FIG.5C, tank number 1 has been regenerated to full or 100% capacity, while the remaining capacities of tanks 2 and 3 continued to drop during the regeneration of tank 1, due to the use of softened water. Tank 1 will return to the service position and all three tanks will remain in service until tank 2 or tank three or both are exhausted to a predetermined lower limit, which is normal close to full exhaustion. Assuming that tank 2 is regenerated before tank 3, tank 3 is shown full regenerated in FIG.5D, while the capacities of tanks 1 and 3 continue to be reduced due to the use of softened water while tank 2 is being regenerated. The capacity of tank 3 having been completely exhausted, as shown in FIG. 5D, it will be taken off line to be regenerated while tanks 1 and 2 remain in service to handle all the softening requirements until the regeneration of tank 3 is finished.

As shown in FIG.5E, the remaining capacity of tank 1 will have continued to drop as tank number 3 is regenerated and restored to full or 100% of capacity. All three tanks will be on line again until tank number 1 has been completely exhausted as shown in FIG. 5E. Thereafter, the cyclic regeneration of the tanks will continue as from the condition shown in FIG.5C.

It should be apparent to those skilled in the art, that while what has been described are considered at present to be preferred embodiments of the multi-tank liquid treatment method and apparatus for supplying treated liquid in accordance with this invention, in accordance with the patent statutes, changes may be made in the method and apparatus without actually departing from the true spirit and scope of this invention.

The appended claims are intended to cover all such changes and modifications which fall within the true spirit and scope of this invention.

CLAIMS

WE CLAIM:

1. A method for supplying treated liquid utilizing two essentially identical treatment beds having essentially the same treatment capacity, said treatment beds being connected in parallel such that when both treatment beds are in use,
5 liquid to be treated flows through each of the treatment beds in essentially equal amounts,

measuring the amount of treatment capacity used,

10 recording the amount of treatment capacity used from each of said treatment beds by dividing the amount of treatment capacity used equally between said two treatment beds when both are in use, and applying the amount of treatment capacity used to said treatment bed in use when one of said treatment
15 beds is being regenerated,

initiating a regeneration of one of said treatment beds by supplying a regenerant thereto, when the recorded amount of treatment capacity used from that treatment bed indicates that
20 it has reached a predetermined lower limit of remaining capacity, or initiating a regeneration of said one of said treatment beds having the least remaining treatment capacity when both of said treatment beds have less than a predetermined minimum amount of remaining capacity, which
25 predetermined minimum amount is greater than said predetermined lower limit of remaining capacity and, resetting the recorded amount of treatment capacity used from one of said treatment beds after said treatment bed is regenerated.

2. The method of supplying treated liquid of claim 1, wherein said predetermined minimum amount of remaining capacity is equal to one half of the total capacity of one of said treatment beds.

3. The method of supplying treated liquid of claim 1, wherein the use of said treatment beds is initiated with both of said treatment beds at full capacity, and the regeneration of a first one of said treatment beds is initiated when the
5 total recorded treatment capacity used from said treatment beds equals the treatment capacity of one of said treatment beds.

4. The method of supplying treated liquid of claim 1, wherein a regenerant is supplied from a single source to each of said treatment beds in a predetermined amount capable of fully regenerating one of said treatment beds from said
predetermined lower limit of treatment capacity.

5. The method of supplying treated liquid of claim 1, wherein said liquid to be treated is water, said treatment beds comprises resin beds for softening the water, and said regenerant is a brine solution.

6. The method of claim 1, wherein treated liquid is used in the regeneration of said treatment beds.

7. A system for supplying treated liquid utilizing two essentially identical treatment beds having essentially the same treatment capacity, said treatment beds being connected in parallel such that when both of said treatment beds are in
5 use, liquid to be treated flows through each of said treatment beds in essentially equal amounts,

a measuring means for measuring the amount of treatment capacity used,

a recording means for recording the amount of treatment
10 capacity used as measured by said measuring means, recording the amount of treatment capacity used from each of said treatment beds by dividing the amount of treatment capacity used equally between said two treatment beds when both are in use, and applying the amount of treatment capacity used to

15 said treatment bed in use when one of said treatment beds is being regenerated,

a control means for initiating regeneration of said treatment beds, said control means receiving a signal from said recording means and initiating a regeneration of one of said
20 treatment beds when the recorded amount of treatment capacity used from that treatment bed reaches a predetermined lower limit of remaining capacity, or initiating a regeneration of said one of said treatment beds having the least remaining treatment capacity when both of said treatment beds have less
25 than a predetermined minimum amount of remaining capacity, which predetermined minimum amount is greater than said predetermined lower limit of remaining capacity and, and resetting the recorded amount of treatment capacity used from each bed after said treatment bed is regenerated.

8. The system of supplying treated liquid of claim 7, wherein said predetermined minimum amount of remaining capacity is equal to one half of the total capacity of one of said treatment beds.

9. The system of supplying treated liquid of claim 7, wherein the use of said treatment beds is initiated with both of said treatment beds at full capacity, and the regeneration of a first one of said treatment beds is initiated when the
5 total recorded treatment capacity used from said treatment beds equals the treatment capacity of one of said treatment beds.

10. The system of supplying treated liquid of claim 7, including a single source of regenerant for regenerating said treatment beds, said single source supplying said regenerant in a predetermined amount capable of fully regenerating one of
5 said treatment beds from said predetermined lower limit of treatment capacity.

11. The system of supplying treated liquid of claim 7, wherein said liquid to be treated is water, said treatment

beds comprise resin beds for softening the water, and said regenerant is a brine solution.

12. The system of supplying treated liquid of claim 7, wherein said measuring means comprises a turbine type flow meter placed in the flow path of the treated liquid.

13. The system of supplying treated liquid of claim 7, wherein said recording means and said control means comprise a microprocessor.

14. A method for supplying treated liquid utilizing at least two essentially identical treatment beds having essentially the same treatment capacity, said treatment beds being connected in parallel such that when all of said treatment
5 beds are in use, liquid to be treated flows through each of the treatment beds in essentially equal amounts,

measuring the amount of treatment capacity used,

recording the amount of treatment capacity used from each of said treatment beds by dividing the amount of treatment
10 capacity used equally between all of said treatment beds when all of said treatment beds are in use, and applying the amount of treatment capacity used to only said treatment beds in use when one of said treatment beds is being regenerated,

initiating a regeneration of one of said treatment beds when
15 the recorded amount of treatment capacity used from that treatment bed indicates that it has reached a predetermined lower limit of remaining capacity, or initiating a regeneration of said one of said treatment beds having the least remaining treatment capacity when all of said treatment
20 beds each have less than a predetermined minimum amount of remaining capacity, which predetermined minimum amount is greater than said predetermined lower limit of remaining capacity and, resetting the recorded amount of treatment capacity used from each of said treatment beds after said
25 treatment bed is regenerated.

15. The method of supplying treated liquid of claim 14, wherein said predetermined minimum amount of remaining capacity is equal to the total capacity of one of said treatment beds divided by the number of said treatment beds connected in parallel.

16. The method of supplying treated liquid of claim 14, wherein the use of said treatment beds is initiated with all of said treatment beds at full capacity, and the regeneration of a first one of said treatment beds is initiated when the
5 total recorded treatment capacity used from said treatment beds equals the treatment capacity of one of said treatment beds.

17. The method of supplying treated liquid of claim 14, wherein a regenerant is supplied from a single source to each of said treatment beds in a predetermined amount capable of full regeneration of one of said treatment beds from said
5 predetermined lower limit of treatment capacity.

18. The method of supplying treated liquid of claim 14, wherein said liquid to be treated is water, said treatment bed comprises a resin bed for softening the water, and said regenerant is a brine solution.

19. The method of supplying treated liquid of claim 14, wherein treated liquid is used in the regeneration of said treatment beds.

20. A system for supplying treated liquid utilizing at least two essentially identical treatment beds having essentially the same treatment capacity, said treatment beds being connected in parallel such that when all of said treatment
5 beds are in use, liquid to be treated flows through each of said treatment beds in essentially equal amounts,

a measuring means for measuring the amount of treatment capacity used,

a recording means for recording the amount of treatment capacity used as measured by said measuring means, recording the amount of treatment capacity used from each of said treatment beds by dividing the amount of treatment capacity used equally between all of said treatment beds when all of said treatment beds are in use, and applying the amount of treatment capacity used to only said treatment beds in use when one of said treatment beds is being regenerated,

a control means for initiating regeneration of said treatment beds, said control means receiving a signal from said recording means and initiating a regeneration of one of said treatment beds when the recorded amount of treatment capacity used from that treatment bed reaches a predetermined lower limit of remaining capacity, or initiating a regeneration of said one of said treatment beds having the least remaining treatment capacity when all of said treatment beds each have less than a predetermined minimum amount of remaining capacity, which predetermined minimum amount is greater than said predetermined lower limit of remaining capacity, and resetting the recorded amount of treatment capacity used from one of said treatment beds after said treatment bed is regenerated.

21. The system of supplying treated liquid of claim 20, wherein said predetermined minimum amount of remaining capacity is equal to the total capacity of one of said treatment beds divided by the number of said treatment beds connected in parallel.

22. The system of supplying treated liquid of claim 20, wherein the use of said treatment beds is initiated with all of said treatment beds at full capacity, and the regeneration of a first one of said treatment beds is initiated when the total recorded treatment capacity used from said treatment beds equals the treatment capacity of one of said treatment beds.

23. The system of supplying treated liquid of claim 20, including a single source of regenerant for regenerating all of said treatment beds, said single source supplying said regenerant in a predetermined amount capable of fully
5 regenerating one of said treatment beds from said predetermined lower limit of treatment capacity.

24. The system of supplying treated liquid of claim 20, wherein said liquid to be treated is water, said treatment beds comprise resin beds for softening the water, and said regenerant is a brine solution.

25. The system of supplying treated liquid of claim 20, wherein said measuring means comprises a turbine type flow meter placed in the flow path of the treated liquid.

26. The system of supplying treated liquid of claim 20, wherein said recording means and said control means comprise a microprocessor.

Fig. 1

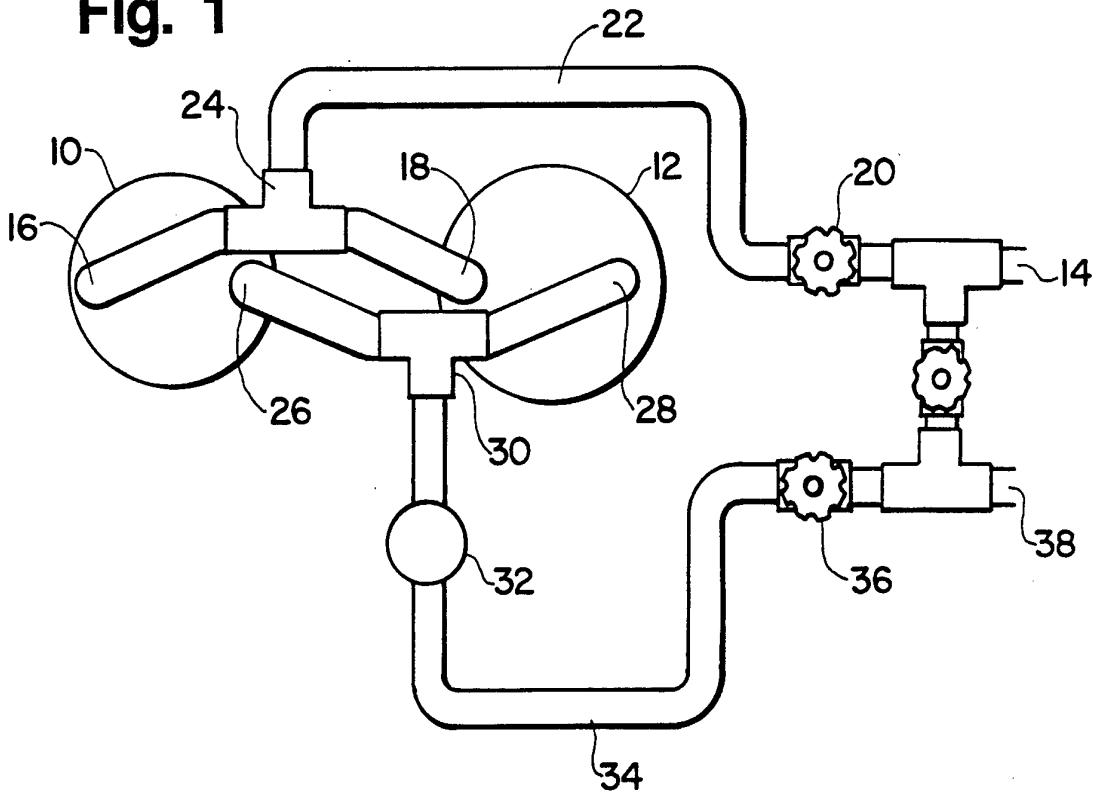


Fig. 2

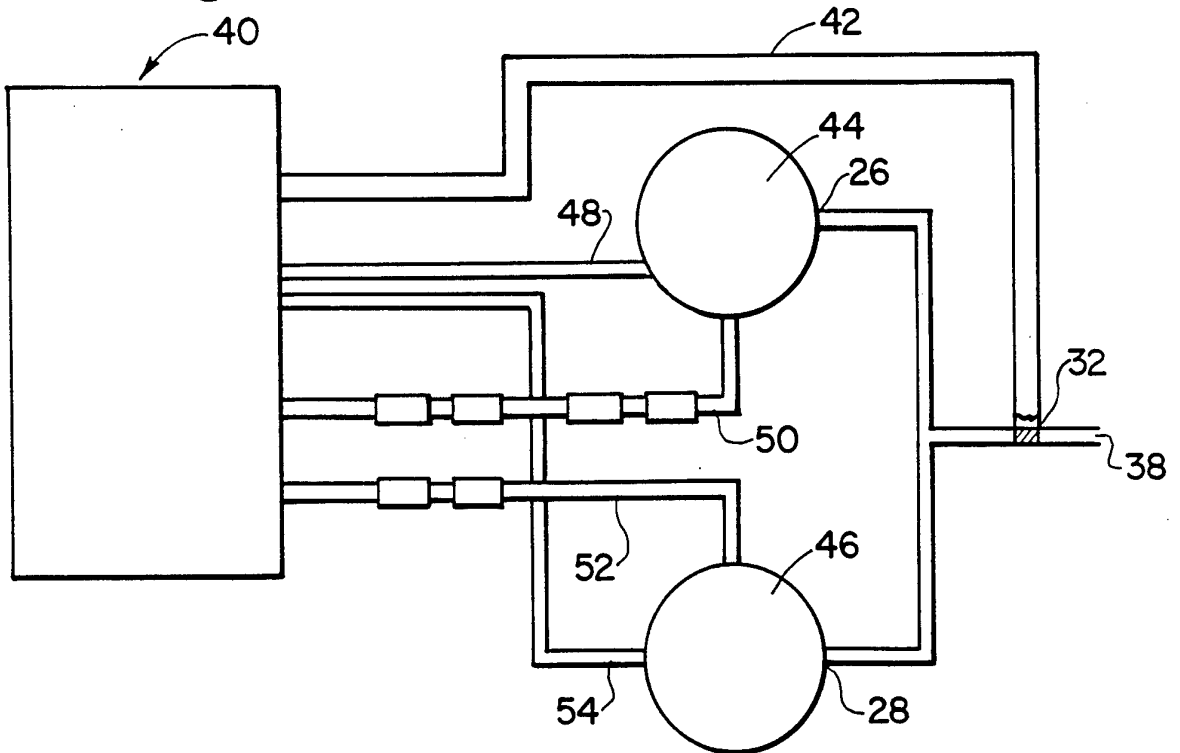


Fig. 3A

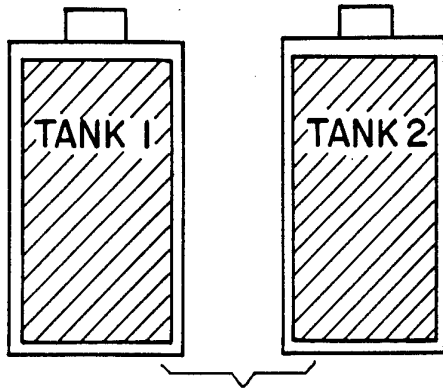


Fig. 3B

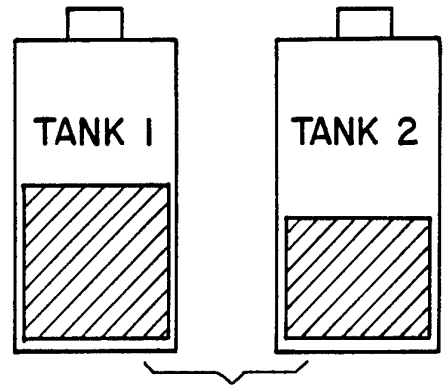


Fig. 3C

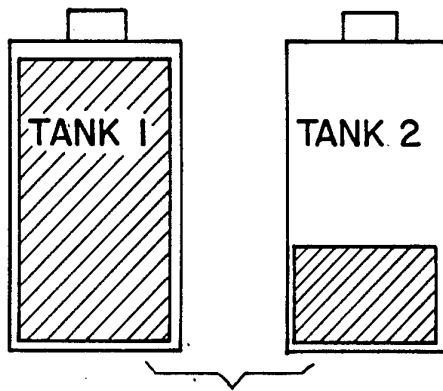


Fig. 3D

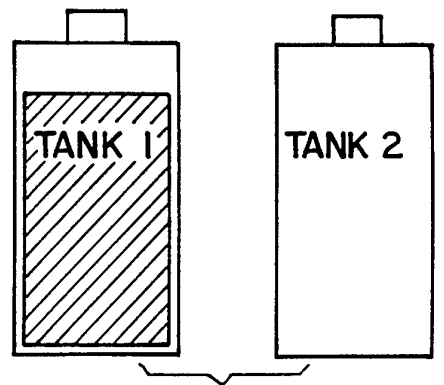


Fig. 3E

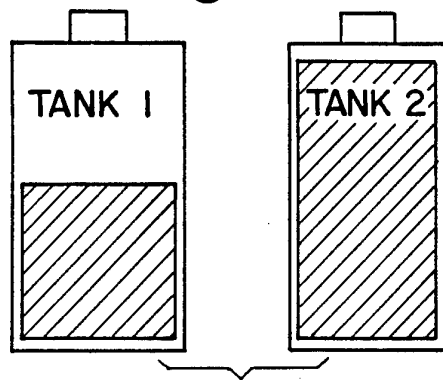
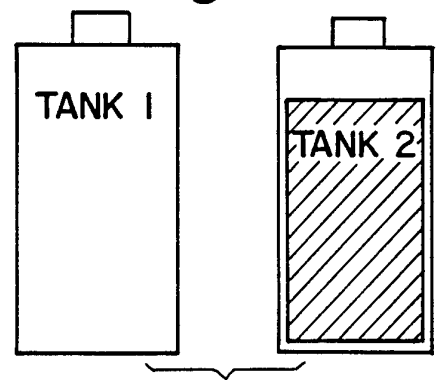


Fig. 3F



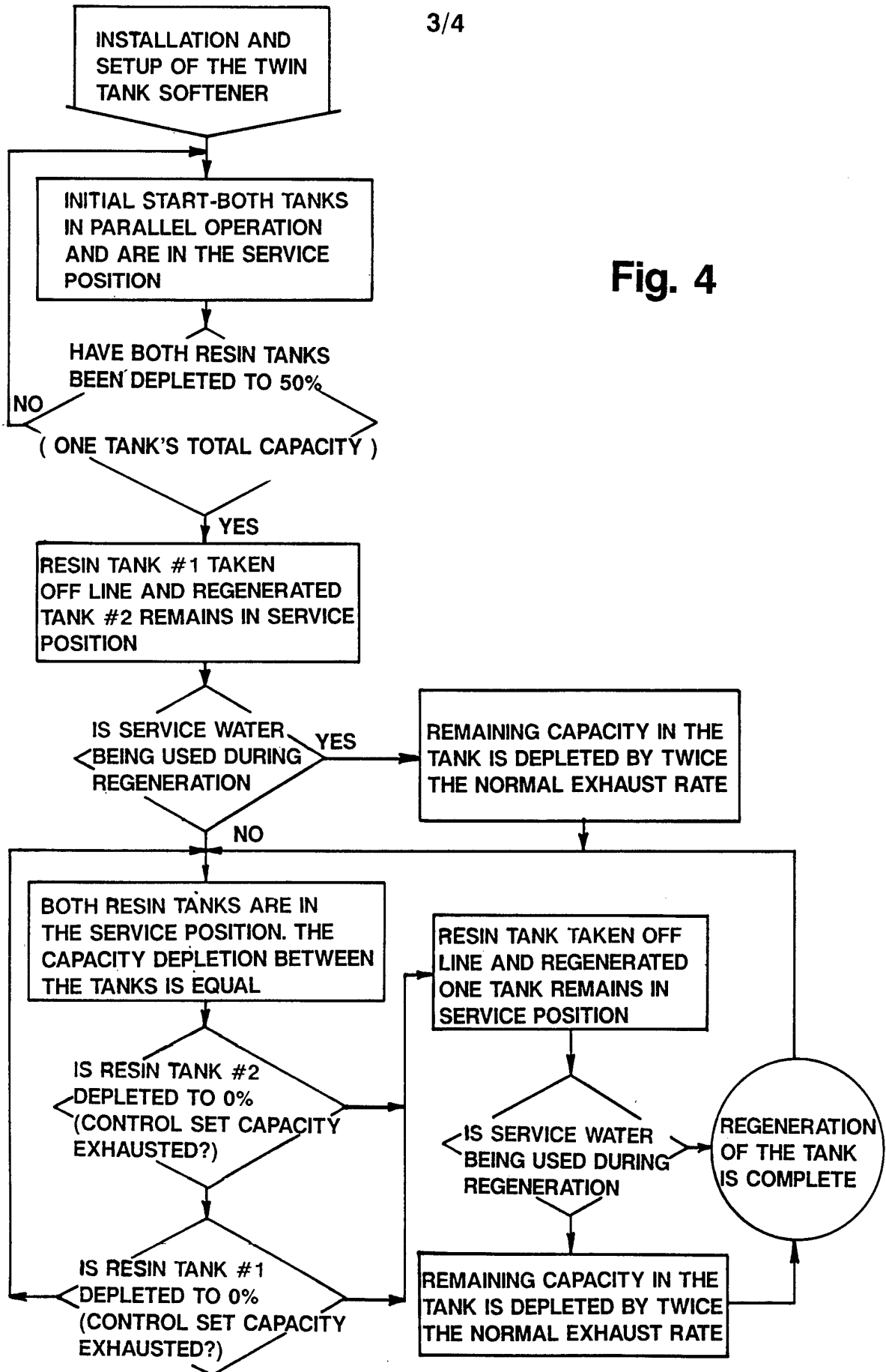


Fig. 4

Fig. 5A

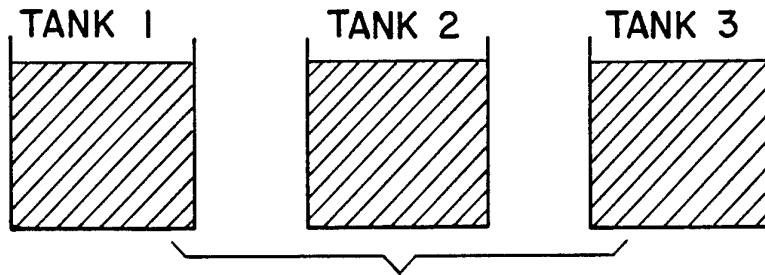


Fig. 5B

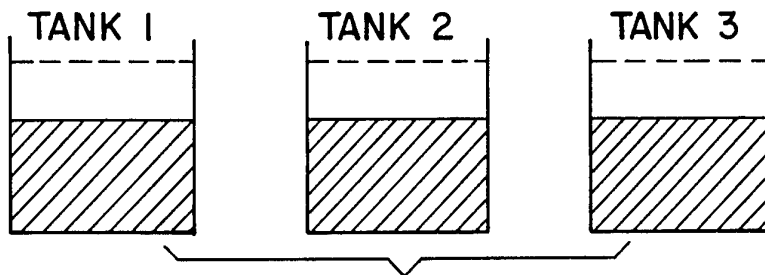


Fig. 5C

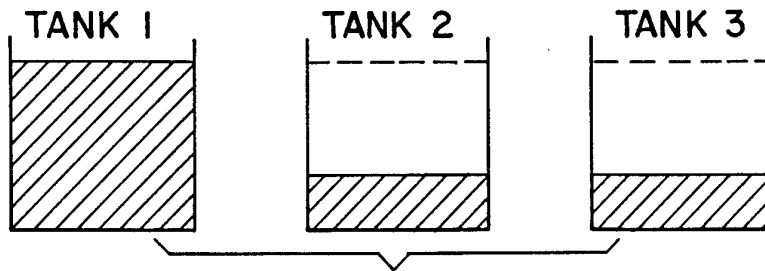


Fig. 5D

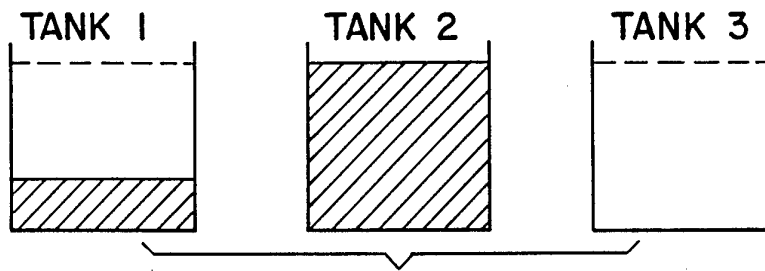
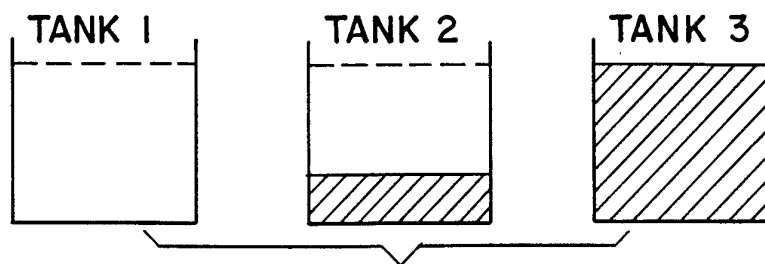


Fig. 5E



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/12201

A. CLASSIFICATION OF SUBJECT MATTER		
IPC(5) : B01D 15/00 US CL : 210/662,670,677,678,96.1,98,138,140-143,190,269.278.279,284 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) U.S. : 210/662,670,677,678,96.1,98,138,140-143,190,269.278.279,284		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched None		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) None		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 3,396,845 (Bouskill) 13 AUGUST 1968, see entire document	1,4-7,10,11, 13,14,17-20, 23,24,26
Y	US, A, 5,073,255 (Chili et al) 17 DECEMBER 1991, col. 7, lines 50-68	1,4-7,10,11, 13,14,17-20, 23,24,26
Y	US, A, 3,891,552 (Prior et al) 24 JUNE 1975, col. 3, lines 5-14.	12,25
Y	US, A, 5,089,140 (Brane et al) 18 FEBRUARY 1992, cols. 10-11.	1-26
A	US, A, 4,722,797 (Gauer et al) 02 FEBRUARY 1988, see entire document.	1-26
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means		
"P" document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search 02 February 1994	Date of mailing of the international search report 16 FEB 1994	
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. NOT APPLICABLE	Authorized officer <i>Cynthia L. Nessler</i> CYNTHIA L. NESSLER Telephone No. (703) 308-3843	