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Nelson

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[45] **Feb. 6, 1973**

[54] **ASEPTIC STORAGE AND VALVING SYSTEM**

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[73] Assignee: **Purdue Research Foundation,** Lafayette, Ind.

[22] Filed: **May 18, 1972**

[21] Appl. No.: **254,733**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 40,550, May 26, 1970, Pat. No. 3,678,956.

[52] **U.S. Cl.** **137/238**

[51] **Int. Cl.** **F16k 51/00**

[58] **Field of Search** 21/91, 94; 137/15, 238, 240, 137/241, 332; 99/105, 154, 155, 186

[56] **References Cited**

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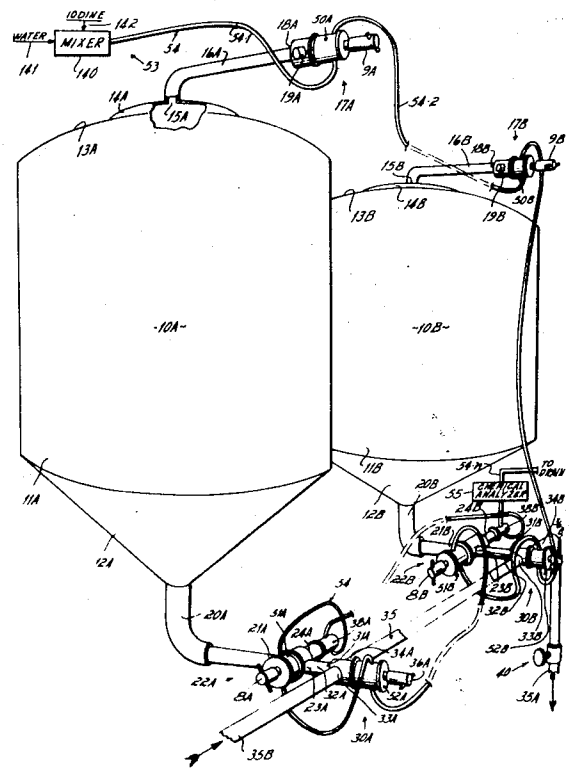
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Primary Examiner—Henry T. Klinksiek
Attorney—James S. Hight et al.

[57] **ABSTRACT**

A plurality of storage tanks for bulk storage of materials under aseptic conditions in which valves associated with the tanks have chambers filled with liquid chemical sterilant surrounding movable valve actuators for preventing the influx, via the valve actuators, of contaminants to the material stored in the tanks. The chemical sterilant is unheated to prevent the transfer of heat from the sterilant to the stored material. The sterilant chambers are connected serially to form a cascade between a source of fresh sterilant and a chemical analyzer, with the chambers which become more contaminated in use being connected in the cascade more remote from the fresh sterilant supply. The sterilant chambers are recharged with fresh sterilant by a flow of fresh sterilant from the supply through the cascade, which flow is terminated when the sterilant leaving the last chamber of the cascade upon analysis by the chemical analyzer has reached a sterile level indicating that the fresh sterilant has propagated through the cascaded chambers successively flushing the chambers in the cascade of inactive, or stale, sterilant and replenishing the chambers with fresh sterilant. Each sterilant chamber is provided with an inlet passage and an outlet passage located at the bottom and top of the chambers, respectively, such that fresh sterilant enters the bottom of the chamber, forcing inactive, or stale, sterilant from the chamber through the top, insuring complete recharging of the entire chamber with fresh sterilant.

9 Claims, 5 Drawing Figures



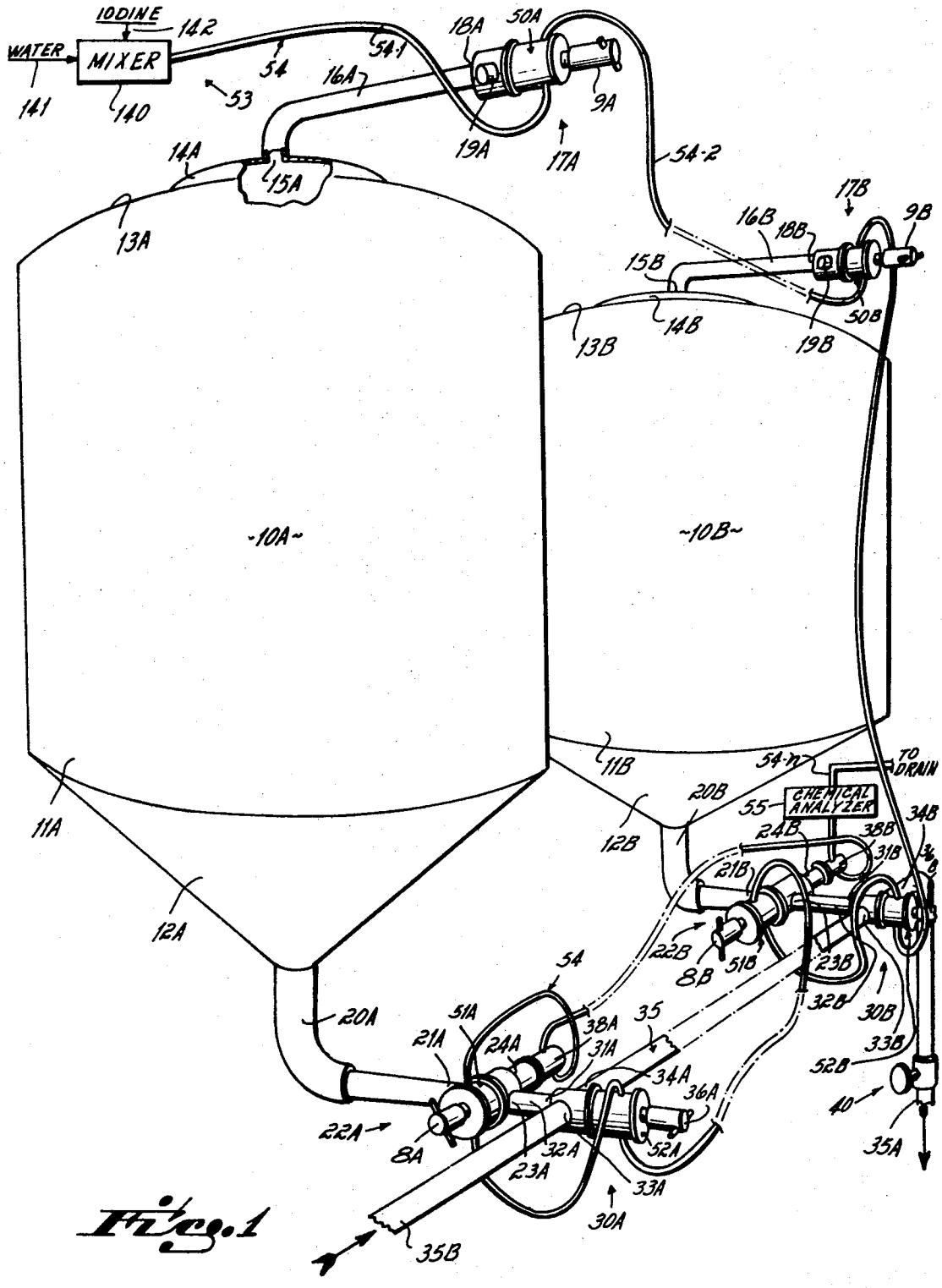

IODINE
142
WATER
MIXER
141
140
53
54
54-1
16A
18A
50A
9A
19A
17A
54-2
14A
15A
13A
17B
16B
18B
9B
15B
14B
50B
19B
13B
10A
10B
11A
12A
11B
12B
54-n
TO DRAIN
CHEMICAL ANALYZER
55
20B
24B
38B
34B
31B
21B
22B
8B
51B
23B
32B
30B
33B
52B
40
35A
54
20A
51A
21A
24A
38A
31A
35
34A
36A
22A
8A
32A
23A
52A
33A
30A
35B

Fig. 1

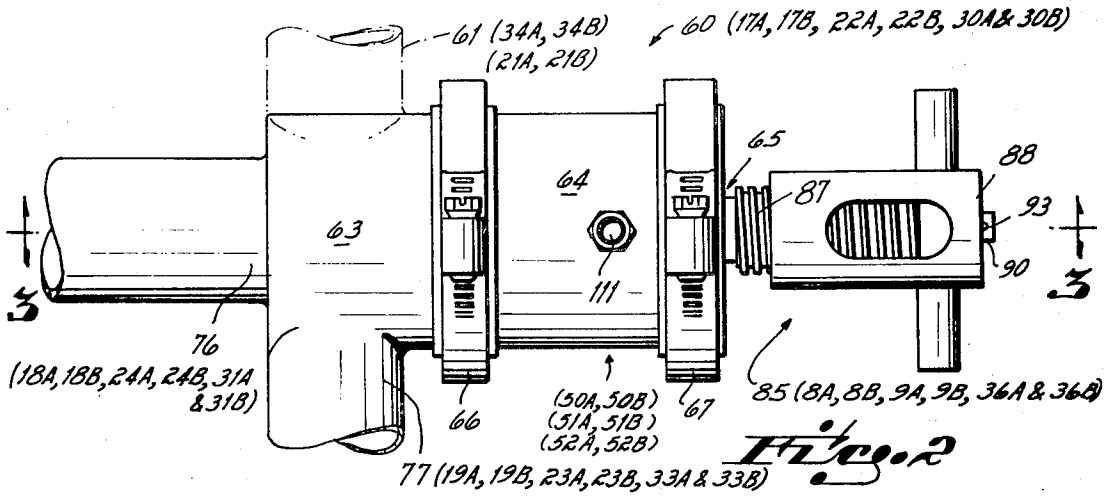


Fig. 2

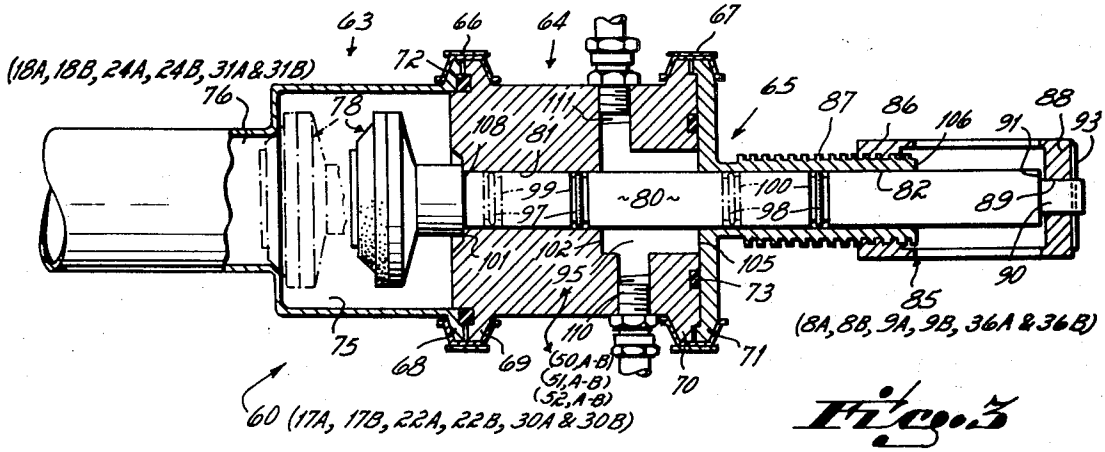


Fig. 3

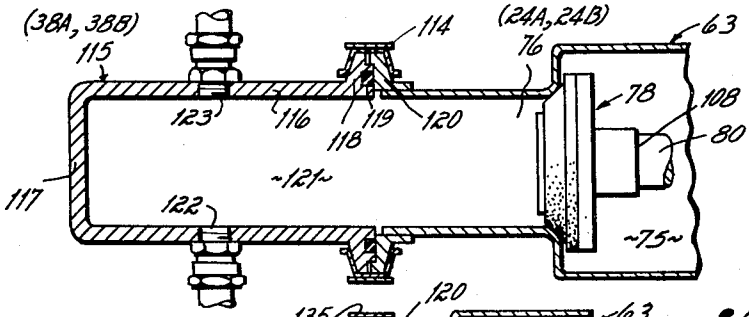


Fig. 4

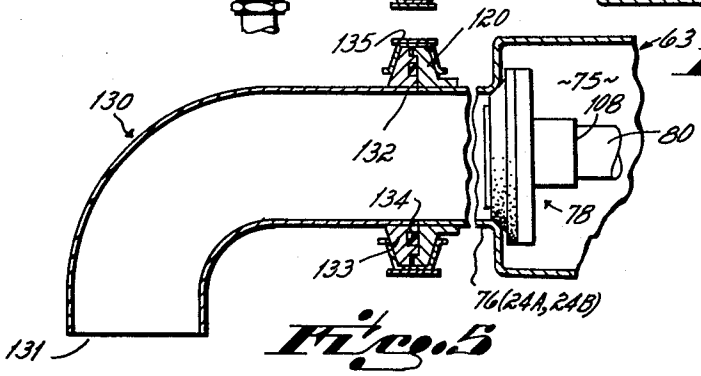


Fig. 5

ASEPTIC STORAGE AND VALVING SYSTEM

This application is a continuation-in-part of the pending application of Philip E. Nelson for "Aseptic Storage and Valving System," Ser. No. 40,550, filed May 26, 1970, now U.S. Pat. No. 3,678,955.

BACKGROUND OF THE INVENTION

This invention relates to the storage of material under aseptic conditions, and more particularly to an aseptic valving and storage system suitable for use with storage tanks in which material such as food, pharmaceuticals, and the like, is stored in bulk form.

In the processing of edible material, and prior to final packaging in small units for consumer use, it is often necessary to store large quantities of the material in bulk form and to do so under aseptic conditions in order to insure ultimate purity of the material as supplied to the consumer. The problem of aseptically storing material in bulk form is compounded by two factors. First, it is often necessary that the material remain in storage tanks for protracted periods of time, often exceeding 3 months. Such is the case, for example, in the processing of tomato products which are sold throughout the year although available for harvesting during only a few months. When edibles are stored for protracted periods, contaminants, such as microorganisms, if admitted into the tank, even when admitted in only small quantity, will eventually contaminate the entire tank. Such is due to the characteristic rapid growth, or multiplication, of microorganisms which persists over the protracted storage period. Contamination of an entire tank is a particularly acute problem in practice due to the fact that conventional bulk storage tanks often store 50,000–70,000 gallons each, and contamination of even one tank therefore represents a substantial loss.

The second factor aggravating the bulk storage problem is that it is often necessary to store the bulk material without a change in its temperature. This is particularly true when the bulk material has been previously partially or fully processed to a predetermined desired intermediate or final condition, and change of its temperature during storage will adversely affect the predetermined desired condition of the stored material which resulted from its pre-storage processing. When storage of partially or fully processed bulk material is required without elevation of its temperature, it is essential that the means utilized to facilitate aseptic storage does not transfer heat to the stored material and thereby occasion undesired increases in stored material temperature. Since heat transfer to the stored material during storage frequently must be avoided, utilization of thermal sterilizing agents such as steam, often a sterilizing agent in aseptic valving systems, is not feasible since such will in time result in an undesirable increase in temperature of the stored material.

SUMMARY OF THE INVENTION

Accordingly, it has been an objective of this invention to provide means for storing large quantities of bulk material under aseptic conditions, particularly for protracted periods, and to do so without increasing the temperature of the stored material. This objective has been accomplished in accordance with certain of the principles of this invention by providing storage tanks

in which previously sterilized material can be placed for bulk storage with aseptic valves which are characterized by having a chamber surrounding the movable valve actuator which is filled with a liquid sterilant of a chemical nature. The use of a chemical sterilant, such as an iodine-based detergent sanitizer, permits aseptic storage to be effected with an unheated sterilant and, hence, without the transfer of heat and consequent elevation in temperature of the stored material as would necessarily occur if thermal sterilizing agents, such as steam, were utilized.

In addition to facilitating aseptic storage without undesirable increase in stored material temperature, the use, in combination with a storage tank, of a chemically sanitized valve vis-a-vis a thermally sanitized steam valve provides a further advantage. Specifically, it dispenses with the complications and expense of generating steam. Steam sterilization is complicated and expensive because the steam which is generated must be free of mineral deposits to minimize lime deposits in the steam plumbing. Also, the steam generating equipment used must necessarily be operated on a 24 hour basis due to the relatively short-lived sterilization capability of thermal sterilants. Twenty-four hour operation is a particularly expensive proposition when material is to be stored for long periods, such as 3 months or more; whereas, a chemically sanitized valve must be recharged with fresh sterilant on only an intermittent basis, e.g., once per day, since chemical sterilants maintain their aseptic nature for extended periods of time.

In accordance with a preferred embodiment of the aseptic storage and valving system of this invention, the chemical sterilant is in liquid form and the sterilant chambers of the valves have a sterilant inlet passage at the bottom of the chamber and a sterilant outlet passage at the top of the chamber. Utilization of a chemical sterilant in liquid form with sterilant chambers having lower and upper sterilant inlet and outlet passages insures that when sterilant is introduced into the chamber any entrapped air will be forced upwardly through the sterilant exit passage, facilitating filling of the entire volume of the chamber with sterilant. Additionally, location of the sterilant discharge passage at the top of the chamber enables the entire volume of the chamber to be filled with liquid sterilant before the sterilant flows out of the chamber via the exit passage.

It has been a further objective of this invention to provide simple and efficient means for periodically replenishing, or recharging, the sterilant chambers of the valve with a fresh supply of sterilant. This objective has been accomplished in accordance with certain principles of this invention by connecting the sterilant chambers of the valves in serial fashion, forming a cascade or chain, the cascade or chain in turn being connected at its inlet end to a supply of fresh sterilant and at its outlet end to a chemical analyzer. By virtue of this unique combination, the aseptic solutions in the valve sterilant chambers can be periodically replenished and done so with a minimum of equipment, insuring that the strength of the sterilant in the chambers is at all times maintained at a suitable level.

In operation, periodic replenishing, or recharging, of the valve sterilization chambers with fresh sterilant is accomplished by activating the fresh sterilant supply,

causing fresh sterilant to be pumped into the first chamber of the cascade or chain. The fresh sterilant entering the first chamber forces out of that chamber the old, or stale, sterilant stored therein. This substitution of fresh sterilant for stale sterilant propagates down the cascade or chain until the stale solution in all chambers has been expelled or flushed and fresh sterilant substituted in its place. Continued pumping of fresh sterilant results in fresh solution being introduced into the chemical analyzer from the chamber of the last valve in the cascade or chain. When this occurs, the chemical analyzer provides information indicating that fresh solution has been transmitted the entire length of the chain, and that all valve chambers have been charged with fresh aseptic solution. The sterilant supply now terminates operation, and the fresh solutions in the chambers remain until the next chamber recharging cycle.

The foregoing approach to recharging the sterilant chambers on a periodic basis is particularly advantageous because it permits the supply of fresh sterilant to utilize completely conventional equipment. In a preferred form, the source of fresh sterilant is a conventional liquid metering device which is connected to both a supply of water and a supply of concentrated chemical liquid sterilant. When recharging is required, water is automatically mixed by the mixer with the sterilant concentrate at a predetermined ratio, which ratio is independent of the flow rate of the water. Thus, the sterilant recharging system of this invention requires, in a preferred form, no equipment which is not already commercially available.

It has been discovered that in practice certain of the valves associated with the storage tanks are more likely to become contaminated than other valves. For example, in a system having one set of valves used only for admitting cleansing solution into the tanks for cleaning purposes and a second set of valves for filling and draining the tanks of stored material, it has been found that the filling and draining valves are much more likely to become contaminated than the tank cleansing valves. This is due to the fact that the lines leading to the filling and draining valves after a filling and/or draining operation, notwithstanding that such a periodically flushed, contain traces of stored material which are subject to decay, providing a potential source of contaminant in the valve. Whereas, the cleansing valves, through which only cleansing solution passes as it is introduced into the tanks, are not subject to problems introduced by trace amounts of material which is subject to decay since only cleansing solution passes through these valves and not the material which is stored.

It has been an objective of this invention to provide an aseptic storage and valving system which minimizes the contamination problem occasioned by the presence of trace amounts of stored material in the filling and draining valves associated with the tanks. This objective has been accomplished in accordance with certain additional principles of this invention by locating in the series-connected cascade of the valve sterilant chambers, at a point which is remote from the supply of fresh sterilant, the chambers of those valves which are more susceptible to contamination. By ordering the sterilant chambers of the cascade in this manner, i.e., the more contaminated ones remote from the sterilant supply, the stale sterilant of the more contaminated chambers, when purged from the chambers by incoming fresh sterilant, travels through a minimum number of chambers in the course of flushing the cascade. With the stale sterilant of the more contaminated chambers following the shortest possible path out of the chain, contamination of the other, less contaminated chambers by the more highly contaminated stale sterilants is reduced.

While the valve sterilization chambers can be maintained with a full supply of sterilant throughout the material loading and storage period, I have empirically determined that the present aseptic valving system is so effective in practice that the valves can in fact be drained of sterilant throughout the major portion of the storage period. This is particularly advantageous not only because it lowers the operating cost, but also because it eliminates problems of freeze-up of the sterilizing system in installations exposed to very low temperatures.

More particularly, I have determined that material may be aseptically stored and maintained under aseptic conditions for protracted periods by merely subjecting the valves to a sterilizing action prior to the loading of the tank and during the loading operation. Thereafter, the sterilizing system can be shut down and the valves and system drained. The chemical sterilizing system need be filled only in the event that a sample is to be taken or in the event that part of the contents of a tank are to be withdrawn.

DESCRIPTION OF THE DRAWINGS

These and other objectives and advantages of the invention will become more readily apparent from a detailed description of the invention taken in conjunction with the drawings in which:

FIG. **1** is a perspective view of an aseptic storage and valving system constructed in accordance with the principles of this invention.

FIG. **2** is a front elevational view of an aseptic valve having a chemical sterilant chamber surrounding the valve actuator.

FIG. **3** is a cross-sectional view taken along line 3—3 of FIG. **2**.

FIG. **4** is a vertical cross-sectional view through a portion of an aseptic valve, showing a selectively sealable port and cap therefor which together form a chemical sterilant chamber.

FIG. **5** is a vertical cross-sectional view through the port of the valve of FIG. **4**, showing the port with the cap removed and a 90° elbow substituted therefor to facilitate removal of a sample of material from the storage tank with which the valve is associated.

DESCRIPTION OF PREFERRED EMBODIMENT

A preferred embodiment of the aseptic storage and valving system of this invention is depicted in FIG. **1**. With reference to FIG. **1** the aseptic storage and valving system is seen to include a plurality of storage tanks **10A** and **10B** in which previously sterilized bulk material, such as crushed tomatoes, is adapted to be stored under aseptic conditions. The storage tanks **10A** and **10B** can be of any suitable size and shape, and fabricated from any suitable material. Preferably the

storage tanks 10A and 10B have cylindrical side sections 11A and 11B closed at the bottom with conical, or funnel-shaped, bottom sections 12A and 12B and at the top with domed sections 13A and 13B which are provided with selectively removable flanged manhole covers 14A and 14B. The funnel-shaped bottom sections 12A and 12B facilitate removal of stored material from the tanks 10A and 10B by gravity action. The flanged manhole covers 14A and 14B permit maintenance personnel to enter the interior of the tanks for maintenance purposes. The tanks 10A and 10B preferably are fabricated of welded steel sections to which is secured on the inside surfaces thereof a protective lining of glass, plastic, or the like. Such lined steel tanks are commercially available from a number of sources including The Bishopric Products Company, Cincinnati, Ohio. While only two tanks 10A and 10B are shown in FIG. 1, it is to be understood that any number of tanks can be used.

The tanks 10A and 10B are provided with cleansing ports 15A and 15B through which liquid cleansing solution can be introduced for cleaning and flushing the interior of the tanks when free of stored material. Conduits, or pipes, 16A and 16B, which are connected at one end to the cleansing ports 15A and 15B, are also provided to facilitate cleansing of the tank interiors. Aseptic valves 17A and 17B, to be described in detail hereafter, control the flow of cleansing solution to the interior of the tanks 10A, 10B via the pipes 16A and 16B. Valves 17A and 17B have outlet ports 18A and 18B connected to the conduits 16A and 16B and inlet ports 19A and 19B which are selectively connectable to a source of cleansing solution (not shown). The ports 18A and 19A of valve 17A and ports 18B and 19B of valve 17B can be selectively interconnected to permit the flow of cleansing solution from a supply (not shown) to the interiors of tanks 10A and 10B via pipes 16A and 16B by movement of respective valve actuators 9A and 9B from an inner, closed position, to an outer, open position, in a manner to become apparent hereafter.

The tanks 10A and 10B are each provided with inlet/outlet pipes, or conduits, 20A and 20B through which bulk material flows when the tanks are being filled or emptied with bulk material to be stored or which has been stored, respectively. The inlet/outlet pipes 20A and 20B at their upper end are connected to the lowermost portion, or apex, of the funnel-shaped tank bottom sections 12A and 12B of tanks 10A and 10B, and at their other ends are connected to ports 21A and 21B of aseptic valves 22A and 22B, to be described. The valves 22A and 22B have second ports 23A and 23B, respectively, which are always in communication, or connected, to ports 21A and 21B, respectively, regardless of whether the respective valve actuators 8A and 8B are in outer, open or inner, closed positions. Valves 22A and 22B have third ports 24A and 24B which can be selectively connected to the ports 21A, 23A, 21B, 23B by movement of valve actuators 8A and 8B from their inner, closed position to their outer, open position.

The ports 24A and 24B of the valves 22A and 22B are provided with selectively removable caps 38A and 38B. When the caps 38A and 38B are secured to the ports 24A and 24B, the otherwise open ends of the ports are closed by the caps. The caps 38A and 38B can, however, be removed. When caps 38A and 38B are removed, a sample of the material stored in the tanks 10A and 10B can be taken by interconnecting the ports 24A and 21A, and the ports 24B and 21B, by movement of their respective actuators 8A and 8B from the inner, closed position to the outer, open position. When ports 24A and 21A are connected, material in tank 10A flows out port 24A via pipe 20A and port 21A. Similarly, when ports 24B and 21B are connected, material in tank 10B flows out port 24B via pipe 20B and port 21B.

A second set of aseptic valves 30A and 30B, to the described, is also associated with tanks 10A and 10B. The valves 30A and 30B include port 31A and 31B which are connected via conduits, or pipes, 32A and 32B to the ports 23A and 23B of the valves 22A and 22B. The valves 30A and 30B also include a pair of ports 33A and 34A, and 33B and 34B. The ports 33A and 34A of valve 30A, and the ports 33B and 34B of valve 30B, are connected in series in a main bulk material flow line 35. The ports 33A and 34A of the valve 30A are always connected to each other to permit flow therebetween regardless of the position of a valve actuator 36A. Similarly, ports 33B and 34B of valve 30B are always connected for flow therebetween regardless of the position of a valve actuator 36B. The port 31A of valve 30C can be selectively connected to ports 33A and 34A by movement of the valve actuator 36A from its inner, closed position to its outer, open position. Similarly, the port 31B of the valve 30B can be selectively connected to the ports 33B and 34B by movement of its actuator 36B from its inner, closed position to its outer, open position.

A valve 40 is connected in the main bulk material flow line 35 at the discharge end 35A thereof and is provided to selectively open or close flow through the discharge end 35A of the main pipe 35. A source of bulk material which has previously been sterilized (not shown) is connected to the inlet end 35B of main flow line 35. The source of sterilized bulk material (not shown) connected to inlet end 35B of main flow line 35 may be the output of a bulk tomato processing line of the type disclosed and claimed in the copending application Ser. No. 40,549 of Philip E. Nelson and Glenn H. Sullivan, entitled "Method for Processing and Storing Tomatoes," filed May 26, 1970, and assigned to the assignee of this invention, which is incorporated herein by reference.

In operation, assuming previously sterilized bulk material is input to the inlet end 35B of the main flow pipe 35 from a source (not shown), tanks 10A and 10B are charged, or filled, by opening their respectively associated valves 30A and 30B by moving actuators 36A and 36B from their inner, closed position to their outer, open position. This functions to connect port 31A to port 33A, and port 31B to port 33B, permitting bulk material to flow from the main flow line 35 to the pipes 32A and 32B associated with the tanks 10A and 10B. The bulk material in the pipes 32A and 32B then flows into the tanks 10A and 10B, respectively, via lines 20A and 20B, respectively, through ports 23A and 21A of valve 22A and ports 21B and 23B of valve 22B, respectively, which ports are always connected regardless of the position of their actuators 8A and 8B. Of course, in

filling the tanks 10A and 10B the ports 24A and 24B of valves 22A and 22B must not be interconnected with ports 21A and 23A and ports 21B and 23B, respectively. This can be assured by positioning valve actuators 8A and 8B in their inner, closed position.

If desired, only one of the tanks 10A or 10B can be filled. If tank 10A only is to be filled, then the actuator 36A of valve 30A is moved to its outer, open position to interconnect the ports 33A and 31A, allowing flow from the supply pipe 35 to the pipe 32A, valve 22A and inlet/outlet pipe 20A. The actuator 36B of valve 30B is left in its inner, closed position when filling only tank 10A. This disconnects ports 31B and 33B to prevent the flow of material from the main flow line 35 to the tank 10B via the pipe 32B, valve 22B and inlet/outlet pipe 20B. In a similar manner the tank 10B can be filled without filling tank 10A.

To insure that the material stored in the tanks 10A and 10B, and which has previously been sterilized, is maintained in a sterile condition, the valves 17A and 17B, 22A and 22B, and 30A and 30B are provided with aseptic devices 50A and 50B, 51A and 51B, and 52A and 52B, respectively, which are described in detail hereafter. It is sufficient at this point to note that aseptic devices 50A and 50B, 51A and 51B, and 52A and 52B include chambers surrounding their respectively associated valve actuators 9A and 9B, 8A and 8B, and 36A and 36B which contain chemical sterilant for establishing a sterile zone or barrier around the actuators for preventing the entry of contaminants into the tanks 10A and 10B via the bores in the valves in which the actuators move. Since the chemical sterilant in the chambers of aseptic valve devices 50A and 50B, 51A and 51B, and 52A and 52B has a tendency to become stale, i.e., to lose its sterilizing capability due to chemical decomposition after a predetermined length of time, a sterilant chamber recharging system is provided. This system includes a source of fresh chemical sterilant 53, a sterilant supply line 54 to which the sterilant chambers are connected, and a sterilant analyzer 55. Collectively the interconnected sterilant supply 53, supply line 54, and analyzer 55 function to periodically flush the stale sterilant from the sterilant chambers and replenish them with fresh sterilant.

To insure that contaminants do not enter the tanks 10A and 10B via the sample ports 24A and 24B of valves 22A and 22B, the chambers defined by the ports 24A and 24B when sealed with the caps 38A and 38B, are also filled with chemical sterilant and connected in the sterilant supply line 54 for periodic flushing of stale sterilant and replenishment with fresh sterilant from the fresh sterilant supply 53.

With reference to FIGS. 2 and 3, an aseptic valve 60 is shown in solid lines which is identical to valves 17A and 17B. The valve 60, which is shown in solid lines, when provided with a port 61 (shown in phantom lines) is then identical to valves 22A, 22B, 30A and 30B. In describing the valve 60 of FIGS. 2 and 3, parenthetical reference numerals are provided to identify corresponding elements of the valves 17A, 17B, 22A, 22B, 30A and 30B shown in FIG. 1.

The valve 60 includes a valve body having detachable body sections 63, 64 and 65 which are coaxially connected together to form a unitary valve structure by circular clamps 66 and 67. Clamps 66 and 67 function to urge together circular flanges 68 and 69 of valve body sections 63 and 64 and flanges 70 and 71 of valve body sections 64 and 65. A gasket 72 seals the mating surfaces of circular flanges 68 and 69 when clamped together by clamp 66. A gasket 73 seals the mating surfaces of the valve body sections 64 and 65 when clamped by clamp 67.

The valve body member 63 is provided with a cavity 75. Communicating with the cavity 75 is a port 76, a port 77, and the optional port 61, the latter port being omitted in valves 17A and 17B and included in valves 22A, 22B, 30A and 30B. Positioned within the cavity 75 is a valve sealing member 78 which is selectively movable to an inner, closed position shown in phantom lines in FIG. 3 to terminate communication between the port 76 and the cavity 75 and, hence, between the port 76 and the port 77 and the optional port 61. The valve sealing member 78 is also selectively movable to an outer, open position shown in solid lines in FIG. 3 to connect the port 76 and the chamber 75, and hence to connect the port 76 to the port 77 and the optional port 61. Regardless of whether the valve sealing member 78 is in its inner, or sealed, position shown in phantom lines or its outer, or open, position shown in solid lines, the port 77 and the optional port 71 always communicate with the cavity 75. Hence, if the optional port 61 is provided, the ports 61 and 77 are always in communication with each other to enable flow therebetween regardless of the position of the valve sealing member 78.

To facilitate movement of the valve sealing member 78 between its inner, closed position shown in phantom lines and its outer, open position shown in solid lines, an actuating stem 80 is provided. The actuating stem 80 is fixedly connected at its inner end to the valve sealing member 78. The central section of the valve stem 80 is fitted in a circular bore 81 formed in the valve body section 64 and in a circular bore 82 formed in the valve body section 65. The fit between the valve stem 80 and the bores 81 and 82 of the valve body sections 64 and 65 is such as to permit the valve stem 80 to slide and rotate within the bores 80 and 81.

To facilitate translation of the valve stem 80 between its inner, closed position shown in phantom lines and its outer, open position shown in solid lines, an actuating handle 85 is provided. The actuating handle 85 is in the form of a hollow tube which at its inner end 86 threadably engages external threads 87 provided on the axially projecting section of the valve body member 65. The actuating handle 85 is provided at its outer end with a cap 88 having an axial bore 89 therethrough which receives a stepped-down diameter section 90 of the actuating stem 80. A shoulder 91 on the actuating stem 80 engages the cap end 88 of the handle 85, enabling the actuating stem 80 and, hence, the valve seal member 78 to be moved from the outer, open position shown in solid lines to the inner, closed position shown in phantom lines when the handle 85 is rotated to translate it to the left as viewed in FIG. 3. A transverse pin 93 passing through a cross bore in the stepped-down diameter section 90 of the actuating stem 80 and projecting radially beyond the stepped-down diameter section 90, engages the outer end 88 of the handle member 85 to facilitate movement of the actuator stem 80 and, hence, of the valve seal member 78

from its inner, closed position shown in phantom lines to its outer, open position shown in solid lines when the handle **85** is rotated to translate it to its outer or right position shown in FIG. **3**.

The central valve body member **64** is provided with a chamber **95** which completely encircles a portion of the actuator stem **80** at a point intermediate its inner and outer ends. The chamber **95** is adapted to contain chemical sterilant for the purpose of establishing a sterile barrier or zone circumscribing the stem **80** to prevent the influx of contaminants to the cavity **75** and, hence, to the stored material in the tank with which the valve is associated, via the bores **82** and **81** in valve body members **65** and **64** in which the valve stem **80** translates in the course of moving between its inner, closed and outer, open positions shown in phantom and solid lines.

To seal the actuator stem **80** relative to the bores **81** and **82** formed in the valve body members **64** and **65**, O-rings **97** and **98** located in circular grooves **99** and **100** formed in the stem are provided. The groove **99** and O-ring **97** are located on the stem **80** at a point such that the O-ring **97** always remains in the bore **81** intermediate the ends **101** and **102** thereof, regardless of whether the valve stem is (a) in its outer position wherein the O-ring **97** is in proximity to the end **102** of bore **81** as shown in solid lines, or (b) in its inner position wherein the O-ring **97** is proximate the end **101** of the bore **81** as shown in phantom lines. The groove **100**, and hence the O-ring **98**, is axially located relative to the stem **80** such that the O-ring **98** remains in the bore **82** between its ends **105** and **106**, regardless of whether the valve stem **80** is (a) in its inner position wherein the O-ring **98** is proximate the end **105** of the bore **87** as shown in phantom lines, or (b) in its outer position wherein the O-ring **98** is in a central position within the bore **82** as shown in solid lines.

To prevent retraction of the stem **80** to a point such that the O-ring **97** passes out of the bore **81** beyond the end **102** into the sterilant chamber **95**, which would destroy the seal produced by bore **81** and O-ring **97**, a shoulder **108** is formed on the inner end of the stem **80**. The shoulder **108** abuts the inner, left-hand face **101** of the valve body member **64** to prevent and limit movement of the O-ring **97** beyond the solid line position shown in FIG. **3**, preventing the O-ring **97** from leaving the bore **81** and entering the chamber **95** and thereby destroying the seal. Movement of the stem **80** inwardly to a point where O-ring **98** passes beyond the end **105** of bore **82**, which would destroy the seal between bore **82** and O-ring **98**, is prevented by abutment of sealing member **78** and port **76** which occurs when the stem is moved to its inner, closed position shown in phantom lines.

To facilitate flushing of chemical sterilant from the chamber **95** and the replenishment thereof with fresh sterilant as is necessary periodically since the chemical sterilant decomposes, losing its aseptic characteristics, a sterilant inlet passage **110** and a sterilant outlet passage **111** are provided.

The chemical sterilant inlet passage **110**, if the sterilant is in liquid form, is preferably located in the bottom of the chamber **95** while the sterilant outlet passage **111** is preferably located in the top of the chamber. By locating the sterilant inlet and outlet passages **110** and **111** in the bottom and top of the chamber **95**, two unobvious advantages are provided. First, the tendency of gas to be trapped in the chamber **95** is overcome since provision of the sterilant outlet passage **111** in the top of the chamber **95** permits such gas to bubble out through the top of the chamber via the sterilant outlet passage **111**. With the possibility of entrapping gas in the chamber **95** removed, the chamber **95** can be completely filled with sterilant. Second, by locating the inlet and outlet passages **110** and **111** in the bottom and top of the chamber **95**, the chamber **95** can be entirely filled with sterilant entering through passage **110** before sterilant drains out of the chamber via passage **111**.

Were the sterilant outlet passage **111** to be disposed horizontally, that is, at a point 90° angularly displaced about the axis of stem **80** from the position shown in FIG. **3**, it would be possible for gas to be trapped in the upper half of the chamber **95**, preventing the chamber **95** from being completely filled with liquid sterilant. Additionally, were the passage **111** to be disposed horizontally, liquid sterilant entering the chamber **95** from the inlet passage **110** would, before completely filling the chamber **95**, flow out of the chamber via the outlet passage **111**, preventing the chamber from being completely filled with sterilant.

FIG. **4** illustrates the port **76** of valve **60** sealed by a cap **115**. The cap **115** includes a tubular section **116** which at its left end **117** is closed. The right-hand end of the tubular section **116** is provided with a circular flange **118**. The flange **118**, when the cap **115** is secured to the port **76**, mates with a corresponding circular flange **120** formed on the end of the port **76**, sandwiching a gasket **119** therebetween. To maintain the flanges **118** and **120** in their mating, sealing condition, a circular clamp **114** is provided which, in the clamped position shown in FIG. **4**, urges the mating surfaces of the flanges together to sandwich the gasket **119** therebetween. The cap **115** can be removed for unsealing the port **76** by removal of the circular clamp **114** from the flanges **118** and **120**.

When the cap **115** is secured to the valve port **76** and the valve seal member **78** is in its inner, closed position shown in FIG. **4**, a chamber **121** is defined by the cap, port and valve seal member. To prevent contaminants from entering the valve cavity **75**, and, hence, the storage tank with which the valve is associated, the chamber **121** is filled with chemical sterilant. To facilitate flushing of the chamber **121** of stale sterilant and the replenishment thereof with fresh sterilant, sterilant inlet and outlet passages **122** and **123** are provided in the bottom and top,respectively, of the cap **115** which partially defines the chamber **121**. The sterilant inlet and outlet passages **122** and **123** function with respect to the cavity **121** in a manner identical to the manner in which the inlet and outlet passages **110** and **111** function relative to the cavity **95**, i.e., to facilitate flushing of stale sterilant and replenishment with fresh sterilant. The inlet and outlet passages **122** and **123** are provided at the bottom and top, respectively, of the cavity **121** for the same reason that the inlet and outlet passages **110** and **111** are provided in the bottom and top of the cavity **95**, i.e., to prevent gas entrapment and to prevent draining of sterilant from the cavity **121** via passage **122** before the cavity is entirely filled with sterilant.

FIG. 5 shows the port 76 of valve 60 with the cap 115 removed therefrom and a 90° elbow 130 substituted therefor. The elbow 130 permits a sample of the material stored in the tank with which the valve having port 76 is associated to be conveniently removed from the tank via the port 76 when the sealing member 78 is moved to its outer, open position as shown in FIG. 5 wherein port 76 is connected to valve cavity 75. The 90° elbow 130 includes a first open end 131 through which the sample is discharged into a suitably positioned flask or the like container, and an open end 132 which communicates with the outer end of the port 76. The end 132 of the elbow 130 is provided with a circular flange 133 and a gasket 134 which is adapted to mate with the circular flange 120 formed on the outer end of the port 76. The flanges 133 and 120 are maintained in engaged position, sandwiching the gasket 134 therebetween, as shown in FIG. 5, by a circular clamp 135.

The clamps 66, 67, 114 and 135 include a variable diameter central circular section flanked on each side by variable diameter, circular, diverging side sections. The diameter of the clamps 66, 67, 114 and 135 when reduced urges the mating flanges engaged by the clamp together, and when increased permits the mating flanges associated therewith to become separated from each other and from the clamp.

To facilitate periodic flushing of the chambers 95 and 121 of stale chemical sterilant, that is, of sterilant which has decomposed and lost its aseptic qualities, and the replenishment thereof with fresh chemical sterilant, the source of fresh sterilant 53, sterilant supply line 54, and sterilant analyzer 55 are provided. The supply of fresh sterilant 53, while capable of taking many forms, preferably includes a conventional liquid mixer 140 having a first inlet connected to a supply of pressurized sterilant carrier 141 and a second inlet connected to a supply of concentrated chemical sterilant 142. The mixer 140, when actuated, provides to the sterilant supply line 54 fresh chemical sterilant comprising a mixture of (a) a carrier, and (b) concentrated sterilant at a predetermined weight ratio. In accordance with a preferred embodiment of this invention, the carrier is water and the sterilant concentrate is an iodophor compound. A suitable iodophor compound is marketed by Klenzade Products, Division of Economics Laboratory, Inc., St. Paul, Minnesota, under the trademark MIKRO-KLENE and includes the following compounds by weight:

Active butoxpolyprotoxy, polyethoxy, ethanol-iodine complex, providing 1.75% titratable iodine	15.5%
Phosphoric acid	6.5%
Inner liquid carrier	78.0%

When a chemical sterilant concentrate is used of the type set forth above, the sterilant concentrate is mixed with the carrier, which preferably is water, at a ratio by weight of 20–25 parts of iodine per million parts of water.

The mixer 140 can take any form and preferably is of the type commercially available from Economics Laboratory, Inc., St. Paul, Minn., marketed under the name Micro-Master, Model 5C63.

To facilitate the simple and efficient flushing of the chambers 121 and 95 of stale sterilant and the replenishment thereof with fresh sterilant from the supply 53, the sterilant chambers 95 and 121 of the valves 60 are connected in series in the sterilant supply line 54 to form a chain or cascade of sterilant chambers. Specifically, the sterilant chambers 50A, 50B, 52A, 51B, 52B, 51A, 38A–24A and 38B–24B are connected in series in the order mentioned in the sterilant supply line 54. With the sterilant chambers so connected in the supply line 54 to the source of fresh sterilant 53 pumped into the inlet end 54–1 of supply line 54, the stale sterilant in the series-connected sterilant chambers 50A, 50B, 51B, 52B, 51B, 52A, 38A–24A and 38B–24B is flushed from the chambers and the supply of sterilant replenished with fresh sterilant, the chambers being flushed and replenished on a sequential basis in the order mentioned. Specifically, when the supply of fresh sterilant 53 is first activated, fresh sterilant is pumped into the supply line section 54–1 to the bottom of the sterilant chamber of aseptic device 50A of valve 17A. The entry of fresh sterilant into the bottom of the chamber 95 of aseptic device 50A via line 54–1 and associated sterilant inlet passage 110 functions to flush out of the top of that chamber the stale sterilant therein, forcing such stale sterilant into sterilant supply line section 54–2 via sterilant outlet passage 111. The stale sterilant flushed out of the sterilant chamber 95 of aseptic device 50A of the valve 17A and which is in sterilant supply line section 54–2, then enters the bottom of the chamber 95 of aseptic device 50B of valve 17B via passage 110, forcing out of the top of that chamber the stale sterilant via outlet passage 111. This process continues until the stale sterilant in all chambers 95 and 121 of the aseptic devices 50A, 50B, 52B, 51B, 52A, 51A, 38A–24A and 38B–24B connected in the line 54 has been flushed and fresh sterilant from supply 53 substituted therefor.

To readily determine when all the stale sterilant has been flushed from the chambers 95 and 121 of the aseptic devices 50A, 50B, 51A, 51B and 52A, 52B, 38A–24A and 38B–24B and fresh sterilant from the supply 53 substituted therefor, the chemical analyzer 55 is provided which is connected via supply line section 54–*n* to the sterilant outlet passage 123 of the sterilant chamber 121 of the last aseptic device 38B–24B in the cascade. The chemical analyzer 55 monitors the sterilant in line 54–*n* leaving the last sterilant chamber 121 of device 38B and determines the sterilization capability of the sterilant in line 54–*n*. When the sterilant leaving the last sterilant chamber 121 of aseptic device 58B–24B of the cascade or chain via line 54–*n* corresponds in strength, that is, in sterilization capability, to that of the fresh sterilant leaving the supply 53 and entering the cascade or chain via supply line section 54–1, the sterilant supply 53 is deactivated, stopping the flow of fresh sterilant into line 54–1. At this point the stale sterilant in all the chambers 95 and 121 of the cascaded chain of aseptic devices 50A, 50B, 52B, 51B, 52A, 51A, 38A–24A and 38B–24B is deemed to have been flushed from the chain or cascade, and the sterilant chambers of the chain or cascade replenished with fresh sterilant from supply 53.

To remove a sample of stored material from one of the tanks 10A or 10B, cap 38A or 38B, as the case may be, is removed from the port 24A or 24B by removing the associated clamp 114. The elbow 130 is then

secured to the port 24A or 24B using the clamp 135, which clamp in reality would preferably be the same clamp as clamp 114 which held the cap 38A or 38B secured to the port 24A or 24B. With the elbow 130 in place and a suitable flask positioned in communication with the elbow mouth 131, the valve actuator 8A or 8B is moved to its outer position causing the valve sealing member 38 to unseal the port 24A or 24B. When the sample is obtained, the valve actuator 8A or 8B is moved to its inner position to seal the port 24A or 24B with the valve sealing member 78. The port 24A or 24B is again sealed by the cap 38A or 38B using the clamp 114. At this point it is desirable to recharge all sterilant chambers in the cascade, thereby returning the port 24A or 24B and associated cap 38A or 38B which collectively define a sterilant chamber 121, which is associated with the tank from which the sample has just been removed, to a sterile condition.

The chemical analyzer 55, while capable of a variety of designs, preferably is designed in accordance with the principles incorporated in the iodine/chlorine Test Kit No. 101 marketed by Klenzade Products, Division of Economics Laboratory, Inc., St. Paul, Minn.

To retard the decomposition of chemical sterilant, the sterilant supply line 54 and the aseptic devices 50A, 50B, 51A, 51B, 52A, 52B, 38A–24A and 38B–24B are preferably opaque, thereby shielding the sterilant from sunlight which accelerates decomposition of the sterilant, making it become stale more quickly. Additionally, the supply line 54 and the aseptic devices 50A, 50B, 51A, 51B, 52A, 52B, 38A–24A and 38B–24B are preferably fabricated of material as chemically inert as possible. This prevents decomposition of the sterilant and retards corrosion by the sterilant of the tubing 54 and the aseptic devices 51A, 51B, 52A, 52B, 50A, 50B, 38A–24A and 38B–14B. A material having the desired opacity to retard decomposition of the sterilant, and the desired inertness to resist corrosion by the sterilant as well as decomposition of the sterilant, is stainless steel.

The chemical sterilant, if in the form of an iodine-based liquid, should be maintained at a temperature below 110° F. above which iodine sublimes to gas.

It has been discovered in practice that the chemical sterilant in certain of the series connected sterilant chambers 95, 121 of aseptic devices 50A, 50B, 51A, 51B, 52A, 52B, 38A–24A and 38B–24B in line 54 tend to become contaminated to a greater extend than the chemical sterilant in certain other of the sterilant chambers. Specifically, it has been found in practice that the sterilant in chambers 121 of the type defined by caps 38A and port 24A, and cap 38B and port 24B tends to become more contaminated than the sterilant in chambers 95 of aseptic devices 52A, 52B, 51A and 51B due to residues of stored material which remain in ports 24A and 24B when samples are withdrawn; and that the sterilant in chambers 95 of aseptic devices 51A, 51B, 52A and 52B tends to become more contaminated than the sterilant in chambers 95 of aseptic devices 50A and 50B due to the fact that stored material passes through valves 22A, 22B, 30A and 30B and not through valves 17A and 17B. In view of this tendency of the sterilant of certain of the sterilant chambers to become more contaminated than others, the sterilant chambers should be connected in series in a line 54 such that the sterilant chambers which are contaminated to a greater extend are closer to the drain end 54–*n* of the sterilant supply line 54, and the sterilant chambers which tend to become contaminated to a lesser extent are closer to the supply of fresh sterilant 53. In this way the sterilant of the chambers which become contaminated to the greatest extent, i.e., chambers 121 of devices 38A–24A and 38B–24B, is not passed through the sterilant chambers of the devices which become contaminated to a letter extent, i.e., chambers 95 of aseptic devices 50A, 50B, 51A, 51B, 52A and 52B, which if allowed to occur would unnecessarily introduce contaminants from the more contaminated sterilant chambers into the less contaminated sterilant chambers, compounding the overall contamination problem.

While the valves may be kept full of sterilant which is periodically replenished throughout the entire period of storage, I have empirically determined that in many installations this is not required. Specifically, I have determined that a satisfactory alternate method of operation involves the sterilization of the valves as described above prior to the loading of the tanks. The valves are maintained in a sterilized condition during the loading operation with the sterilant being periodically replenished as described above. However, after the tanks have been loaded, the valves and sterilant system are drained. Unless, samples are to be taken or the tank is to be partially emptied, the contents of the tanks are maintained in an aseptic condition during the entire period of storage without further operation of the sterilizing system.

In the event a sample is to be taken, the sterilizing system is charged with sterilant and operated as described above prior to and during the period of sampling. After the sample has been taken, the valves and sterilizing system can be shut down and drained. If all of the material from the tank is to be removed at one time, I have determined that is is unnecessary to recharge the sterilant system during the withdrawal period. If, however, only a portion of the contents of the tank are to be removed, the sterilizing system should be operated immediately prior to the removal of material from the tank, during the period of removal and for a brief period immediately following removal. After this, the sterilizing system can be shut down and drained and the remaining material in the tank will be kept under aseptic conditions.

Having described the invention, what is claimed is:

1. A method of recharging with fresh chemical sterilant and flushing stale sterilant from sterilant-containing chambers which surround movable actuators of aseptic valves, comprising the steps of

connecting the chambers in series to form a cascade, and

pumping fresh sterilant from a source thereof to the first chamber of said serially connected cascade of said chambers while exhausting stale sterilant from the last chamber of said cascade.

2. The method of claim 1 wherein said connecting step includes connecting an output passage of each of said chambers located in the top thereof to an input passage of the successive chamber in said cascade located in the bottom thereof, and said pumping and exhausting step includes pumping sterilant from said

source into the input passage of said first chamber and draining sterilant from the output passage of said last chamber.

3. The method of claim 1 further including the step of analyzing the sterilant exhausted from said last chamber and terminating said pumping when the analysis indicates fresh sterilant is being exhausted from said last chamber.

4. A method of maintaining in an aseptic condition material stored in a tank having an aseptic valve, the method comprising the steps of

charging a chamber surrounding a movable actuator of said valve with a chemical sterilant prior to the time said tank is filled with the material to be stored,

thereafter periodically recharging said sterilant-containing chamber with fresh chemical sterilant and flushing stale sterilant from said sterilant-containing chamber, and

after said material has been loaded into said tank, draining said sterilant-containing chamber.

5. The method of claim 4 comprising the further step of recharging said chamber with fresh chemical sterilant prior to and during the removal of a sample from said tank and subsequently draining said chamber after said sample has been withdrawn.

6. The method of claim 4 comprising the further step of recharging said sterilant-containing chamber with fresh chemical sterilant prior to and during the period in which a portion of the contents of said tank are withdrawn and emptying said sterilant-containing chamber after the said portion of the contents has been withdrawn, whereby the remaining contents of said tank are maintained in sterile condition.

7. A method of maintaining in an aseptic condition material stored in a plurality of tanks each having an aseptic valve, the method comprising the steps of

charging a chamber surrounding a movable actuator of each said valve with a chemical sterilant prior to the time said tanks are filled with the material to be stored,

thereafter periodically recharging said sterilant-containing chambers with fresh chemical sterilant and flushing stale sterilant from said sterilant-containing chambers, and

after said material has been loaded into said tank, draining said sterilant-containing chambers.

8. The method of claim 7 comprising the further step of recharging said chambers with fresh chemical sterilant prior to and during the removal of a sample from said tanks and subsequently draining said chambers after said sample has been withdrawn.

9. The method of claim 7 comprising the further step of recharging said sterilant-containing chambers with fresh chemical sterilant prior to and during the period in which a portion of the contents of said tanks are withdrawn and emptying said sterilant-containing chambers after the said portion of the contents has been withdrawn, whereby the remaining contents of said tanks are maintained in sterile condition.

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