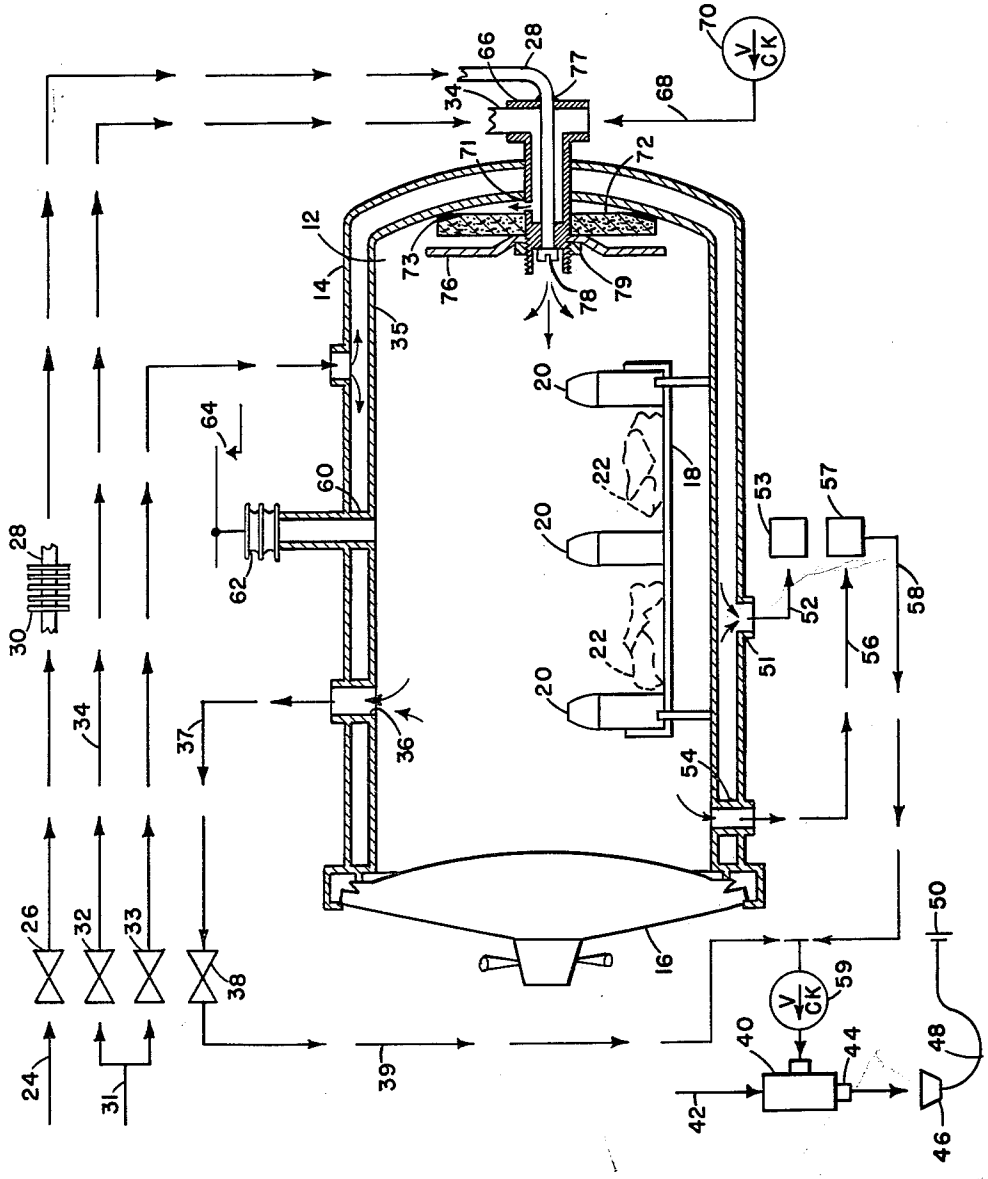
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METHOD FOR THE CONTROLLED REDUCTION OF TEMPERATURE IN A STERILIZING CHAMBER

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METHOD FOR THE CONTROLLED REDUCTION OF TEMPERATURE IN A STERILIZING CHAMBER

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My invention relates to methods and apparatus for the controlled reduction of temperature in a sterilizing chamber of sterilizers and more particularly as applied to sterilizers for use in hospitals and medical clinics.

In both hospitals and medical clinics the operating requirements for sterilizers vary greatly with the nature of the matter being sterilized. Sterilizers for use in hospitals and medical clinics must be adapted for sterilizing surgical instruments, bandages or other cloth material and fluid in containers. One of the big problems encountered in sterilizing fluids in containers is the amount of fluid which evaporates during the sterilizing cycle and cooling cycle. Hospitals and clinics have learned to compensate for this evaporation by initially filling the bottle or container to a calculated quantity in excess of the ultimate desired quantity after sterilizing and cooling of the fluid. However, in order to calculate a quantity sufficient to compensate for the evaporation which will take place, a controlled cooling cycle must be provided. Therefore, it is an object of my invention to provide improved methods and apparatus for controlling the cooling cycle of sterilized fluids.

A further problem encountered in the cooling of fluids following sterilization thereof, is the boiling of the fluid within the bottle resulting from a reduction in temperature and pressure surrounding the container in excess of that existing inside the container. Therefore, it is a further object of my invention to provide methods and apparatus which will prevent boiling of the fluids during the cooling cycle.

For many years excessive evaporation and boiling of fluids within containers following sterilization thereof could only be prevented by leaving the fluid filled containers in the sterilizers for an extended period of hours, during which time the sterilizing chamber was not opened and the fluids simply remained in the sterilizers. Thus, the sterilizer and the chamber therein were permitted to cool down at an extremely low rate of speed. This permitted the fluid within the container itself to gradually cool down at substantially the same rate as the chamber itself.

Obviously, this first method in cooling fluids in containers was most unsatisfactory. This gave rise to a more recent development in the art by which the sterilizing cycle of a sterilizer was followed by slow exhaust of the steam. The exhaust passage leading from the sterilizer is sufficiently restricted so that the exhaust of steam from the sterilizing chamber takes sufficient time to prevent the boiling or bubbling of the sterilized fluids or solutions. This permits the temperature of fluids or solutions to drop at substantially the same rate as the temperature in the sterilizing chamber but at an increased rate over the previous method. The duration of the slow exhaust cycle just described is determined by a pressure responsive switch adapted to signal the operator when the temperature and pressure within the sterilizing chamber has reached a pre-determined value. Although a vast improvement over prior methods of cooling sterilized fluids and solutions, the last described advancement in this art requires cooling periods ranging from approximately 40 to 90 minutes, depending upon the load in the sterilizer.

My invention is capable of fulfilling the same cooling requirements in approximately 15 minutes. It is, therefore, another object of my invention to provide improved methods and apparatus by which the time required for cooling sterilizer fluids will be greatly reduced.

Another object of my invention is to provide a relatively simple and inexpensive apparatus of the nature described above.

It will be understood that the temperature of the fluid or solution in the container will drop at substantially the same rate as the drop in temperature and pressure in the chamber with some lag which varies with the specific gravity of the solution and the thermal conductivity of the container. However, if the temperature in the chamber is reduced at a rate in excess of that by which the fluid or solution is capable of doing, then auxiliary cooling must be supplied in order to prevent boiling and evaporation. Therefore, it is a further object of my invention to supply sufficient auxiliary cooling to the load so that both the temperature of the fluid or solution and the temperature in the chamber will drop at an increased rate until both reach the pre-selected value, preferably 212° F. at atmospheric pressure, without the solution boiling.

Recognizing the cooling benefit derived from spraying liquids onto fluid filled containers if the temperatures of liquids lag behind the temperature of the fluid in containers, it is a further object of my invention to provide methods and apparatus for cooling sterile fluids in containers by spraying the containers with a fluid at a temperature lagging behind the temperature of fluid in the container and in a manner which will not damage the container itself or have any deleterious effect on the fluid in the container.

One of the difficulties encountered with both of the prior cooling cycles for bottled fluids or solutions has been the uneven cooling as between bottles or containers within the sterilizing chamber. The uneven cooling was caused by radiated heat from the chamber walls. This radiant heat would not permit certain bottles usually closest to the chamber walls to cool as fast as those bottles which were further removed from the chamber walls. This not only unduly lengthened the cooling period but also increased the evaporation and boiling of the fluids in these outside bottles. This meant that after solutions were sterilized and cooled there was a great variance in proportions of constituent elements of the solutions as between bottles. Therefore, it is another object of my invention to provide methods and apparatus for evenly cooling the entire load of fluid filled containers so that substantially all of the load will be cooled at the same rate.

Further objects and advantages of my invention will be particularly set forth in the claims and will be apparent from the following description when taken in connection with the accompanying drawing in which:

FIG. 1 is a side elevation of the sterilizing chamber in section, including a schematic view of the flow of air and steam to and from the sterilizing chamber.

Referring to the drawing, my invention is adaptable for use with essentially all sterilizers. A sterilizer chamber **12** is surrounded by a jacket **14**; a door **16** is adapted for hermetically sealing the left end of chamber **12** through which the chamber is loaded and unloaded. As stated above, my invention is adaptable for use with a sterilizer capable of sterilizing instruments, bandages or cloth material and bottles in containers. In the illustrated embodiment of my invention I have shown a rack **18** which may be placed inside of the chamber **12** for supporting the load to be sterilized. In solid line, I have shown a load of fluids bottled in containers **20** and in broken line, I have illustrated packages of bandages **22**.

I have chosen to show the packages of bandages 22 in broken line to better illustrate the two different loads sterilized by the two cycles of the sterilizer for which my invention is adapted as will be revealed hereinafter.

A steam line 24 is connected to a valve 26 through which steam is conducted to a liquid cooling steam conduit 28, having laterally spaced fins 30 surrounding a portion of the length thereof. A steam line 31 supplies steam to two valves 32 and 33 which in turn control the flow of steam to a sterilizing steam conduit 34 and to the jacket 14 respectively. It is understood that the valve 33 will be open to supply heat to the jacket prior to starting a sterilizing cycle so that the jacket 14 will be preheated. This avoids cold spots on the chamber wall 35 and initial condensation when steam is introduced into the chamber 12. Steam is supplied continuously to the jacket 14 during sterilization. At the top of the sterilizer there is an opening 36 to which is connected an exhaust line 37 leading to a valve 38. An exhaust line 39 connected on the other side of valve 38 is connected through a check valve 59 to a water aspirator 40. This check valve opens on increased chamber pressure. Fluid flowing through aspirator 40 enters at 42 and is discharged at 44 into a funnel 46 and passes through a line 48 to a waste line 50. A drain 51 in the lower part of the jacket is connected to a line 52 to a jacket steam trap 53, and a drain 54 in the lower part of the chamber is connected by a line 56 to a chamber steam trap 57. The other side of the chamber steam trap 57 is connected by a line 58 through the check valve 59 to the aspirator 40. The chamber 12 is provided with a conduit 60 through which fluid in the chamber is conducted to a bellows 62 adapted for controlling a switch 64 so that the switch completes a circuit (not shown) after the pressure and temperature in the chamber 12 have been reduced to the desired value during the liquid-cooling cycle to be described hereinafter. The completion of this circuit effectuates the closing of valves 26, 32 and 38 which is the "off" position of the sterilizer. It will be understood that preferably either a valve is provided in conduit 60, a switch is provided in circuit with switch 64 or some other well known means is provided to render bellows 62 effective to control switch 64 only during the sterilizing and cooling cycle for liquids.

Although not a part of my invention, it will be understood that all valving changes described in this application can be made automatic.

Conduit 34 is connected to one side of a T-pipe 66 and the other side of the T-pipe is connected to an air line 68. Atmospheric air is introduced into the chamber through line 68 when the pressure in the chamber has been reduced below atmospheric pressure, which reduction in pressure opens an air inlet check valve 70. The T-pipe 66 has an opening or orifice 71. A circular filter 72, preferably of a ceramic material, is supported on T-pipe 66 and the entire periphery thereof is sealed at 73, possibly by a rubber gasket or other suitable sealing means, to the inside wall of chamber 12. The orifice 71 is located between the filter 72 and the interior wall 35 of the chamber 12. A baffle 76 is preferably of the same configuration as the filter 72 but somewhat larger in surface area. The liquid-cooling steam conduit 28 extends concentrically through the center of the T-pipe 66 and is rigidly connected thereto at 77. A nozzle 78 is threaded onto the conduit 28 and sealed against a shoulder of T-pipe 66 as illustrated in the drawing. A nut 79 threaded onto the end of T-pipe 66 frictionally engages baffle 76 in order to securely seal the filter 72 at 73 to the interior wall 35 of the chamber. Thus, I have provided a filter conveniently located inside the sterilizing chamber for easy replacement thereof. The nozzle 78 has an adjustable orifice for varying the size of the jet of steam being discharged therethrough. This orifice is preferably not adjusted after it has been initially adjusted to suit the user's purpose. It will be understood that the filter 72 is replaced by simply removing the baffle 76 and nut 79 without disturbing the adjustment of the orifice of nozzle 78.

In operation, an operator opens the door 16 of the chamber 12 after the jacket 14 has been heated and the operator places the medical instruments or fluid bottled in containers or bandages to be sterilized on the rack 18. First, I shall assume that the operator loads the chamber with packages of bandages 22 and I will describe a sterilizing cycle for bandages and cloth materials as applied to my invention. The packages of bandages 22 are placed on the rack 18 and the door 16 is sealed by the operator. The operator causes valves 26 and 38 to close and valves 32 and 33 to open so that steam continues to flow into jacket 14 and to be introduced into sterilizing chamber 12. Steam is introduced into the chamber 12 until the sterilizer provides a suitable temperature to all portions of the load for a desired period of time depending upon the nature of the goods to be sterilized.

The steam entering chamber 12 passes through filter 72. The steam flowing through line 34 enters the T-pipe 66 and cannot escape to the outside through line 68 because of check valve 70 which only opens when pressure in line 68 is reduced below atmospheric pressure; therefore, the steam is forced through orifice 71. Because of the seal at 73, the steam is forced through the filter 72 and is deflected by the baffle 76 so that the steam will not be discharged directly onto the load. The filter 72 serves to remove moisture and foreign matter from the steam so that the filtered and deflected steam is dry and clean. The moisture removed by filter 72 collects at the bottom of the filter 72 and seal 73 and seeps through the filter onto the lower portion of the interior wall 35 of the chamber and follows the contour of the interior surface 35 to drain 54 where it is discharged.

After the period of sterilization of the packages of bandages 22 has been completed, the valving arrangement is thereafter changed for a drying cycle. The valve 32 is closed and the valve 38 is opened. Also, the aspirator 40 is rendered operatively effective, by the passage of fluid through the aspirator 42 to 44, to draw steam out of the chamber 12 at the exhaust opening 36. The aspirator is also effective to reduce the pressure at drain 54 to prevent condensate being drawn back into the chamber from line 56 while the chamber is being evacuated. When the check valve 70 is opened by the reduction of pressure in line 68 to subatmospheric pressure, the aspirator 40 draws atmospheric air through the line 68, T-pipe 66, orifice 71, filter 72 and is deflected by the baffle 76. Thus, air from the atmosphere is brought into the chamber through the filter 72 which not only renders steam dry and clean for sterilization but also renders air substantially bacteria free for drying of bandages and other cloth items. The aspirator 40 continues to draw air into the chamber until sufficient time has lapsed to completely dry the load 22. After the required period of time for drying the load 22, the operator may open the door 16 and remove the sterilized and dry load 22.

It is understood that the above described sterilizing cycle may be used to sterilize medical instruments. Likewise, the above described drying cycle is adapted for drying the sterilized instruments, but the length of time of the drying cycle may be appreciably shorter than is required for a load of bandages.

If the operator desires to sterilize fluids bottled in containers 20, the door 16 is opened and the load of containers 20 is placed on the rack 18. After the operator has placed the containers 20 in the sterilizer thereafter, the operator shuts and hermetically locks the door 16. Then the operator effectuates the opening of the valves 32 and 33 and the closing of valves 26 and 38. The main difference between the cycle described above for sterilizing and drying bandages and the one which now ensues in order to sterilize fluids is the manner in which the chamber is returned from elevated to atmospheric temperature and pressure.

After the required period of sterilization has been completed, a liquid-cooling cycle to regulate and increase the rate of cooling of the fluids in containers **20** is initiated by changing the valving arrangement to open valves **26** and **38** and close valves **32** and **33**. When valve **38** is opened, internal chamber pressure forces steam out of the chamber **12** at the same rate as steam is exhausted during the exhaust cycle for bandages. The opening of valve **26** permits steam to flow from line **24** through conduit **28** past fins **30**. Fins **30** are optional; they serve to condense or render wetter the steam in the conduit **28** so that when it is discharged at the orifice of nozzle **78**, the steam is wetter than steam conducted through conduit **34** for the sterilizing cycle. Depending upon the desired wetness of the steam, the number and surface area of the fins **30** may be varied. The wet steam flowing in conduit **28** is at a pressure in excess of that retained within the chamber and preferably at approximately 40 to 60 pounds per square inch. This is discharged at the orifice of nozzle **78** where it is greatly expanded in volume and greatly reduced in pressure. The steam is introduced at **78** in a somewhat lesser volume or at a slower rate than it is being exhausted at **36**. The rapidity with which the steam is expanded within the chamber **12**, immediately after being introduced into the chamber through orifice of nozzle **78**, may be increased by aspirator **40** exhausting the steam from the chamber while steam is being introduced into the chamber at **78**. This expansion of the steam produces a cooling effect within the chamber **12**. The rate of pressure and temperature descent in the chamber is the difference between the rate of exhaust and the rate of incoming steam.

The wet steam flowing in the conduit **28** is at elevated temperatures relative to the chamber temperature, but when introduced into the chamber at **79**, it drops instantaneously to equalize with the temperature of the steam vapor in the chamber **12**. The temperature of the wet steam decreases at a faster rate than the temperature of the containers **20**, the fluids therein and the interior walls **35**. Therefore, as the cooler drops of moisture from the wet steam touch the containers **20**, heat is absorbed from the containers thereby causing a corresponding reduction of the temperature of the fluid inside the containers **20**. A further cooling of the fluids is derived from heat absorbed by the conversion from liquid to steam of at least part of the cooler moisture when it makes contact with the hotter containers **20**.

The steam is introduced into the chamber **12** by spraying it through the nozzle **78** with a high speed jet action from the steam supply onto the containers **20**; this provides a circulating effect of the vapors in the chamber so that the steam is evenly distributed to substantially all of the surfaces of all containers **20**. This prevents uneven cooling of the containers and prevents radiant heating of fluids in the containers located closest to the chamber walls **35**.

Thus, it is obvious that two desirable functions are performed during the liquid-cooling cycle: first, the even distributed cooling of the fluids, resulting from the combination of the rapid expansion of the steam introduced into the chamber at the orifice **78**, the cooling effect of the condensate making contact with the containers **20** and partially converted to steam, and the circulating effect of steam; second, the retarding of the rate at which the chamber is exhausted by the introduction of steam. The retarding of the exhaust speed provides a means for controlling the descent in temperature and pressure within the chamber to prevent boiling of the fluid in the containers **20** while they are cooled.

The combination of these two functions appreciably increases the rate at which heat may be transferred from the fluid inside the containers **20** to the steam within the chamber **12** without boiling of the fluid or evaporating of the fluid in excess of a small calculated percent of evaporation generally occurring during the sterilizing

cycle of fluids. Hence, this liquid-cooling cycle provides a rapid reduction in vessel temperature and pressure following a sterilizing cycle for fluids without an increased fluid loss from the containers being cooled. The important advantage of preventing evaporation of fluid, resides in the fact that hospitals and medical clinics most often uiltize sterilizers for sterilizing solutions; by preventing excessive evaporation, there is no appreciable change in the proportion of the solutions.

Check valve **70** only opens after the chamber pressure has been reduce to sub-atmospheric pressure which does not occur during the liquid-cooling cycle. The conduit **60**, bellows **62** and switch **64** provide a pressure-responsive switching arrangement by which the switch **64** completes a circuit that closes valve **26** at the time the pressure in the chamber **12** is reduced to a predetermined value, preferably atmospheric pressure. This is the end of the liquid-cooling cycle. Immediately after the liquid-cooling cycle has been completed, the operator may open the door **16** and remove the containers **20** without evaporation or boiling of the fluid therein.

While I have shown and described the preferred embodiment of my invention, it will be apparent that various changes and modifications may be made therein, particularly in the form and relation of parts, without departing from the spirit of the invention as set forth in the appended claims.

I claim:

1. A method for reducing temperature in a sterilizing chamber comprising the following steps of: introducing steam into the chamber after sterilization when the chamber and contents are still at the effective sterilization temperature and exhausting the chamber at a selected faster rate than steam is being introduced into the chamber, thereby to selectively reduce the temperature and pressure in the chamber.

2. A method in accordance with claim 1 including a step for greatly expanding said steam when it is introduced into the chamber.

3. A method for reducing temperature of a load in a container, in turn, being within a sterilizer chamber comprising the following steps of: introducing wet steam into the chamber after sterilization when the chamber and contents are still at the effective sterilization temperature and exhausting the chamber at a selected faster rate than steam is being introduced into the chamber, thereby to selectively reduce the temperature and pressure in the chamber.

4. A method for reducing temperature of a load in a container, in turn, being within a sterilizing chamber comprising the following steps of: forcing steam into the chamber from a confined area after sterilization when the chamber and contents are still at the effective sterilization temperature, expanding the steam in the chamber and exhausting the steam from the chamber at a selected faster rate than it is being forced into the chamber, thereby to selectively reduce the temperature and pressure in the chamber.

5. A method for reducing temperature of fluids in containers being supported in a chamber of a sterilizer comprising the following steps of: introducing steam under pressure from a relatively small conduit into the chamber after sterilization when the chamber and contents are still at the effective sterilization temperature and reducing the pressure of the steam when it is introduced into the chamber, exhausting said steam from said chamber at a selected faster rate than the steam is being introduced into the chamber, thereby to selectively reduce the temperature and pressure in the chamber.

6. A method in accordance with claim 5 including a step of cooling said steam in said conduit before it is discharged into the chamber.

7. A method for evenly reducing temperature of a load in a container, in turn being within a sterilizing chamber comprising the following steps of: spraying steam into

said chamber after sterilization when the chamber and contents are still at the effective sterilization temperature, circulating said steam inside said chamber, and exhausting the chamber at a selected faster rate than steam being sprayed into the chamber, thereby to selectively reduce the temperature and pressure in the chamber.

8. A method for reducing temperature of fluids in containers within a sterilizer chamber after sterilization with steam at elevated temperatures comprising the following steps of: introducing steam into said chamber of a temperature greater than the temperature of the steam already in the chamber following sterilization and at a time when the chamber and contents thereof are still at the effective sterilization temperature, greatly expanding said steam when discharged into said chamber, and exhausting the chamber at a selected faster rate than said

steam is introduced, thereby to selectively reduce the temperature and pressure in the chamber.

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