Jan. 30, 1968 O. NEISS 3,366,442
STERILIZATION DEVICE WITH MEANS FOR SUPPLYING A SEPARATE COOLING MEDIUM AT CONTROLLED TEMPERATURE AND PRESSURE
Original Filed May 29, 1961 2 Sheets-Sheet 1

Fig. 1

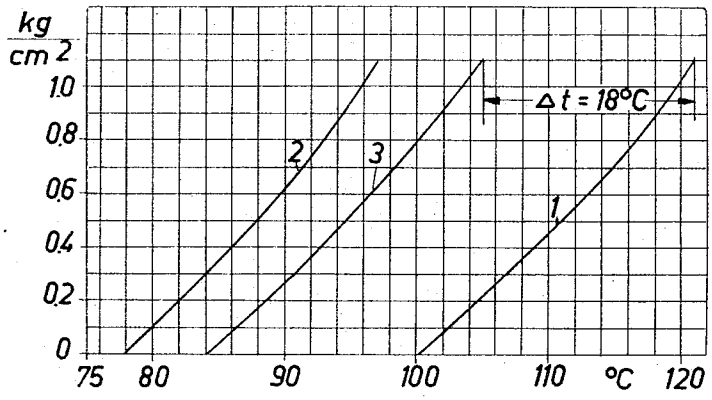
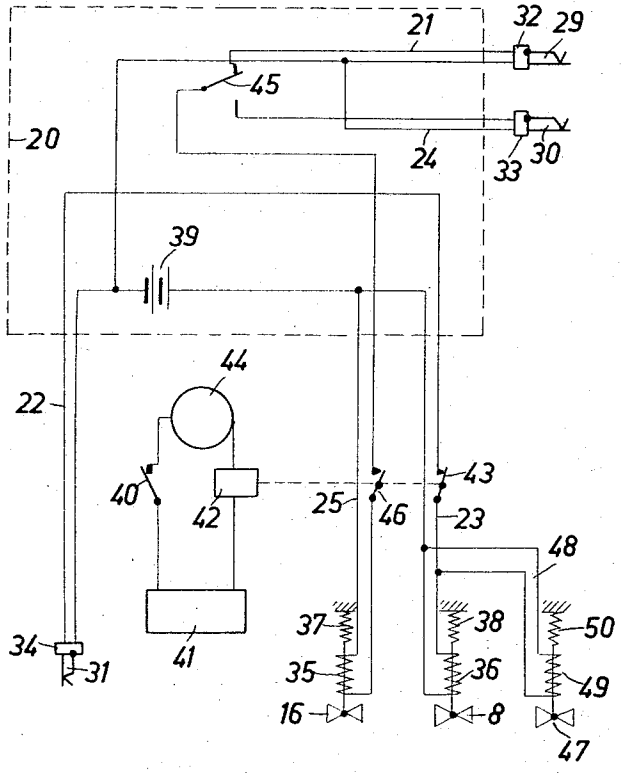
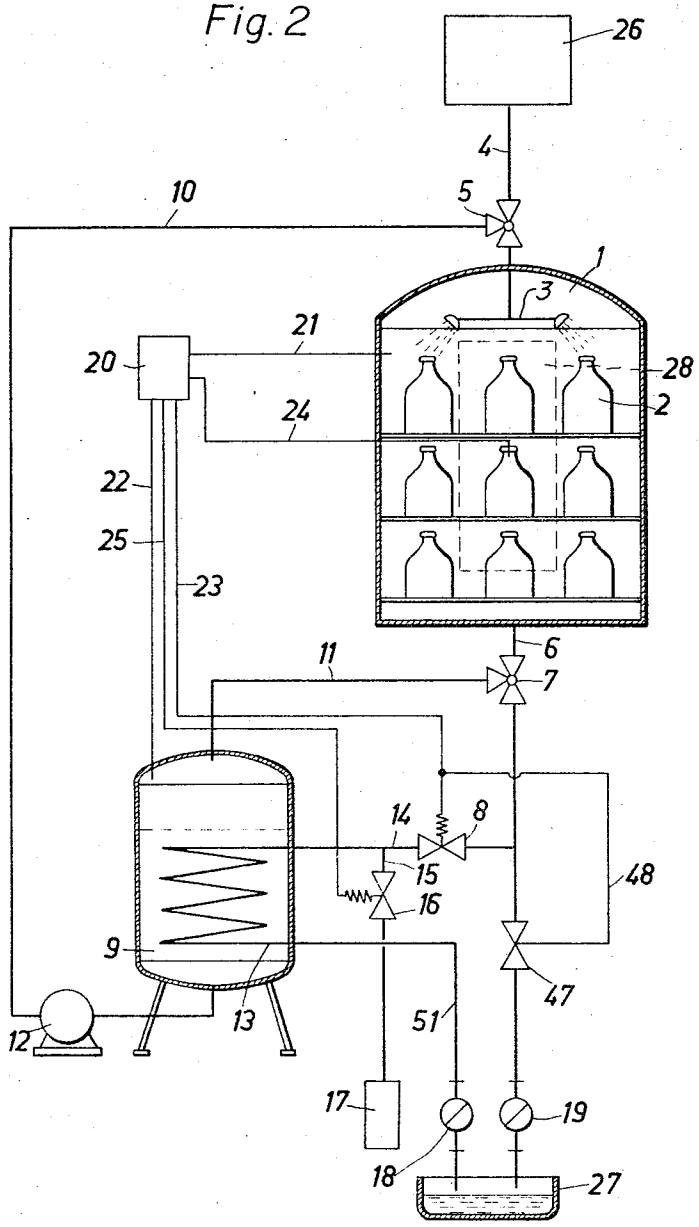


Fig. 3



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STERILIZATION DEVICE WITH MEANS FOR SUPPLYING A SEPARATE COOLING MEDIUM AT CONTROLLED TEMPERATURE AND PRESSURE
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Fig. 2



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STERILIZATION DEVICE WITH MEANS FOR SUPPLYING A SEPARATE COOLING MEDIUM AT CONTROLLED TEMPERATURE AND PRESSURE

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Original application May 29, 1961, Ser. No. 113,323. Divided and this application June 22, 1964, Ser. No. 376,682

Claims priority, application Germany, June 7, 1960, N 18,455

3 Claims. (Cl. 21—91)

ABSTRACT OF THE DISCLOSURE

A sterilization device for use with vapor under pressure as sterilization medium in an autoclave and with means for supplying to the autoclave at a pressure not exceeding said vapor pressure a cooling medium which has a vapor pressure curve substantially parallel with that of the sterilization medium and the same vapor pressure at lower temperatures.

This application is a division of application Ser. No. 113,323 filed May 29, 1961 and now abandoned.

References made hereinafter to the sterilization of solutions in bottles relate to the preferred embodiment of the invention. The invention, is however, not so limited but also relates to other embodiments.

It is known to insert firmly closed bottles containing the solutions in an autoclave and to heat them to the desired temperature by means of saturated steam. The solutions may in particular be common salt or glucose solutions. The sterilization is carried out with steam under pressure within the range of 1.1 to 2.4 atms. The heating time is generally brief, since there is good heat transfer between the steam and the bottles. After the solutions have been retained for a predetermined period in a position exposed to the effect of the pressurized steam, the sterilization is discontinued.

A particular difficulty arises in the cooling of the solutions to room temperature. In this connection, it is to be noted that the bottles are subjected to the vapor pressure of the solutions after conclusion of the sterilization. Before the bottles can be removed from the autoclave they must be cooled. In certain cases, the cooling period should not be prolonged since many solutions decompose or change color during the long cooling periods. This is disadvantageous in particular for so-called intravenous solutions. In such cases, the difficulties arising are increased additionally in that the sterilization temperature must, on bacteriological grounds, often be 134° C. Numerous attempts have been made to avoid these difficulties. Although the devices provided for this purpose solve the problem, the solution is not wholly satisfactory, since they either cannot be used under all conditions or they require extraordinarily large apparatus and involve high costs. In this connection it is to be noted that all known apparatus are based on the fact that the pressure differential between the pressure prevailing in the bottles and the pressure outside the bottles should not exceed a value of 0.2 atms. since higher pressure differentials cause the bottles to crack.

For shortening the cooling period, it has for example been proposed to inject steam at a lower pressure so as to bring about a temperature fall for cooling the bottles. However, this can only be done in devices operating at temperatures up to 100° C. and is therefore not suitable for most sterilization devices.

Further, it is also known to carry out the cooling of

the solution bottles by means of supplying heated water under pressure together with compressed air in such a manner that the pressure of the compressed air is reduced as the temperature of the solution bottles falls. This device has the disadvantage of a high outlay from the point of view of apparatus and of not being very efficient.

The invention provides an apparatus which, without the expenditure connected with known devices, enables the cooling of the objects to be sterilized from the sterilization temperature to any temperature at which the objects are fit for use. According to the invention, the device is such that after conclusion of the sterilization period, a liquid cooling medium is supplied to the autoclave which has a vapor pressure characteristic with substantially the same curve as the characteristic of the pressurized and saturated steam or other sterilizing medium, but which, in contrast thereto, extends at a lower temperature. Thus the cooling medium has a vapor pressure characteristic which at low temperatures extends parallel with the vapor pressure characteristic of the sterilizing medium so that the cooling occurs by maintaining the required pressure. Such a device, for example, may operate at sterilizing temperatures of 121° C. and preferably at 134° C. and above.

Preferably, the cooling medium is pumped through the device in considerable amounts, for example at the rate of 50 litres per minute. In this way, the heat may be transferred from the bottles directly to the cooling fluid.

Advantageously, in a preferred embodiment of the invention, the pressure and also the temperatures in the autoclave and the cooling medium are sensed and regulated and the temperature is sensed in a bottle containing solution or a sterilizing article in a container.

The cooling medium may be, for example, a mixture containing isopropyl alcohol. In another device, the cooling medium contains spirit and any other substances which fulfill the requirements are within the scope of the invention.

The distance between the characteristic curves of vapor pressure for the sterilizer medium and for the cooling medium can be altered by changing the substances, for example, by changing the proportion of water. It is possible to use a constant cooling medium composition. Alternatively, the composition of the cooling medium may be changed during the processing, for example, with a view to making the temperature differential during cooling in the lower range greater than in the higher temperature ranges.

The apparatus according to the invention comprises thus an autoclave for receiving, say, the solution bottles. This autoclave can be connected by known means to a vapor inlet and a vapor or condensate outlet conduit. According to the invention, a pressure chamber for the cooling medium may be connected in parallel to the autoclave and move particularly at the above-mentioned inlet and outlet conduits. In this pressure chamber or tank there is preferably provided a heat exchanger including a tubular coil which is connectable on the one hand to the vapor inlet conduit or preferably the vapor or condensate outlet conduit, or on the other hand to a source of cooling medium such as, for example, to a water supply.

Preferably, a pump is provided between the pressure chamber for the cooling medium and the autoclave inlet. The pump drive can suitably be coupled with a valve in the cooling medium supply to the above-mentioned tubular coil in the pressure chamber or tank in such manner that the cooling medium is conducted into the tubular coil on the supply of the cooling medium into the autoclave following switching on of the pump. It is to be understood that in the case of an automatically operating device, a connecting valve corresponding, for example, to

the valve for supplying a heating medium to the tubular coil, is correspondingly connected under automatic control to the condensate outlet conduit before the cooling stage is initiated.

In a particularly preferred embodiment of the invention there is provided a device for sensing the pressure and conveniently also the temperature both in the pressure tank and in the autoclave, and comprising a measuring arrangement whereby the pressure in the pressure tank is so controlled that it does not exceed the value of the vapor pressure in the autoclave or the pressure in the bottles. Preferably, this device also comprises a temperature-sensing device for sensing the temperature in the solution bottles.

The invention also comprises a novel cooling medium for use in the sterilization device. This cooling medium has a characteristic temperature-pressure curve, which is parallel with the corresponding curve for the vapor and extends in a lower temperature range. One such cooling medium is characterized in that it contains isopropyl alcohol and water. Another preferred cooling medium contains equal portions of water and another substance. In order to produce a constant drop in the temperature, there may be provided according to the invention either a greater portion of the additional substance than of water or more water than additional substance.

Further advantages and features of the invention will be apparent from the following description of an exemplary embodiment thereof illustrated in the accompanying drawings.

In the drawings:

FIG. 1 shows a pressure-temperature curve explaining the operation of the device according to the invention;

FIG. 2 shows a diagrammatic representation of a device according to the invention; and

FIG. 3 shows a diagram of the switching connection layout in a regulating device according to the invention.

In the diagram shown in FIG. 1, explaining the principle on which the device according to the invention operates, pressure values are shown along the ordinate and temperature values along the abscissa. The curve indicated by reference numeral **1** shows the cooling in the bottles in practice. This curve corresponds essentially to the characteristic vapor pressure curve of saturated steam. The curve **2** is the characteristic vapor pressure curve for pure spirit having a specific density of 0.815 at 20° C. related to water. It can be seen that the curve **2** is substantially parallel with the curve **1**. At a pressure of 1.0 kg./cm.^{2}, the temperature differential amounts, for example, to 24° C. and at a pressure of 0 kg./cm.^{2} it is 22° C. The curve **2** can be displaced in the direction of the higher temperature range if a mixture of spirit and water (with reference to the illustrated embodiment) is used. The curve **3** relates to a mixture of equal portions of spirit and water. This mixture has a specific gravity of 0.93 at 20° C. As may be seen, at the pressure value 1.1 kg./cm.^{2}, the temperature differential amounts to only 18° C. This is a temperature differential which can advantageously be used for cooling. This curve **3** could be displaced in either direction by altering the composition of the mixture.

When the cooling medium is introduced into the autoclave, its pressure is substantially equal to that prevailing in the autoclave but, due to its lower temperature, it causes cooling through a definite temperature interval. In consequence of this cooling, the pressure in the autoclave decreases, whereby the continuing supply of further-cooled cooling medium leads to a continuous pressure drop with constantly decreasing temperatures. In this connection, it is pointed out that the cooling medium is pumped through in considerable quantities so that the cooling medium substantially remains in its liquid phase.

FIG. 2 shows diagrammatically an autoclave **1** in which are arranged bottles **2** containing the solution to be sterilized. A vapor inlet conduit **4** extends to the autoclave

from a vapor source **26** and is connected within the autoclave to a manifold **3**. In the vapor inlet conduit **4** there is provided a valve **5** for controlling the vapor supply. This valve is constructed as a three-way valve. To the autoclave is also connected a vapor or condensate outlet conduit **6**. In this conduit there is also located a three-way valve **7**.

A pressure vessel or tank **9** is connected by conduits **10**, **11** between the branch connections of the three-way valves **5** and **7**. In the conduit **10** there is a delivery pump **12** for the medium equipped, for example with a flange-mounted drive motor.

In the pressure tank **9** there is further provided a tubular coil **13** which serves for heating and cooling the medium in this pressure tank **9**. This tubular coil is connected by a conduit **14** to the inlet conduit **6** at the side of the valve **7** remote from the autoclave **1**. A regulating valve **8** is arranged in the conduit **14**. This conduit **14** is furthermore connected, between the tubular coil **13** and the regulating valve **8**, via a conduit **15** and a regulating valve **16** to a source **17** of cooling medium, for example, water. The source **17** contains devices for effecting circulation of the cooling medium. Outlets **18**, **19** extend through condenser conduits in a closed circuit or into collecting vessels **27** as is known in the art. The conduit contains furthermore a valve **47**. This valve is actuated in the reverse sense to the operation of the valve **8**, that is to say, when the valve **8** is opened the valve **47** closes and vice versa. The control connection for actuating the valve **47** is shown at **48**.

The cooling medium is located in the pressure tank **9**. After switching on the pump **12** and after connecting the branch connections of the valves **5** and **7** to the inlet and outlet conduits to and from the autoclave, this cooling medium can be pumped through the autoclave.

The apparatus hereinbefore described operates as follows:

The bottles **2** are placed into the autoclave **1** through a door **28**, which can be closed in an air-tight manner. After the door **28** has been closed and made air-tight, vapor is supplied from the vapor inlet conduit **4** through the valve **5**, the branch of which, extending to the conduit **10**, is closed during this working phase. During this same working phase, the valve **7** communicates with the outlet conduit **6**, whilst its branch to the conduit **11** is closed. During the heating stage, the valve **8** is operated so as to connect the outlet conduit **6**, from the autoclave with the conduit **14**. During this heating stage, the condensate is formed. The condensate is thus supplied through the conduit **14** to the heating coil **13** so that the cooling medium in the pressure tank **9** is heated. If the valve **8** is actuated in order to connect the outlet conduit **6** with the conduit **14**, the valve **47** is simultaneously closed.

Between the autoclave **1** and the pressure tank **9**, there is arranged an automatically operating device **20**. This device has joining members or connecting lines **21**, **22**, leading on one side to the autoclave **1** and on the other side to the pressure tank **9**, by means of which the vapor pressure in the autoclave and the pressure in the tank **9** are controlled by temperature sensing means or pressure gages in such a way that the pressure in the tank **9** is prevented from rising above the value of the vapor pressure in the autoclave or in the bottles. Furthermore, through a joining member or connecting line **24** there is provided a temperature control by the device **20**, the temperature junction **24** extending not only into the autoclave **1** but also into a solution bottle **2**.

The regulating valve **16** is actuated by an actuating connecting member, such as, for example a rod, a servo-pressure conduit or, in the case of electrical construction, an electrical connecting line **25**, in such a way that the required conditions are fulfilled. A connecting line **23** corresponding to the connecting line **25**, and adapted to be controlled as a function of the temperature in the pressure tank **9**, serves for the corresponding actuation

of the regulating valve 8 by which the vapor or condensate outlet conduit is connected to the tubular coil 13.

FIG. 3 shows diagrammatically and by way of non-limitative example an arrangement for the electric actuation of valves 16, 8, 47. Contact actuating pressure- or temperature-sensing devices 29, 30, 31 are, for example, respectively connected to the connecting lines 21, 24, 22. Obviously as shown by the arrangements 32, 33, 34, intermediate relays can be provided in order to provide a lower switching current for the temperature-sensing contacts.

For energising the regulating valves 8, 47 and 16, which are constructed as magnet valves, the magnet systems 35, 36, 49 of which may act, for example, against the force of springs 37, 38, 50, there is provided a battery 39. The magnet system 49 and the spring 50 are arranged in such a manner that the said valve 47 is actuated in the opposite sense to the actuation of the valve 8. The temperature sensing device 31 serves for controlling the regulating valve 8 via conductors 22, 23. The regulating valve 16 is controlled by the temperature sensing devices 29, 30, whereby the type of control is selectively and arbitrarily adjustable by a manual switch 45 in the regulating device 20. As can be seen, the circuit flow extends through the conductors 21 or 24 and 25 and the battery 39. FIG. 3 also shows the circuit for the drive motor of the pump 12. This motor is indicated by reference numeral 44. The energising circuit of the motor is connected through a switch 40 to an energisation source 41. The energising circuit contains a relay 42 which has a normally closed contact 43 in the energising conductor 23 to the regulating valve 8 and a normally open contact in the supply conductor 25 of the regulating valve 16. The contacts 43 and 46 are so constructed that the contact 46 operates in a coupled manner and, since the valve 8 is closed, the opening of the circuit 23 is effected by movement of the contact 43 at a time before the valve is opened.

The arrangement is such that the sensing devices 29, 30 are normally closed and open if the temperature is substantially below the characteristic provided. The regulating circuits for the sensing devices 29, 30 and the regulating valve 16 thus operate according to the holding current principle, whereby this regulating circuit is first closed at the beginning of the cooling process when the pump is switched on.

Similarly, the sensing device 31 has a contact which normally opens under predetermined conditions and thereby actuates the regulating valve 8 in the closing direction. This regulating valve 8 is closed at the beginning of the cooling stage, that is to say, on switching on the pump 12, since the energising circuit is then interrupted.

At the beginning of the cooling stage, the valves 5 and 7 are so adjusted that the conduits 10, 11 are connected and the pressure tank 9 is in communication with the autoclave 1. The device 20 then ensures, through the operation of the sensing device 31 and the subsequent control of the valve 8, that the pressures in the pressure tank 9 and the autoclave are equal. When the pump 12 is switched on, the cooling medium is pumped from the pressure tank 9 through the autoclave 1. Intimate contact between the cooling medium and the bottles 2 withdraws heat from the bottles since —for example when a cooling medium with the characteristic temperature-pressure curve 3 according to FIG. 1 is used—there is a temperature differential of 18° C. at the same pressure.

Simultaneously with the switching on of the pump 12, the valve 16 is opened so that cooling water flows through the tubular coil 13. The cooling medium which circulates in the pressure tank 9 tends to take on a higher vapor pressure because of the heat withdrawn from the solution bottles. These phenomena permit the reflux of the cooling medium through the three-way valve 7 to the pressure tank 9 in which it is further cooled by contact with the tubular coil 13.

It can be seen that the present invention provides a very quick and intensive cooling of the solution bottles by means of an extraordinarily simple apparatus, wherein the temperature differential between the solution bottle temperature and the cooling medium temperature may be altered by selecting the composition of the mixture.

I claim:

1. In a sterilization device for use with vapor under pressure as sterilization medium, an autoclave, a vapor source, a vapor supply conduit connecting said autoclave with said vapor source, first valve means in said vapor supply conduit, a first outlet conduit from said autoclave, second valve means in said first outlet conduit, a pressure tank, first conduit means connecting said pressure tank with said first valve means, pump means in said first conduit means, second conduit means connecting said pressure tank with said second valve means, heat exchanger means in said pressure tank, third conduit means connecting one end of said heat exchanger means with said first outlet conduit, a second outlet conduit connected to the other end of said heat exchanger means, third valve means in said third conduit means, a cooling medium source, fourth conduit means connecting said cooling medium source with said third conduit means at a point between said heat exchanger means and said third valve means, fourth valve means in said fourth conduit means, drive means for said pump means, control means for said third valve means, means connecting said drive means with said third valve means and adapted to close said third valve means upon energization of said drive means, control means for said fourth valve means, means connecting said drive means with said fourth valve means and adapted to open said fourth valve means upon energization of said drive means, temperature sensing means in said autoclave and said pressure tank, and means connecting said temperature sensing means with said control means for said third valve means and for said fourth valve means so as to maintain the pressure in said pressure tank at a value not exceeding the pressure in said autoclave.

2. In a sterilization device for use with vapor under pressure as sterilization medium, an autoclave, a vapor source, a vapor supply conduit connecting said autoclave with said vapor source, first valve means in said vapor supply conduit, a first outlet conduit from said autoclave, second valve means in said first outlet conduit, a pressure tank, first conduit means connecting said pressure tank with said first valve means, pump means in said first conduit means, second conduit means connecting said pressure tank with said second valve means, heat exchanger means in said pressure tank, third conduit means connecting one end of said heat exchanger means with said first outlet conduit, a second outlet conduit connected to the other end of said heat exchanger means, third valve means in said third conduit means, a cooling medium source, fourth conduit means connecting said cooling medium source with said third conduit means at a point between said heat exchanger means and said third valve means, fourth valve means in said fourth conduit means, drive means for said pump means, control means for said third valve means, means connecting said drive means with said third valve means and adapted to close said third valve means upon energization of said drive means, control means for said fourth valve means, means connecting said drive means with said fourth valve means and adapted to open said fourth valve means upon energization of said drive means, pressure sensing means in said autoclave and said pressure tank, and means connecting said pressure sensing means with said control means for said third valve means and for said fourth valve means so as to maintain the pressure in said pressure tank at a value not exceeding the pressure in said autoclave.

3. In a sterilization device for use with vapor under pressure as sterilization medium, an autoclave, a vapor source, a vapor supply conduit connecting said autoclave

with said vapor source, first valve means in said vapor supply conduit, a first outlet conduit from said autoclave, second valve means in said first outlet conduit, a pressure tank, first conduit means connecting said pressure tank with said first valve means, pump means in said first conduit means, second conduit means connecting said pressure tank with said second valve means, heat exchanger means in said pressure tank, a cooling medium source, means selectively connecting said heat exchanger means to said vapor source and said cooling medium source, sensing means in said autoclave and said pressure tank,

and control means connecting said sensing means with said selective connecting means to automatically maintain the pressure in said pressure tank at a value below the pressure in said autoclave.

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