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STERILIZING PROCESS AND APPARATUS

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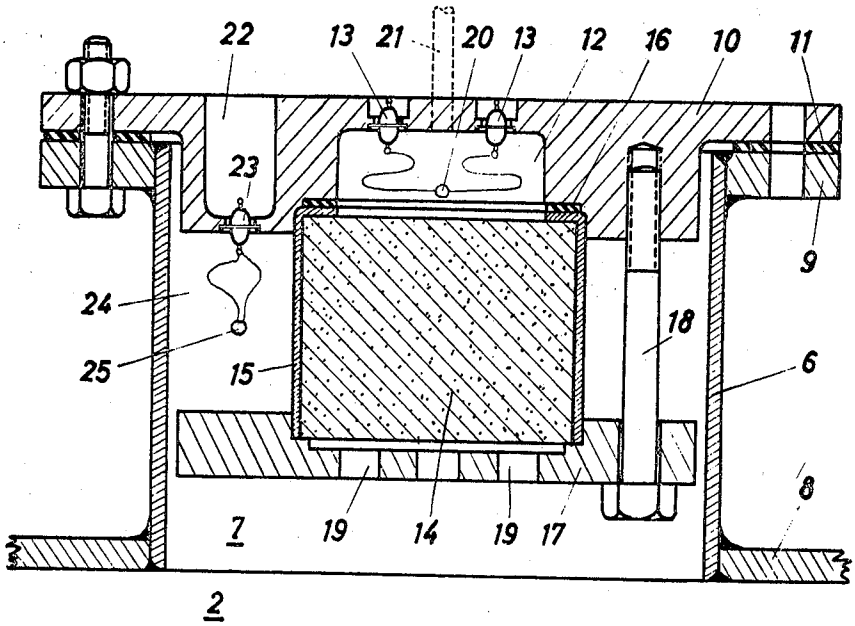


Fig. 2

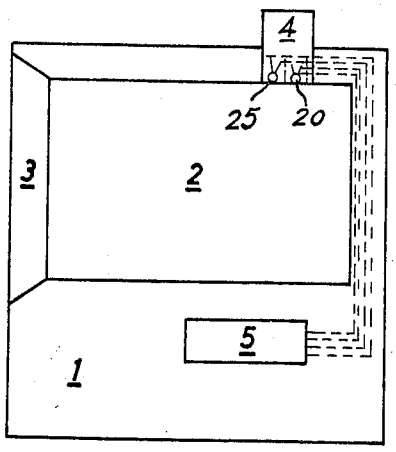


Fig. 1

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ABSTRACT OF THE DISCLOSURE

A steam sterilizing process and apparatus for sterilizing articles having varying degrees of steam permeability wherein the steam chamber has a coverable opening for permitting the introduction of the articles into the chamber. A removable porous insulating member is provided for insulating a temperature sensing element from the chamber and is secured to the chamber walls. The insulating member is chosen to have a steam permeability closely approximating the steam permeability of that article in the sterilizing chamber having the lowest steam permeability. Control means are provided for interpreting the temperature sensed by the temperature sensing means for controlling the time during which the articles are exposed to bacterial killing steam.

The invention relates to sterilizing apparatus having a chamber for the reception of articles to be sterilized by means of steam and having also control apparatus for the automatic control of the sterilizing operation, said sterilizing operation including repeatable periods of "pressure decrease-pressure increase," said terms referring to operations of evacuating the chamber followed by steam entry or referring also to steam venting and further steam entry.

There are already known sterilizing apparatuses of the above-designated type in which the course of a sterilizing operation is controlled according to a fixed program by means of an appropriate control apparatus. In such a program the several operations of evacuating the chamber, feeding steam into the chamber, holding the steam pressure and admitting air to the chamber are fixed according to exact time periods. The values of vacuum attainable are determined by the characteristics of several apparatuses whose attainable temperature and vacuum are determined primarily by the nature of the steam used. In such apparatus, the sterilizing procedure is carried out according to a previously determined pattern which is often a part of the repeatable pattern of the program. It cannot be determined with certainty whether all the air present in places in the articles being sterilized, which places are difficult for steam to enter, will be removed during the carrying out of the sterilizing operation in order that the necessary disinfecting temperature will be attained before the termination of the sterilizing operation. Therefore, there exists some uncertainty concerning the length of the period during which a sterilizing operation should continue. The time determined in a given control program for the carrying out of a sterilizing procedure is therefore determined on the basis of experience derived from a large number of sterilizing procedures and such time periods are made very long in order to be sure of an effective sterilization of the articles. Especially the steps of evacuating and feeding the steam are, for this reason, repeated many times. It is already known that, in the sterilizing operation, the air contained, for example in textile materials, is removed by the application of the vacuum in the sterilizing chamber when the steps of evacuating and steam entry are repeated many times. It still cannot be said whether fewer repetitions of such operations will be safe or not. However, when one diminishes such repetitions one then cannot be certain whether all places of the goods being sterilized are or are not brought to the required temperature of 134 degrees centigrade. This temperature is, however, necessary in order to make certain that all bacteria therein are killed. Hence, there is required a long period for a sterilizing operation which makes it impossible to achieve an efficient use of the sterilizing apparatus. Hence, particularly in a case where a large number of articles are to be sterilized, there is required the use of a very large sterilizing apparatus. Further, different types of articles, for example, operating gloves, do not need to be exposed for so long a time to a temperature of 134 degrees centigrade so that the long sterilizing time under the circumstances above mentioned require different programming corresponding to the particular articles to be sterilized and this in turn requires the use of an appropriate control apparatus. Hence, the long sterilizing time can up to now not be dispensed with in the interest of maintaining safety.

The purpose of the invention is to provide sterilizing apparatus which, with the help of a simple control apparatus, assures a safe sterilization within a short period of time.

This purpose is attained according to the invention in that in the sterilizing apparatus of the previously described type there is provided a temperature responsive device protected by a screen of fine porosity and penetrable only with difficulty by the steam from the sterilizing chamber. Said temperature responsive device, after being warmed by the steam penetrating the barrier means to a predetermined temperature sufficient to assure safe sterilizing, acts in cooperation with the control apparatus to terminate the pressure decrease-pressure increase phases of the sterilizing program and to commence the final phase of admitting air into the chamber.

By this arrangement of a thermosensitive unit protected from the chamber of the sterilizing apparatus, the temperature measured by said unit during the sterilizing operation reaches a predetermined desired value corresponding to the temperature of the places in the articles being sterilized which the steam can reach only with difficulty. Through appropriate dimensioning, the fine porosity screen can be so constructed that its capacity for steam pentration can with certainty be made of the same degree of difficulty as exists in those articles which are difficult to sterilize, for example, thickly packed wash cases. The construction of the screen can be determined by cut and try methods. If the thermosensitive unit which is separated from the chamber by an appropriate screen indicates during the sterilizing operation a temperature appropriate for the killing of bacteria it can be concluded with safety that this temperature has also been attained throughout the material being sterilized. Thus, the protected thermosensitive unit can be utilized to control the sterilizing operation. At the attainment of the temperature necessary for killing of bacteria, the termination of the sterilizing operation can be caused to take place in cooperation with the control apparatus at the earliest possible moment. The use of a temperature sensitive unit surounded by a standardized protector, such temperature sensitive unit being constant and giving reproduceable results for the most difficult materials to be sterilized, makes possible for the first time a comparison of operating experiments with different sterilizing apparatus and methods. The records of the protective temperature sensitive units which are standardized to the same characteristics of steam pentration therethrough provide accurate reference values for such comparisons.

It is advantageous to provide in the sterilizing apparatus according to the invention, in addition to the temperature sensitive unit protected by fine porosity screen, a further temperature sensitive unit relatively freely penetrable by steam and wherein the control apparatus measures the temperature difference between the two temperature sensitive units and effects, in response to the difference between both temperature sensitive units, the termination of the pressure decrease-pressure increase period and actuates the apparatus for the readmission of air. The measuring of the temperature difference between an easily accessible temperature sensitive unit and a protected temperature sensitive unit makes possible the control of the continuous apparatus. If the protective screen is defective, steam will flow very quickly to the protected temperature sensitive unit and warm same as quickly as the easily accessible temperature sensitive unit. In such case at the beginning of a sterilizing operation the temperature difference, which appears with certainty in connection with a well-functioning protected unit, will not appear between the two temperature sensitive devices including the defective one. The control apparatus for the sterilizing device can thus be so built that in the case of equal temperature designations occurring at both units, the sterilizing apparatus is disconnected and a breakdown signal is given.

An increase in the precision of control for the control apparatus is advantageoulsy obtained in that each thermosensitive unit is constructed as a known "cold conductor" or a thermistor. Cold conductors have a very steep change of conductivity corresponding to temperature changes and show temperature alterations therefore very accurately.

It is very advantageous to construct the sterilizing apparatus acording to the invention in such a manner that the readily accessible temperature sensitive unit produces, at a lower temperature than the ultimately desired final temperature a repeating of the "pressure decrease-pressure increase" cycle at each appearance of such lower temperature, until the temperature difference between both temperature sensitive units vanishes. In this manner, the "pressure decrease-pressure increase" periods follow quickly one after another. In this manner the air entrained within the materials to be sterilized is very quickly removed and said materials become very quickly warmed by newly entering steam. A long holding of the steam in the chamber and the warming by steam of the air-filled places in the goods which are difficult for steam to enter is less effective and is inefficient.

The manufacture of the screen for the temperature sensitive unit, which unit is to be protected from free access by the steam and whose steam penetrability is to correspond exactly to the penetrability to be determined through trial and error, is rendered possible in a simple manner. A presently known sintered material, such as carborundum, may serve as the material of fine porosity. The desired steam penetrability in each desired case can be provided by appropriate preparation and dimensioning of this material. An advantageous application of the protected temperature sensitive unit in the sterilizing apparatus may according to the invention be accomplished by placing the protected temperature sensitive unit in a chamber provided with an opening which is connected to the sterilizing chamber and which has a plug of sintered material placed therein.

For increasing the reliability of the sterilizing operation, the sterilizing apparatus according to the invention can be so constructed that the control apparatus, after the termination of the "pressure decrease-pressure increase" period, provides for the delayed activation of the "air inlet" end phase. This apparatus operates, after the attainment by all parts of the articles being sterilized of the temperature necesary for killing the bacteria, to hold the steam in the chamber for a short time and thereby to

permit a more effective working of such temperature on the bacteria.

An advantageous modification of the sterilizing apparatus is to construct the control apparatus so that after the termination of the pressure decrease-pressure increase period and before the re-entry of air, there will be brought about and held for a controllable time a vacuum in the chamber. In this manner the condensed water remaining in the goods to be sterilized is again converted into steam by the heat entering thereinto from the still warm walls of the chamber. The sterilized goods will in this manner be at least partially dried before removal from the chamber. Finally, it is very advantageous to control the sterilizing operation from the outside if the control apparatus comprises apparatus showing the temperature difference between the two temperature sensitive units either optically or acoustically, for example, in the form of a magic eye. In this manner unskilled service personnel can determine the end of the sterilization operation and can make preparations for emptying the chamber and for recharging same. Also, malfunctions in the operation of the sterilizing apparatus are quickly and readily made known.

Further features of the invention will appear in the following description of an illustrative embodiment shown in the accompanying drawings.

In the drawings:

FIGURE 1 is a schematic view of a sterilizing apparatus.

FIGURE 2 is a sectional view of the temperature measuring portion of the apparatus shown mounted on the sterilizing chamber.

The sterilizing apparatus **1** comprises a sterilizing chamber **2** which is accessible from the outside through a door **3**. A measuring device **4** is mounted adjacent the chamber **2** for providing suitable signals to the control apparatus **5** (FIGURE 1).

The measuring device **4** comprises a vertically arranged tube **6** whose lower end is connected, as by welding, in a steam-tight manner with the edge of an opening **7** in the sterilizing chamber wall **8** (FIGURE 2). A flange ring **9** is suitably connected, as by welding, to the upper end of the tube **6**, and a cover **10** is fastened, here by bolting, in a steam-tight manner to the upper end of the tube **6**. A seal ring **11** of any convenient type of sealing material is provided between the flange ring **9** and the cover **10**. A recess **12** is provided at the middle of the cover **10** and on the side thereof facing the interior of the sterilizing chamber **2**, which recess **12** is connected to the upper side of the cover through two passageways. In these passageways there are provided two commercially available glass beads **13**, in a steam-tight manner, for the introduction of electrical conductors into the pressure chamber. The pressure chamber is closed by a fine porosity cylinder **14** made from carborundum, same being placed between the sterilizing chamber **2** and the open side of the recess **12**. The cylinder **14** is disposed within a metal casing **15** which has an annular ring at its upper end. This annular ring lies against a seal ring **16** made from sealing material, which sealing ring is arranged in the lower open rim of the recess **12** in the cover **10**. The lower end of the cylinder **14** is received in a recess in a plate **17** and is pressed by the plate **17** against the seal ring **16** around the rim of the recess **12** in the cover **10**. Said cylinder **14** is pressed against said seal ring **16** in this embodiment by means of screws **18** which extend through openings in the plate **17** and are screwed into suitbale threaded openings in the cover **10**. The screws **18** are drawn down sufficiently that the border ring of the metal housing **15** lies in a steam-tight manner against the seal ring **16**. The plate **17** has passageways **19** located under the cylinder **14** which effect a direct connection of the sterilizing chamber **2** with the fine porosity protective material in the cylinder **14**. The use of the screws **18** for fastening the cylinder **14** to the cover plate **10**

makes possible the installation of cylinders of different length as well as the use of cylinders of different steam permeability for adjusting the degree of protection as above discussed. A cold conductor bead **20** is provided in the recess **12** and is screened by the cylinder **14** from the sterilization chamber **2**. The terminals of the bead **20** are soldered to the lower ends of the conductors extending through the glass beads **13** and said bead hangs freely in the cavity **12**. The cold conductor bead constitutes a protected thermosensitive unit **20** according to the invention. In the particular construction illustrated, an evacuating and air supply passageway **21** can extend from the protected cavity **12** through the cover **10** and may then be connected to the vacuum equipment of the sterilizing apparatus.

The cover **10** is provided with a recess **22** on its outward side and offset from its middle, which recess at its lower end is provided with two passageways therethrough. In these passageways glass beads **23** are inserted and fastened in a steam-tight manner. Conductors extend through these glass beads **23** and their lower ends extend into the space **24** which is directly connected with the sterilizing chamber **2**. A cold conductor bead is soldered at both of its terminals to these two lower conductor ends. The cold conductor beads hangs freely in the space **24** and provides the temperature sensitive unit **25** which is easily accessible to the steam from the sterilizing chamber **2**, according to the invention.

The cylinder **14** is dimensioned and is made from fine grained carborundum so that its steam permeability is reliably less than that of the most difficult of the goods to be sterilized within the chamber **2**.

Before the beginning of a sterilizing operation, the same conditions exist at the protected temperature sensitive unit **20** in the space within the recess **12**, at the easily accessible temperature sensitive unit **25** in the space **24**, and also in the sterilizing chamber **2**. During the operation of the sterilizing procedure, the easily accessible temperature sensitive unit **25** always shows the temperature in the chamber **2** while the protected temperature sensitive unit **20** at first shows a lower temperature. The protected temperature sensitive unit **20** first becomes slowly warmed by steam which passes through the cylinder **14** and indicates a temperature which lies somewhat below that which exists in the most protected places in the goods to be sterilized. The temperature signals from both temperature sensitive units **20** and **25** are conducted into the control apparatus **5**.

The control apparatus **5** consists, for example, of a measuring and switch unit and an electric motor which drives notched discs through magnetic clutches, which notched discs in turn act through switches associated therewith for the operation of magnetic valves.

The control apparatus **5** controls the operation of the sterilization procedure so that it begins with the evacuation of the chamber **2** (phase 1, evacuation). In this step the air is withdrawn from the chamber **2** and also at least a part of the air entrained within the goods to be sterilized and in the protective cylinder **14** is removed. Steam is then introduced into the chamber **2** (phase 2, steam inlet). The temperature in the chamber **2** rises rapidly and also it does the same in the space **24** which is directly connected to the chamber **2**. The temperature sensitive unit **25** is rapidly warmed. However, the steam penetrates through the cylinder **14** very slowly into the protected recess **12** and even then a portion condenses in the pores of the cylinder **14**. The temperature sensitive unit **20** accordingly is warmed much more slowly than the temperature sensitive unit **25**. The readings of the temperature sensitive units **20** and **25** are continuously compared in a difference circuit. When the easily accessible temperature sensitive unit **25** attains a constant temperature, for example, 120 degrees centigrade, less than the 134 degrees centigrade necessary for the killing of bacteria, and if at this point the temperature difference between the easily accessible unit **25** and the protected unit **20** is still greater than a predetermined difference A, the control apparatus stops the phase 2 (steam inlet) and restarts to phase 1 (evacuating). If there is no temperature difference between the temperature sensitive units shown the first time that phase 2 is carried through, then there exists a defect in the protective screen of the temperature sensitive unit **20**. The control apparatus disconnects the sterilizing apparatus and gives a trouble signal, for example, by lighting a warning lamp.

If the control apparatus **5** switches to phase 1 again, then the air present in the goods to be sterilized and in the recess **12** and in the cylinder **14** is together with the steam further removed by the vacuum.

Finally the control apparatus again switches to the phase 2 (steam inlet). The temperature difference between the two temperature sensitive units **20** and **25** diminishes noticeably because the protected temperature sensitive unit **20**, on account of the lessened air content in the recess **12**, is better warmed by means of the newly entered steam. If the easily accessible temperature sensitive unit **25** is again warmed to about 120 degrees centigrade and if the temperature difference is still greater than the predetermined temperature difference A, the apparatus is again automatically switched to phase 1 (evacuating) and the operation begins anew. If, however, the temperature difference is smaller than the predetermined temperature difference A, then the steam is maintained in the chamber **2**. The temperature of the easily accessible temperature sensitive unit **25** then climbs quickly to 134 degrees centigrade. If the temperature difference after a predetermined period of time T_1 after the signal point at which the easily accessible temperature sensitive unit **25** reached 120 degres centigrade, is still greater than a predetermined tolerance B of about 2 degrees centigrade, then the control apparatus again shifts automatically to phase 1 (evacuation) and the operation begins anew. If the temperature difference after the predetermined elapse of time, however, remains within the tolerance B, then the steam is held sufficiently long in the chamber **2** that the temperature of 134 degrees centigrade necessary for the killing of the bacteria also appears at the protected temperature sensitive unit **20**. Following the commencement of this time period, the steam is still held in the chamber **2** for a further predetermined period of safety time T_2. Finally the control apparatus **5** switches to the phase 3 (suction). In this phase the chamber **2**, as in phase 1 becomes evacuated. Simultaneously, however, the recess **12** also is evacuated through the passageway **21** in the embodiment where such is provided. The vacuum is then held for a short fixed period of time in order that a part of the condensed water present in the material to be sterilized and in the cylinder **14** may be re-evaporated by heat entering there into from the still warm walls of the chamber **2**. Through the vertical arrangement of the tube **6** and the cylinder **14** on the upper wall of the sterilizing chamber **2** the danger is that condensed water accumulating during operation and sterilizing procedure in the space **25** and in the cylinder **14** can drain into the chamber **2**. This problem is eliminated by the phase 3 (suction) step. Finally, the control apparatus shifts to phase 4 (air admission). At this point the chamber **2** is aerated together with the protected cavity **12** in case a tube **21** has been provided. At this point sterilization procedure is completed.

For the control of the sterilization operation by means of service personnel it is advantageous if the measured temperature difference between the easily accessible temperature indicator and the protected temperature indicator is carrid out by a "magic eye" during the sterilization operation.

The above-described features of the invention can be arranged in various desired combinations in addition to those particularly shown in the drawings and the description of the particular illustrated embodiment, and, there-

fore, the invention contemplates such modifications and changes as lie within the scope of the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A sterilizing process comprising:
placing the articles to be sterilized in a sterilizing chamber;
selecting an insulation member having a maximum steam permeability equal to the one of said articles to be sterilized having the lowest steam permeability;
placing said selected insulation member between said sterilizing chamber and a control chamber to thereby isolate said control chamber from said sterilizing chamber;
evacuating the sterilizing chamber to remove air therefrom;
supplying steam to the sterilizing chamber;
measuring the temperature in said control chamber, which temperature in said control chamber is at least as low as the temperature of that one of said articles having the lowest steam permeability;
repeating the steps of evacuating the sterilizing chamber and supplying steam to the sterilizing chamber in response to said measuring of the temperature in said control chamber so that steam passing through said insulation member will raise the temperature in said control chamber to a value indicating that sterilization of the articles has been completed; and
removing the steam from the sterilizing chamber and admitting air into the sterilizing chamber in response to said measuring of the temperature in said control chamber to thereby complete the sterilization procedure.

2. A sterilizing process, comprising:
placing articles of varying permeability in a sterilizing chamber;
evacuating the sterilizing chamber to remove air from the sterilizing chamber;
supplying steam to the sterilizing chamber;
simultaneously measuring the temperature of the steam in the sterilizing chamber and the temperature of a control chamber which is isolated from the sterilizing chamber by a permeable insulator element whose permeability is, at a maximum, equal to the permeability of one of the articles being sterilized having the lowest steam permeability, which temperature in said control chamber is at least as low as the temperature of the most protected portions of the articles being sterilized;
repeating the steps of evacuating the sterilizing chamber and supplying steam to the sterilizing chamber in response to the measurement of said temperatures so that the temperature in said control chamber is within a predetermined amount of the temperature of the steam in the sterilizing chamber; and then
removing the steam from the sterilizing chamber and admitting air into the sterilizing chamber in response to the measurement of said temperatures to complete the sterilization procedure.

3. A serilizing process according to claim 2, in which between the final step of supplying steam and the removing of steam from the sterilizing chamber, there is carried out the additional step of holding the steam in the sterilizing chamber for a predetermined period of time.

4. A sterilizing process according to claim 2, in which the final step of removing the steam from the sterilizing chamber includes holding a vacuum in the sterilizing chamber for a predetermined period of time to evaporate condensed steam in the sterilizing chamber.

5. A steam sterilizing apparatus for sterilizing articles having varying degrees of steam permeability, comprising in combination:
a steam chamber having a coverable opening, said coverable opening permitting the introduction of said articles into said chamber;
first means sensing a first temperature;
control means connected in circuit with said first temperature sensing means for comparing said first temperature to a reference for controlling the time during which the articles are exposed to bacterial killing steam;
removable permeable insulating means isolating said first temperature sensing means from said chamber, said permeable insulating means having a permeability regulating the passage of steam therethrough toward said temperature sensing means, said permeability being, at a maximum, equal to the permeability of the one of said articles in said chamber having the lowest steam permeability whereby said steam will enter said chamber and penetrate said insulating material at at least a rate not greater than the rate of steam penetrating into said one of said articles.

6. The steam sterilizing apparatus defined in claim 5, wherein said means sensing a first temperature is a thermistor.

7. The steam sterilizing apparatus defined in claim 5, wherein said reference comprises second means located within said sterilizing chamber and connected in circuit with said control means for sensing a second temperature in said chamber, said control means comparing said first and second temperatures when said first and second temperatures differ by a predetermined temperature differential to alter the steam supply for controlling the time during which the articles are exposed to bacterial killing steam.

8. The steam sterilizing apparatus defined in claim 7, wherein said first and second temperature sensing means are thermistors.

9. The steam sterilizing apparatus defined in claim 5, wherein said insulating means is composed of a sintered material.

10. The steam sterilizing apparatus defined in claim 9, wherein said sintered material is silicon carbide.

11. The steam sterilizing apparatus defined in claim 9, wherein said steam chamber is comprised of first and second compartments, said first compartment containing the articles to be sterilized, said second compartment being isolated from said first compartment by said permeable sintered material; and
wherein said first temperature sensing means is positioned within said second compartment whereby said steam will enter said first compartment and penetrate said articles therein as well as penetrate said permeable sintered material at a maximum rate equal to the rate of steam penetrating into said one of said articles having the lowest steam permeability.

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