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3,093,449

STERILIZING APPARATUS

Filed Nov. 14, 1958

2 Sheets-Sheet 1

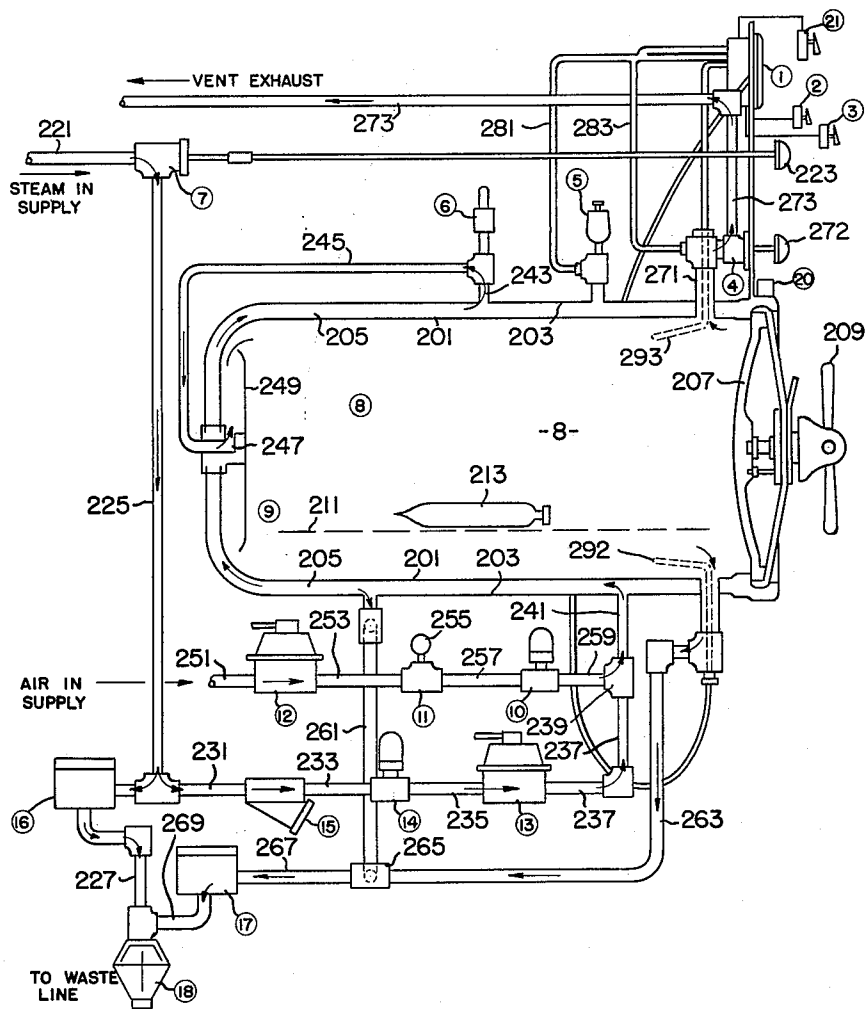


FIG. 1

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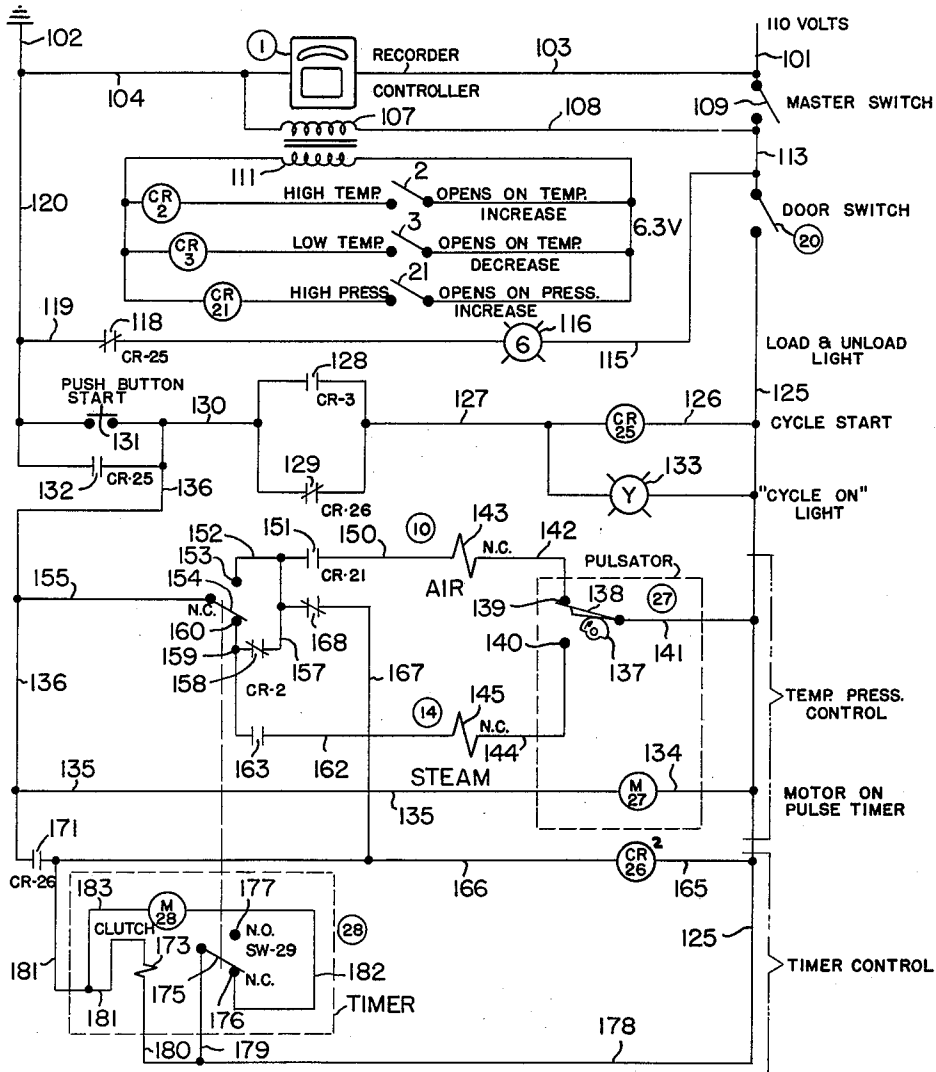


FIG. 2

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3,093,449

STERILIZING APPARATUS

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This invention relates to a sterilizing apparatus and method of sterilization, particularly for use by pharmaceutical manufacturers or laboratories, physicians, hospitals, etc.

An object of the invention is the provision of a generally improved and more satisfactory sterilizer, and a generally improved and more satisfactory method of sterilization.

Another object is the provision of a sterilizing apparatus and a sterilizing method by which goods in sealed containers (e.g., ointment in a tube) can be satisfactorily sterilized without danger of rupture of the sealed container.

Still another object is the provision of sterilizing apparatus, and a sterilizing method, by which goods able to withstand only relatively low temperature sterilization can be sterilized at a pressure higher than the steam pressure which would normally correspond to the sterilizer temperature selected, this higher pressure serving externally to balance internal pressure in a sealed container, to avoid rupture or explosion of the container.

A further object is the provision of sterilizing apparatus so designed and constructed as to maintain, for a preselected time, a sterilizing chamber at a predetermined temperature and pressure, the pressure being, if desired, considerably higher than the pressure which would normally correspond to steam at the selected temperature.

These and other desirable objects may be attained in the manner disclosed as an illustrative embodiment of the invention in the following description and in the accompanying drawings forming a part hereof, in which:

FIG. 1 is a diagrammatic view of a sterilizer in accordance with a preferred embodiment of the present invention; and

FIG. 2 is a wiring diagram of the electrical control parts for the same.

The same reference numerals throughout the several views indicate the same parts.

In the art of sterilization in the medical field, as commonly practiced in pharmaceutical manufacturing establishments or laboratories, and in hospitals, it is customary and convenient to place the article to be sterilized within an autoclave or sterilizing chamber which may be sealed against the outside atmosphere by means of an airtight door or the like, and then to introduce steam under pressure into the sterilizing chamber. As well known to those familiar with the science of thermodynamics, there is a definite relation between the temperature of the steam and its pressure, this relationship being ascertainable by reference to standard steam tables as published in many reference books. For example, it is well known that saturated steam at standard atmospheric pressure (gage pressure of zero) has a temperature of 212 degrees F. At a gage pressure of 10 p.s.i. (absolute pressure of about 24.7 p.s.i.) it has a temperature of about 239 degrees F. Again, saturated steam at a temperature of 270 degrees F. has a gage pressure between 27 and 28 p.s.i. Other correlated values of pressure and temperature are, as above mentioned, readily obtainable from published steam tables.

It may be desired, however, to conduct sterilization at a pressure in excess of the pressure which corresponds to the desired temperature of sterilization. An example of

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this is the sterilization of certain kinds of pharmaceutical ointments, which may be unable to withstand a high temperature without decomposing or losing some of their effectiveness. For example, it may be necessary to sterilize at a temperature of only 220 degrees F. This temperature (of saturated steam) corresponds to a gage pressure of between 2 and 3 p.s.i. But if the ointment is sterilized after being placed within a sealed tube, or other sealed container, the rise in temperature of the contents of the container will cause the contents to tend to expand to the point where the container may easily explode or otherwise rupture. To counterbalance the internal expansive force within the tube or other container, so as to prevent rupture, it is desirable to have the container surrounded by an atmosphere at an elevated pressure sufficiently high to prevent rupture; for example, a pressure of about 16 or 17 pounds per square inch. This pressure would correspond to a saturated steam temperature of about 252 degrees F. which, as above stated, might be considerably in excess of the safe sterilization temperature of the ointment. Moreover, even if the ointment could stand such a high temperature, the higher temperature of sterilization would cause greater expansive force within the tube or other sealed container, so that a still higher external pressure would be needed to counterbalance the internal expansive force, so as to avoid rupture.

Situations of this kind have caused considerable difficulty in the past. The present invention enables the sterilization under these difficult conditions to be accomplished in a simple, easy, and safe manner.

Briefly, sterilization is accomplished according to the present invention by introducing into the sterilizing chamber both steam and compressed air, the steam furnishing the desired sterilizing temperature while the compressed air supplies the desired excess pressure over and above the pressure corresponding to steam at the desired sterilizing temperature. According to a more detailed aspect of the present invention, the steam and compressed air are introduced in pulses or cycles as required first to build up the temperature to the desired amount and then to build up the pressure to its desired amount. Further steam and compressed air may be introduced into the sterilizing chamber in pulses which may alternate during the sterilizing cycle as required from time to time to maintain the desired temperature and pressure, and then pressure in the sterilizing chamber is maintained during at least a part of the cooling cycle, by further introduction of compressed air to compensate for what would otherwise be a lowering of pressure as the cooling continues and the steam condenses.

Referring now to FIG. 1 of the drawings, there is shown diagrammatically a sterilizing chamber of the double walled cylindrical type, with its axis arranged horizontally. The inner wall is indicated at 201, the outer wall at 203, and the space between the two walls forms a jacket 205, while the space within the inner wall constitutes the sterilizing chamber 8. One end of the sterilizing chamber is provided with a door 207 which can be locked in an airtight manner by manipulating a handle 209, so as to seal the sterilizing chamber 8 to enable any desired pressure (within reasonable limits) to be built up therein.

The construction of the sterilizing chamber, jacket, and door may all be conventional, and need not be further described herein.

Within the chamber may be any suitable support for the articles to be sterilized; for example, a shelf 211 on which tubes of ointment 213 may be placed.

A steam supply conduit 221 is connected to any suitable source of supply of steam, at any pressure convenient to the establishment where the sterilizing appara-

tus is located, so long as the temperature and pressure of the steam are at least as high as the highest temperature and pressure that will be wanted in the sterilizer during any sterilizing operation. Conveniently the steam may be at a gage pressure of about 27 p.s.i., corresponding to a temperature of about 270 degrees F. The steam for use in the sterilizer passes from the supply line 221 through a manual shut-off valve 7 controlled by a handle 223 accessible near the front of the sterilizer, thence downwardly through a conduit 225 to a steam trap 16 of the thermal type, which serves to remove water from the steam, the water flowing down a conduit 227 to a condensation funnel 13 and thence out through a waste line.

One branch of the conduit 225 extends at 231 to a strainer 15, thence onwardly at 233 to the solenoid controlled steam valve 14, thence onwardly at 235 to the steam pressure reducing valve 13 (preferably adjustable), thence onwardly at 237 to a T-fitting 239 where it joins the compressed air inlet line. From this T-fitting 239, the conduit continues at 241 and enters the jacket 205 of the sterilizing chamber. Any steam (or compressed air) admitted through the conduit 241 may fill the jacket and flow around the various parts of the jacket to exit at the top thereof through a conduit 243 one branch of which leads to a pressure safety valve 6, and another branch of which leads at 245 to enter the main sterilizing chamber 8 itself, approximately at the center of the rear wall thereof, as at 247. This entrance preferably is behind a baffle 249 so that as the steam or compressed air enters, it does not shoot straight out into the center of the sterilizing chamber but is baffled and dissipated so as to avoid stratification within the sterilizing chamber. There being no valve in the conduits 243, 245 between the jacket and the chamber, it will be apparent that the pressure in the jacket is at all times equal to the pressure within the sterilizing chamber 8 itself, and hence it will be realized that the use of a jacket is optional and that, if desired, the sterilizing chamber may have no jacket and the steam and compressed air may be introduced directly into the sterilizing chamber, preferably behind a baffle as shown.

The compressed air supply conduit is indicated at 251, and is connected to any suitable source of compressed air having a pressure at least as high as the highest pressure that will be wanted within the sterilizing chamber under normal operating conditions. The supply conduit leads to an adjustable pressure reducing valve 12, thence onward at 253 to a fitting 11 having a pressure gage 255 mounted on it; thence onward at 257 to the solenoid controlled air supply valve 10; thence onward at 259 to the previously mentioned T-fitting 239, where the air supply joins the steam supply and enters the sterilizer through the connection 241.

A drainage conduit 261 leads downwardly from the bottom of the jacket 205, and another drainage conduit 263 leads downwardly from the bottom of the sterilizing chamber 8, these two conduits joining each other at a T-fitting 265 from which the drain conduit leads onward at 267 to a steam trap 17 of the float type, thence from the steam trap through a conduit 269 to the same condensation funnel 13 which was used for the outflow from the thermal steam trap 16.

An exhaust vent conduit 271 leads upwardly from the top of the sterilizing chamber 8, through a manual exhaust valve 4 controlled by an accessible handle 272, thence onwardly at 273 to any suitable exhaust place or area. When the manual valve 4 is opened, any pressure within the sterilizing chamber 8 or within the jacket 205 will be vented. When the manual valve 4 is closed, and assuming also that the door 207 is closed and tightly sealed, then any desired pressure can be built up within the sterilizing chamber 8 and the jacket 205, at least until the pressure reaches the value for which the safety valve 6 is set. In normal use, the valve 4

is kept slightly open during the sterilizing cycle, to provide a bleed port permitting constant slight outflow from the sterilizing chamber, so that there may be a continued slight overflow of steam or compressed air.

Mounted at a conveniently visible and accessible position near the front of the sterilizer is a pressure and temperature recorder indicated in general at 1, of any suitable conventional construction. For example, the recorder may be of the familiar type having a rotary support to which a paper chart or disk is applied, there being means for driving the chart support to rotate it past a pen or pencil which records on the chart the pressure within the sterilizer chamber, and another pen or pencil which records on the chart the temperature within the sterilizing chamber. A pressure conduit 281 may lead from the sterilizer chamber or its jacket to the pressure responsive device within the recorder 1 which controls the pressure recording pen or pencil. On a branch of this conduit 281 there may be a vacuum breaker 5 of any suitable known construction, to avoid the formation of a vacuum of more than a predetermined set amount, within the sterilizer.

In case it is desired to have separate pens or pencils in the recorder, for recording the pressure within the sterilizing chamber itself as distinguished from the pressure within the jacket (although normally the two would be the same, in the particular construction here described) the above mentioned connection 281 may lead from the jacket, and there may be another connection 283 leading from the sterilizing chamber to the recorder 1.

As above mentioned, compressed air and steam are admitted to the sterilizer through the solenoid controlled valves 10 and 14, respectively. The mechanism (mainly electrical) for controlling the entire operation of the sterilizer, including the control of the valves 10 and 14, will now be described mainly with reference to the wiring diagram constituting FIG. 2, some of the parts also being indicated diagrammatically in FIG. 1.

The main electric supply line, supplying current at conventional 110 volts, is indicated at 101 and 102. From these mains, branches 103 and 104 respectively lead to the recorder 1. The primary 107 of a stepdown transformer is also connected by a circuit 108 across the mains 101 and 102, but this circuit passes through a manual master switch 109 which, when opened, cuts off all electric connections for the sterilizer assembly except the recorder 1, which may run continuously, if desired.

The secondary winding 111 of the transformer furnishes current at a reduced voltage (e.g., 6.3 volts) to three switches 2, 3, and 21, which are in series with three control relays, the coils of which are indicated respectively at CR-2, CR-3, and CR-21. In other words, as will be readily seen from the wiring diagram, when the switch 2 is closed, current from the secondary 111 of the transformer flows through the coil of the relay CR-2, and when the switch 2 is open, no current flows through this relay. Likewise, with respect to the other switches and the coils of their respective relays.

The switch 2 is a high temperature switch, which opens on increase of temperature and closes whenever the temperature sensed by this switch is at or below the value for which the switch is adjustably set. The switch 3 is a low temperature switch which opens when the temperature decreases below the value for which it is set, and which closes when the sensed temperature is at or above the set value. The switch 21 is a high pressure switch, which opens whenever the sensed pressure rises above the pressure for which the switch is adjustably set, and which closes whenever the sensed pressure is at or below the set value. The temperature sensing bulb or element for the high temperature switch 2 is preferably located near the bottom of the sterilizer chamber 8, as indicated in FIG. 1 at 292, while the sensing bulb or element for the low temperature switch 3 is preferably located near the top of the sterilizer chamber 8 as indicated at

293 in FIG. 1. Thus if, because of stratification or any other reason, the temperature is not uniform throughout the height of the sterilizing chamber, the switch 2 will not open until the set temperature is reached at the bottom of the sterilizing chamber (which is likely to be the coolest part of the chamber, if there is any difference) and the switch 3 will not open until the temperature at the top of the chamber (likely to be the hottest part, if there is any difference) drops below the set value.

All three of these switches 2, 3, and 21 are manually settable to various values of respective temperatures and pressure, by turning adjusting hands or knobs with reference to a calibrated dial or graduated scale, switches of this kind being well known per se. For clarity of illustration, these switches 2, 3, and 21 are indicated both in FIG. 1 and in FIG. 2 as separate switches, although in actual practice the temperature switches 2 and 3 may be combined into one unit and all three of the switches are preferably mounted (along with their control knobs) in a single housing or casing, located preferably next to or even, if desired, as part of, the recorder 1.

In the wiring diagram, FIG. 2, the coils of the control relays CR-2, CR-3, and CR-21, as well as other relays hereafter mentioned, are indicated by circles bearing within them the identifying numbers. The various electrical switch contacts controlled by the respective relay coils are, for convenience of illustration, separated from the relay coils themselves, but are keyed to the respective relays by the use of the same identifying numbers which appear within the circles representing the coils. Relay-controlled contacts or switches which are normally open (i.e., when no current is flowing in the respective relay coils) are indicated by short parallel vertical lines slightly spaced from each other in a horizontal direction. Similar relay-controlled contacts or switches which are normally closed (i.e., when no current is flowing through the respective control relay coils) are indicated by similar parallel spaced lines, but with an oblique or slanting stroke or line drawn through them. With this explanation, it will be possible to follow the wiring diagram very easily and quickly.

Beyond the master switch 109, the circuit conductor 113 leads to a door switch 20 which is operated by the sterilizer door 207 in such fashion that when the door 207 is tightly closed and sealed, the switch 20 is closed, and when the door 207 is unlocked and opened, the switch 20 is opened. Switches of this kind are well known per se, and the details of this particular switch are not important for purposes of the present invention.

From the circuit conductor 113 between the two switches 109 and 20, there is a branch 115 which leads to a green pilot light 116, the other side of which is connected by a circuit conductor 117 to a normally closed contact switch 118 controlled by a relay CR-25 to be further mentioned below. Beyond the switch 118, the circuit continues at 119 back to the circuit conductor 120 which is connected to the second side 102 of the main supply circuit. Thus, assuming that the master switch 109 is closed, it is apparent that whenever no current is flowing through the relay CR-25, the green pilot light 116 will be lit, thus signalling to the attendant that the sterilizer is in condition for loading or unloading and that the door 207 may be opened if it is closed.

Beyond the door switch 20, this side of the circuit continues through a conductor 125, one branch 126 of which leads to the coil of the above mentioned control relay CR-25. Beyond this control relay, the circuit continues through the conductor 127 to the normally open switch contacts 128 controlled by the relay CR-3, and, in parallel with the switch 128, another switch 129 which is normally closed and which is controlled by the coil of a relay CR-26 to be further mentioned below. Beyond these two switches 128 and 129 the circuit continues at 130 to a normally open starting push button 131, the other side of which is connected as shown to the conductor 120 leading to the second side 102 of the electric supply line.

In shunt or parallel around the push button starting switch 131 is a normally open switch 132 controlled by the coil of the above mentioned relay CR-25.

Going back for a moment to the coil of the relay CR-25, there is a yellow pilot light 133 connected around the coil of relay CR-25 in shunt or parallel therewith. Whenever current is flowing through the coil CR-25, current will likewise flow through the pilot light 133, indicating that the sterilizing cycle is "on" or in progress.

The equipment includes a pulsator unit indicated in general at 27, and having a motor M-27 one side of which is connected by the circuit conductor 134 to the conductor 125, the other side of the motor being connected by the circuit conductor 135 to the conductor 136 which is connected to the above mentioned conductor 130, this circuit being completed through either the start push button switch 131 or the switch 132 when either one of them is closed (provided, of course, that the door switch 20 and the master switch 109 are also closed). This motor M-27 drives a rotating cam 137 which, at suitable intervals, swings a switch arm 138 so that it makes contact alternately with contact members 139 and 140. A conductor 141 leads from the switch arm 138 to the conductor 125. A conductor 142 leads from the contact 139 to one side of the coil 143 of the solenoid valve 10 which controls admission of compressed air. The valve is normally closed, and opens only when current flows through the coil. Another conductor 144 leads from the second pulsator contact 140 to one side of the coil 145 of the solenoid steam valve 14. This steam valve also is normally closed, and opens to admit steam only when current flows through the solenoid.

From the second side of the coil 143 of the solenoid air valve 10, a conductor 150 leads to a normally open switch 151 controlled by the coil of the previously mentioned high pressure relay CR-21. Beyond this switch 151, a conductor 152 leads to an upper normally open contact 153 of a timer unit indicated in general at 28, which will be further described below. The switch arm 154 of this timer switch is connected by a conductor 155 to the previously mentioned circuit wire 136 which, as above mentioned, goes back to the push button switch 131 and the relay switch 132.

A conductor 157 branches off of the conductor 152 and leads to one side of the normally closed relay switch 158 controlled by the relay CR-2. The other side of this switch 158 is connected by a conductor 159 to the lower and normally closed contact 160 of the timer switch 154.

From the second side of the coil 145 of the solenoid steam inlet valve 14, a conductor 162 leads to one side of the normally open switch 163 which, like the normally closed switch 158, is controlled by the relay CR-2. The other side of the switch 163 is connected to the timer switch contact 160 by the same conductor 159 which serves also to connect one side of the switch 158 thereto.

A branch conductor 165 leads from the conductor 125 to one side of the coil of a control relay CR-26. The other side of this control relay is connected by the conductor 166 to a second conductor 167 leading to one side of the normally closed switch 168 controlled by the relay CR-21. The other side of the switch 168 is connected to the conductor 157 previously mentioned.

Also connected to the conductors 166 and 167 is a conductor 170 which leads to one side of the normally open switch 171 controlled by the relay CR-26, the other side of which switch 171 is connected to the conductor 136.

The above mentioned timer mechanism or unit is indicated in general at 28, and includes a motor M-28 driving conventional timing mechanism through an electrically controlled clutch, the control coil of which is indicated at 173. The timer mechanism, known per se, is manually settable or adjustable to run for various intervals of time (e.g., any desired time for which it is set, up to a maximum of say an hour and a half or two hours) and at the

end of the interval for which it is set, the motor will serve to swing the above mentioned switch arm 154 from the normally closed contact 160 to the normally open contact 153, and simultaneously will swing a second switch arm 175 from the normally closed contact 176 to the normally open contact 177 (the latter being, in this case, a "blank" contact not electrically connected to any other part). As long as the clutch coil 173 remains energized, after the completion of the time cycle, the arms 154 and 175 will remain in contact with their respective contacts 153 and 177. As soon as current ceases to flow through the clutch coil 173, a spring will return the switch arms 154 and 175 into contact with their normally closed contact members 160 and 176, respectively, and they will remain in this position until a new time cycle has been completed, and all other parts of the timer mechanism will be reset by springs to initial starting position.

From the conductor 125 there is a conductor 178 having one branch 179 leading to the above mentioned switch arm 175, and having another branch 180 leading to one side of the clutch coil 173. The other side of the clutch coil is connected by a conductor 181 to the conductor 170 previously mentioned. From the normally closed contact 176 of the switch arm 175, a conductor 182 leads to one side of the timer motor M-28. The other side of the timer motor is connected by the conductor 183 to the conductor 181. It is seen, therefore, that the motor M-28 of the timer can be energized only so long as the switch arm 175 remains in its normally closed position. At the end of the cycle for which the timer has been set, the motor will move the switch arm 175 to open this switch, which will automatically break the circuit supplying current to the motor, so that the motor will stop. However, the opening of the switch 175 does not affect supply of current to the clutch coil 173, so this clutch coil will remain energized at this time (until current is interrupted by other means) and thus will maintain the switch arm 175 (and the companion switch arm 154) in the upper positions against the force of the spring which tends to move them down to their lower or normally closed position. Then when (by the operation of other means) the flow of current through the clutch coil 173 is interrupted, the clutch is opened and the switch arms 154 and 175 can return under the influence of their springs to their lower positions and the timer will reset itself to initial starting position, ready for the next cycle.

Since the various relay-controlled switches are separated from the relay coils themselves, in the wiring diagram constituting FIG. 2, it may be convenient at this point to recapitulate the various switches which are controlled by the various relay coils.

Relay CR-2 operates normally open switch 163 and normally closed switch 158.

Relay CR-3 operates normally open switch 128.

Relay CR-21 operates normally open switch 151 and normally closed switch 168.

Relay CR-25 operates normally open switch 132 and normally closed switch 118.

Relay CR-26 operates normally open switch 171 and normally closed switch 129.

The operation is as follows: Let it be assumed that the master switch 109 is closed, since if this master switch is open the entire electrical mechanism (except the recorder 1) is deprived of current and nothing will happen. Let it also be assumed that the parts are in a quiescent state, as would be the case, for example, before undertaking the first sterilizing operation of the day. The green pilot light 116 will be lit, thus indicating to the attendant that the sterilizer is in proper condition for loading or unloading the sterilizing chamber, as the case may be.

The operator may now load into the sterilizer the articles to be sterilized, such for example as tightly sealed tubes of ointment as indicated diagrammatically at 213

in FIG. 1, or other desired material in sealed containers. Of course unsealed material can also be sterilized, but the particular advantage of the present sterilizer is that it enables sterilization of sealed containers without rupture thereof. However, this same sterilizing apparatus and method would be useful, for example, in the sterilization of liquids in open receptacles, as the pressure within the sterilizing chamber could be kept high enough to prevent boiling and evaporation of the liquids.

The manual setting handles or controls of the temperature and pressure switches 2, 3, and 21, and of the timer 28, are appropriately set to the desired values. If the operator now presses the start button 131 without first closing the door 207, nothing will happen because the electric circuit of the start button is broken at the open door switch 20. However, the closing of the door 207 and locking thereof by the handle 209 serves to close the door switch 20, completing the circuit at this point. Then if the operator pushes the start button 131, the circuit thereof will be closed through the normally closed switch 129 controlled by the control relay CR-26. Since of course no current is flowing through this relay at the time the cycle starts, it follows that the normally closed switch 129 thereof is closed.

The coil of the control relay CR-25 being in series with the starting button circuit through the switch 129 is now energized, and simultaneously therewith the yellow pilot light 133 becomes lit, indicating that the cycle of operation is "on." The flow of current through the relay CR-25 immediately opens the normally closed contact switch 118 thereof, to extinguish the green pilot light 116, and simultaneously closes the normally open contact switch 132, in parallel with the push button switch 131, so that the circuit at this point remains closed even though the push button switch 131 is immediately released. In other words, only a momentary contact of the switch 131 is needed to start the cycle, and thereafter the switch 131 can open because the switch 132 has closed.

At the start of the cycle the sterilizer is presumably cold, or at least relatively cool, even though there may be some slight retained heat carried over from a previous operating cycle. Therefore, it follows that the high temperature switch 2 will be closed, and the relay CR-2 controlled thereby will be energized. Likewise, the low temperature switch 3 will be open, and the relay CR-3 controlled thereby will not be energized. Also, at the start of the cycle the pressure within the sterilizer is, of course, at atmospheric pressure; therefore the pressure switch 21 will be closed, and the relay CR-21 controlled thereby will be energized.

The following results flow from this condition just described: Since the control relay CR-2 is energized, the normally open contact switch 163 thereof will be closed, and the normally closed contact switch 158 thereof will be open. Since the control relay CR-21 is also energized, the normally open switch contact 151 thereof will be closed and the normally closed switch contact 168 thereof will be open. Of course the timer 28 has not yet completed its cycle; in fact, is still at its initial position with the timing cycle not yet started. Therefore the switch arms 154 and 175 of the timer will be in their lower positions in contact with the respective contacts 160 and 176.

The motor M-27 of the pulsator unit will begin to run, since this motor is energized as soon as either the switch 131 or 132 is closed (assuming, of course, that switches 20 and 109 have previously been closed) and is not dependent upon any relay. Hence the operation of the pulsator will swing the switch arm 138 thereof alternately into engagement with the two contacts 139 and 140, repeating this constantly as long as the cycle is in progress. Now when the switch arm 138 is engaged with the contact 140, the circuit through the coil 145 of the solenoid steam valve 14 will be closed, as seen from the wiring diagram, because it will be remembered

from the above explanation that the switch 163 is closed at this time. Therefore the steam valve 14 will be opened, and steam will be admitted through the conduits 235, 237, 241 into the sterilizer. This admission of steam continues for a short interval, depending upon the speed at which the pulsator is designed to operate. Ordinarily the switch arm 138 will be engaged with the contact 140 for just a few seconds, then will be moved into engagement with the other contact 139 for a few seconds, then back into engagement with the contact 140, and so on. So for a few seconds, steam is introduced into the sterilizer.

When the pulsator reaches the position where the arm 138 is engaged with the contact 139, the circuit wire 141 is thereby connected to the circuit wire 142 leading to the coil 143 of the solenoid operated compressed air valve 10. However, even though the switch 151 is closed at this time (since the pressure in the sterilizer is still below the pressure for which the switch 21 is set, so that the relay CR-21 is energized) the circuit through the coil 143 of the compressor valve is broken at the switch 158 which is now open because the relay CR-2 is energized. Therefore, there is no admission of compressed air at this time. But when the pulsator subsequently makes connection with the contact 140, another shot of steam is introduced into the sterilizer; then cut off while the pulsator switch is engaged with the contact 139; then another shot of steam while the pulsator switch is again engaged with the contact 140; and so on.

This intermittent admission of steam continues until the temperature in the sterilizer reaches the temperature for which the high temperature switch 2 has been set. When this temperature is reached, the switch 2 opens, so that the relay CR-2 becomes deenergized, thereby opening its switch 163 and closing its switch 158. Because the switch 163 is open, the circuit through the coil 145 of the steam admission valve 14 is broken, so no more steam will be admitted so long as the temperature in the sterilizer remains high enough to keep the switch 2 open. However, the closing of the switch 158 at this time performs two functions: first, it enables the completion of the circuit through the coil 143 of the compressed air valve 10, thereby enabling intermittent admission of compressed air whenever the pulsator switch arm 138 is engaged with the contact 139. Second, it enables completion, whenever the switch 168 also closes, of a circuit through the control relay CR-26, by means of the circuit conductors 165, 166, 167, and 157.

As the operation of the pulsator unit 27 continues, pulses or shots of compressed air only will be admitted so long as the pressure in the sterilizer remains below the pressure for which the pressure switch 21 has been set, and so long as the temperature remains above the temperature for which the switch 2 has been set. If, however, the temperature drops below the desired temperature, before the pressure is built up sufficiently to open the switch 21, the switch 2 will close again and this will again energize the relay CR-2, which will open the switch 158 so that no more compressed air can be admitted, and will close the switch 163 so that more steam can be admitted. Then when the temperature is built up again to open the switch 2 and deenergize the relay CR-2, the position of the switches 158 and 163 will be reversed so that again compressed air can be admitted during part of each pulse cycle, and no more steam will be admitted unless and until the temperature drops once more to a point below the setting of the switch 2.

The admission of compressed air (interspersed with whatever additional steam is required to keep up the temperature) finally reaches the point where the pressure in the sterilizer is increased enough to open the switch 21. This, of course, deenergizes the relay CR-21, so that the switch 151 controlled thereby is opened and the switch 168 controlled thereby is closed. The open-

ing of the switch 151 breaks the circuit of the compressed air valve 10 so that no more air is admitted. The closing of the switch 168 has the effect (assuming that the temperature is still high enough so that the switch 158 is also closed) of completing the circuit through the control relay CR-26, by means of the circuit wires 165, 166, 167, switch 168, wire 157, switch 158, wires 159, 155, and 136.

As soon as the current begins to flow through the relay CR-26, the relay closes its own circuit maintenance switch 171 so that this relay will continue to be energized during the remainder of the operating cycle, regardless of the subsequent condition of the switches 168 and 158, which function (so far as the relay CR-26 is concerned) only to start the energization of this relay when both the temperature and pressure conditions in the sterilizer reach the proper values, without having any subsequent effect upon this relay.

The closing of the switch 171 by energization of the relay CR-26 has the further effect, not only of keeping the relay itself in operation, but also of closing the circuit through the motor M-28 and the clutch coil 173 of the timer unit 28. Thus the timer unit starts to operate as soon as the desired sterilizing temperature and pressure in the sterilizer are both reached, but neither temperature nor pressure alone will start the timer.

Both the pulsator unit 27 and the timer unit 28 now continue in operation throughout the remainder of the cycle. Compressed air and steam continue to be admitted into the sterilizer in intermittent pulses, as may be required from time to time in order to keep the pressure and temperature up to the desired values.

It will be remembered from the previous description that the valve 4 is preferably kept slightly open, to allow a constant bleed or exhaust. Therefore, so long as the sterilizing part of the cycle continues there will be occasional need for additional compressed air to keep the pressure up to the desired point, and need for additional steam to keep the temperature up. It will be apparent from the wiring diagram and from what has been said above that this is automatically accomplished. As soon as the pressure decreases enough to close the valve 21, the relay CR-21 is energized, to close the switch 151, to enable operation of the compressed air valve coil 143 so as to introduce more compressed air, the next time that the operation of the pulsator causes the switch arm 138 to engage the contact 139. Of course the energization of the relay CR-21 also opens the switch 168, but as above explained, this is of no further concern, since the closing of this switch is needed only for the initial starting of operation of the relay CR-26 and this relay keeps itself in operation (by means of the switch 171) after once it is started, without further dependence upon the position of the switch 168. Also, during continuance of the sterilizing cycle, whenever the temperature drops so that more steam is needed, the switch 2 closes, the relay CR-2 is energized, the switch 163 is closed, and more steam can be admitted.

Thus the operation continues so long as the time cycle determined by operation of the timer 28 is not completed. During the entire time cycle, both the temperature and the pressure are kept at the desired values for which the respective switches 2 and 21 have been set, by the above mentioned occasional admission of additional steam or additional compressed air, as required. Because of the extra pressure in the sterilizing chamber (higher than the pressure corresponding to the temperature of the steam) the various sealed containers 213 within the sterilizing chamber are subjected to external pressure tending to counterbalance the internal expansive pressure caused by heating the contents, thereby preventing explosion or rupture of the containers of material to be sterilized.

When the timer 28 completes its time cycle, indicating that the contents of the sterilizing chamber have been

subjected to both the desired temperature and the desired pressure for the desired length of time, the operation of the timer in known manner flips the contact arms 154 and 175 respectively out of engagement with the contacts 160 and 176 respectively, and into engagement with the contacts 153 and 177, respectively. The disengagement of the arm 175 from the contact 176 serves to break the circuit of the motor M-28 at this point, so that the timer motor stops. However, it does not break the circuit of the clutch coil 173, so the clutch remains engaged, and thus the timer does not reset itself but, because of the operation of the clutch, keeps the arms 154 and 175 engaged with the respective contacts 153 and 177.

Now that the arm 154 is engaged with the contact 153 rather than the contact 160, the circuit through the coil 145 of the steam admission valve 14 is broken and there can be no further admission of steam. However, the circuit from the compressed air control coil 143 can still be effective (through the conductor 152, contact 153, and arm 154) and thus compressed air will still be intermittently admitted to such extent as is necessary in order to keep up the pressure to the valve set on the switch 21. The sterilizer will gradually cool off, due partly to radiation of its heat to the surrounding atmosphere, and partly to the intermittent admission of more compressed air, which will have a tendency to cool the interior of the sterilizer. As the temperature gradually drops, it finally reaches the point for which the low temperature switch 3 has been set, so that this switch 3 opens, thereby breaking the circuit to the relay CR-3 and deenergizing this relay. This has the effect of opening the switch 128, which is normally open when the relay CR-3 is not energized, and closed when this relay is energized.

Now to go back, it will be remembered that when the push button or start button 131 was initially pressed, the circuit 130, 127, 126 through the relay CR-25 was closed because at this time the relay CR-26 was not in operation, and therefore the normally closed switch 129 of this relay served to complete the circuit between the conductors 130 and 127. Later in the cycle, when both the temperature and the pressure had risen enough to open both of the switches 2 and 21, the relay CR-26 had become energized, thereby opening the switch 129. But before this occurred, the temperature had obviously risen enough to close the switch 3 (since the temperature setting of this switch is lower than the temperature setting of the switch 2) and thus the relay CR-3 had been energized before the relay CR-26 had been energized, thereby closing the switch 128 before the switch 129 was opened. Hence the circuit 130, 127, 126 through the relay CR-25 had remained closed notwithstanding the operation of the relay CR-26 to open the switch 129, and hence the relay CR-25 and the yellow pilot light 133 had remained in operation during all of the cycle down to this point now reached by this description.

But the cycle as now described has reached the point where the sterilizer has cooled sufficiently to cause the switch 3 to open. The opening of the switch 3 deenergizes the relay CR-3, thereby causing the switch 128 to open. Since the relay CR-26 is still in operation at this time, it follows that the switch 129 is likewise open. Therefore, both switches 128 and 129 will be open at the same instant, thereby breaking the circuit through the relay CR-25, which will become deenergized.

Upon the deenergization of the relay CR-25, its normally open switch 132 opens, and its normally closed switch 118 closes. The closing of the switch 118 completes the circuit 115, 117 through the green pilot light 116, which lights up. The opening of the switch 132 breaks all the remaining circuits which were dependent upon it, so that the pulsator 27 stops, and also the clutch coil 173 of the timer is deenergized, thereby releasing the clutch so that the spring in the timer automatically

resets the timer to initial starting position and resets the switch arms 154 and 175 into engagement with the respective contact members 160 and 176.

The electrically controlled cycle is thus completed, the parts are all back to initial starting position, and the illumination of the green pilot light 116 indicates to the attendant that the cycle is over and that the door of the sterilizer may now be opened in order to remove the sterilized contents and to load into the sterilizer a new batch of material to be sterilized. In case there is still some residual pressure in the sterilizer at the time that the temperature drops to open the switch 3, it is desirable to provide the sterilizer door with an interlock pressure switch of known mechanical construction to prevent the door from being opened until the pressure has dropped substantially to atmospheric pressure, which can be hastened, of course, by further opening the valve 4 by means of the handle 272.

While compressed air has been mentioned as the preferred gaseous fluid for building up the pressure above the pressure corresponding to steam at the desired sterilizing temperature, it is apparent that other gaseous fluids under pressure may be used, instead of air. An inert gas such as nitrogen is particularly suitable. Also a compressed gas which itself has a sterilizing effect may be employed. The gas, whether compressed air or of other composition, may also be introduced into the sterilizing chamber through a bacteria filter which itself is located in the sterilizing chamber, so that during each sterilizing cycle the filter itself automatically becomes freshly sterilized.

The increased pressure above the pressure corresponding to that of saturated steam at the desired temperature may be conveniently called a super pressure.

It is seen from the foregoing disclosure that the above mentioned objects of the invention are well fulfilled. It is to be understood that the foregoing disclosure is given by way of illustrative example only, rather than by way of limitation, and that without departing from the invention, the details may be varied within the scope of the appended claims.

What is claimed is:

1. Sterilizer apparatus comprising, a closed sterilizing chamber, steam control means responsive to the chamber temperature for admitting steam to said chamber when the temperature therein is within a predetermined range, compressed air control means responsive to the chamber pressure for admitting compressed air to said chamber when the pressure therein is within a predetermined range and means responsive to the chamber temperature for preventing admission of compressed air into said chamber when the temperature is below a predetermined value.

2. Sterilizer apparatus comprising, a closed sterilizing chamber, steam control means responsive to the chamber temperature for admitting steam to said chamber when the temperature therein is within a predetermined range, compressed air control means responsive to the chamber pressure for admitting compressed air to said chamber when the pressure therein is within a predetermined range, and means responsive to the chamber temperature for controlling said compressed air control means to prevent admission of compressed air into said chamber when the temperature is below a predetermined value.

3. Sterilizing apparatus comprising a closed sterilizing chamber, a steam supply conduit leading to said chamber to supply steam thereto, a compressed air conduit leading to said chamber to supply compressed air thereto, a first electric circuit, a first electrically controlled valve in said steam supply conduit and operatively connected to said first circuit to open said first valve to permit flow of steam while electric current is flowing in said first circuit and to close said first valve when no electric current is flowing in said first circuit, a second electric circuit, a second electrically controlled valve in said compressed air conduit and operatively connected to said second circuit to open said second valve to permit flow of com-

pressed air while electric current is flowing in said second circuit and to close said second valve when no electric current is flowing in said second circuit, a switch in said first circuit controlled by temperature in said sterilizing chamber for opening said first circuit when temperature in said sterilizing chamber exceeds a predetermined amount, a switch in said second circuit controlled by pressure in said chamber for opening said second circuit when pressure in said chamber exceeds a predetermined amount, and another switch in said second circuit controlled by temperature in said chamber for opening said second circuit when temperature in said chamber drops below a predetermined amount.

4. Sterilizing apparatus comprising a closed sterilizing chamber, a steam supply conduit leading to said chamber to supply steam thereto, a compressed air conduit leading to said chamber to supply compressed air thereto, a first electric circuit, a first electrically controlled valve in said steam supply conduit and operatively connected to said first circuit to open said first valve to permit flow of steam while electric current is flowing in said first circuit and to close said first valve when no electric current is flowing in said first circuit, a second electric circuit, a second electrically controlled valve in said compressed air conduit and operatively connected to said second circuit to open said second valve to permit flow of compressed air while electric current is flowing in said second circuit and to close said second valve when no electric current is flowing in said second circuit, a switch in said first circuit controlled by temperature in said sterilizing chamber for opening said first circuit when temperature in said sterilizing chamber exceeds a predetermined amount, a switch in said second circuit controlled by pressure in said chamber for opening said second circuit when pressure in said chamber exceeds a predetermined amount, another switch in said second circuit controlled by temperature in said chamber for opening said second circuit when temperature in said chamber drops below a predetermined amount, an electric supply source, and a motor driven switch arm operatively connecting said source alternately and repeatedly to said respective first and second circuits.

5. A sterilizer comprising a sterilizing chamber, a conduit for supplying steam to said chamber, a conduit for supplying compressed gas to said chamber, a first electric

control circuit effective when current flows therethrough to cause steam to be supplied to said chamber, a second electric control circuit effective when current flows therethrough to cause compressed gas to be supplied to said chamber, first and second switches in said first and second control circuits, respectively, both of said switches being responsive to temperature within said chamber to close said first switch and open said second switch when the temperature within said chamber falls below a predetermined amount and to open said first switch and close said second switch when the temperature within said chamber exceeds a predetermined amount, and a third switch in said second control circuit, said third switch being responsive to pressure within said chamber to close said third switch when the pressure within said chamber falls below a predetermined amount and to open said third switch when the pressure within said chamber exceeds a predetermined amount.

6. A construction as defined in claim 5, further including a motor driven timer effective to determine the length of a sterilizing cycle during which both said first and second control circuits may be operative and effective at the end of said sterilizing cycle and during a subsequent cooling cycle to render said first control circuit inoperative while said second control circuit may remain operative, and an electric switch responsive to temperature within said chamber for rendering said timer inoperative and terminating said cooling cycle when the temperature within said chamber falls below a predetermined amount substantially lower than said predetermined amount which controls said first and second switches.

7. A construction as defined in claim 6, further including a motor driven pulsator for alternately supplying electric current intermittently first to one and then to the other of said control circuits, said electric switch for rendering said timer inoperative serving also to render said pulsator inoperative at termination of said cooling cycle.

References Cited in the file of this patent

UNITED STATES PATENTS

2,536,115	Wilbur	Jan. 2, 1951
2,592,705	Jewell et al.	Apr. 15, 1952
2,713,702	Jewell	July 26, 1955
2,868,616	Poitras	Jan. 13, 1959