ABSTRACT OF THE DISCLOSURE

Vacuum drying apparatus having a stationary, hermetically sealable chamber to receive the article to be dried, the chamber being heated to a predetermined temperature the article can tolerate, the chamber also being subjected to a vacuum to reduce the boiling point of the moisture in the article below the predetermined temperature to boil-off of the moisture which is vented from the chamber.

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

The invention relates to an apparatus for drying articles and, more particularly, to an apparatus for vacuum drying articles having a low heat tolerance, such as nylon parachutes.

Investigations of U.S. naval aircraft accidents have revealed instances where lack of adequate drying apparatus has contributed to malfunctioning of deployed parachutes. This malfunctioning occurs when a dump parachute is repacked, flown to a high altitude where it freezes, and the parachute is again deployed on landing before it has the opportunity to defrost. The accepted standard for the amount of humidity in a parachute is 5% of the dry weight, and if the humidity is at this level or less, the parachute can be repacked. The problem of adequately drying parachutes has long been a problem in the U.S. naval service particularly on board aircraft carriers where available space for tower-type drying is limited and costly. Conventional clothes drying methods all have serious limitations. Because of the low heat tolerance of nylon, being the conventional parachute material, hot air drying is time consuming and inefficient especially where the ambient air is hot and humid. Dehumidification does not work efficiently where it is cold and humid. Tests have indicated that the combination of tumbling the parachute with an air flow is not satisfactory because the fibers separate and give the parachute a nap-like anger.

Although prior art devices have allegedly used vacuum techniques in association with heat for drying purposes, the vacuum was used solely as a suction means to draw off the moistened air from the drying chamber into which ambient air was introduced during the drying process.

SUMMARY OF THE INVENTION

The problem of drying an article, such as a parachute, has been solved by employing and using a high vacuum for boiling-off the moisture without the requirements of tumbling, circulating hot air, or relying on ambient air or other climatic conditions. The parachute is inserted into a stationary, hermetically sealed chamber which is then heated to a temperature that the article can tolerate. The heating is preferably supplied by a flexible blanket inside the chamber into which the article is folded back-and-forth, and by an external blanket around the chamber, if needed. The chamber is also subjected to a substantially high vacuum, preferably, the highest vacuum that is obtainable using commercially available pump equipment, which is about 29.5" Hg. With such a vacuum, the boiling point of the moisture in the parachute can be reduced to about 60° F. Obviously, the higher the parachute can be heated safely over the boiling point of the moisture, the quicker the article can be dried. For example, with the chamber heated to 125° F., and a vacuum of 29.5" Hg, a normal drying cycle will comprise a 10-minute heat build-up, a 25-minute vacuum phase, and a 5-minute pressure dump and cool-down phase. The latter phase dissipates the vacuum in the chamber to permit access to the chamber, and cooling of the parachute to a handling temperature. The length of the heat phase, vacuum phase, and cool phase can be manually or automatically varied in length and is controlled by a timer in an electrical circuit.

STATEMENT OF THE OBJECTS OF THE INVENTION

A principal purpose of the invention is to provide an apparatus for drying articles having a low heat tolerance quickly, effectively, and in an apparatus occupying a minimum of space making it particularly suitable for shipboard use.

Another important object of the invention is to provide a drying apparatus which does not require the chamber to be rotated for tumbling the article to be dried, and which does not require the introduction of ambient air into the apparatus during the drying cycle.

A further object is to provide such drying equipment that can be ganged together in parallel and thereby utilize a common vacuum source.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a perspective view of the novel drying apparatus with the parachute partially broken away to show the internal heating blanket in a slightly extended position, the parachute being omitted;

FIG. 2 is a side elevation of the drying chamber and pump assembly;

FIG. 3 is a partial elevation in section of the drying apparatus showing the internal heat blanket connections; and

FIGS. 4 and 5 are schematic wiring diagrams of a power circuit and a control circuit, respectively.

Referring to the drawings where like reference numerals refer to similar parts throughout the figures there is shown in FIG. 1 the novel vacuum drying apparatus 10 of this invention which is designed principally, although not necessarily limited to, drying articles having a low tolerance to heat and to tumbling. An example of articles of this type are parachutes made of synthetic fibers, such as nylon. It has been found that a normally wet standard 28 ft. diameter Navy service type parachute contains about 4 pounds of water that should be removed. A normally wet parachute is considered one that has been subjected to rain. It has been determined that when the chamber is maintained at 125° F., 333 cu. ft. of vapor must be off-gassed for each pound of water. To maintain the temperature of 125° F., requires an additional heat of 1000 B.t.u.'s per pound, regardless of the degree of vacuum that is to be maintained.

Dryer 10 comprises a drum-shaped chamber 12 fabricated of a tubular metal side wall 14 having welded thereto a bottom plate 16, and an upper neck collar 18 to which a door 20 is hinged at 22. Door 20 is provided with an O-ring 24 for sealable contact with collar 18.
making the chamber hermetically air tight when closed. In the particular installation being described because of the high vacuum being employed the chamber is fabricated of heavy plate aluminum, the side walls being ¼" in thickness, the top door being ¾" thick and the bottom plate being 1" thick. Because of the vacuum being employed no latches are needed to lock the door in a closed position. The door has a large diameter to provide maximum access to the chamber for loading and unloading the parachutes which are somewhat bulky, and to facilitate folding of the parachute within the chamber in a manner to be described. Chamber 12 is supported on a base cabinet 26 having leveling legs 28. A console 25 is mounted adjacent chamber 12 and contains the operating controls as will be described. Chamber 12 may be heated by an external and internal heating means singly or in combination as the heating requirements may dictate. External heating is performed by an electric blanket 30 which is snugly wrapped externally around chamber 12 and is provided with cutout portions at 31 to accommodate a heating junction box 32 and other elements attached to the chamber. An external heater blanket 30a is also secured to the bottom surface of plate 16. An insulating jacket 33 is mounted around the internal heater blanket 30 and is held in position by a thin split tubular metal shroud 34 held together by a plurality of bands 36 and fasteners 38. A bottom insulation pad 33a is also provided for the bottom heater blanket 30a.

A unique feature of the novel drying apparatus is the employment of a flexible internal heater blanket 40, preferably electrically controlled, which blanket serves principally to supply the additional heat to the parachute, approximately 4000 B.t.u., to maintain the drying temperature of 125°F. The internal temperature of the chamber is indicated at gauge 41 on console 29. In the specific installation herein described the combined internal and external heat sources have a capacity of 12,000 B.t.u./hr. For a chamber having an internal diameter of 30 inches, internal blanket 40 is dimensioned 22 inches in width and approximately 120 inches in length. The internal heater blanket is constructed as flexible as possible to allow folding to a 1" minimum radius, the space between the sides of the blanket and the inside wall of the chamber allowing room for the parachute when folded. The technique of folding the parachute and the internal heater blanket ensures maximum heating contact as well as providing voids to permit the escape of the vapor being generated. As shown in Fig. 3, one end of internal heater blanket 40 is secured to a chamber floor plate 42 by a pair of discarded straps 44. Floor plate is secured to bottom plate 16 in spaced relation thereto by bolts 46 and spacers 48 providing a sump 50 for any water draining from the wet parachute when initially placed in the chamber. There is no need to drain sump 50 as the moisture will be quickly evaporated when the chamber is subjected to the drying cycle.

Internal blanket 40 is suitably controlled in automatic or manual operation by a control circuit to be described, being connected by conductor 51 to receptacle 52 mounted on the chamber wall and grounded by strap 54 (Fig. 2). The openings through chamber 12 for the electrical connections are sealed by epoxy so that the installation is helium tight.

As previously described, the chamber is subjected to a very high vacuum to reduce substantially the boiling point of the moisture in the parachute, the latter perfecting the vacuum the quicker the drying cycle. For example, it has been found that the boiling point of the moisture can be reduced to 30°F when the chamber is subjected to a vacuum of 29.8" Hg, whereas the boiling point increases to 105°F when a vacuum of 27.8" Hg is employed. However, for the contemplated use of drying parachutes the employment of exotic equipment to obtain the highest vacuum is not considered warranted. The best results that can be obtained with present day commercially available equipment achieves the operating vacuum of about 29.5" Hg which reduces the boiling point of the water in the parachutes to about 60°F. The equipment employed in the described installation includes a 10 H.P. motor 56 which drives a 200 c.f.m. pump 88 having a muffler 60 to keep the noise level at 55 db or lower. The pump is connected to chamber 12 via a 3" flexible pipe 62 and through a solenoid operated vacuum valve 64 and outlet 66 which controls the vacuum in chamber 12 and the dumping of the vapor being formed. A direct reading vacuum meter 67 is conveniently mounted in the front of the chamber 12.

A guard plate 68 is welded to the inside of chamber 12 is spaced relation to outlet 66 to prevent the parachute from accidentally blocking the outlet when folded into the chamber (Fig. 1). After the completion of the vacuum drying cycle, the chamber is relieved of the vacuum by a solenoid operated dump valve 70 mounted to chamber 12 (Fig. 2).

The various valves and heating elements in the drying apparatus are operated in a controlled circuit 72. The controlling circuit includes common relay switches and the circuits are separately illustrated for clarity. The 220 v. power circuit is diagrammatically illustrated in Fig. 4, being the controlled circuit, and the 110 v. controlling circuit is diagrammatically illustrated in Fig. 5. Referring to Fig. 4, the voltage of 220 v. (3 phase, 20 amp) is connected through suitable circuit breakers 72 across resistance-type heating elements 74, 76, and 78 of the internal, external, and bottom heater blankets 40, 30, and 30a, respectively. Each line to the respective heating elements are provided with suitable thermostat relay switches 80, 82, and 84, each relay being a double-pole-double throw-type and preset to limit its respective blanket to a predetermined temperature and controlled in operation by the control circuit in Fig. 5. Solenoid operated vacuum valve 64 and dump valve 70 are separately connected in parallel across the line voltage, and each are provided with a relay switch 86 and 88, respectively.

The control circuit in Fig. 5 is also connected to 220 v. line voltage through a step-down transformer 90 which reduces the 220 v. line voltage to 110 v. A fuse 93 protects the control circuit. The control circuit includes 3 toggle switches 92, 94 and 96 arranged in parallel circuit for controlling the power circuits to the heaters, and the circuits including the vacuum valve and the dump valve, respectively. Each toggle switch has three positions, namely, AUTOMATIC, MANUAL, and OFF. Connecting to each AUTOMATIC position of the switches for automatically controlling the operation of the various respective circuit components in accordance with the selected cycle. The MANUAL position of each toggle switch is connected in the control circuit in a manner to bypass the timer to permit manual operation of the individual components when desired.

As is apparent from the drawings, the solenoid portions for the various relay switches in the power circuit of Fig. 4 are located in the control circuit of Fig. 5. Heater switch 92 controls the three parallel heater circuits. The internal heater circuit includes relay 80 and a variable temperature control 100 (0-300°F.) which permits a manual mode of the internal heater. The external heater control circuit includes relay 82 and a variable temperature control switch 102, while bottom heater control circuit includes a variable control 104. Likewise, the vacuum valve toggle switch 94 includes solenoid 86, and dump valve toggle switch 96 includes solenoid 88.

As previously mentioned, one drying cycle that has been found to work satisfactorily for drying standard parachutes includes a 10-minute heat build-up stage by the various heater elements to achieve a 125°F tempera-
ature in the drying chamber which is thereafter maintained by the thermostatic controls. Normally, it is not desirable to commence evacuating the chamber prior to the heat build-up phase because it would be more difficult and take much longer time to reach the desired temperature of 125°F. After the heat build-up stage, a 25-minute vacuum phase is commenced. During the vacuum stage the internal heater is one primarily involved in maintaining the 125°F temperature to replace the heat lost in evaporation. Obviously, the internal heater is cycled more often during the initial vacuum stage. After the vacuum phase a 5-minute dump phase is initiated in which the dump valve 1 operated to admit ambient air into the chamber to dissipate the vacuum and to cool the parachute to permit the chamber to be opened and the parachute removed.

The various valves for the vacuum, temperature and phase duration of the heating cycle heretofore described are intended to be only illustrative, and may vary depending on the specific article to be dried and the amount of moisture to be removed.

The novel dryer apparatus satisfies a long-felt requirement for a compact dryer that will dry articles quickly and efficiently, especially articles that cannot tolerate high drying temperatures. The drying operation is achieved without the need for moving parts in the chamber, the use of ambient air, or the need for blowers which might otherwise damage sensitive fabrics. These results are achieved by the use of a high vacuum and the unique arrangement of heater elements, particularly the flexible internal heater, to enable the removal of moisture in the article by a boiling-off process.

What is claimed is:

1. Apparatus for drying an article comprising a hermetically sealable chamber having an access door for receiving the article to be dried; conduction-type means for heating the chamber to a safe temperature below which the article can tolerate thereby avoiding the need for introducing ambient air in the chamber; said heating means comprising a flexible blanket positioned within the chamber into which the article to be dried can be folded to provide an intimate drying surface; means for creating a vacuum within said chamber for reducing the boiling-point of any moisture within the article; means for exhausting the boiled-off vapor from within the chamber; and means for reliving the vacuum within the chamber to complete the drying cycle.

2. The drying apparatus of claim 1 wherein an electric blanket is also provided externally around said chamber to provide an external heat source for the chamber.

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