

AUTOMATIC DRYING DEVICE

(Industrial Field)

This invention relates to a dry treatment in a closed cabinet for storing cameras, lenses, photographs, electronic parts, dried food, chemicals and the like under a condition of ambient temperature and low humidity.

(Prior Art)

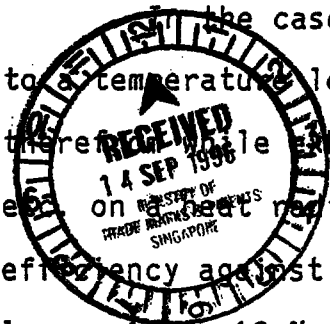
Japanese Utility Model Kokai No. 64-1374 (Reference No. 1) discloses a conventional drying device of an electronic refrigeration type based on Peltier effect of a cooling and heating element which exhibits a heat exchange function when direct current is charged.

Further, Japanese Patent Kokai No. 7-163,831 (Reference No. 2) discloses a drying device provided with a closed type cabinet in which a protective cover of a drying unit is partially inserted into a back wall plate of the cabinet.

(Problems to be solved by the Invention)

In the case of Reference No. 1, air in the cabinet is cooled to a temperature less than the dew point to remove moisture therefrom. While exhausting heat out of the cabinet by means fins, etc. on a heat radiating side. Thermal efficiency (cooling efficiency against electric power input) of the device is usually low as 10 to 12 %, which is undesirably ineffective with respect to higher power cost.

In the case of Reference No. 2, the dehydrating ability of the device is improved by devising a fixing position of a drying means together with a heating manner by a heating element or by



arranging a time limiting means and a humidity controller. However, there still leaves room for improvement to further increase the dehumidifying ability, humidity control accuracy and goods storing capacity in the cabinet.

Accordingly, it is an object of the present invention to provide an improved automatic drying device without accompaniment of conventional inconvenience as described above.

Another object of the present invention is to provide an automatic drying device for improving and keeping the dehumidifying and drying abilities in a cabinet.

Still another object of the present invention is to provide an automatic drying device for improving a humidity control accuracy in a cabinet.

A further object of the present invention is to provide an automatic drying device of improved durability.

A still further object of the present invention is to provide an automatic drying device having an increased storing capacity of a cabinet.

A specific object of the present invention is to provide an automatic drying of an improved dehydrating ability.

(Means to solve the Problems)

According to the present invention, these and other objects can be achieved as in the following:

(1) An automatic drying device provided with a regeneratively treatable drying means for keeping an inside of a closed cabinet under a low humidity condition in which a heat generating means is arranged in a ventilating passage zone around said drying means charged with a moisture absorbent such as a drying

agent;

(2) An automatic drying device described in the above item (1) in which said heat generating means is comprised of a part of a timer means for controlling an electric charge to a heating means for heating a moisture absorbent in said automatic drying device;

(3) An automatic drying device described in the above item (1) or (2) in which a humidity sensing element of a humidity control means provided with said humidity sensing element for controlling humidity in said closed cabinet is arranged in a location where is not affected by heat of a heated drying agent and radiation from said heat generating means;

(4) An automatic drying device described in above items (1) to (3) which comprises a blowing means for forcedly blowing air responsible for a drying agent in said drying means;

(5) An automatic drying device described in the above item (4) in which said blowing means can be driven intermittently;

(6) An automatic drying device provided with a regeneratively treatable drying means for keeping an inside of a closed cabinet under a low humidity condition in which a casing of said drying means is partially inserted into said cabinet, whereas a timer means is arranged out of the cabinet while leaving a part thereof in the cabinet;

(7) An automatic drying device provided with a regeneratively treatable drying means for keeping an inside of a closed cabinet under a low humidity condition described in the above items (1) to (5) in which a moisture absorbent such as B-type silica gel is stuck on an inner surface of a dry treatment chamber in the drying means; and

(8) An automatic drying device provided with a regeneratively treatable drying means for keeping an inside of a closed cabinet under a low humidity condition in which at least plural drying means are installed in the cabinet so that respective moisture-absorbing and -liberating sides of dry treatment chambers are arranged opposingly each other.

(Preferred Embodiments of the Invention)

Referring now to the drawings, the present invention will be detailed in the following.

(Embodiment 1)

(1) Overall Structure

As shown in Figs. 1 and 2, an automatic drying device D₁ comprises an operable closed type cabinet 1 provided with a front door 11, a drying means 200, a timer means 300 and a humidity controlling means 400 allocated on a back wall 12. Because of such structure as described above, goods G to be stored such as camera lenses, dried food, electronic parts, chemicals and the like put on shelves 500 in the cabinet 1 can be kept for a longer period of time under a stabilized and low humidity condition, thereby preventing fungal or rust contamination and minimizing change in quality of the goods G.

(2) Structure of each Part

(i) Drying Means 200

Structure of the drying means 200 is shown in Figs. 1 and 2, in which the drying means 200 is fitted to the cabinet 1 while inserting a part thereof into a fitting hole 13 cored in the back wall plate 12 of the cabinet 1. As to inner structure thereof, there are arranged upper and lower ventilation control chambers 204

and 205 divided with upper and lower barriers 202 and 203 in a casing 201 and a dry treatment chamber 206 formed between these barriers 202 and 203, while the upper and lower ventilation chambers 204 and 205 are opened both to the inside and outside of the cabinet 1. Upper and lower shutters 217 and 218 are rockingly fitted to support walls 215 extended from the casing 201 by upper and lower axes 216a and 216b so that the dry treatment chamber 206 are interconnected to the upper and lower ventilation chambers 204 and 205 when upper and lower ventilation openings 213 and 214 are selectively opened and closed by means of these shutters.

Further, as shown in figs. 2 and 3, a first housing portion 220 for storing a timer means 300 is formed protrudingly on and integrally with a left side wall 221 (left side of the front view of the cabinet 1) of the casing 201, through a dividing wall 224, while a second housing portion 223 for storing a humidity controlling means 400 is connected to a right side wall 222 thereof. The first housing portions 220 together with the timer means 300 and the second housing portions 223 together with the humidity controlling means are allocated the outside and inside of the back wall plate 12 of the cabinet 1, respectively, as shown in Fig. 4.

A drying agent container 226 made of moisture permeable molding material is arranged in the dry treatment chamber 206 as shown in Fig. 2. The drying agent container 226 comprises a drying agent 227, a heater element 230 for heating and regenerating the drying agent 227 and, in addition, a coiled shape memory alloy wire 229 which penetrates a through-hole 228 without bringing contact with the container 226. Each end of the coil wire 229 are tensely connected to each one end of the upper and lower shutters 217 and

218 through connecting wires 231, while a coiled spring 232 is tensely stretched between the other ends, thereby interlocking both shutters 217 and 218. During a time period except when the heater element 230 is charged with electricity to heat and regenerate the drying agent, the shape memory alloy wire 229 is kept expansively, thereby the upper and lower shutters 217 and 218 being displaced to a solid-lined arrangement in Fig. 1. When the shape memory alloy wire 229 is heated by the heater element 230, the shape memory alloy wire 229 transforms and shrinks, so that the upper and lower shutters 217 and 218 are displaced to a broken-lined imaginary arrangement in Fig. 1 while opposing to tensile strength of the coiled spring 232.

(ii) Timer Means 300

An IC timer 301 is arranged in the timer means 300, while a resistor 303 is placed in the dry treatment chamber 206 and is connected to outer ends of lead wires 225 which penetrate through-holes 225 of a dividing wall 224 so as to link the IC timer 301. Such structure of the timer means 300 as described above makes it possible to control the electric charging time to the heater element 230.

(iii) Humidity Control Means 400

The humidity control means 400 comprises a humidity controller 401 which can previously set desirable humidity in the cabinet 1 by a manually dialing operation.

(iv) Other Structure

In Figs. 1 and 5, numeral 600 designates a fan driven intermittently by means of a timer, thereby forcedly blowing air in the dry treatment chamber 206.

2. Automatic Dry Treatment

(i) Dry Treatment Process

When goods G including cameras, electronic parts such as semiconductor tips and etc. are stored under a low humidity condition in the cabinet 1, the humidity controller 401 is manually set to keep humidity in the cabinet 1 in a range of about 30 % to 50 % after such goods G are put on shelves 500, followed by turning on the IC timer 301.

When the door 11 is closed in the above mentioned situation, the inside of the cabinet 1 is enclosed, while air around the dry treatment chamber 206 is gradually dehumidified by the drying agent 227 so that weight thereof is lost to cause an ascending air current as shown in Fig. 1 by arrows ① and ②. In addition, the working IC timer 301 allows to charge electricity from a power source P to the included resistor 303 which drops voltage thereby generating heat. The heat thus generated is partially utilized to heat air in the dry treatment chamber 206, which effectively accelerates the ascending current of dehumidified air and a flow thereof into the cabinet 1 through the upper ventilating hole 213 and the the upper opening 209 as shown in Fig. 1 by an arrow ③. On the other hand, an equivalent volume of air left in the cabinet 1 spontaneously circulates by convection and flows into the dry treatment chamber 206 through the lower opening 210 and the lower ventilation opening 214 as shown by an arrow ④. The air is successively dehumidified by the drying agent in the above mentioned manner so that the inside of the cabinet 1 is kept at preset humidity of about 40 %, the goods G being stored safely under a low humidity condition.

(ii) Regenerating Treatment Process of the Drying Agent

A moisture absorbing ability of the drying agent 227 is gradually decreased as the above mentioned dehumidification proceeds. The IC timer 301 or a microcomputer (not shown) is then actuated to charge the heater element 230 with electricity from the power source P and to heat the drying agent 227, followed by liberation of moisture absorbed therein and regeneration thereof. In this regenerating process, as the shape memory alloy wire 229 rapidly transforms and shrinks due to heat thus generated, the upper and lower shutters 217 and 218 pivot clockwise and counter-clockwise on axes 216a and 216b, respectively, while opposing to tensile strength of the coiled spring 232. As a result, these shutters 217 and 218 are displaced to the broken-lined imaginary arrangements in Fig. 1. The air is introduced in the dry treatment chamber 206 through the lower ventilation opening 214, heated therein, raised upward with moisture liberated from the drying agent 227 as an ascending air current and exhausted out of the cabinet 1 through the upper ventilation opening 213 and the upper opening 211 as shown in Fig. 1 by an arrow ⑤. At the same time, fresh air is introduced from the outside of the cabinet 1 to the dry treatment chamber 206 through the lower opening 212 as shown in Fig. 1 by an arrow ⑥ and successsibly subjected to the regenerating treatment. The regenerating treatment is similarly conducted when other driving force such as electromagnetic force to open and close the upper and lower shutters 217 and 218.

When the regenerating treatment of the drying agent 227 is completed, an electric discharge to the heater element 230 is discontinued by means of the IC timer 301 or a microcomputer so

that the heater element is cooled either spontaneously or forcedly by means of the fan 600 driven intermittently. The shape memory alloy wire 229 is then expanded as the temperature thereof falls down, thereby returning the upper and lower shutters 217 to the solid-lined arrangements ready to further dehumidify the cabinet 1 as shown in Fig. 1.

Each timing of the above mentioned processes is controlled by a timer.

In the case of a processing cycle of 4.5 hours, as shown in Fig. 6(a), the drying agent 227 is subjected to the heating and regenerating treatment for 0.5 hour, followed by a forced air circulation in the cabinet 1 by means of the fan 600 for 1.0 hour and a subsequent spontaneous air circulation without the fan 600 for 3 hours. Accordingly, the cabinet 1 is treated for 4.0 hours in total to effectively keep the inside thereof in a low humidity condition. In the case of a processing cycle of 6.0 hours, as shown in Fig. 6(b) wherein the fan 600 is not used or neglected, the drying agent 227 is heated to regenerate for 0.5 hour, followed by the dehumidifying treatment of the inside of the cabinet 1 over remaining 5.5 hours.

Fig. 7 shows a performance test result of an actual automatic drying device D₁ according to the Embodiment 1 under an ambient condition around the cabinet 1 of a temperature of 25°C and humidity of 80 %.

Fig. 7(a) shows a performance curve (X) indicating change in humidity within a conventional cabinet which is not provided with a heating means actuated by a timing device, wherein the ordinate and the abscissa show humidity in the cabinet 1 and a passage of

time, respectively. It is clear that the initial humidity of about 60 % in the cabinet 1 is decreased with time to 34 %, 28 % and 25 % after 6, 12 and 24 hours past, respectively, and finally stabilized.

While in the case of the Embodiment 1, an air circulation around the drying agent 227 is promoted by the drying means 200 which is partially heated due to heat generation related to the timer means 300, thereby accelerating the dehumidification under the same ambient condition as described above. As shown in Fig. 7(b) by performance curves, when the fan 600 is driven intermittently, the initial humidity of about 60 % in the cabinet 1 is gradually decreased to 28 %, 22 % and 20 % after 6, 12 and 24 hours past, respectively, which demonstrates that the dehumidifying ability in the cabinet 1 is nearly doubled, i.e., the present drying device functions more than two conventional ones (see, a performance curve (Y)). While the final humidity in the cabinet 1 is about 25 % when the fan 600 is continuously driven (see, a performance curve (Z)), that of the present Embodiment 1 is about 20 % because of less leakage of air from the cabinet 1, although the fan 600 is intermittently driven.

Accordingly, it is clear from these performance test data that the present invention considerably contributes to miniaturize the automatic drying device D_1 and improve the dehumidifying ability.

(Embodiment 2)

Difference between two automatic drying devices D_1 and D_2 according to Embodiments 1 and 2, respectively, is as in the following. As shown in Fig. 8, a moisture absorbent 700 comprising

a powerful moisture absorbing agent such as B-type silica gel is stuck on inner surfaces of front and back walls 207 and 208 of a dry treatment chamber 206 in Embodiment 2. Other structure is common to both automatic drying devices D_1 and D_2 and is not detailed herein.

Air in the cabinet 1 is dehumidified through a drying means 200 comprising the above mentioned moisture absorbent 700 and a regenerative drying agent 227. The automatic drying device D_2 is able to conduct dehumidification even under a temporarily overloaded condition where an excessive amount of moisture should be dehumidified, for example, for preparing dry flowers or drying thoroughly wet shoes. An increase in humidity around 80 % to 90 % in such a case can be dropped to about 60 % to 50 % rapidly by means of the moisture absorbent 700, followed by dehumidification by means of the regenerative drying agent 227, thereby exhibiting a quick drying effect. The moisture absorbent 700 thus absorbed is dehumidified and refreshed by means of the automatic drying device D_2 after the treated goods such as shoes are taken out.

(Embodiment 3)

As shown in Fig. 9, two drying means 200A and 200B of an automatic drying device D_3 according to Embodiment 3 are installed on a back wall plate 12 of a cabinet 1 so that respective moisture-absorbing and -liberating sides thereof are arranged opposingly each other. Internal structure of the automatic drying device D_3 is in common with that of shown in Fig. 1 and is not detailed herein.

A humidity controller 401 and a relay circuit (not shown) allow the drying means 200A for absorbing moisture to actuate so as

to decrease the humidity by dehumidification when the humidity in the cabinet 1 is higher than a preset level, e.g., 50 %, while the humidity controller 401 allows the other drying means 200B for liberating moisture in the inside of the cabinet 1 to actuate so as to increase the humidity therein when the humidity drops under a preset level, e.g., 40 %. Because these drying means 200A and 200B are arranged on the cabinet 1 to opposingly absorb and liberate moisture each other, the humidity in the cabinet 1 can be automatically maintained within a mediate level, usually at 40 % to 60 %.

It should be understood that the humidity controller 401 may be fitted not only to the front wall but other walls of the second housing portion 223 in any drying device of Embodiments 1 to 3.

While transformation of the shape memory alloy (SMA) wire 229 due to heat exposure is characteristically utilized to open and close the upper and lower shutters 217 and 218, the same effect can be obtained when expanding and shrinking properties thereof are opposite, if the direction of the bias spring is reversed. Further, any form of the shape memory alloy other than coils would bring about substantially the same result.

(Effect of the Invention)

Typical effects achieved by the present invention will be described in the following.

(1) Improvement in Dehumidifying and Drying Abilities

An arrangement of a heat generating means is in a ventilating passage zone around a drying means for heating air in a drying chamber allows to cause an ascending air current and increase an air current around an drying agent, thereby dehumidifying and

drying abilities being improved considerably. In addition, the drying ability is effectively improved by an ascending air current caused by partially utilizing heat generation of a timer means.

(2) Improvement in Humidity control Accuracy

As a humidity sensing element of a humidity control means is arranged in a location so as not to be affected by the heating means, the humidity control accuracy in the cabinet is improved and damages of stored goods therein is prevented.

(3) Improvement in Regenerating Treatment Effect of a Drying Agent

As air around the drying agent is forcedly blown by a blowing means, regenerating treatment of the drying agent is conducted rapidly.

(4) Stabilized Low Humidity Condition and Improvement in Durability

As the blowing means is intermittently driven by means of a timer only for a required time period, humidity is rapidly dropped in the beginning and kept safely at a low level for a longer period of time with less leakage of air, thereby improving durability and other performances as well as power cost.

(5) Low Humidification in a Cabinet and Improvement in Storing Capacity

As major parts of a casing of the drying means and a timer means are protruded outwardly from the cabinet, goods storing capacity and stock ability of the cabinet are markedly improved, while most of heat generated by these means is discharged out of the cabinet without thermally affecting, deteriorating or damaging the stored goods.

(6) Improvement in Dehumidifying Function

As a regenerative drying means and a moisture absorbent such as B-type silica gel are employed in combination, speedy and averaged dehumidifying ability of the cabinet is effectively obtained. For example, because of a shorter drying period of time at a normal temperature, an original color of dry flowers can be kept as it is, or clogs such as shoes can be dried without damaging leather.

(7) Preservation of Constant Humidity

As plural drying means including the regenerative drying agent are installed so that respective moisture-absorbing and -liberating sides thereof are arranged opposingly each other, a constant humidity condition of, e.g., 50 % in the cabinet is stably kept throughout all seasons without supplying moisture.

(BRIEF DESCRIPTION OF THE DRAWING)

Fig. 1 is a cross-sectional view of an automatic drying device according to Embodiment 1 of the present invention;

Fig. 2 is a sectional rear elevation of a drying means of Fig. 1;

Fig. 3 is a front view of a drying means of Fig. 1;

Fig. 4 is a front view of a drying means in a installed situation of Fig. 1;

Fig. 5 is a structural arrangement of Fig. 1;

Fig. 6 is a time chart of Fig. 1;

Fig. 7 is graphs illustrating relationship between humidity and treating time of a drying device shown in Fig. 1 and a conventional one;

Fig. 8 is a fragmentary side view of an automatic drying

device according to Embodiment 2 of the present invention; and

Fig. 9 is a front view of an automatic drying device provided with a drying means according to Embodiment 3 of the present invention.



What is claimed is:

1. An automatic drying device provided with a regeneratively treatable drying means for keeping an inside of a closed cabinet under a low humidity condition, characterizing in that a heat generating means is arranged in a ventilating passage zone around said drying means charged with a moisture absorbent such as a drying agent.

2. An automatic drying device claimed in Claim 1 in which said heat generating means is comprised of a part of a timer means for controlling an electric charge to a heating means for heating a moisture absorbent in said automatic drying device.

3. An automatic drying device claimed in Claim 1 or 2 in which a humidity sensing element of a humidity control means provided with said humidity sensing element for controlling humidity in said closed cabinet is arranged in a location where is not affected by heat of a heated drying agent and radiation from said heat generating means.

4. An automatic drying device claimed in Claims 1 to 3 which comprises a blowing means for forcedly blowing air responsible for a drying agent in said drying means.

5. An automatic drying device claimed in Claim 4 in which said blowing means can be driven intermittently.

6. An automatic drying device provided with a regeneratively treatable drying means for keeping an inside of a closed cabinet under a low humidity condition, characterized in that a casing of said drying means is partially inserted into said cabinet, whereas a timer means is arranged out of the cabinet while leaving a part thereof in the cabinet.



7. An automatic drying device provided with a regeneratively treatable drying means for keeping an inside of a closed cabinet under a low humidity condition claimed in Claims 1 to 5 in which a moisture absorbent such as B-type silica gel is stuck on an inner surface of a dry treatment chamber in the drying means.

8. An automatic drying device provided with a regeeratively treatable drying means for keeping an inside of a closed cabinet under a low humidity condition, characterized in that at least plural drying means are installed in the cabinet so that respective moisture-absorbing and -liberating sides of dry treatment chambers are arranged opposingly each other.