

METHOD AND DEVICE FOR STORING ARTICLES UNDER CONTROLLED ATMOSPHERE

5 The present invention relates to the field of
devices for storing articles under a controlled
atmosphere.

Specifically, it is known that in many branches
of industry (such as electronics, or alternatively the
food or even pharmaceutical industry), objects need to
10 be stored on some form of temporary basis under a
controlled atmosphere while they are awaiting use or
during manufacture.

The storage atmosphere may typically be a dry
air or alternatively an atmosphere of nitrogen
15 containing no more than a given limited content of
residual oxygen or residual water vapour.

Thus, for example, taking the example of the
electronics industry, it is commonplace to find means
of storing, under nitrogen or alternatively under dry
20 air, electronic components which are in the process of
manufacture, for example:

- for storing printed circuits prior to mounting
them;
- for storing bare chips prior to mounting them
25 on electronic boards;
- certain sensitive passive components such as
piezoelectric quartz or alternatively relays;
- for storing certain new generation components
such as QFPs or BGAs, which are sensitive to moisture
30 not only at their metal terminations but also in their
plastic casing.

Also to be found within this industry are means
of storing, under dry air or under nitrogen, electronic
components which may be qualified as obsolete or
35 strategic, and which the user is not sure of being able
to source in the years to come, and of which he quite
simply keeps his own long-term stock (for what may be
as much as several years).

There are therefore to be found, within the industry, and depending on the application involved, types of storage which differ very greatly, from stores which are open several times a day or even an hour, right out to stores which are opened once a month or even less frequently.

It will be understood that such storage operations are needed in order to prevent any interaction between the component and the ambient air, the main risks being associated with the uptake of moisture from the ambient air by the components, with the oxidation of the metal parts of the components or of the tracks of a printed circuit for example, with the uptake of moisture by the plastic encapsulation casings (the "popcorn" effect), or alternatively with a reaction with some of the polluting particles in the ambient air, such as sulphur oxide or halogenated compounds.

These problems of the uptake of moisture by certain plastic encapsulation casings force users to bake the electronic components in question at temperature, typically for 24 to 48 hours, and the negative aspects of such baking, both in economic terms and in terms of productivity will be appreciated.

As mentioned earlier, when such storage devices are used for short periods, the components being introduced into or removed from the storage member according to the needs of the user site, the storage modules are then opened and closed again extremely often, sometimes several times an hour.

Of course, the problems of the uptake of moisture also exist in the case of long-term storage cabinets.

The storage modules or cabinets have varying volumes, within an approximate range commonly extending from 100 litres to 2000 litres, the flow rates continuously injected generally being fairly low, of the order of 50 to 150 litre/h.

One of the easy ways of best visualizing the operating problems of such storage cabinets is to calculate the time taken to recondition the atmosphere after the door has been opened.

5 To do this, use is made of the traditional so-called "dilution purge" mathematical model:

$$V_p = V_0 \times \log (X_0/X_F)$$

V_p representing the volume of gas injected, V_0 the volume of the chamber, X_0 the initial content in
10 the chamber of the element in question (for example oxygen, 21% when a door has been opened and air has been let in), X_F representing the desired final content of the element in question.

To give a concrete example and allow for a
15 better understanding of the problems that may arise, let us consider below two examples of industrial storage cabinets:

a) the first example of a cabinet has a volume $V_0 = 0.22 \text{ m}^3$ and is used to store electronic
20 components under nitrogen in a cruising atmosphere (therefore desired atmosphere) which must not contain more than 100 ppm of residual oxygen ($X_F = 100 \text{ ppm}$).

X_0 therefore corresponds to air (21% of residual oxygen) following the opening of a door.

25 The flow rate of nitrogen injected permanently here in this first example is $0.25 \text{ m}^3/\text{h}$.

From this it can then be deduced that the volume V_p of nitrogen needed is equal to 1.683 m^3 which, after the cabinet has been opened, yields a
30 reconditioning time of $1.683/0.25 = 6.73 \text{ h}$, namely 6 hours and 43 minutes.

- b) Let us now consider the second example of a cabinet of a larger size, the volume V_0 of which is 1.4 m^3 , here too used to store electronic components
35 under nitrogen, the desired cruising atmosphere once again being an atmosphere of nitrogen in which the residual oxygen content does not exceed 100 ppm ($X_F = 100 \text{ ppm}$).

The flow rate of nitrogen constantly injected was the same as in the first example ($0.25 \text{ m}^3/\text{h}$).

It can therefore be deduced from this that the volume V_p of nitrogen needed is equal to 10.7 m^3 and that the time needed to recondition the cabinet after opening is calculated at $10.7/0.25 = 42.8 \text{ h}$, namely 42 hours and 48 minutes!

It can therefore be seen that in both instances the reconditioning times are not suited to temporary storage and that in these concrete examples where the storage cabinets are, on average, opened four to five times an hour, storage is ineffective, being unable to maintain over the components an atmosphere in which the residual oxygen content is actually what is desired, i.e. equal to 100 ppm or lower. This reality also makes any attempt, on this basis, at controlling and regulating the atmosphere, illusory.

From the foregoing, it can therefore be seen that there are real needs, within industry, for improved article storage under controlled atmosphere which, on the one hand, can achieve the desired storage atmospheres (for example a low residual content of oxygen or water vapour in a nitrogen atmosphere), but which can also achieve quick reconditioning of the atmosphere after opening, compatible with operations in which the storage members are opened as needed several times an hour.

The device for storing articles under an atmosphere according to the invention therefore comprises:

i) at least one storage module capable of accommodating the articles that are to be stored;

j) means for setting up the storage atmosphere inside the module;

and is characterized in that at least one of the said storage modules is of substantially parallelepipedal shape, having two substantially vertical and opposed walls, and in that the means of setting up the storage atmosphere comprise a first gas-

conveying system located near to one of the said two substantially vertical walls of the module, the first conveying system being capable of making the gas flow substantially laterally and with laminar flow towards the second substantially vertical wall opposite it of the module.

The device according to the invention may also adopt one or more of the following features:

- at least one of the said storage modules comprises means of discharging gas from inside the module to outside the module, these means being capable of discharging the gas through the top of the device;

- the said at least one of the said storage modules comprises a second gas-diffusing system located near to the said second substantially vertical wall of the module and defining with this wall a second chamber, the first gas-conveying, system and the second gas-diffusing system defining between them a space for storing the articles;

- the said second substantially vertical wall of the said at least one of the said storage modules is formed of a second gas-diffusing system capable of allowing gas to pass from the module in question towards a storage module juxtaposed with it;

- the first conveying system defines with the said first wall a first chamber, and it comprises means of injecting gas into this first chamber;

- the device comprises several storage modules which can be stacked to obtain the desired overall storage volume for the articles, and each module comprises means of discharging gas from inside the module to outside the module, the said discharge means comprising at least one duct/chimney system, one of the said duct/chimney systems being located between the two second chambers of two stacked modules, so as to allow the gas to be discharged from the second chamber of the lower module into the second chamber of the upper module of the two stacked modules in question;

- each of the modules has its own first gas-conveying system capable of supplying it with gas independently of the other modules;

5 - the device comprises several storage modules that can be juxtaposed to obtain the desired overall storage volume for the articles, and each module has its own first gas-conveying system capable of supplying it with gas independently of the other modules, and its own second chamber, and it comprises means for
10 discharging gas from inside each module to outside each module, each of the discharge means being connected to the second chamber of each module in question;

15 - the device comprises several juxtaposable and communicating storage modules to obtain the desired overall storage volume for the articles, thus defining a first module of the juxtaposition and a last module of the juxtaposition, and only the first module of the juxtaposition has a first gas-conveying system located near one of its two substantially vertical walls
20 forming an external wall of the juxtaposition, and capable of making gas flow substantially laterally and with laminar flow towards the other of its two substantially vertical walls which is opposite it, and then from there to the next modules in the
25 juxtaposition;

30 - the last module of the juxtaposition has a second gas-diffusing system located near to one of its two substantially vertical walls which forms the external wall of the juxtaposition and defining with this wall a second chamber, the second chamber being
35 equipped with a gas discharge means capable of discharging to the outside the gas which reaches the last module of the juxtaposition from the module preceding it;

 - one of the two substantially vertical walls of the last module of the juxtaposition, which forms the external wall of the juxtaposition, is formed of a second gas-diffusing system capable of allowing gas

reaching the last module of the juxtaposition from the module preceding it to be discharged to the outside;

- the device comprises at least two parallel series of juxtaposed and communicating modules, only the first module of each juxtaposition having a first gas-conveying system, the last module of each juxtaposition being equipped with a second diffusing system located near to its vertical wall forming the external wall of the juxtaposition, and forming with this external wall a second chamber, the second chamber being equipped with a gas discharge means capable of discharging to the outside the gas which reaches the last module of the juxtaposition from the module preceding it in the juxtaposition in question;

- the device comprises at least two parallel series of juxtaposed and communicating modules, only the first module of each juxtaposition having a first gas-conveying system, the vertical wall of the last module of each juxtaposition which forms the external wall of the juxtaposition in question being formed of a second diffusing system capable of discharging to the outside the gas which reaches the last module of the juxtaposition from the module preceding it in the juxtaposition in question;

- the device is formed of an arrangement of at least two stacked series of juxtaposed and communicating modules capable of allowing gas to flow from the last module of one series towards the module above it in the stack, and so on right up to the last module of the uppermost series of the stack, which last module is equipped with a gas discharge means capable of discharging to the outside the gas which reaches this last module from the module preceding it, the arrangement being supplied with gas at a single gas-conveying system supplying the first module of the arrangement when considering the direction in which the gas flows;

- communication between two juxtaposed modules is achieved by a gas-diffusing system that forms a common wall between the two juxtaposed modules in question;

- the said first conveying system comprises a first gas-diffusing system defining with the said first wall a first chamber, and comprises means of injecting gas into this first chamber;

- the said first conveying system consists of one or more porous tubes opening inside the module and extending along the said first vertical wall;

- at least one of the gas-diffusing systems of the device consists of a panel made of porous material;

- at least one of the gas-diffusing systems of the device consists of a panel made of ceramic, sintered metal, polymer or textile;

- at least one of the gas-diffusing systems of the device consists of a metal mesh;

- the two gas-diffusing systems of the said at least one of the said storage modules consist of panels made of porous material, and the thickness of the second gas-diffusing system is greater than the thickness of the first gas-diffusing system;

- the two gas-diffusing systems of the said at least one of the said storage modules consist of panels made of porous material, and the porosity of the second gas-diffusing system is lower than the porosity of the first gas-diffusing system;

- the means of injecting gas into the first chamber consist of an orifice made in one of the walls of the module;

- the means of injecting gas into the first chamber consist of one or more pipe(s) opening inside the first chamber and equipped with gas-injection orifices, the orifices being directed towards the said first substantially vertical wall of the module;

- the means of injecting gas into the first chamber consist of one or more porous tubes opening into the first chamber;

The invention also relates to a method of storing articles under an atmosphere in an arrangement of at least one storage module capable of accommodating the articles that are to be stored, and of substantially parallelepipedal shape, having two substantially vertical opposed walls, employing means of setting up the storage atmosphere inside the said at least one module, the setting-up means being capable of making the gas flow substantially laterally and with laminar flow from one of the said two substantially vertical walls towards the other of the said two walls which is opposite it.

As will have been understood from the foregoing description as a whole, the method according to the invention can use arrangements of several storage modules which can be stacked and/or juxtaposed to obtain the desired overall storage volume for the articles, be they in gaseous communication or not.

In the case of the use of a device of several modules, it will be preferable to supply the device in parallel, that is to say with a gas inlet specific to each module, and this, it will be understood is so that only the module which has been opened will have to be swept and reconditioned after opening (speed, efficiency, avoiding contaminating other modules which are not affected, etc).

However, in certain special cases, particularly when considering the number of storage modules employed, it is possible to envisage, still within the scope of the present invention, supplying the device in series, the arrangement being supplied with gas at just one point of entry, the gas flowing from one module to the other.

In one of the embodiments of the invention, the setting-up means comprise a first gas-conveying system located near to one of the said two substantially vertical walls of the module and a second gas-diffusing system located near to the other of the said two substantially vertical walls of the module, defining

with this other wall a second chamber, and the gas is discharged upwards from the arrangement with the aid of at least one chimney duct system, one of the said chimney duct systems being located between the two
5 second chambers of two stacked modules, so as to allow the gas from the second chamber of the lower module to be discharged into the second chamber of the upper module of the two stacked modules in question.

Advantageously, the module or arrangement of
10 several modules used is supplied with gas at one or other of the following rates, in order to set up the said atmosphere:

- when the door of the or a storage module of the arrangement is opened, the method waits for the door in
15 question to be closed and then triggers the injecting of gas into the module or arrangement of modules used at a conditioning flow rate Q_c for a conditioning time t_c ;

- beyond the conditioning time t_c , the method
20 returns to a sustain rate in which the gas is injected into the module or arrangement of modules used at a sustained flow rate Q_m , Q_m being below Q_c ;

- as long as the door of a given module of the system is not opened, gas continues to be injected at
25 the abovementioned sustain rate.

It will be understood that the conditioning time t_c is perfectly adjustable and controllable by an external member such as a programmable controller, to suit the desired atmosphere specifications.

In an advantageous embodiment, it is the
30 closing of the door of a module (after it has previously been opened) which triggers the switching to the conditioning rate (for example by triggering a time-delay relay which will itself actuate an
35 electrically operated valve in the gas circuit).

Other features and advantages of the present invention will emerge from the following description of some embodiments, given by way of entirely non-limiting

illustration, and made with reference to the appended drawings, in which:

- Figure 1 is a diagrammatic depiction of a device according to the invention employing an arrangement of stacked modules, each module of the stack being supplied with gas separately;

- Figure 2 provides another diagrammatic depiction of a device according to the invention, employing an arrangement of stacked modules, the device being supplied at a single point of entry;

- Figures 3 and 4 are diagrammatic depictions of devices according to the invention, employing an arrangement of juxtaposed modules;

- Figure 5 is a diagrammatic depiction of a device according to the invention employing an arrangement of two stacked series of communicating and juxtaposed modules, the arrangement being supplied with gas at a single gas-conveying system which supplies the first module of the arrangement when considering the direction in which the gas flows;

- Figure 6 is a diagrammatic depiction of a device according to the invention employing an arrangement of four parallel (stacked) series of juxtaposed and communicating modules, only the first module of each juxtaposition being equipped with a gas-conveying system;

- Figure 7 is a diagrammatic depiction of an overall installation including storage devices according to the invention, the performance of which are controlled and regulated.

Several stacked storage modules (X, Y, Z, ...) are depicted in the embodiment depicted in Figure 1, only the module X being depicted in detail.

As described below, the embodiment of Figure 1 illustrates one instance of a gas inlet per module, discharge being via the second chambers of the stacked modules (duct/chimney systems).

The module X (just like the other storage modules stacked on it) is of substantially

parallelepipedal shape, therefore defining a first substantially vertical wall P_{x1} and a second substantially vertical wall P_{x2} .

5 The module X also comprises a first gas-diffusing system 5 and a second gas-diffusing system 6, defining between the two diffusing systems a space 1 for the storage of articles, in which storage space there is, here, provision for a shelf 2.

10 The two panels are, in this instance, made of a sintered polymeric material, in this case sintered polyethylene, the panel 5 being of a thickness close to 2 mm, while the panel 6 is close to 4 mm thick.

15 One could just as easily have installed panels made of other materials such as porous ceramics, sintered metals or alternatively textiles (weaves, felts, nonwovens, etc), or even metal meshes.

20 The first gas-diffusing system 5 defines with the first wall P_{x1} a first chamber 3, while the second gas-diffusing system 6 defines with the second wall P_{x2} a second chamber 4.

A pipe 7, which has gas-injection orifices, and which opens to the inside of the first chamber 3, allows gas from an external source, not depicted in the figure, to be conveyed into this chamber 3.

25 It will be understood that depending on the specifications for the atmosphere to be set up in the module, the gas source may vary greatly. By way of illustration, for a user site requiring its articles to be stored under a nitrogen atmosphere with a certain limit on the residual oxygen content in the stores, nitrogen of cryogenic origin or alternatively nitrogen obtained by separating air by adsorption or by permeation may be proposed, this nitrogen having a certain oxygen content that is compatible with the
30 abovementioned limit.
35

It will be noted that the injection orifices of the pipe 7 in this instance face towards the first wall P_{x1} of the module, forcing the injected gas to effect an outward and return movement towards the first diffusing

system 5, as depicted diagrammatically by the arrows 8 in the figure.

The gas injected by the pipe 7 therefore travels, through the first diffusing system 5 and along the storage space 1, towards the second diffusing system 6, through which it passes, to enter the second chamber 4.

As depicted diagrammatically by the arrows 9 in the figure, the gas is then discharged from the second chamber 4 of the module X towards the second chamber 12 of the module Y (which is stacked on it) via a duct/chimney 10, and then from there to the second chamber of the storage module Z, also via a duct/chimney 11 connecting the second chamber of the module Y to the second chamber of the module Z, and so on.

It will be understood that the ducts/chimneys for discharging from one chamber to the other are preferably hermetically connected to the module to which they relate.

The advantageous embodiment illustrated in the context of this Figure 1 therefore has the following features and advantages:

- gas is made to flow, in the depicted arrangement of modules, from the bottom of the device towards the top of the device, with the gas being discharged from the top of this device;

- the second diffusing system 6 makes it possible, on the one hand, to isolate the discharge corridor 4 from the storage zone 1, in particular avoiding returns of gas and therefore of air from the discharge corridor to the storage chamber (non-return system);

- but the presence of the second diffusing system 6 also makes it possible to maintain a slight overpressure in the storage zone 1;

- the "pipe 7/first diffuser 5" grouping allows the gas leaving the diffuser to be diffused

substantially laterally and at low speed (preferably a few centimetres per second);

- the "pipe 7/first diffuser 5/second diffuser 6" assembly makes it possible to achieve an effect that could be described as being a "piston" effect, preventing the injected gas from mixing with the atmosphere of the chamber and thus effectively making it possible to reduce the reconditioning time after opening.

Without being restricted by the explanation given below, it may actually be thought that there is obtained, leaving the gas diffuser 5, a sufficiently laminar buffer of nitrogen travelling laterally at low speed towards the second diffuser 6 which, through the pressure drop it creates, itself acts as an obstacle and stopper to the movement of the gas, the nitrogen buffer driving the atmosphere of air that already exists inside the module towards the diffuser 6 because a door has been opened, with the creation, between the air and the nitrogen buffer, of a zone which probably has some intermediate composition.

The air is thus driven, with a minimum of turbulence and therefore of mixing phenomena, towards the second chamber 4 and from there towards the discharge from the device.

It may be noted that the choice, according to the invention, to inject gas from a side wall of the module makes it possible, if necessary, for shelves intended to support the articles that are to be stored to be mounted inside the module without these shelves introducing any significant change to the flow of gas, unlike what would have happened if the gas had, for example, been injected from the bottom of the module upwards or from the top of the module downwards.

Figure 1 depicts one embodiment in which the system for injecting gas into the first chamber 3 consists of a simple pipe 7 with injection orifices. It is, however, possible, without departing from the scope of the present invention, to envisage other

advantageous systems for injecting gas into the chamber 3, such as those reported in the documents EP-A-659,515 and EP-A-686,844, in the name of the Applicant Company, these documents disclosing gas-injection assemblies
5 that make it possible to achieve excellent levels of uniformity across the entire area of a chamber and therefore being well suited to the implementation of this invention.

Likewise, while we have illustrated here the
10 case of gas-conveying systems which consist of the combination of a pipe 7 and of a diffusing system 5 along the first wall of the module, it is possible (as already mentioned earlier in this description) to envisage other conveying systems that make it possible
15 to obtain such a lateral and laminar flow of gas, such as a porous tube extending along all or part of one dimension of the wall P_{x1} of the module X.

Figures 2, 3 and 4 illustrate other embodiments of devices according to the invention, implementing, as
20 the case may be, arrangements of stacked or juxtaposed modules, which embodiments will be described more briefly in what follows:

- as will have been understood from reading the embodiment of Figure 2, the stack of modules X, Y and Z
25 is here supplied through the single pipe 7 which opens into the first chamber of the module X, the gas then flows substantially laterally and with laminar flow through the module X to enter the second chamber of X, and from there flows into the second chamber Y via the
30 duct/chimney 10, to then enter the module Y and travel laterally through it before being discharged via the duct/chimney 11 to the module Z and so on.

Here, too, the gas is made to flow, through the depicted arrangement of modules, from the bottom of the
35 device towards the top of the device, where the gas is discharged.

It is appropriate in this embodiment not to attach too strict an importance to the terms "first chamber" and "second chamber", but rather to consider

the function of each part: thus, the duct 10 allows the gas to be made to emerge in what can simultaneously be considered as being a second chamber of Y, but which can also be considered as a first chamber of Y when it is considered that this chamber becomes the point of entry of the gas into the module Y.

- Figure 3 for its part illustrates one scenario of a juxtaposition where each module X, Y and Z, is supplied by a separate gas inlet (pipe 7 into each first chamber) and, for each module, the gas escapes through its own duct/chimney (10, 11, ...) connected to the second chamber of each module.

This mode illustrates another instance in which the discharging of the gas from the top of the device has been preferred.

- as far as Figure 4 is concerned, the juxtaposition of the modules X, Y and Z is, in this instance, in communication, and therefore supplied through the single pipe 7 located in the first chamber of the module X; the gas therefore flows substantially laterally and with laminar flow through the module X to enter Y, through which it passes, and from there into Z, communication between two juxtaposed modules being via a gas-diffusing system forming a common wall between the two juxtaposed modules in question (13 and 14 in the figure).

The gas then escapes from the device via the second chamber of the module Z and the duct/chimney 10 attached to it.

As already mentioned, it will, however, be preferable, according to the invention, to adopt independent supplies for each module, and therefore the embodiments described in Figures 1 and 3.

As to Figures 5 and 6, they illustrate two arrangements of modules according to the invention:

- the device of Figure 5 is formed of an arrangement of two stacked series of juxtaposed and communicating modules, the arrangement being supplied with gas at a single gas-conveying system 50 - not

detailed in the figure - supplying the first module (50A) of the arrangement when considering the direction in which the gas flows.

5 The gas thus passes from one module of the lower juxtaposition to the other until it reaches the last module (50F) of this lower juxtaposition, and then from there passes to the module (50G) above it in the stack, and so on right up to the last module (50L) of the uppermost series of the stack, which last module is
10 equipped with a gas discharge means 51 capable of discharging to the outside the gas which reaches this last module from the module preceding it.

The discharge means 51 is advantageously equipped with a valve.

15 - the device of Figure 6 is formed of an arrangement of four parallel (stacked) series of juxtaposed and communicating modules (60A to 60F, 70A to 70F, 80A to 80F, and 90A to 90F), only the first module of each juxtaposition being equipped with a
20 first gas-conveying system (not detailed in the figure but 60, 70, 80 and 90, respectively), the vertical wall of the last module of each juxtaposition, forming the external wall of the juxtaposition in question, being formed of a second diffusing system capable of
25 discharging to the outside, through a chimney duct, the gas which reaches the last module of the juxtaposition from the module preceding it in the juxtaposition in question.

Each chimney duct is advantageously fitted with
30 a valve.

Figure 7 is a diagrammatic depiction of a global installation including storage devices according to the invention, and the performance of which can be controlled and regulated.

35 Figure 7 shows two storage devices 20A and 20B according to the invention, supplied with gas by lines 21A and 21B respectively, these lines themselves being connected to a gas source 23 by the line 22 which includes an electrically operated valve 24.

Each device 20A and 20B therefore comprises an arrangement of one or more storage modules that can be stacked and/or juxtaposed.

5 The installation also comprises an oxygen probe
25 located in the room or workshop in which the stores
20A and 20B are located, a data input and processing
system 26 (for example a programmable controller), and
a display system 27 such as a PC.

For ease of reading:

10 - dot-and-dash chain line has been used to depict
the flow of information to the controller 26 (for
example the residual oxygen contents 30A and 30B
originating from the stores, or alternatively the
residual oxygen content 30C in the workshop,
15 originating from the probe 25);

 - dashed lines, with arrow heads at one or both
ends have been used to represent the feedback action of
the controller on an element of the installation, or
alternatively hybrid scenarios in which the controller
20 receives information from one element and has a
feedback action that depends on this information.

 By way of an illustration, there can be seen
here an action 40B of the controller on the valve 24
allowing the gas supply to be stopped or modified as
25 needed. There is also a two-way flow 40A between the
controller and the reservoir of gas 23, allowing the
controller not only to receive information about the
source (pressure, flow rate, residual oxygen content,
etc.) but also, as needed, to act on this source, for
30 example to modify the residual oxygen content of a
nitrogen produced by air separation by permeation or
adsorption. Likewise, there may be a two-way flow of
this type between the controller 26 and the PC 27, so
that chosen data can be dispatched regularly to the PC
35 to thus allow regular supervision by the user (nitrogen
consumption, change over time in residual oxygen
content in the stores, reconditioning time, etc) and
also in the opposite direction to alert the controller

when a drift is observed and allow it to take the appropriate action.

It will be therefore be understood that because of the remarkable performance obtained by virtue of the storage devices according to the invention (reconditioning time, etc), it is possible, with such an installation, to envisage procedures for controlling (supervising) and/or regulating the storage conditions and safety conditions of the assembly as a whole, if necessary also providing the installation with remote monitoring (the sending of data regularly or at a specific instance to an assessment unit sited some distance from the user site).

An installation like the one illustrated in the context of Figure 1, comprising two stacked storage modules, has been used to provide examples of the implementation of the invention, under the following operating conditions:

- each module had an internal volume of 27 litres and was supplied by a dedicated nitrogen (of cryogenic origin) inlet, the flow rate of which was close to 2 Nm³/h;

- each module was equipped with two porous diffusers (5 and 6 in Figure 1) made of polyethylene with a porosity of 40 microns, the thickness of the diffuser 5 being 2 mm while the thickness of the diffuser 6 was 4 mm;

- a duct/chimney connected the second chamber of the bottom module to the second chamber of the module stacked on it;

The results obtained under such operating conditions can be summarized as follows:

- following the opening of a door (for example that of the bottom module), the oxygen content of the atmosphere in the module concerned changed from 21% to a level below 100 ppm in a little over four minutes;

- following this same opening of a door, the dew point (that represents the water vapour content) of the

atmosphere of the module in question changed from +12°C to -27°C in about five minutes.

It can therefore be seen, on the one hand, that such performance, obtained according to the invention, makes such storage perfectly compatible with short-term storage operations i.e. with frequent opening of the doors, but also, for a more medium- or long-term storage, ensures that moisture will not be taken up. It was also found that for applications in which the atmosphere specifications were less strict (for example where the limiting oxygen content was not 100 ppm but 1000 or 2000 ppm), the reconditioning time was then even faster, in such cases as low as three minutes, which once again makes operation in which the doors are opened several times an hour perfectly feasible.

Another advantage of the present invention was also observed, by the fact that bringing electronic components or circuits into contact with a neutral gas at ambient temperature in this way for a time which will of course vary depending on the characteristics of each component (typically from a few hours to 48 hours) allows the components to be dried out, the proof of this lying in the decrease in the "popcorn" phenomenon.

Although the present invention was described in conjunction with specific embodiments, it is not in any way restricted thereto but can be modified and varied in ways that will be obvious to the person skilled in the art. Thus, while the invention was quite specifically exemplified by its performance and advantages in the case of the injection of an inert gas, it will be understood in the light of all the spectacular results described earlier that it has applications in other fields, such as, for example, with N₂/CO₂ mixtures in the food industry.



CLAIMS

1. Device for storing articles under an atmosphere, comprising:
 - 5 i) at least one storage module (X, Y, Z, ...) capable of accommodating the articles that are to be stored;
 - j) means (5, 7) for setting up the said storage atmosphere inside the said at least one module;
- 10 characterized in that at least one of the said storage modules is of substantially parallelepipedal shape, having two substantially vertical and opposed walls (P_{x1} , P_{x2}), and in that the means of setting up the storage atmosphere comprise a first gas-conveying
- 15 system (5, 7) located near to one (P_{x1}) of the said two substantially vertical walls of the module, the first conveying system being capable of making the gas flow substantially laterally and with laminar flow towards the second substantially vertical wall (P_{x2}) opposite it
- 20 of the module.
2. Device according to Claim 1, characterized in that at least one of the said storage modules comprises means (10) of discharging gas from inside the module to outside the module, these means being capable of
- 25 discharging the gas through the top of the device.
3. Device according to Claim 1 or 2, characterized in that at least one of the said storage modules comprises a second gas-diffusing system (6) located near to the said second substantially vertical wall of
- 30 the module and defining with this wall a second chamber (4), the first gas-conveying system and the second gas-diffusing system defining between them a space (1) for storing the articles.
4. Device according to Claim 1 or 2, characterized
- 35 in that the said second substantially vertical wall of the said at least one of the said storage modules is formed of a second gas-diffusing system capable of allowing gas to pass from the module in question towards a storage module juxtaposed with it.



5. Device according to one of Claims 1 and 2, characterized in that the first conveying system defines with the said first wall a first chamber (3), and in that it comprises means (7) of injecting gas
5 into this first chamber.

6. Device according to Claim 3 or 4, characterized in that the first conveying system defines with the said first wall a first chamber (3), and in that it comprises means (7) of injecting gas into this first
10 chamber.

7. Device according to Claim 3 or 6, characterized in that it comprises several storage modules (X, Y, Z) which can be stacked to obtain the desired overall storage volume for the articles, and in that each
15 module comprises means (10) of discharging gas from inside the module to outside the module, the said discharge means comprising at least one duct/chimney system (10, 11), one of the said duct/chimney systems being located between the two second chambers of two
20 stacked modules, so as to allow the gas to be discharged from the second chamber (4) of the lower module into the second chamber (12) of the upper module of the two stacked modules in question.

8. Device according to Claim 7, characterized in
25 that each of the modules has its own first gas-conveying system capable of supplying it with gas independently of the other modules.

9. Device according to Claim 3 or 6, characterized in that it comprises several storage modules (X, Y, Z)
30 that can be juxtaposed to obtain the overall desired storage volume for the articles, and in that each module has its own first gas-conveying system (7) capable of supplying it with gas independently of the other modules, and its own second chamber, and
35 characterized in that it comprises means (10, 11, ...) for discharging gas from inside each module to outside each module, each of the discharge means being connected to the second chamber of each module in question.



10. Device according to one of Claims 1 to 3, characterized in that it comprises several juxtaposable and communicating storage modules (X, Y, Z) to obtain the desired overall storage volume for the articles, thus defining a first module (X) of the juxtaposition and a last module (Z) of the juxtaposition, and in that only the first module of the juxtaposition has a first gas-conveying system (7) located near to one of its two substantially vertical walls forming the external wall of the juxtaposition, and capable of making gas flow substantially laterally towards the other (13) of its two substantially vertical walls which is opposite it, and then from there to the next modules in the juxtaposition.

11. Device according to Claim 10, characterized in that the last module (Z) of the juxtaposition has a second gas-diffusing system located near to one of its two substantially vertical walls which forms the external wall of the juxtaposition and defining with this wall a second chamber, the second chamber being equipped with a gas discharge means (10) capable of discharging to the outside the gas which reaches the last module (Z) of the juxtaposition from the module (Y) preceding it.

12. Device according to Claim 10, characterized in that the substantially vertical wall of the last module of the juxtaposition, which forms the external wall of the juxtaposition, is formed of a second gas-diffusing system capable of allowing gas reaching this last module of the juxtaposition from the module preceding it to be discharged to the outside.

13. Device according to one of Claims 10 to 12, characterized in that the first conveying system of the said first module of the juxtaposition defines with the said vertical wall forming the external wall of the juxtaposition a first chamber, and in that it comprises means (7) of injecting gas into this first chamber.

14. Device according to one of Claims 1 to 3, characterized in that the device comprises at least two



parallel series of juxtaposed and communicating modules (60A to 60F, 70A to 70F, ...), only the first module (60A, 70A, ...) of each juxtaposition having a first gas-conveying system (60, 70, ...) located near to one of its
5 two substantially vertical walls forming the external wall of the juxtaposition in question, capable of making the gas flow substantially laterally towards the other (13) of its two substantially vertical walls opposite it, then from there to the next modules in the
10 juxtaposition in question.

15. Device according to Claim 14, characterized in that the last module of each juxtaposition (60F, 70F, ...) has a second diffusing system located near to its vertical wall forming the external wall of the
15 juxtaposition, and forming with this external wall a second chamber, the second chamber being equipped with a gas discharge means capable of discharging to the outside the gas which reaches the last module of the juxtaposition from the module preceding it in the
20 juxtaposition in question.

16. Device according to Claim 14, characterized in that the substantially vertical wall of the last module (60F, 70F, ...) of each juxtaposition which forms the external wall of the juxtaposition is formed of a
25 second gas-diffusing system capable of allowing gas reaching this last module of the juxtaposition from the module preceding it to be discharged to the outside.

17. Device according to one of Claims 14 to 16, characterized in that the first conveying system of the
30 said first module of each juxtaposition defines with the said vertical wall forming the external wall of the juxtaposition in question a first chamber and in that it comprises means (7) of injecting gas into this first chamber.

35 18. Device according to one of Claims 1 to 3, characterized in that the device is formed of an arrangement of at least two stacked series of juxtaposed and communicating modules (50A to 50F, 50G to 50L) capable of allowing gas to flow from the last



module (50F) of one series towards the module (50G) above it in the stack, and so on right up to the last module (50L) of the uppermost series of the stack, which last module is equipped with a gas discharge means (51) capable of discharging to the outside the gas which reaches this last module from the module preceding it, the arrangement being supplied with gas at a single gas-conveying system (50) supplying the first module (50A) of the arrangement when considering the direction in which the gas flows.

19. Device according to Claim 18, characterized in that the said first conveying system of the first module of the arrangement defines with the vertical wall forming the external wall of the juxtaposition a first chamber, and in that it comprises means (7) of injecting gas into this first chamber.

20. Device according to one of Claims 10 to 19, characterized in that communication between two juxtaposed modules is achieved by a gas-diffusing system that forms a common wall between the two juxtaposed modules in question.

21. Device according to one of Claims 10 to 17, characterized in that a gas discharge means which is fitted with a valve is associated with each last module of a juxtaposition.

22. Device according to one of Claims 1 to 21, characterized in that the said first conveying system consists of one or more porous tubes opening inside the module and extending over all or part of one dimension of the said first wall.

23. Device according to one of Claims 3 to 7, characterized in that at least one of the gas-diffusing systems of the device consists of a panel made of a porous substance or of a metal mesh.

24. Device according to Claim 23, characterized in that at least one of the gas-diffusing systems of the device consists of a panel made of ceramic, sintered metal, polymer or textile.



25. Device according to Claim 6, characterized in that the two gas-diffusing systems of the said at least one of the said storage modules consist of panels made of porous material, and in that the thickness of the
5 second gas-diffusing system is greater than the thickness of the first gas-diffusing system.

26. Device according to Claim 6, characterized in that the two gas-diffusing systems of the said at least one of the said storage modules consist of panels made
10 of porous material, and in that the porosity of the second gas-diffusing system is lower than the porosity of the first gas-diffusing system.

27. Device according to one of Claims 5, 6, 13, 17 and 19, characterized in that the said means of
15 injecting gas into the first chamber, defined by the said first conveying system, consist of an orifice made in one of the walls of the module in question.

28. Device according to one of Claims 5, 6, 13, 17 and 19, characterized in that the said means of
20 injecting gas into the first chamber, defined by the said first conveying system, consist of one or more pipe(s) opening inside the first chamber and equipped with gas-injection orifices, the orifices being directed towards the said first substantially vertical
25 wall of the module.

29. Device according to one of Claims 5, 6, 13, 17 and 19, characterized in that the said means of injecting gas into the first chamber, defined by the said first conveying system, consist of one or more
30 porous tubes opening into the first chamber.

30. Method of storing articles under an atmosphere in an arrangement of at least one storage module (X, Y, Z, ...) capable of accommodating the articles that are to be stored, and of substantially parallelepipedal shape,
35 having two substantially vertical opposed walls (P_{x1} , P_{x2}), employing means (5, 7) of setting up the storage atmosphere inside the said at least one module, characterized in that the gas is made to flow substantially laterally and with laminar flow from one



of the said two substantially vertical walls towards the other of the said two walls which is opposite it.

31. Method according to Claim 30, characterized in that use is made of several storage modules (X, Y, Z) which can be stacked and/or juxtaposed to obtain the overall desired storage volume for the articles.

32. Method according to Claim 31, characterized in that each of the modules is supplied independently of the other modules.

33. Method according to one of Claims 30 to 32, characterized in that the module or arrangement of several modules used is supplied with gas, in order to set up the said atmosphere, as follows:

- when the door of the or a storage module of the arrangement is opened, the method waits for the door in question to be closed and then triggers the injecting of gas into the module or arrangement of modules used at a conditioning flow rate Q_c for a conditioning time t_c ;

- beyond the conditioning time t_c , the method returns to a sustain rate in which the gas is injected into the module or arrangement of modules used at a sustained flow rate Q_m , Q_m being below Q_c ;

- as long as the door of a module of the system is not opened, gas continues to be injected at the said sustain rate.

34. Method according to Claim 33, characterized in that it is the closing of the door in question, which was previously opened, which automatically triggers the switching to the conditioning rate.

35. Method according to one of Claims 30 to 34, characterized in that the content of a given element in the atmosphere of the storage space of the said at least one module is controlled (26, 27).

36. Method according to one of Claims 30 to 35, characterized in that the content of a given element in the atmosphere of the storage space of the said at least one module is regulated (26, 27).



37. Method according to one of Claims 35 and 36, characterized in that the change in the said content of a given element in the atmosphere of the storage space of the said at least one module is monitored remotely.

5 38. Method according to one of Claims 30 to 37, characterized in that the said articles are electronic circuits or components.

39. Method according to Claim 38, characterized in that the said storage atmosphere brought into contact
10 with the articles allows them to be dried at ambient temperature.

40. Method according to Claim 38 or 39, characterized in that the said storage atmosphere is made of a neutral gas.

15 41. Method according to Claim 40, characterized in that the neutral gas used is a nitrogen of cryogenic origin.

42. Method according to Claim 40, characterized in that the neutral gas used is a nitrogen obtained by
20 separating air by permeation or adsorption.