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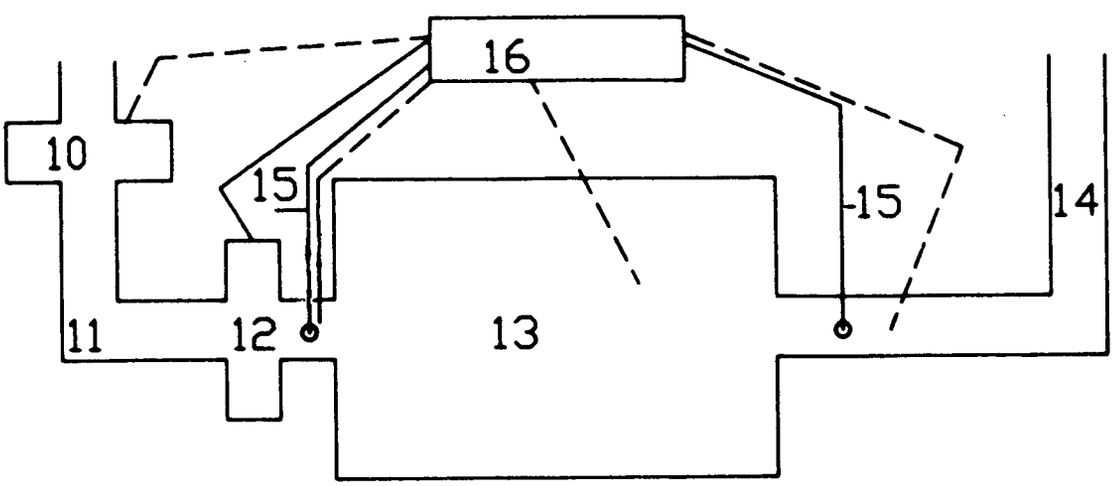
## (54) Equipment for continuous moisture control in drying processes.

(57) Equipment for continuous moisture control of manufactured articles subjected to drying processes using heated gas flows is described. It allows measurement, regulation and control of temperature differences of the gas flow at the inlet (11) and the outlet (14) with respect to the environment (13) in which is performed the drying process of manufactured articles, the moisture content of which it is desired to control.

**FIG. 1**




EP 0 479 204 A1

## Field of the invention

The present invention relates to equipment which allows continuous moisture control of manufactured articles subjected to drying and/or desiccation using heated gas flows consisting of two or more sensors which measure the gas temperature at the inlet and outlet of the drying system and optionally in the intermediate process phases, connected to a microprocessor or microcontroller allowing setting, varying and controlling of said temperatures in accordance with the processing requirements by operating appropriately the gas flow heaters and/or flow generators and/or the handling systems and/or mechanical, pneumatic or electrical systems which intervene in the drying and/or desiccation process.

## State of the art

In drying processes which use heated gas flows, usually air, it is very important to determine precisely the degree of residual moisture in the manufactured articles so as to optimize work times and avoid possible damage to the material subjected to the process with an inadequate treatment. This problem is particularly felt in the field of textile production in which different materials, e.g. wools, cottons, linens, hemps, synthetic fibre fabrics, etc., require of course different operating conditions which depend not only on the differences in the materials but also on the type of manufactured article which is subjected to the process, e.g. spools, skeins, thread, reels, wide or corded fabric, flock, finished garments, etc.

Measurement of moisture content in drying processes known heretofore, in particular for textiles, is performed with humidistats based on measurement of electrical conductivity or thermo-stats and timers which regulate temperature for a given time or two control thermo-stats which set an initial and a final temperature. All these methods display various shortcomings which make their use ineffective and especially give results with low reproducibility because they can be influenced by the humidity in the air or sudden variations in the temperatures as well as in the quantity of liquid, water or solvents present in the manufactured articles at the beginning of the process.

In addition the above methods are inflexible because they do not allow adaptation of the work cycles to the various requirements which arise upon changing of the material or the type of manufactured article to be dried and thus require continuous adjustment, often unavoidably inaccurate.

## Detailed description of the invention

The present invention overcomes the above shortcomings and offers the advantage of a very wide field of applications and extreme flexibility in operation thanks to equipment consisting of two or more sensors connected to a microprocessor or microcontroller system on which are easily set the data required and which permit continuous control of said parameters by acting on members used for the heating of the gas flow and/or the generators of said flow and/or on the handling system and/or other mechanical, pneumatic or electrical systems which intervene in the drying and/or desiccation process. The equipment thus enables setting, changing and controlling continuously the moisture content of the manufactured articles by measuring the temperature of the gas, normally air, at the outlet of the drying system, and comparing it with that of the gas at the inlet. It also permits stopping the process when the best moisture content for the materials or for the subsequent operation of the process to which they are to be subjected is reached.

It is known that as a result of evaporation of a liquid there is a lowering of the temperature, hence the hot dry air entering the drying chamber and causing evaporation of the water will undergo cooling and will emerge from the chamber at a temperature lower than that of inlet proportionately to the quantity of liquid evaporated. The temperature, and hence indirectly the moisture content of the gas flow, can be as mentioned regulated and controlled by the microprocessor or microcontroller system connected to the gas flow heaters and/or on the generators of said flow and/or on the handling systems and/or other mechanical, pneumatic or electrical systems which intervene in the process of drying and/or desiccation.

The invention will be better understood with the help of FIG. 1 which shows a block diagram of the equipment, given here by way of nonlimiting illustration.

In FIG. 1 the gas flow generator is indicated by reference number 10 while 11 indicates the gas inlet duct, 12 the heaters for the gas at the inlet, 13 the drying environment, 14 the gas outlet stack, 15 the sensors and 16 the microprocessor or microcontroller system connected to the sensors and to the gas heater 12. The broken lines represent connections between the microprocessor or microcontroller system and any other sensors or, as specified above, with other mechanical, pneumatic, electrical systems which intervene in the drying and/or desiccation process.

The gas flow generators can be blowers, compressors, compressed gas tanks, etc.

The heaters can consist of steam or superheated water heating batteries, various types of heat exchangers, electrical resistances, burners,

etc.

The drying environment can be a fixed or mobile drying chamber with or without bulkheads.

The sensors can be any type of instrument designed to measure variations in the temperature of a gas such as thermometers, thermocouple probes, thermal resistances probes, pyrometers, telecameras, infrared detectors, etc., and in particular, depending on the preferred version, platinum thermal resistances with stainless steel covering are used.

The microprocessor or microcontroller system can be any microprocessor microcontroller control system equipped with appropriate software and hardware allowing performance of the required operations, in particular there has been used a MICRO-GAM Compact programmer produced by S.A.T.E. s.n.c.

By mechanical, pneumatic and electrical systems are intended all those components of the drying process acting upon which there can be achieved the desired results such as bulkheads, material conveyor belts, etc., for example by accelerating or slowing down the travel of the material, extending opening and closing times of the bulkheeds, etc.

In accordance with a preferred version of the present invention the gas flow is held uniform during the drying process and the microprocessor or microcontroller system acts on the heaters, thus varying the gas flow temperature, and on the opening and/or closing of the bulkheads to allow homogenization and conditioning.

The programme used provides:

- regulation of the heaters in such a manner as to have predetermined values of initial and final temperature of the inlet gas flow;
- control of outlet gas temperature, hence indirectly the moisture content, at the end of processing;
- continuous regulation of inlet gas temperature and adaptation thereof to the requirements of the drying cycle;
- homogenization of the manufactured articles by keeping the gas in circulation in a closed cycle in the drying environment once the actual drying process is terminated, i.e. once the desired outlet gas temperature is reached;
- regulation of the gradual return of the internal temperature of the drying chamber to values equal to the external ones (conditioning).
- in addition as already mentioned there can be controlled other operations such as opening and closing of the inlet and outlet doors of the materials from the drying chamber, speed of the conveyor belts, etc.

Of course the system shown diagrammatically in FIG. 1 can constitute a unit of a higher order of system consisting of several of said units arranged in series and in which the material to be dried is made to pass from one unit to another. In this case each of the various units will be controlled in an interactive manner with the others by using the microprocessor or microcontroller system.

As may be seen in FIG. 1 one of the sensors is installed immediately after the inlet gas heating element while another is in the outlet stack.

At the beginning of the process the desired initial and final temperature values T1 and T2 of the first sensor respectively (see FIG. 2) and the desired final temperature value T4 of the second sensor are assigned. The difference between T2 and T4 represents the temperature difference which there should be at the end of the drying process between the inlet gas and the outlet gas and said difference will be a function of the residual moisture content of the manufactured article to be dried and can be modified at will by the above mentioned adjustments to allow adaptation of the process to any requirement.

In addition this system affords inlet gas temperature regulation by modifying it in accordance with the requirements of the programme loaded as the outlet gas temperature approaches the final value, thus permitting optimization of processing time without subjecting the manufactured articles to uselessly high temperatures during the drying phases which they do not require.

The temperature variations during the process are represented schematically in the diagram shown in FIG. 2 wherein on the axis of the abscissas are shown the times and on that of the ordinates the temperatures and in which T1 and T3 represent the initial temperatures measured respectively by the inlet and outlet sensors while T2 and T4 represent the respective final temperatures. It is clear that by merely changing the data for the required temperatures the drying system can be quickly adapted to extremely diverse manufactured articles and hence requiring equally diverse working conditions.

At the end of the actual drying process, by adjusting the appropriate bulkheads, cutting off heating and circulating the gas by the flow generator for a certain time, temperature is made uniform in the entire manufactured article being treated. Finally the temperature inside the drying chamber is gradually returned to the values of the surrounding temperature (conditioning). As may be seen, by operating as explained, the humidity in the drying chamber is set and controlled without undergoing any influence of the surrounding humidity.

EXAMPLE

Test material: twisted mixed wool acrylic yarn skein.
Weight of material under normal conditions (dry): 140g.
Weight of soaked and wrung material: 600g.
Water in material before drying process: 460g.

The test material was soaked and wrung out and subjected to the drying process under the following conditions:
Heating gas used: air
Heating performed with electrical resistances
Sensors: platinum thermal resistances
Initial temperature set for inlet gas (T1) = 100 ° C
Final temperature set for first sensor (T2) = 88 ° C
Final temperature set for outlet gas (T4) = 70 ° C
Temperature (T3) = 43 ° C where said temperature (T3) is the temperature taken at the beginning of the desiccation cycle on the outlet gas sensor when the inlet gas temperature had already been stabilized at 100 ° C.

As may be seen the difference between T1 and T3 is 57 ° C and is a function of the moisture content at the beginning of the cycle in the fibre to be dried (approximately 400%).
The time used to reach the set temperature T1 = 10'.
Time of drying cycle, i.e. for passage from T1 to T2 = 110'.
Homogenization time at 80 ° C = 15'.
Time for conditioning to surrounding temperature = 10'.
Total time employed for the process = 145'.
Weight of skein at end of cycle = 140g.
Water removed = 460g.

At the end of the cycle the skein thus appears in exactly the same condition as before soaking.

## Claims

1. Equipment allowing continuous control of moisture content of manufactured articles subjected to drying and/or desiccation processes using heated gas flows and consisting of two or more sensors (15) which measure the inlet (11) and outlet (14) gas temperatures of the drying system, and optionally in the intermediate processing steps, connected to a microprocessor or microcontroller system (16) making it possible to set, vary and control said temperatures in accordance with the processing requirements by appropriately adjusting gas flow heaters (12) and/or the flow generators (10) and/or the handling systems and/or other mechanical, pneumatic and electrical systems which intervene in the drying and or desiccation process.

2. Equipment in accordance with claim 1 in which the microprocessor or microcontroller (16) system acts on the gas flow heaters (12).

3. Equipment in accordance with claims 1 and 2 in which the sensors (15) for measurement of the inlet (11) and outlet (14) gas temperatures of the drying chamber and optionally during the intermediate process steps consist of platinum thermal resistances.

4. Equipment in accordance with claims 1-3 in which the sensor (15) controlling the inlet (11) gas temperature regulates said temperature on the basis of the outlet (14) gas temperature and optionally the temperature of the intermediate processing steps.

5. Process for drying manufactured articles in systems which operate with heated gas flows in which there is used equipment in accordance with claims 1-4.

6. Process in accordance with claim 5 in which the gas used for the drying process in air.

7. Process in accordance with claims 5 and 6 in which the materials subjected to the drying process are textile materials or products.

8. Apparatus made up of several individual equipments in accordance with claims 1-4 in which said equipments can be independent or connected together or integrated in a single system for control of continuous drying and/or desiccation systems or with a succession of chambers or in multiple chambers or in mobile cells or chambers or with successive steps.

FIG. 1

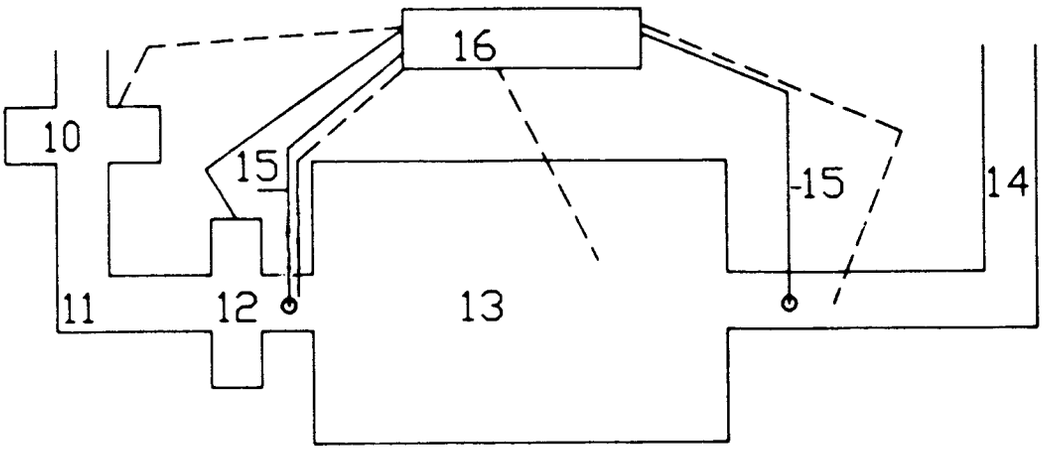
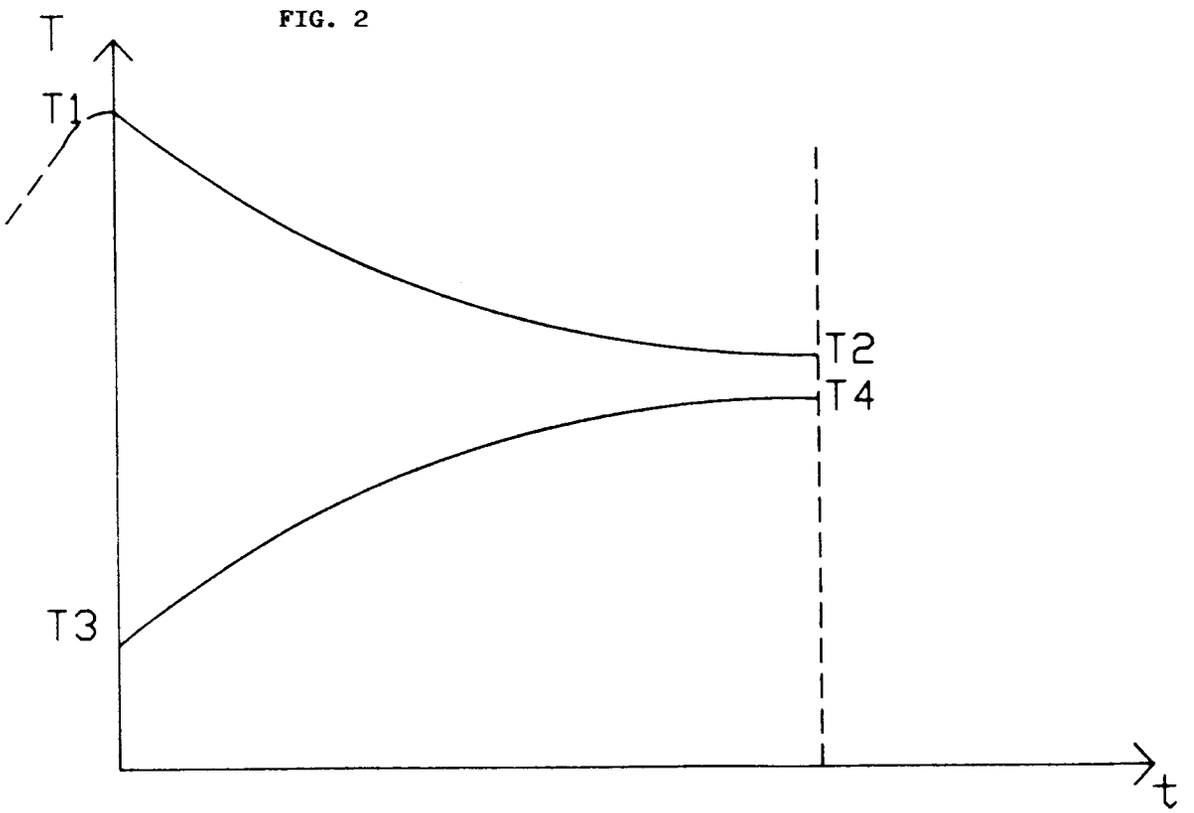



FIG. 2



European Patent Office

# EUROPEAN SEARCH REPORT

Application Number

EP 91 11 6694

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.5) |
|---|---|---|---|
| X<br>A | US-A-4 701 857 (ROBINSON)<br>(* the whole document *) | 1,2<br>4-8 | F 26 B 21/10 |
| X<br>A | US-A-4 599 808 (GELINEAU ET AL)<br>(* the whole document *) | 1,2<br>4,5,6 | |
| X<br>A | FR-A-2 506 916 (BABCOCK-BSH AG)<br>(* the whole document *) | 1<br>6,8 | |
| A | US-A-4 922 624 (THARPE) | | |
| A | FR-A-2 390 690 (BABCOCK-BSH AKTIENGESELL-SCHAFT VORMALS BUTTNER-SCHILDE-HAAS AG) | | |

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

F 26 B

The present search report has been drawn up for all claims

| Place of search | Date of completion of search | Examiner |
|---|---|---|
| The Hague | 07 January 92 | SILVIS H. |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same catagory
A : technological background
O : non-written disclosure
P : intermediate document
T : theory or principle underlying the invention

E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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