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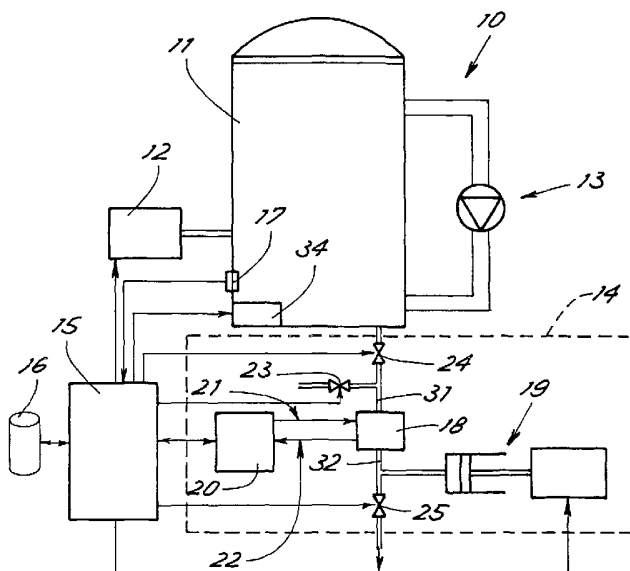
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[Continued on next page]

(54) Title: DYEING MACHINE WITH AUTOMATIC IN-LINE DIP DEPLETION CONTROL



(57) Abstract: A dyeing machine comprises a container (11) in which products to be dyed are placed, a source (12) of coloring liquids adding liquids on command into the container to realize a dye dip, and a unit (13) to circulate the dye dip with respect to the product. During the dyeing process a sampling and analysis device (14) automatically takes samples of the liquid from the container at intervals and performs a spectroscopic analysis thereon. An electronic control and calculation device (15) receives the spectroscopic analysis data and calculates therefrom the concentrations of the various dyestuffs in the dip. The behavior thus obtained of the dip can be memorized for future use and/or can be used to command appropriate corrective parameters of the dyeing process.



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

"DYEING MACHINE WITH AUTOMATIC IN-LINE DIP DEPLETION CONTROL"

The present invention relates to a dyeing machine capable
5 of automatically recording dye concentrations in the dye
dip during the process, testing their trend over time and
if necessary changing it by acting on appropriately chosen
control parameters, for example temperature, pH and so on.
The machine is designed in particular but not exclusively
10 for textile products.

In the prior art of dying machines the importance of the
so-called 'formula', that is to say the composition of the
dye dip, to achieve optimal results is well known.

Usually, dye dips are made from a composition of several
15 dyestuffs and if necessary additives in solution or aqueous
dispersion or with solvents. During the dyeing process the
various dyestuffs are often absorbed at different speeds by
the product being dyed. When one of the dyestuffs is no
longer present in the dip in sufficient quantity the dip is
20 depleted. It is therefore important to know the evolution
of the dip during the process to be able to optimize the
dip formula and to ensure good execution of the process.

In the known art, a series of samplings of the dye liquid
are usually made at intervals during a process and the
25 samples are analyzed in a laboratory to go back to the
dynamics of the concentrations of the various dyes during
the process. Since this operation is costly in terms of
time and money, it is generally performed only for one or a
few initial sample processes in order to optimize the dip

formula and the application methodology for subsequent in-line processing. During normal in-line dyeing processes dip analysis is no longer performed or is performed rarely while trusting that the dip will always hold the same behavior found at the beginning.

Unfortunately, the course of the dyestuff concentrations depends in reality on various parameters such as temperature, pH, salinity, auxiliary product quantities, circulation pump speed et cetera.

- 10 It has been proposed to monitor the behavior of the colors in the dye dip by using colored filters chosen to have a decomposition of the dip in three basic colors. But this solution proved to be very rough and unsuited to in-line use.
- 15 The general purpose of the present invention is to remedy the above mentioned shortcomings by making available a dyeing machine which would perform measurement of the dyestuff concentrations in the dip during normal processing and take the necessary corrective measures as required.
- 20 In view of this purpose it was sought to provide in accordance with the present invention a dyeing machine comprising a container in which products to be dyed are placed, a source of coloring liquids adding liquids on command into the container to realize a dye dip, and a unit
- 25 to circulate the dye dip with respect to the product characterized in that it comprises in addition a sampling and analysis device which, during the dyeing process, would automatically take liquid samples from the container at intervals and perform thereon a spectroscopic analysis and

an electronic control and calculation device receiving the spectroscopic analysis data and calculating therefrom the concentrations of the various dyes in the dip on the basis of previously memorized spectroscopic information for the individual dyes.

To clarify the explanation of the innovative principles of the present invention and its advantages compared with the prior art there is described below with the aid of the annexed drawings a possible embodiment thereof by way of non-limiting example applying said principles. In the drawings:

FIG 1 shows a diagrammatic view of a machine in accordance with the present invention, and

FIG 2 shows a diagrammatic view of a detail of the machine of FIG 1.

With reference to the figures, FIG 1 shows a textile products dyeing machine designated as a whole by reference number 10 and comprising a container 11 pressurized or not in which are placed the products to be dyed in the form of yarn, loose textile fiber, mouse ribbon or tow or bolts of cloth wound or not on cones or supports depending on the requirements of the prior art. A known liquid dyestuffs source 12 inputs on command into the container the liquids to prepare a desired dye dip which is held in circulation with respect to the product by means of a purposeful circulation unit 13, for example a pump or a product handling system.

A sampling and analysis device 14 is connected to the container to take samples of the liquid in the container at

intervals and perform a spectroscopic analysis thereon. The analysis device 14 sends the analysis data to an electronic control and calculation device, for example an appropriately programmed personal computer which after
5 receiving the spectroscopic analysis data calculates therefrom the concentrations of the various dyestuffs in the dip on the basis of previously memorized spectroscopic information on the individual dyestuffs. This information may have been supplied or purchased separately.

10 The device 14 can be limited to memorizing in a memory 16 the data on the evolution of the dip concentrations for future use or can even compare the concentrations with the depletion behavior of the dip preset for reference and take action on parameters of the process through appropriate
15 known actuators 34 (heaters, pH correctors) and by varying the dip circulation speed so as to control the absorption of the various dyestuffs by the product. For example, by reducing dip temperature, dyestuff absorption can be slowed. Corrections of the dyeing process behavior can be
20 performed automatically this way.

To expand the information on the evolution of the process the machine can also comprise known sensors 17 for detection of various preselected physical magnitudes of the dip.

25 The device 15 can correlate the measurements of the sensors 17 with the dyestuff concentrations calculated starting from the spectroscopic analysis and memorize the correlations for future analysis and optimization of the process. For example, it might be sensed that a dyestuff is

not absorbed well when the dip temperature exceeds a certain value and this could serve to optimize the behavior of temperatures in the future. The physical magnitudes detected by the sensors can advantageously comprise the temperature and pH of the dip, the speed of the recirculating pump, salinity et cetera. Correlations can also be established between the behavior of the concentrations and the addition of additives - for example, salts - so as to optimize the times of addition of these additives to the dip.

It is also very important to be able to appreciate the different profiles of depletion of the specific dyestuffs in the dye dip with variation in the surrounding parameters and the dyestuffs.

The sensors can also act as feedback for accurate control of the actuators 34.

The spectroscopic analysis device comprises a reading cell 18, a suction device 19 which fills the cell with the liquid taken from the container 11, and a spectrophotometer 20. Advantageously the sampling device is a syringe device which sucks the liquid through the cell to then return it into the container 11 after measurement. This avoids waste of liquid even with high measurement frequency.

The analysis device can also comprise circulation of washing liquid, advantageously water or having an aqueous base with appropriate additives, which could be added on command through a valve 23 (to replace the dyestuff liquid intercepted by a valve 24) and drained through a valve 25. Thus it is possible to ensure that in the reading cell

there remains no residue capable of affecting the measurements.

In addition, the water coming from the outside is necessary for calibration of the device. The spectrophotometer has
5 high resolution in the visible and is advantageously connected by optical fibers 21,22 to the reading cell 18.

FIG 2 shows diagrammatically in greater detail an advantageous embodiment of the reading cell 18. As may be seen in the figure, the reading cell has a passage 26 for
10 the liquid between one light emitting surface 27 and a reading surface 28. The surface 27 is connected through the optical fiber 21 to an appropriate light source 29 while the facing reading surface 28 is connected through the optical fiber 22 to the sensor 30 of the spectrophotometer.
15 One end of the passage 26 is connected through a duct 31 to the dip container while the other end of the passage is connected through a duct 32 to the controlled suction device 19. The detected measurement light passes thus through the liquid thickness which is formed between the
20 two faces 27 and 28 after the passage from the spectrophotometer which performs the spectroscopic analysis.

The gauge 'd' of the reading passage 26 can be changed with precision by means of the controlled movement of the
25 surface 27 by an actuator 33, for example a stepping motor. In this manner, before each measurement the control device 15 can adjust the gauge 'd' for measuring on the spectrophotometer a peak of absorbance included between minimum and maximum values predetermined to be optimal for

correct measurement. Thanks to the changeable optical path it is possible to perform the readings in the entire range of concentrations which might be of interest by adopting the best reading conditions of the instrument based on the
5 behavior in absorbance of the signal and in particular on the peak values.

Indeed, instrumental analysis of concentrations with a spectrophotometer is based on the well known law of Lambert and Beer which is applicable within a certain range of
10 absorbance proportionate to the dyestuff concentration. At high dyestuff concentrations, in addition to leaving the linearity range, instrumental reading problems can arise because of the low signal and resulting possible confusion with the instrument's background noise. In the prior art of
15 laboratory analysis it is necessary to perform a dilution and enter the resulting ratio in the calculation. This system would however be too costly to apply in an in-line automatic measurement since it is extremely difficult to obtain accurate dilutions automatically. There would also
20 be a loss of dip since it is not possible to add the sample again at the cost of changing the dip ratio or having unacceptable loss of dyestuff in small machines.

In the machine in accordance with the present invention all this is avoided by using a variable step reading probe
25 allowing the use of reading gauges of a magnitude inversely proportionate to the absorbance or proportionate to the transmittance (dyestuff concentration) of the dip.

The passage gauge is variable in a range between 0 and 25 mm and advantageously between 0 and 10 mm with steps

around 0.01 mm or even less.

The difficulty of determining the size of the gauge because of the however limited mechanical construction inaccuracies of the probe give as a result an effective minimum
5 absorbance value different from 0 and different from one instrument to another when the distance 'd' is reduced to the minimum possible quantity, i.e. when the actuator 33 is operated to take the surfaces 27,28 toward mutual contact. To avoid this, a special system allowing calculation of
10 this space and bringing back the values read to the nominal calculation values was defined. The corrected values are used to set the optimal reading step by starting the stepping motor. The reading can always be performed automatically this way in an optimal manner.

15 Since for equal liquid the relationship between absorbance and gauge is linear, to compensate for the residual space the actuator 33 is controlled by the electronic control and calculation device 15 to perform measurements on the same liquid for different 'd' gauges, for example between 0 mm
20 and 1 mm, which must give a straight line in the absorbance-gauge graph. If the gauge 0 does not correspond to the actual contact of the surfaces 27,28 the resulting straight line will not pass through the zero but will intersect the axis of the gauges at a negative point
25 corresponding to the residual gauge which can thus be calculated, memorized and used by the electronic device to compensate for the normal measurements.

This results in an indirect optical manner of calculating a mechanical gauge otherwise difficult to evaluate because of

its possible scantiness and because it is important to evaluate it with the probe assembled.

Correct calculation of this parameter always influences the results of the measurements progressively more as the measurement gauge decreases.

The parameter memorized by the electronic device remains linked to the specific measurement device.

It is now clear that the preset purposes have been achieved. During operation the machine will perform a dyeing cycle while the detected and possibly recorded data will be processed in the device 15 to find the data on concentration of the dyestuffs in the dip. The correlation of dyestuff concentrations with time, temperature, pH, salinity, pump flow rate (in dip circulation equipment) or material recirculation speed (in equipment with the goods moving), supplies data on the rising dynamics of the dyestuffs on the material being dyed (dip depletion). In addition, calculations covering the full range of wavelength measurement of the spectrophotometer with the squared minimums method as an alternative to or in combination with calculation based on neural or similar networks can be used. The system is very accurate and reliable compared with for example prior art proposals where it is attempted to analyze the liquid by means of simple colored filters.

The data taken and calculated can be used for optimization of future processing or for changing dip parameters in real time. The control device can then even take action on the process parameters by means of the above mentioned

appropriate actuators 34.

With the machine in accordance with the present invention it is possible to adjust and optimize the rise of the dyestuffs on the products to be dyed while optimizing
5 processing times, dyeing uniformity and control of dyestuff quantities drained into the sewage et cetera. It is also possible to optimize the rise of the dyestuffs on the material to be dyed by changing one of more process variables. It is also possible to have accurate indication
10 of dip depletion and the percentages of each dyestuff of the formula with each reading.

Sampling of the concentration measurements can be performed with high frequency with resulting identification of deleterious transients for the correctness and quality of
15 the dyeing process and with the capability of fast, accurate action during the process.

All this would be impossible with the costly prior art operations of dye dip sampling, laboratory control and the resulting loss of the dip portion taken. Loss of dip and
20 the need for a long laboratory tie up among other things make possible in practice only a limited number of samplings and analyses for each processing cycle and, in any case, the resulting data can serve if at all for improvement of subsequent processing but not as self-
25 adjustment of the cycle underway.

Naturally the above description of an embodiment applying the innovative principles of the present invention is given by way of non-limiting example of said principles within the scope of the exclusive right claimed here. For example,

depending on the specific dyeing processes the machine could comprise appropriate additional members and known devices for the performance of such processes.

CLAIMS

1. Dyeing machine comprising a container (11) in which products to be dyed are placed, a source (12) of coloring liquids adding liquids on command into the container to realize a dye dip, and a unit (13) to circulate the dye dip with respect to the product characterized in that it comprises in addition a sampling and analysis device (14) which during the dyeing process automatically takes liquid samples from the container at intervals and performs thereon a spectroscopic analysis, and an electronic control and calculation device (15) receiving the spectroscopic analysis data and calculating therefrom the concentrations of the various dyes in the dip on the basis of previously memorized spectroscopic information for the individual dyes.

2. Machine in accordance with claim 1 characterized in that the sampling device has an analyzed samples drain connected to the container to return the samples into the container.

3. Machine in accordance with claim 1 characterized in that the sampling and analysis device comprises a reading cell having a liquid passage with controlled variable gauge and through said gauge is made to pass a measuring light detected, after the passage, by a spectrophotometer sending the data to said electronic device which performs the spectroscopic analysis for calculation of the concentrations.

4. Machine in accordance with claim 3 characterized in

that before each measurement the gauge of said passage in the reading cell is adjusted on command by the electronic device to detect at the spectrophotometer outlet an absorbance peak included between the predetermined maximum and minimum values.

- 5 5. Machine in accordance with claim 3 characterized in that the passage gauge is adjusted on command to have a reading gauge of a magnitude inversely proportionate to the liquid absorbance.
- 10 6. Machine in accordance with claim 3 characterized in that the passage gauge is variable in a range included between 0 mm and 25 mm with steps around 0.01 mm.
7. Machine in accordance with claim 3 characterized in that the passage in the reading cell is connected on one
15 side to said container and on the other side to a controlled suction device for sucking liquid from the container to the cell and vice versa.
8. Machine in accordance with claim 7 characterized in that the suction device is a syringe aspirator.
- 20 9. Machine in accordance with claim 1 characterized in that it comprises dip physical magnitude detection sensors whose measurements are sent to an electronic device which correlates said measurements with the concentrations calculated by the spectroscopic analysis.
- 25 10. Machine in accordance with claim 9 characterized in that the physical magnitudes detected include one or more magnitudes chosen from among temperature, pH and salinity of the dip and speed of circulation of the dip with respect to the product.

11. Machine in accordance with claim 1 characterized in that the electronic device which receives the spectroscopic analysis data and calculates therefrom the concentrations of the various dyestuffs in the dip compares the calculated
5 concentrations with a preset behavior in time and commands dyeing parameters on the basis of the results of the comparison.

12. Machine in accordance with claim 11 characterized in that the dyeing parameters include one of more magnitudes
10 chosen from among temperature, pH and salinity of the dip and circulation speed of the dip with respect to the product.

13. Machine in accordance with claim 3 characterized in that during a phase of the spectroscopic analysis device
15 said device is commanded by the electronic control and calculation device to perform a series of measurements of absorbance of the liquid with different gauge of said passage with the electronic device calculating a gauge-absorbance line identified by the series of measurements
20 and memorizing as residual gauge the intersection of said line with the axis of the gauges with the residual gauge being subsequently used by the electronic device for correcting the gauges used in subsequent measurements.

14. Machine in accordance with claim 3 characterized in
25 that during a phase of the spectroscopic analysis device said device is commanded by the electronic control and calculation device to reduce to the minimum the gauge of said passage and measure the absorbance of a liquid remaining in the residual gauge with said absorbance

measurement being memorized by the electronic device and used subsequently for correcting the subsequent measurements by said residual gauge.

15. Machine in accordance with claim 3 characterized in
5 that it comprises a circuit for controlled inlet and extraction of a washing liquid in the reading cell.

16. Machine in accordance with claim 13 characterized in that the washing liquid is water or water based with additives.

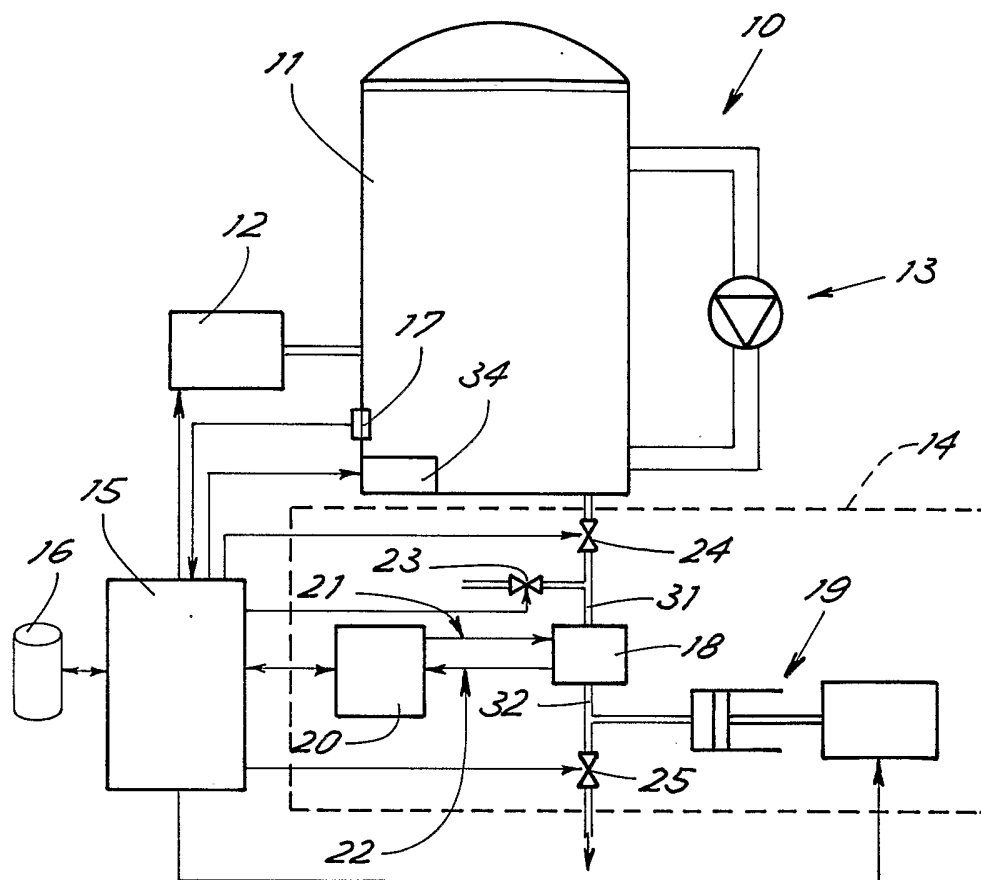


Fig. 1

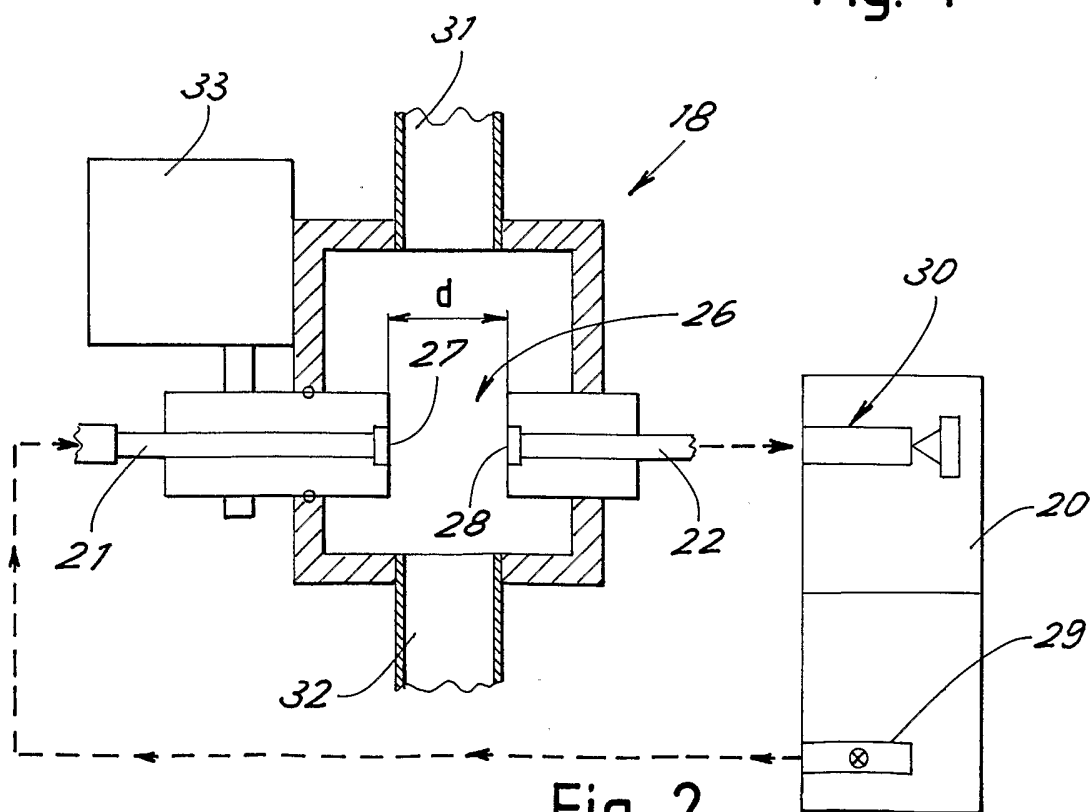


Fig. 2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 03/05285

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 D06B23/28 G01N21/85

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 D06B G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	claims 1, 4, 5, 8 ---	14
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Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

° Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
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- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *Z* document member of the same patent family

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INTERNATIONAL SEARCH REPORT

Int nal Application No

PCT/EP 03/05285

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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