

Description

[0001] The present invention relates to a method and closed circuit machine for washing and/or drying products.

[0002] The method and machine according to the present invention are designed for washing and drying any type of product, such as fabrics, metal and non-metal objects, etc.

[0003] Products are often washed with solvents, for example, hydrocarbons, which are flammable. The concentration of the flammable solvent in the air/solvent mixture inside the washing drum during drying of the products washed may exceed what is known as the "lower explosion limit, or "LEL".

[0004] A first possibility for preventing the air/solvent mixture in the drum from igniting or exploding is to reduce the concentration of oxygen O₂ in the mixture by introducing an inert gas, such as N₂, into the drum during drying. This method is disadvantageous due to the cost of the inert gas.

[0005] The use of an inert gas would also necessitate further specific elements in the machine, and so would increase the costs of the machine itself.

[0006] A second possibility for preventing the air/solvent mixture in the drum from igniting or exploding is to keep the temperature of the air/solvent mixture in the drum below a safety level, for example 15°C below what is known as the "flash point" of the solvent.

[0007] Methods of this type are known, as described in the preamble to claim 1, which for regulating the temperature and concentration of the air/solvent mixture in the drum during drying envisage continuous measurement of the solvent concentration and the temperature of the air/solvent mixture at the outfeed of and/or inside the machine drum. These continuously measured parameters are processed by a computer so as to regulate, on the basis of this data, the heat supplied to the drum and, therefore, indirectly or directly, the temperature and concentration in the drum.

[0008] One disadvantage of these known systems is that the measurement of the solvent concentration in the air/solvent mixture is complicated and is not always completely reliable because the precision of the measurement of the concentration largely depends on the external conditions in the measuring area. In areas with turbulent currents, as in this case inside and at the outfeed of the drum, it is quite possible that the actual maximum values in the control zone are not measured.

[0009] Measurement of the solvent concentration at a single point in the drum and/or at the drum outfeed is insufficient, since conditions are extremely turbulent and so uneven. Measurement of the concentration at a plurality of points inside and/or at the outfeed of the drum is also insufficient, since in a turbulent area it is impossible to pre-establish fixed measuring points for maximum solvent concentrations.

[0010] As a result, it is practically impossible to meas-

ure and control the solvent concentration of the air/solvent mixture inside and/or outside the drum with absolute certainty and reliability.

5 [0011] The aim of the present invention is, therefore, to overcome the above-mentioned disadvantages by providing a closed circuit method for washing and/or drying products.

[0012] A further aim of the present invention is to provide a simple, safe and reliable machine which efficiently implements the method according to the present invention.

10 [0013] The technical features of the present invention, in accordance with the above aims, are apparent in the claims herein, and the advantages are more clearly described in the detailed description below, with reference to the accompanying drawing, which illustrates an embodiment of the invention, without limiting the scope of its application, illustrated in the single schematic accompanying drawing of a product washing and drying machine.

15 [0014] With reference to the accompanying drawing, the present invention relates to a method for washing and/or drying products 20 in a closed circuit machine, labelled 1 as a whole.

20 [0015] The products 20, which may be, for example, clothes (labelled 20), fabrics, metal or non-metal objects (labelled 20'), or any other type of products, may be placed in the machine 1 washing zone 2, which in this case takes the form of a washing drum 2, be washed with solvents, for example, flammable hydrocarbons, then dried with hot air in the drum 2. Obviously, the drum 2 may be used for drying only, whilst the washing is done in another machine.

25 [0016] According to the method disclosed by the present invention, the temperature T2 and, therefore, the solvent concentration C2, of the air/solvent mixture in the drum 2 are permanently regulated in an indirect manner during the entire product 20, 20' drying stage on the basis of the actual values of the evaporation pressure P1, measured inside the low pressure zone of the cooling circuit which constitutes the machine 1 condenser 5, and/or the temperature T1 of the air or the air/solvent mixture measured at the infeed 3 of the drum 2. This prevents the temperature T2 and, therefore, the solvent concentration C2, of the air/solvent mixture inside the drum 2 from exceeding the safety limit of the lower flash point.

30 [0017] The actual values of the evaporation pressure P1 and the temperature T1 of the air/solvent mixture at the infeed 3 of the drum 2 are kept below a preset nominal value. If the actual value of the evaporation pressure P1 and/or the temperature T1 exceed the relative preset nominal value, the heat necessary to dry the products 20, 20' is automatically reduced (or, in extreme cases, interrupted) to prevent the temperature T2 and, therefore, the concentration C2 inside the drum from exceeding the safety limit of the lower flash point.

35 [0018] The temperature T1 of the mixture is therefore

measured at the infeed 3 of the drum 2 in order to regulate the amount of heat supplied to the drum 2 and used to extract the solvent from the products 20, 20' in the drum 2 by evaporation.

[0019] The evaporation pressure P1 is measured in order to control the condensing of the solvent evaporated from the products 20, 20' inside the drum 2. A further control may be envisaged by measuring the actual value of the temperature T3 of the air/solvent mixture at the outfeed 4 of the drum 2. The actual value of the temperature T3 of the air/solvent mixture must be below a preset upper limit and above a preset lower limit. If the temperature T3 is above the preset upper limit or below the preset lower limit, the heater 7 is automatically switched off, to prevent the temperature T2 and, therefore, the concentration C2, in the drum from exceeding the safety limit of the lower flash point.

[0020] In accordance with the present invention, the temperature T6 of the mixture can also be measured downstream of the condenser 5 outfeed and upstream of the machine 1 heat pump 6 infeed, to check and indirectly control the operation and status of the condensing process.

[0021] The machine 1 heater 7 can only be started for product 20, 20' drying when the actual value of the evaporation pressure P1 is below a preset nominal value.

[0022] Before being started, the machine 1 is calibrated, that is to say, the nominal values are set on the basis of the solvent concentration C3 in the air/solvent mixture measured at the outfeed 4 of the drum 2 in all possible operating conditions.

[0023] The solvent concentration C3 in the air/solvent mixture at the outfeed 4 of the drum 2 is always kept below the safety limit of the solvent lower explosion limit by adjusting the evaporation pressure P1 of the condenser 5.

[0024] In a preferred embodiment, the actual values T1, P1, T3, T6 of the parameters measured during drying of the products 20, 20' washed with the solvent are controlled using comparison means 17, for example, a control unit 17 which stores the preset nominal values.

[0025] When, during product 20, 20' drying, the control unit 17 detects that the condenser 5 evaporation pressure P1 is above the preset nominal value, or the actual temperature value T1 at the infeed of the drum 2 is above the preset nominal temperature, or the temperature T3 at the outfeed 4 of the drum 2 is above the preset nominal value, the machine 1 drying process is automatically interrupted or stopped.

[0026] The present invention also relates to a closed circuit machine for washing and/or drying products according to the above-mentioned method.

[0027] The accompanying drawing schematically illustrates the machine 1 disclosed, which comprises a washing drum 2, in which the products 20, 20' can be washed with a flammable solvent (not illustrated), for example, hydrocarbons, then dried using hot air to extract the solvent from the products 20, 20' in the drum 2 by

evaporation.

[0028] Moreover, the machine 1 is equipped with means 12, for example, located downstream of the heat pump 6 and upstream of the heater 7, for the forced circulation of the air/solvent mixture (see arrows in the figure) during product 20, 20' drying. Said means 12, of the known type and so not described in detail, may be one or more fans 12 located at any point in the air circuit.

[0029] Downstream of the outfeed 4 of the drum 2, within the machine 1 closed circuit, there is a condenser 5, to which an air/solvent mixture from the drum 2 is directed, in order to condense at least part of, and preferably most of the evaporated solvent. There is also a heat pump 6 which preheats the air containing a reduced solvent concentration or no solvent at all, and a heater 7 for heating the air, to be fed to the drum 2 again at a temperature T1 sufficient to extract the solvent from the products 20, 20' in the drum 2 by evaporation.

[0030] The condenser 5, heat pump 6 and heater 7 are of the known type and so are not described in detail. At the outfeed 4 of the drum 2 there is a first temperature control, preferably using a thermostat 9 to measure the actual temperature T3 of the air/solvent mixture during product 20, 20' drying.

[0031] According to the present invention, the machine 1 is fitted with a pressure gauge 13, designed to measure the actual evaporation pressure P1 values of the condenser 5. The control unit 17 is designed to compare the actual evaporation pressure P1 values of the condenser 5 and the temperature T3 of the air/solvent mixture at the outfeed 4 of the drum 2, measured during product 20, 20' drying, with relative preset nominal values. If at least one of said actual values is above the relative preset nominal value, the control unit 17 automatically stops product 20, 20' drying.

[0032] Moreover, the control unit 17 is designed to automatically stop product 20, 20' drying when, after a given period has elapsed, the actual temperature value T3 is below a second preset nominal value which defines the lower limit for the temperature T3. This is because, after an unsuitable centrifuge cycle, inside the drum 2 at the start of the product 20, 20' drying stage the drum 2 may contain too much solvent. As a result, the value T3 measured at the outfeed 4 of the drum 2 would be too low.

[0033] Moreover, the control unit 17 can automatically stop product 20, 20' drying when the actual evaporation pressure value P1 is below a second preset nominal value which defines a lower limit for said pressure P1. This may occur when the condenser 5 contains no coolant. As a result, the pressure value P1 measured in the condenser 5 cooling circuit would be too low.

[0034] During the normal drying stage, the machine 1 therefore operates only when the respective condenser 5 actual evaporation pressure value P1, temperature value T1 and temperature value T3 are not above the preset nominal values.

[0035] The machine 1 preferably has a second ther-

mostat 16 for measuring the temperature T6 of the mixture downstream of the condenser 5 and, therefore, before the infeed of the heat pump 6, so as to indirectly control the operation and status of the condenser 5 and the ventilation system 12.

[0036] During machine 1 calibration, the machine 1 made according to the present invention has a sensor 10, 11 for measuring the solvent concentration C1, C3 in the air/solvent mixture at the infeed 3 and outfeed 4 of the drum 2, in order to preset the nominal values such as the condenser 5 evaporation pressure P1 and the temperature T3 of the air/solvent at the outfeed 4 of the drum 2.

[0037] The solvent concentration C1 in the air/solvent mixture at the infeed 3 of the drum 2 is, obviously, significantly lower than the solvent concentration C2 at the outfeed 4 of the drum 2, since the condenser 5 condenses at least part of the evaporated solvent in the air from the drum 2. In a preferred embodiment, downstream of the condenser 5 and upstream of the heat pump 6, there is a solvent filter element which increases the condensation, labelled 14 as a whole, with which the concentration of the solvent in the air/solvent mixture from the condenser 5 can be further reduced.

[0038] The filter element 14 consists of at least one wire (not illustrated), constituting a mechanical barrier designed to prevent drops of solvent from passing through the filter element 14 by causing the drop of solvent to stick to one or more portions of the wire in the filter element 14.

[0039] The filter element 14 may consist of at least one wire wound in a disorderly way, forming an irregular surface designed to cause the solvent in the air/solvent mixture to condense, and irregular gaps which allow the passage of air from the condenser 5 to the heat pump. The condenser 5 is preferably designed to cool the filter element 14 as well. The irregular surface of the wire extends in a disorderly way on various planes and is three-dimensional.

[0040] According to an alternative embodiment, not illustrated, the filter element 14 may also consist of at least one wire wound in an orderly way, forming a regular surface designed to cause the solvent in the air/solvent mixture to condense, and gaps for the passage of the air. In this case, the regular surface of the wire extends in an orderly way on various planes and is three-dimensional.

[0041] The filter element 14 preferably consists of at least one tape-shaped stainless metal wire.

[0042] The filter element 14 makes it easy to obtain an air/solvent mixture with a solvent concentration that is lower than that in the mixture arriving from the condenser 5 alone.

[0043] The solvent condensed in the condenser 5 and/or filter element 14 is carried to a separator 18 then stored in a solvent collection tank 15.

[0044] The method and the machine according to the present invention, therefore, have a system designed to

control and regulate the temperature T2 and, indirectly, the solvent concentration C2 in the drum 2 in a simple, precise, reliable way.

[0045] In accordance with the present invention, it is sufficient to directly control the condenser 5 actual evaporation pressure value P1 using the pressure gauge 13, and the temperatures T1 and T3 of the air/solvent mixture at the infeed 3 and outfeed 4 of the drum 2 using the thermostats 8 and 9, in order to check that the machine 1 is functioning correctly during drying of the products 20, 20' previously washed with the flammable solvent in the drum 2.

[0046] If the condenser 5 is not operating correctly, the actual evaporation pressure value P1 is above the nominal value preset during machine 1 calibration, and the control unit 17 automatically stops the drying process to prevent it from exceeding the lower explosion limit and/or flash point of the solvent in the drum 2.

[0047] A fault in the heat pump 6 and/or heater 7, if for example they failed to heat the air to be supplied to the drum 2 sufficiently, would cause a temperature T1 which is too low at the drum 2 infeed, meaning that the nominal concentration and temperature values in the drum 2 cannot be exceeded.

[0048] Incorrect functioning of the fans 12, if for example the actual air flow rate value were too low, would cause overheating of the air in the heat pump 6, which acts as a pre-heater, and in the heater 7. The temperature T1 of the air/solvent mixture at the infeed 3 of the drum 2 would, therefore, be too high, and the control unit 17 would automatically stop the drying process, for example by stopping the fan 12 and/or switching off the heat pump 6 and heater 7.

[0049] In the latter case, a second control may be envisaged, using the thermostat 16 which measures the temperature T6 of the air upstream of the heat pump 6, to check, before the infeed 3 of the drum 2, whether there is any unacceptable rise in the actual air temperature.

[0050] The temperature T1 at the infeed 3 of the drum 2 is then measured by the thermostat 8, to prevent overheating of the air supplied to the drum 2, and to regulate the amount of heat supplied to the drum 2 in order to extract the solvent from the products 20, 20' by evaporation.

[0051] Again for the purpose of safety, as regards machine functioning, particularly during drying, two thermostats 8 and two thermostats 9 are preferably used at the infeed and outfeed 4 of the drum 2.

[0052] The present invention may be subject to numerous variations, all encompassed by the original design concept. Moreover, all parts may be substituted with technically equivalent elements.

Claims

1. A method for washing and/or drying products in a

closed circuit machine (1), in which the products (20, 20') are placed in a washing drum (2) in the machine (1) and washed with a solvent then dried with hot air in the drum (2), and in which the temperature (T2) of the air/solvent mixture in the drum (2) is regulated during the drying stage, the method being characterised in that it envisages regulation of the temperature (T2) of the air/solvent mixture in the drum (2) during the drying of the products (20, 20'), according to the actual evaporation pressure values (P1) measured in a low pressure zone of a cooling circuit, the latter constituting a condenser (5) in the machine (1), and/or the air or air/solvent mixture temperature (T1) measured at the infeed (3) of the drum (2).

2. The method according to claim 1, characterised in that the actual condenser (5) evaporation pressure (P1) value and/or the temperature (T1) of the air/solvent mixture at the infeed (3) of the drum (2) is kept below a preset nominal value, in this way indirectly regulating the temperature (T2).

3. The method according to claim 2, characterised in that the nominal value of the temperature (T1) of the air/solvent mixture at the infeed (3) of the drum (2) is preset at a level which keeps the solvent concentration (C2) in the drum (2) below the lower explosion limit safety level.

4. The method according to any of the foregoing claims from 1 to 3, characterised in that the temperature (T6) of the mixture is measured downstream of the condenser (5) outfeed and upstream of the machine (1) heat pump (6) infeed, for indirectly checking the operation and status of the condenser (5).

5. The method according to any of the foregoing claims from 1 to 4, characterised in that the temperature (T3) of the mixture is also measured at the outfeed (4) of the drum (2).

6. The method according to any of the foregoing claims from 1 to 5, characterised in that the actual values of the solvent concentration (C1, C3) in the air/solvent mixture at the infeed (3) and outfeed (4) of the drum (2) are measured, the machine (1) is calibrated and the nominal values are preset according to the solvent concentration values (C1, C3) measured.

7. The method according to claim 6, characterised in that the solvent concentration (C3) in the air/solvent mixture at the outfeed (4) of the drum (2) is always kept below the solvent lower explosion limit, by regulating the temperature (T1) of the air or the air/solvent mixture measured at the infeed (3) of the drum

(2).

8. The method according to any of the foregoing claims from 1 to 7, characterised in that a control unit (17) compares the actual values (P1, T1, T6) of the parameters measured during drying of the products (20, 20'), previously washed with the solvent, with preset nominal values, automatically stopping the drying process when at least one of the actual values (P1, T1, T6) is above the relative preset nominal value.

9. The method according to any of the foregoing claims from 1 to 7, characterised in that a control unit (17) compares the actual temperature value (T3) of the mixture measured at the outfeed (4) during drying of the products (20, 20'), previously washed with the solvent, with a preset upper nominal value and a preset lower nominal value, automatically stopping the drying process when the actual temperature value (T3) is above the preset upper nominal value or below the preset lower nominal value.

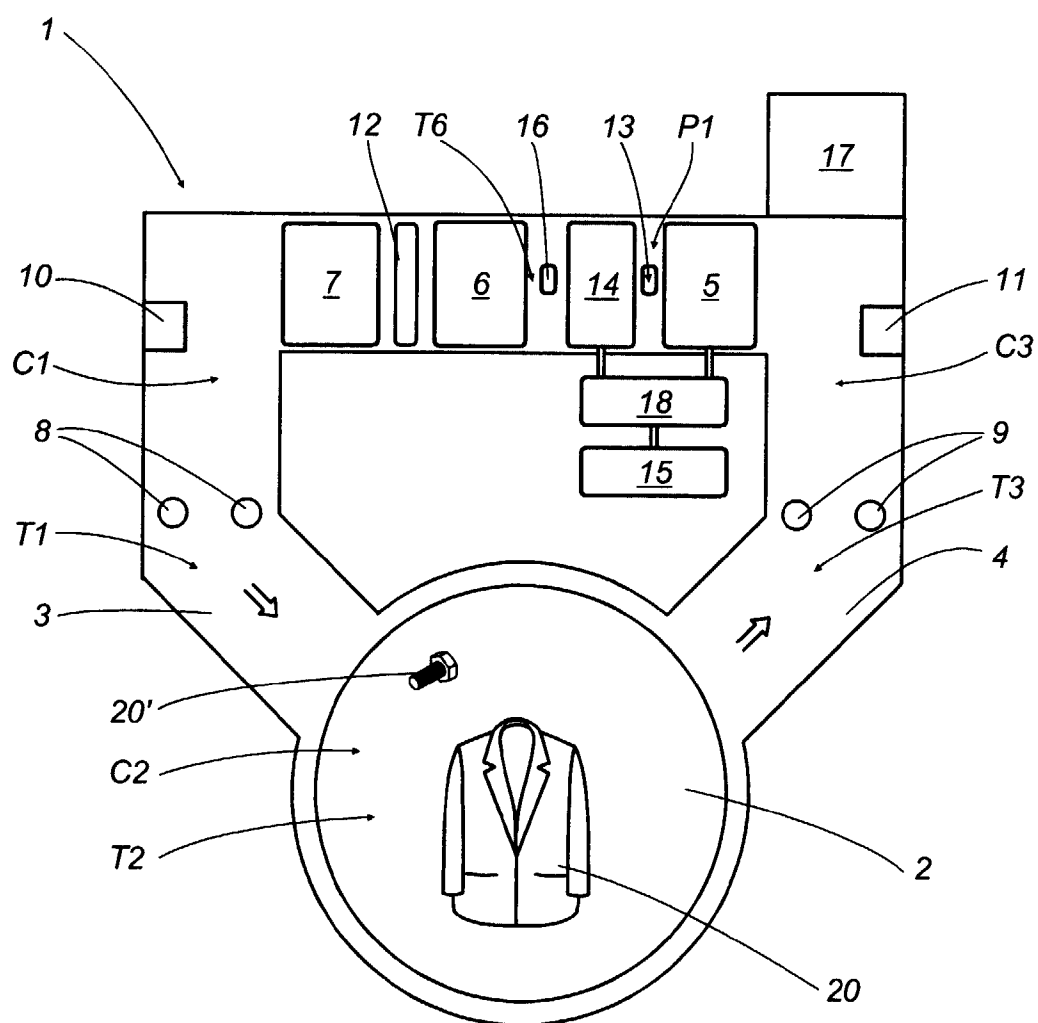
10. A closed circuit machine for washing and drying products according to the method described in claim 1, said machine (1) having a washing drum (2), in which the products (20, 20') can be washed with a solvent and/or then dried with hot air, thus extracting the solvent from the products (20, 20') in the drum (2) by evaporation, means (12) for the forced circulation of an air/solvent mixture during product (20, 20') drying, a condenser (5) for condensing the solvent from the mixture, and a thermostat (8) for measuring the actual temperature value (T1) of the mixture at the infeed (3) of the drum (2), the machine being characterised in that it is fitted with a pressure gauge (13), being designed to measure the actual evaporation pressure values (P1) in a low pressure zone of a cooling circuit, the latter constituting the condenser (5), and means (17) for comparing the actual parameter values measured during product (20, 20') drying with a relative preset nominal value.

11. The machine according to claim 10, characterised in that the comparison means consist of a control unit (17) designed to automatically stop the product (20, 20') drying process when at least one of the actual values is above the relative preset nominal value.

12. The machine according to claim 11, characterised in that the preset nominal value of the temperature (T1) of the air/solvent mixture at the infeed (3) of the drum (2) is such that it keeps the solvent concentration (C2) in the drum (2) below the lower explosion limit safety level.

13. The machine according to any of the foregoing claims from 10 to 12, characterised in that it comprises a thermostat (16) to measure the temperature (T6) of the mixture downstream of the condenser (5) outfeed and upstream of a machine (1) heat pump (6) infeed, in this way indirectly controlling the operation and status of the condenser (5). 5
14. The machine according to any of the foregoing claims from 10 to 13, characterised in that it comprises a thermostat (8) to measure the temperature (T3) of the mixture at the outfeed (4) of the drum (2), so as to regulate the amount of heat to be supplied to the drum (2). 10
15. The machine according to any of the foregoing claims from 10 to 14, characterised in that it comprises a sensor (10, 11) to measure the solvent concentration (C1, C3) in the air/solvent mixture at the infeed (3) and outfeed (4) of the drum (2) during machine (1) calibration, so as to preset the nominal values. 15
16. The machine according to any of the foregoing claims from 10 to 15, characterised in that it is fitted with a separator (18), being located downstream of the condenser (5), for the storage of the condensed solvent. 25
17. The machine according to any of the foregoing claims from 10 to 16, characterised in that downstream of the condenser (5) and upstream of the heat pump (6) there is a filter element (14), for filtering the solvent by condensing it, being designed to further reduce the solvent concentration in the air/solvent mixture arriving from the condenser (5). 30 35
18. The machine according to claim 17, characterised in that the filter element (14) consists of at least one wire, forming a mechanical barrier designed to prevent drops of solvent from passing through the filter element (14) by causing the drop of solvent to stick to one or more portions of the wire in the filter element (14). 40 45
19. The machine according to claim 17 or claim 18, characterised in that the wire of the filter element (14) is wound in a disorderly way, forming an irregular surface designed to cause the solvent in the air/solvent mixture to condense, and having gaps for the passage of the air, and also being characterised in that the condenser (5) is designed to cool the wire. 50
20. The machine according to claim 19, characterised in that the irregular surface of the wire extends in a disorderly way on various planes and is three-dimensional. 55
21. The machine according to claim 17 or claim 18, characterised in that the wire of the filter element (14) is wound in an orderly way, forming a regular surface designed to cause the solvent in the air/solvent mixture to condense, and having gaps for the passage of the air, and also being characterised in that the condenser (5) is designed to cool the wire.
22. The machine according to claim 21, characterised in that the regular surface of the wire extends in an orderly way on various planes and is three-dimensional.
23. The machine according to any of the foregoing claims from 17 to 22, characterised in that the wire is made of a stainless metal and is tape-shaped.
24. The machine according to any of the foregoing claims from 10 to 23, characterised in that a sensor (10) is envisaged at the infeed (3) of the drum (2), there also being a sensor (11) at the outfeed (4) of the drum (2), designed to measure the solvent concentration (C2) in the air/solvent mixture during machine (1) calibration.

FIG. 1





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 83 0283

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.6)
X	US 5 367 787 A (IKEDA TOMOHIKO ET AL) 29 November 1994 (1994-11-29)	1,10	D06F43/08
Y	* column 8; claims; figures * ---	17-23	
X	US 5 689 848 A (SAAL HANS-UDO ET AL) 25 November 1997 (1997-11-25)	1,10	
Y	* abstract; figure 2 * ---	17-23	
A	FR 2 476 160 A (MAESTRELLI SPA) 21 August 1981 (1981-08-21)	1,10	
Y	* page 4, line 3 - line 25; figures * ---	17-23	
A	US 3 949 485 A (FUHRING HEINRICH ET AL) 13 April 1976 (1976-04-13)	1,10	TECHNICAL FIELDS SEARCHED (Int.Cl.6) D06F
	* abstract; claims 13,14; figure 1 * * column 2, line 55 - line 68 * ---	1,10	
A	PATENT ABSTRACTS OF JAPAN vol. 018, no. 058 (C-1159), 31 January 1994 (1994-01-31)	1,10	
	& JP 05 277287 A (SANYO ELECTRIC CO LTD), 26 October 1993 (1993-10-26)	1,10	
	* abstract; figure * ---	1,10	
A	EP 0 679 754 A (SOLBACH LUTZ) 2 November 1995 (1995-11-02)	1,10	
	* claims; figure 2 * ---	1,10	
A	EP 0 053 727 A (MULTIMATIC MASCH) 16 June 1982 (1982-06-16)	1,10	
	* figures * -----		
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 23 August 1999	Examiner Debard, M
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category 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 L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03/82 (F04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 99 83 0283

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

23-08-1999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5367787 A	29-11-1994	JP 6098991 A	12-04-1994
US 5689848 A	25-11-1997	DE 29521540 U	12-06-1997
		EP 0767267 A	09-04-1997
		JP 9173690 A	08-07-1997
FR 2476160 A	21-08-1981	BE 887166 A	14-05-1981
		GB 2069541 A,B	26-08-1981
US 3949485 A	13-04-1976	DE 2242632 A	07-03-1974
		FR 2198612 A	29-03-1974
		GB 1436133 A	19-05-1976
		JP 49060044 A	11-06-1974
JP 05277287 A	26-10-1993	NONE	
EP 0679754 A	02-11-1995	DE 4414324 A	26-10-1995
		DE 59503660 D	29-10-1998
		ES 2124929 T	16-02-1999
EP 0053727 A	16-06-1982	DE 3044331 A	16-06-1982
		JP 57117896 A	22-07-1982