(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 249 467**
**A1**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 87305154.4

(22) Date of filing: 10.06.87

(51) Int. Cl.⁴: **F 28 D 15/02**
F 25 B 23/00

(30) Priority: 11.06.86 GB 8614232

(43) Date of publication of application: 16.12.87 Bulletin 87/51

(84) Designated Contracting States: AT BE CH DE ES FR GB GR IT LI LU NL SE

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(54) **Evaporative cooling system.**

(57) A closed circuit evaporative cooling system for cooling a building containing telephone equipment in which the temperature of the equipment controls the cooling system rather than the ambient temperature. The system has a heat exchanger 1 within the building and a condenser comprising an external heat exchanger 2 mounted above the roofline 3 of the building. The flow of coolant between the internal heat exchanger 1 and the external heat exchanger 2 via conduits 5 and 6 is controlled by a pressure-sensitive valve 7. The valve 7 operates to permit flow of the liquid coolant when the pressure in the system rises above a preset level.

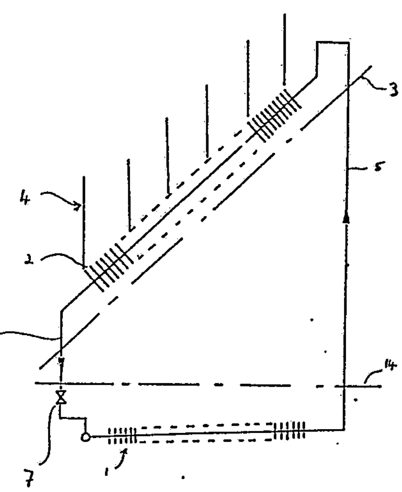


FIG. 1

EP 0 249 467 A1

## Description

# EVAPORATIVE COOLING SYSTEM

This invention relates to evaporative cooling systems, of the closed circuit kind, in which a liquid coolant is evaporated in a heat exchanger, and condensed in a condenser remote from the heat exchanger. The invention has particular application to heat exchangers for the cooling of buildings, such as buildings containing automatic telephone equipment, although the invention finds application also in other circulatory heating or cooling systms, for example dry cooling towers.

In a number of applications, cooling systems are required which function only when the ambient temperature is above a particular level, or when the temperature of that which is to be cooled rises above a particular level. We have now found that very effective control of such systems can be obtained by providing in the system a pressure-sensitive valve for increasing or restricting the flow of coolant, in response to the pressure of coolant in the system.

In accordance with the invention, a closed evaporative heating or cooling system comprises an evaporator, for example a heat exchanger in a building cooling system for extracting heat from a first location, and causing evaporation of a liquid coolant in the evaporator, a condenser remote from the evaporator, for condensing coolant vapour to liquid form, means, for example a first conduit, for returning liquid coolant from the condenser to the evaporator, characterised in that the system comprises a pressure-sensitive valve for sensing the pressure of coolant in the system, and for controlling the flow of coolant through it, and therefore in the system in response to the coolant pressure.

Although, as indicated above, the means for passing coolant vapour to the evaporator, and the means for returning liquid coolant to the evaporator may preferably be separate conduits, they may, in an alternative embodiment of the invention, be constituted by the same conduit, with, for example coolant vapour rising up the central part of the conduit and liquid coolant being returned to the evaporator down the walls of the conduit, as in a conventional "heat pipe".

The arrangement is preferably such that the pressure-sensitive valve is adapted to open to allow an increased flow of coolant, an increase of coolant pressure. An advantage of using a pressure-sensitive valve is that a system having no external power requirements may be constructed.

In one embodiment, the valve may be arranged to operate such that the temperatures of the heat exchange surfaces in the system do not fall substantially below 0°C, in order to reduce icing. In alternative embodiments, the system may be arranged so as to shut down at other temperatures, for example 20°C.

The coolant utilised is preferably one which has a wide variation in vapour pressure, within the range of temperatures likely to be encountered (for example -12 to 40°C, in a typical installation for cooling the interior of a building). It is also desirable that, over this range, the vapour pressure of the coolant should be in excess of one bar, preferably at least 2 bar, so that, in the event of any leak occuring in the system, the result is a detectable loss of refrigerant, rather than an ingress of non-condensible gas. It is further desirable that, at the highest temperature which the system is likely to reach in use, the vapour pressure of the coolant is not excessive, for example does not exceed ten bar. Specifically, it is desirable that the vapour pressure of the coolant over the temperature range -12 to 40°C is greater than one bar, preferably from two to ten bar. It has been found that dichlorodifluoromethane is particularly suitable for use at temperatures in the range of 0 to 30°C.

In order that the pressure of coolant should be a suffciently sensitive indicator of temperature, it is important that the amount of coolant in the system is sufficient that, at the temperature corresponding to the operating pressure of the flow restrictor, liquid coolant is still present in the evaporator. This ensures that the coolant pressure within the system is, in effect, the saturated vapour pressue of the coolant.

A number of preferred embodiments of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a schematic representation of a cooling system in accordance with the invention, installed in a building housing electronic equipment,

Figure 2 is a schematic diagram of a thermosiphon in accordance with the invention, and

Figure 3 represents a conventional pressure-sensitive valve, suitable for use in a system in accordance with the invention.

Referring first to Figure 1, a cooling system for a building housing automatic telephone equipment includes an evaporator consisting of a heat exchanger 1 within the building, and below the ceiling line 14, and a condenser comprising an external heat exchanger 2. External heat exchanger 2 is mounted above the roof line 3 of the building, and is shaded from direct sunlight by a shading matrix 4, mounted on the roof of the building.

A conduit 5 connects internal heat exchanger 1 with external heat exchanger 2 to enable the passage of vapour from internal heat exchanger 1 to external heat exchanger 2. A return conduit 6 is provided to return liquid coolant to internal heat exchanger 1. A pressure-sensitive control valve 7 is provided in the system to control the flow of liquid coolant to internal heat exchanger 1.

The system is arranged such that temperature of the automatic telephone equipment controls the cooling system, rather than ambient temperature. For this reason the amount of coolant in the system is such that on shut down (determined by the higher of the ambient and internal temperatures) liquid will migrate to the cooler heat exchanger (generally the external heat exchanger) which will be completely filled with coolant and thus its heat transfer surface will be blanketed by liquid coolant. Excess liquid remains in the evaporator (internal heat exchanger) and it is the temperature of this heat exchanger which determines the vapour pressure and hence start up of the cooling system.

The structure of the pressure-sensitive control valve is illustrated in more detail in Figure 3, and will be described hereinafter.

The valve 7 operates to permit flow of the liquid coolant when the pressure in the system, represented by the vapour pressure of the coolant, rises above a pre-set level. Thus if, for example, the ambient temperature falls below freezing, such that icing of heat exchange surfaces is likely to arise, control valve 7 closes, to restrict or completely prevent coolant flow.

An alternative embodiment of the invention is illustrated in Figure 2, which is a schematic diagram of a thermosiphon in accordance with the invention, such as might be used for example in a cooling tower.

The system of Figure 2 includes evaporator 10, and a condenser 12, and operates generally in the same manner as a conventional heat pipe, except that a pressure-sensitive valve 13 is provided between the evaporator 10 and the condenser 11. In Figure 2, the arrows 15 and 16 represent heat into the evaporator 10 and heat out of condenser 11, respectively. The pressure-sensitive valve 13 operates to close progressively the pipe 12 as coolant pressure in the pipe decreases. This restricts both the flow of liquid coolant, and coolant vapour, and limits the heat flow along the pipe. As the temperature of evaporator 11 rises, so does the vapour pressure of coolant in the pipe 12, resulting in opening of the valve 13, and increased coolant flow. The pressure-sensitive valve 13 has a continuous spectrum of operating conditions from fully open to fully closed, and preferably is capable of adjustment such that the degree to which the valve is open, for any given pressure, may be adjusted. By this means, variable temperature control can be achieved.

It is a particular advantage of the system in accordance with the invention that the pressure-sensitive valve may be provided at any point within the system, because the flow rates in a typical system will be such that pressure is essentially constant throughout.

Furthermore, in a system such as illustrated in Figure 1 a single pressure-sensitive valve may be provided in a system including several heat exchangers and/or several condensers, by providing a manifold to connect together the said condensers and/or heat exchangers, if desired.

Alternatively and preferably, a control valve may be provided for each evaporator/condenser pair, so as to allow staged operation with increasing cooling capacity as the need requires, and to facilitate maintenance.

Figure 3 illustrates a typical pressure-sensitive valve for use in a system in accordance with the invention. The pressure-sensitive valve includes an inlet 20 and an outlet 21 for coolant, and a diaphragm 22 which co-operates with a seat 23 to check the flow of coolant through the valve. Diaphragm 22 is connected to a helical spring 24 by means of an intermediate member 25. Thus, when the pressure of the fluid in the body valve is greater than a predetermined value, the valve opens to allow passage of coolant.

Clearly a wide range of other embodiments are possible, within the scope of the present invention.

## Claims

1. A closed evaporative heating or cooling system, comprising an evaporator for extracting heat from a first location, and causing evaporation of a liquid coolant in the evaporator, a condenser remote from the evaporator, for condensing coolant vapour to liquid form, means for passing coolant vapour from the evaporator to the condenser, and means for returning liquid coolant from the condenser to the evaporator, characterised in that the system comprises a pressure-sensitive valve for sensing the pressure of coolant in the system, and for controlling the flow of coolant through it and therefore in the system, in response to the coolant pressure.

2. A system as claimed in Claim 1, wherein the means for passsing coolant vapour from the evaporator to the condenser, and the means for returning liquid coolant to the evaporator comprise, respectively first and second conduits.

3. A system as claimed in Claim 1, wherein the means for passsing coolant vapour from the evaporator to the condenser, and the means for returning liquid coolant to the evaporator are together constituted by a single conduit.

4. A system as claimed in any one of the preceding claims, in which the pressure-sensitive valve is adapted to open to allow an increased flow of coolant, on increase of coolant pressure.

5. A system as claimed in any one of the preceding claims, wherein the coolant has a vapour pressure in excess of one bar, at temperatures in the ranges -12 to 40° C.

6. A system as claimed in Claim 5 wherein the coolant is dichlorodifluoromethane.

7. A system as claimed in any one of the preceding claims, wherein the pressure-sensitive valve is arranged to operate such that the temperature of the heat exchange surfaces in the system do not fall substantially below 0° C.

8. A building housing telecommunications equipment, equipped with a cooling system as claimed in any one of the preceding claims.

9. A method of providing cooling for a building housing electronic apparatus, comprising providing the building with a cooling system as claimed in any one of Claims 1 to 7.

10. A cooling system substantially as hereinbefore described with reference to and as illustrated by the accompanying drawings.

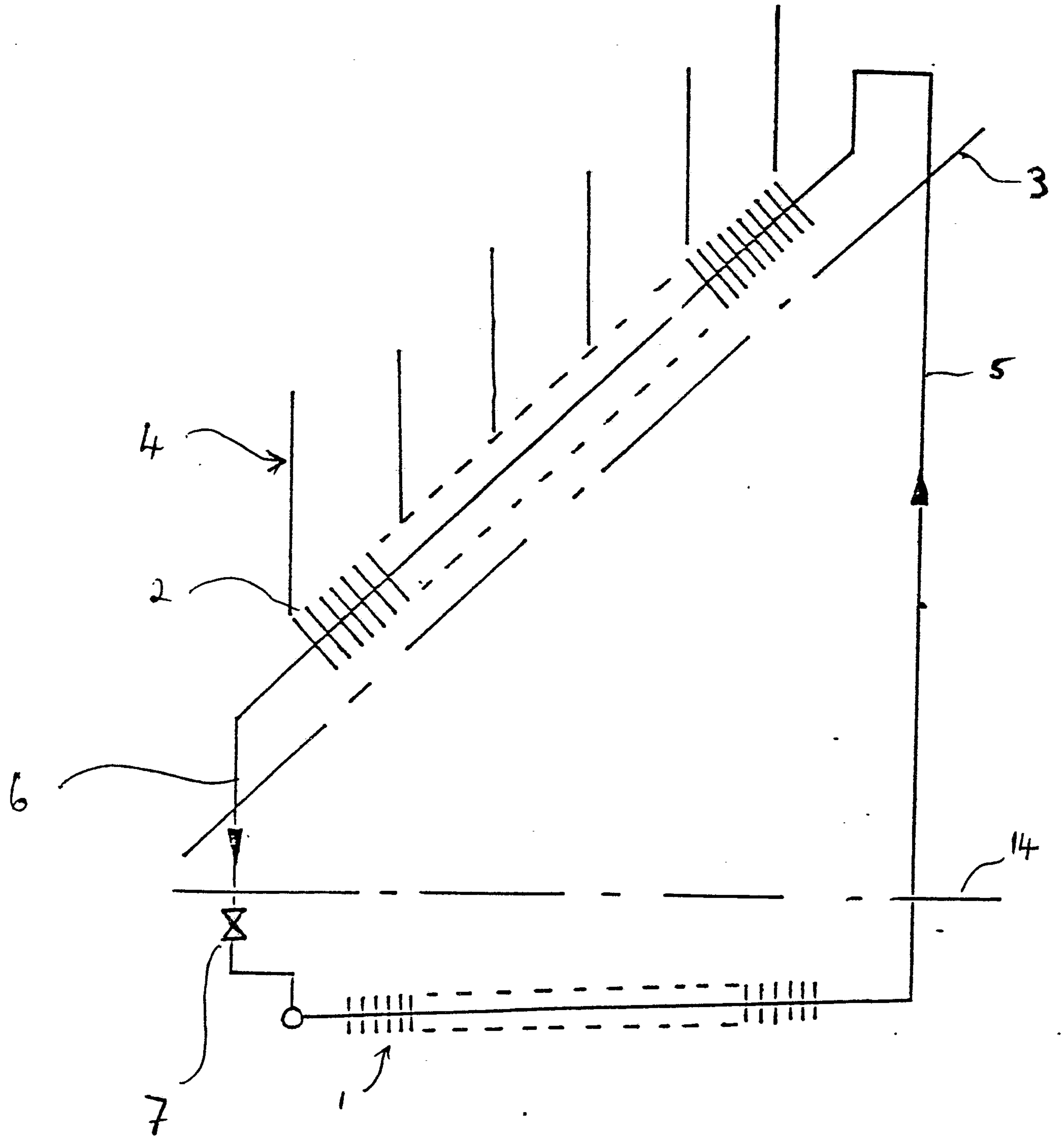


FIG. 1

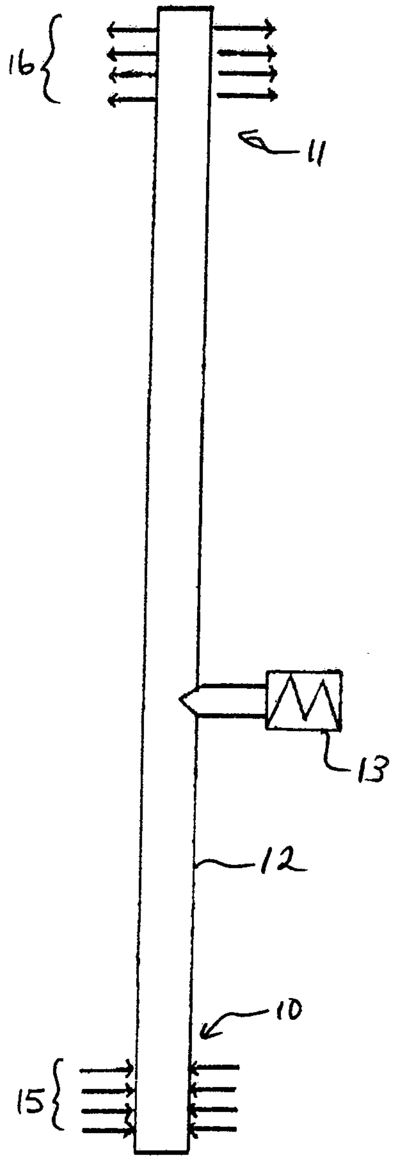


FIG 2.

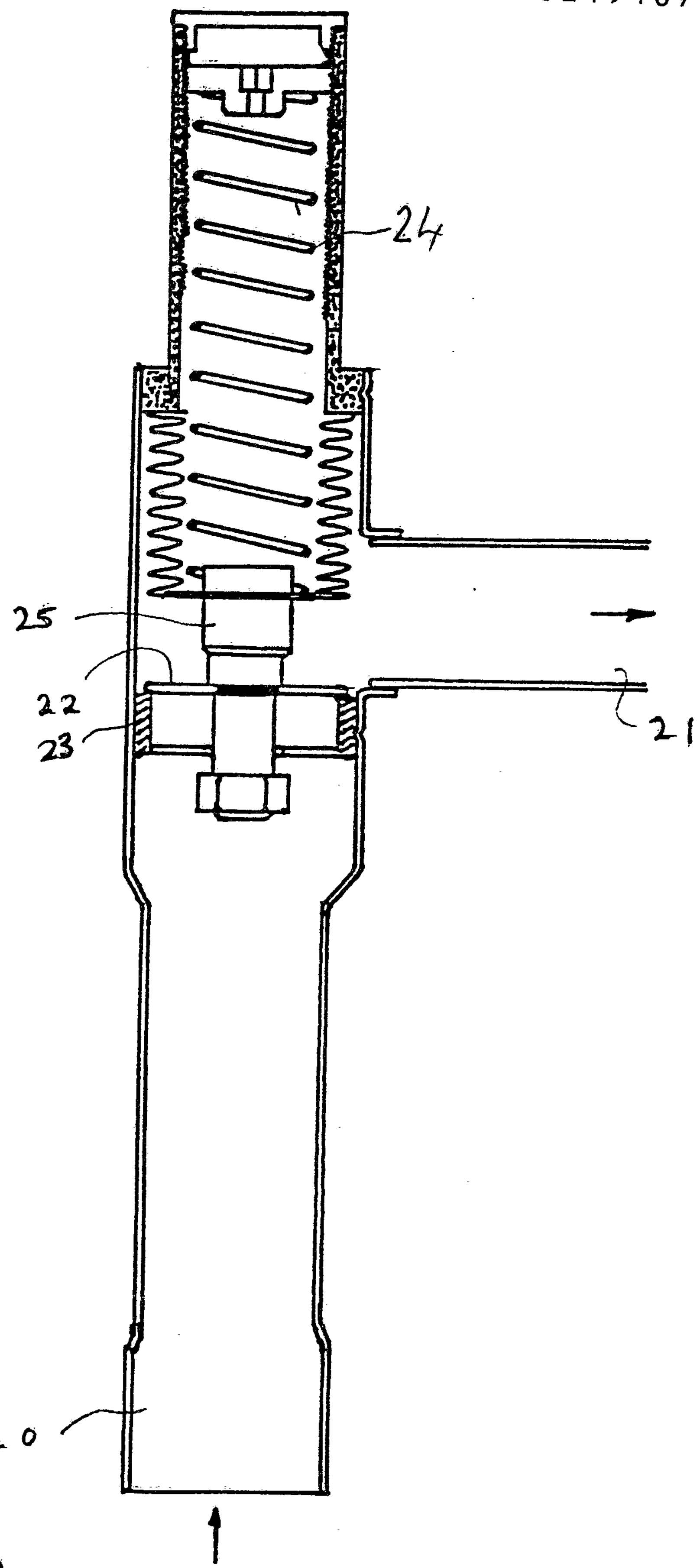


Fig 3

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# EUROPEAN SEARCH REPORT

Application number

EP 87 30 5154

## 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.4) |
|---|---|---|---|
| X | US-A-2 083 611 (MARSHALL)<br>* Page 1, right-hand column, line 46 - page 3, right-hand column, line 44; figures 1-7 * | 1,2,4, 10 | F 28 D 15/02<br>F 25 B 23/00 |
| Y | | 3,5,6, 8,9 | |
| | --- | | |
| Y | GB-A-2 040 033 (DAIKIN KOGYO)<br>* Page 1, line 111 - page 6, line 85; figures 1-10 * | 3,5,6, 8,9 | |
| A | | 2 | |
| | --- | | **TECHNICAL FIELDS SEARCHED (Int. Cl.4)** |
| X | GB-A-1 583 857 (JOHN NOLAN DESIGN)<br>* Page 2, lines 41-77; page 3, line 120 - page 9, line 44; figures 1-23 * | 1,3,4 | F 28 D<br>F 25 B |
| A | | 2 | |
| | --- | | |
| X | GB-A- 669 099 (PRESSED STEEL)<br>* Page 1, line 79 - page 2, line 8; page 2, line 35 - page 7, line 57; figures 1-8 * | 1,5,6 | |
| | --- -/- | | |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 07-09-1987 | BOETS A.F.J. |

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| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.4) |
|---|---|---|---|
| A | --- | 7 | |
| A | AU-B- 414 159 (BALCH) * Page 3, last paragraph - page 8, paragraph 2; figures 1-2 * --- | 1-4 | |
| A | US-A-3 525 670 (BROWN) * Column 3, line 32 - column 4, line 29; figure 2 * --- | 1,2 | |
| A | EP-A-0 002 305 (PHILIPS PATENTVERWALTUNG) --- | | |
| A | US-A-4 494 595 (SCHMID) --- | | |
| A | US-A-3 414 050 (ANAND) --- | | TECHNICAL FIELDS SEARCHED (Int. Cl.4) |
| A | US-A-3 614 981 (COLEMAN) --- | | |
| A | US-A-3 226 941 (SNELLING) --- ----- | | |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
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| THE HAGUE | 07-09-1987 | BOETS A.F.J. |

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