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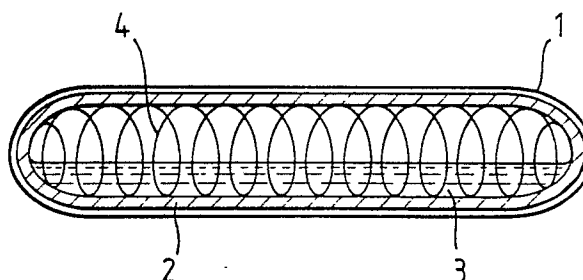
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⑤④ **FLEXIBLE HEAT TRANSFER STRUCTURE AND METHOD OF MANUFACTURING SAME.**

⑤⑦ Flexible heat transfer structure the shape of which can be varied comparatively free in accordance with the condition of use thereof. More particularly, the present invention relates to a flexible heat transfer structure consisting of a working fluid, and a container in which the working fluid is packed, and characterized in that the container is filled with the working fluid when the structure is not in operation, and expanded to increase the volume thereof due to the gasification of the working fluid and form a steam space therein when the structure is in operation.



S P E C I F I C A T I O N
FLEXIBLE HEAT-TRANSFERRING STRUCTURE AND PROCESS OF
PRODUCING THE SAME

TECHNICAL FIELD

This invention relates to a flexible heat-transferring structure which can relatively freely change its form depending on the manner of using.

BACKGROUND ART

A heat-transferring structure conventionally known as heat pipe is obtained by sealing an operating fluid in a metal container while eliminating the gas in the container, and its basic structure and function are proposed in USP3,229,759. The inside of the metal container is filled with the operating fluid and the vapor resulting from the vaporization of the operating fluid.

The heat pipe is functionally constituted by a vaporization region and a condensation region. In the vaporization region, when heat is applied from outside, a portion of the contained fluid is vaporized and becomes a vapor of the operating fluid. At this time, heat is taken from the outside of the vicinity of the vaporization region due to the vaporization. On the other hand, in the condensation region, the vapor of the operating fluid is cooled and condensed to return to the liquid state. At this time, heat is released to the outside of the vicinity of the condensation region due to the condensation. Thus, the transfer of the heat is

conducted based on the absorption and release of the latent heat due to the phase change of the operating fluid.

Further, inside the heat pipe, a material called "wick material" such as metal mesh and sintered metal is inserted, which serves to fluently circulate the operating fluid liquefied at the condensation region to the vaporization region.

In order to effectively conduct the exchange of the heat between the inside and outside of the structure, it has been a prevailing idea to use a metal having a high thermal conductivity as a material for constituting the container or as the wick material.

Although the metal materials have an advantage that they have a high thermal conductivity, they are basically rigid materials. Thus, although small degree of deformation such as bending can be made, their shape is substantially fixed. Further, since the shaping by bending cannot be conducted and since the shape of the container is fixed, the freedom of processing and designing the container is restricted. Further, since it must have a voluminous vaporization space at any time, the volume of the heat pipe is inevitably large and so it may be burdensome when it is not used.

Further, since the metal materials are heavy and have poor flexibility, poor anti-corrosive property and poor chemical resistance, they are not employed for

practical use in daily life.

In view of the above-described drawbacks of the metal heat pipe, this invention provides a flexible heat-transferring structure which excels in formability, flexibility and in anti-corrosive property, which is light in weight, which can freely deform its shape to a certain degree depending on the manner of using, of which volume at the time of non-using is small and so excels in ease of handling, which minimizes the inflation of the container by the increase of the pressure due to the evaporation of the operating fluid.

Further, this invention provides a flexible and high performance heat-transferring structure in which a material such as fibrous material having a high fluid-retaining capability is contained so as to provide an excellent fluency of evaporation of operating fluid and the circulation thereof.

DISCLOSURE OF THE INVENTION

This invention provides a heat-transferring structure comprising operating fluid and a container sealingly containing the operating fluid, characterized in that the container is filled with the operating fluid at the time of not using the heat-transferring structure, while at the time of operation, the volume of the container is increased due to the vaporization of the operating fluid so that a space filled with the vapor is formed.

The heat-transferring mechanism of the heat-transferring structure of the present invention is basically the same as that of the conventional heat pipe.

As is apparent from the heat-transferring mechanism of the structure, heat is not transferred without the vapor space. However, as in employing the metal container, to have the voluminous vapor space even at the time of the heat-transferring structure is not used is entirely unnecessary. The heat transfer can be accomplished if the vapor volume is fluently formed due to the vaporization of the operating fluid at the time of operation.

This requires that the container be flexible and this may be accomplished by selecting, as the material for constituting the container, a sheet material comprising a polymer film and/or a composite polymer film containing an inorganic material. These materials are not only flexible but also much lighter than the metal materials and have much better anti-corrosive property and chemical resistance than the metal materials, so that an operating fluid which cannot be used in the metal container may be employed and optimum operating conditions may be selected from wide range.

The heat-transferring structure constituted by such a flexible container can be bended and can freely adopt an optional form depending on the manner of using. If the container is in the form of a thin sheet, the

heat-transferring structure may be used in a narrow space. That is, heat-absorption and heat-release area can be assured without requiring voluminous space. Further, if the film is in the form of a sheet, the structure may be stored in a wound or bended state.

Further, in the present invention, the heat-transferring function may be more effectively exhibited without degrading the flexibility by inserting a material such as a fibrous material in the container. This is because that such a material has a tendency to adsorb or capture the operating fluid. By inserting the material, evaporation of the operating fluid and its circulation is fluently conducted. Since the move of the operating fluid is fluent, the vibration generated at the time of vaporization is reduced. The circulation of the operating fluid may also be attained by forming grooves in the container. This utilizes a capillary phenomenon.

On the other hand, if the temperature in the vaporization region is higher than the boiling point of the operating fluid, the operating fluid boils. In general, the volume of vapor of a substance is much larger than that of the substance in liquid state. Although there is no problem if the heat release in the condensation region is smoothly conducted at the time of operation, if the calory of the applied heat is much larger than the calory of the heat released, it is possible that the container may largely inflate to burst.

To prevent this, it is advisable to adjust the pressure in the container to not higher than 1 atm. By adjusting the pressure to not higher than 1 atm, the boiling point of the operating fluid is lowered, so that the pressure in the container may be kept at not higher than 1 atm even if the fluid boils, and thus the breakage of the container may be prevented. By so doing, even if the temperature in the vaporization region is lower than the boiling point of the operating fluid at 1 atm, the operating fluid may be vaporized so as to exhibit the heat-transferring function.

Although the increase in the volume of the container is smaller than in the case of not reducing the pressure, the characteristic feature of the invention, i.e., the inflation of the container due to the evaporation of the operating fluid is still attained. However, depending on the degree of reducing the pressure, in some cases, the efficiency of the heat-transfer may be reduced because the move of the vapor in the container is not smoothly conducted since the inflation may require to overcome the atmospheric pressure which may be much larger than the inner pressure, and the vapor space formed by the operating fluid is small. To prevent this, it is important that a vapor space with a reduced pressure is preliminarily formed in the container. That is, an appropriate spacer is preliminarily placed in the container and the pressure in the container is then

reduced so as to form a vapor space with a pressure of not higher than 1 atm. Even in this case, at the time of not using or not operating the heat-transfer structure, the pressure in the container is kept at the vapor pressure of the operating fluid, so that the increase in the volume of the container is attained at the time of operation due to the vaporization of the operating fluid, which is a characteristic feature of the present invention.

Since the heat-transferring structure of the present invention has a large flexibility, it is very useful for the heat-transfer of human body. By taking heat from human body without feeling of incompatibility, the body temperature may be kept at a certain level and the uncomfortable feeling and exhaustion given by the ambient temperature may be avoided.

BEST MODE FOR CARRYING OUT THE INVENTION

The sealed container employed in the present invention is for containing the operating fluid and optionally the material having a property to adsorb or capture the operating fluid, and the spacer. As long as the container can be sealed, its shape is not restricted to cylindrical, and any shape can be selected optionally. The container may be in any form with which the operating fluid may easily be filled or diffused. That is, the container may be, as shown in Figs. 1 - 3, in the form of a flat tube, in the form of two films of which ends are

heat-sealed, or in the form of one film folded and of which ends are heat-sealed. Further, the container may be in the form of a pipe or a hollow fiber. Thus, any form is employable as long as the vapor space is inflated due to the vaporization of the operating fluid. In particular, if the container is in the form of a sheet (flat), very thin and flexible container may be obtained.

If grooves are formed in the inner wall of the sealed container, that is, for example, if thin grooves are aligned along the longitudinal direction of the sealed container, the operating fluid is easily dispersed at the time of not using the heat-transferring structure and the circulation of the operating fluid is aided.

The container of the present invention may have a variation along its longitudinal direction, that is, the shape of the cross-section or the cross-sectional area may be varied.

As to the polymer film or the composite film made of a polymer material and an inorganic material which is the material for constituting the sealed container, the polymer film or the polymer material employed herein may be any polymer such as polyesters, polyamides and polyolefins as long as it has a gas-barrier property and a compatibility with the operating fluid, i.e., insolubility to the operating fluid later described. Examples of the material includes plastic sheets of polyvinyl alcohols, polyesters and polyamides. Preferred

examples of the material includes polymer films with gas-barrier property, such as polyvinilidene chloride, polyvinyl alcohols, Nylon and ethylone-vinyl alcohols.

Although the polymer film or the polymer material may be employed individually, it is preferred to use a composite sheet having two or more of such films because the desired sheet properties, i.e., gas-barrier property and heat-sealing property may easily be obtained and the desired strength for operation may easily be attained. For example, a composite sheet such as a laminate or a coating of a polyester with a high strength and a polyolefin with a gas-barrier property, as well as combination thereof may be employed as a material with good gas-barrier property, adhesivity and durability. Further, a composite sheet of polymer films with good gas-barrier property may preferably be employed. For example, a film with good gas-barrier property such as polyvinilidene chloride, polyvinyl alcohol and polyacrylonitrile and a polymer film with both good gas-barrier property and adhesivity may preferably be employed. Further, a laminate of ethylene-vinyl alcohol copolymer with a good gas-barrier property and polyethylene which can easily be adhered may be employed.

On the other hand, the composite sheets comprising the polymer material and the inorganic material are the sheets made of the above-mentioned polymer film to which a metal or a ceramic such as Al, ZnO_2 or TiO_2 is coated

or vapor-deposited to further promote the gas-barrier property. Such a vapor-deposited composite sheet may be applied not only to the above-mentioned films with a good gas-barrier property, but also to the polymer films with somewhat lower gas-barrier property. Examples of such polymer films include 6-Nylon, polyvinyl chloride, high density polyethylene and polyethylene terephthalate sheet.

Further, the composite sheets which may be employed in the present invention include, besides the laminates of the above-mentioned polymer films, those composite sheets comprising a sheet made of the above-mentioned polymer film and a coating of the above-mentioned metal or ceramic. Still further, laminates of the above-mentioned vapor-deposited films may also be employed.

The composite sheet employed in the present invention may be in the form of a plate or a film, and usually in the form of film.

Even in cases where the container is in the form of a pipe, tube or a hollow fiber, the compositing of the film as described-above can be fully applied. In particular, in case of compositing the polymer material and the inorganic material, the inorganic material in the form of particles may be admixed in the polymer and the polymer may then be shaped or spun.

The operating fluid used in the present invention is

a medium which carries heat, and one which is operable at the temperature range employable for the polymer film or polymer material is selected.

The operating fluid is a medium which induces the gas-liquid phase conversion, and examples of the operating fluid include acetaldehyde, isopentane, ethane thiol, isopropyl chloride, pentane, methyl formate, diethylether, dichloromethane, dibromodifluoromethane, ethyl bromide, tetramethyl silane, trichlorofluoromethane, trifluoro acetic acid anhydride, methyl fluoroacetate, t-butyl amine, methyl iodide, dimethyl sulfide and the like. These fluids are operable at the temperature of human body for which the flexibility is especially required. Further, those substances such as methanol, acetone, ethanol, ethyl formate and water, which have a gas-liquid phase transition point at 20 - 100°C may be operable at a lower temperature under a reduced pressure.

Further, other than these media, mixed media of the above-mentioned media and carbon dioxide, water, acetone, ethanol or formic acid may also be used. Thus, simple substances or mixed media which have gas-liquid transition point between 20 - 45°C may also be used. Examples of these fluids include carbon disulfide/acetone, carbon disulfide/ethanol, carbon disulfide/formic acid, carbon disulfide/ethyl formate, carbon disulfide/methyl formate, carbon disulfide/methyl

acetate, carbon disulfide/cyclopentane, carbon disulfide/ethyl bromide, carbon disulfide/t-butyl alcohol, carbon disulfide/2-propanol, carbon disulfide/pentane, carbon disulfide/methanol, water/pentane, acetone/isopentane, acetone/cyclopentane, acetone/isopentane, acetone, cyclopentane, acetone/pentane, ethanol/isopentane, ethanol/isopropyl chloride, ethanol/cyclopentane, ethanol/pentane, isopentane formate, formic acid/isopropyl chloride, formic acid/isopropyl bromide, formic acid/ethyl bromide, formic acid/pentane, formic acid/methyl iodide, ethyl formate/isopentane, ethyl formate/2,3-dimethylbutane, ethyl formate/pentane, methyl formate/diethyl ether, methyl formate/pentane, methyl formate/dimethyl sulfide, diethyl ether/pentane, 2-propanol/pentane, methanol/isopentane, methanol/isopropyl chloride, methanol/t-butyl chloride, methanol/propyl chloride, methanol/ethyl bromide, methanol/propyl bromide, methanol/pentane, water/carbon disulfide/acetone, water/carbon disulfide/ethanol, ethanol/benzene/heptane, and methyl formate/diethyl ether/pentane.

Here, the temperature range of 20 - 45°C is the temperature range which human experiences in daily life. Thus, the heat-transferring structure which transfers heat under this temperature range is important for appropriately releasing heat from human body to keep the body temperature at a certain temperature.

The operating fluid and the material of container are chosen such that the operating fluid does not corrodes the material. For example, in case of using isopentane as the operating fluid, a container made of polyvinyl alcohol may preferably be selected. Many other combinations can be employed.

By inserting into the container a material which adsorbs or captures the operating fluid, such as a foamed material, a material with fine pores and a fibrous material, as well as these materials which are treated so as to increase their adsorption, the diffusion of the operating fluid at the time of not using the heat-transferring structure is promoted and the evaporation of the operating fluid and its circulation under operation are also aided. The fibrous material to be inserted in the container includes fabrics such as woven fabrics and non-woven fabrics; specific fibers such as super fine fibers and porous fibers; and general fibers for clothes. For example, although it may be an assemblage of yarns which is obtained by twisting a multifilament, non-woven fabrics with good fluid-retaining capability are preferred. The above-mentioned fibrous material may be a synthetic fiber such as polyesters, polyamides and polyolefin fibers.

The spacer employed in the present invention is a structure for forming a vapor space with a pressure of not higher than 1 atm in the sealed container. As the

material for constituting the spacer, a flexible material which is not crushed by the outer pressure (1 atm) and which can form a vapor space (a space with reduced pressure) under the outer pressure is selected. If such a space exists, even at a temperature lower than the boiling point at 1 atm, evaporation of the liquid and its move can be smoothly effected, so that the heat of vaporization can be taken.

The spacer used in the present invention may be a tube or pipe made of silicone, polyester, polyamide or polyolefin, or the spacer may be substituted with a material which adsorbs or captures the operating fluid in the container. For example, non-woven fabrics, knits or nets made of a synthetic fiber, as well as porous material with chemical resistance such as PVDF may be employed.

Further, ruggedness on the inner wall of the container can serve as the spacer.

In the present invention, to make the pressure in the container not higher than 1 atm, the operating fluid is first placed in the container. Thereafter, the gas in the container is drawn from a specific portion of the container with a vacuum pump to reduce the pressure to 1 atm or less, and after attaining an appropriate inner pressure, the specific portion is sealed by, for example, heat-sealing.

The specific portion is the portion through which

air is drawn from the container after placing the fluid to attain an inner pressure of not higher than 1 atm.

As to the appropriate inner pressure means, in case of using n-pentane, for example, heptane boils at 36°C under 1 atm, but boils at 30°C if the pressure is reduced to 0.77 atm. Thus, even if it boils at a temperature of body surface, since the outer pressure (1 atm) is greater than the vapor pressure of pentane, it is prevented for the container to inflate and to burst.

The flexible heat-transferring element of the present invention may be used basically at a portion at which heat is desired to be transferred, utilizing the cooling action at the vaporization region or the heating action at the condensation region. The heat-transferring structure of the present invention may be used not only individually but also in combination with a filament heat-generator, plane heat-generator or with a heat-accumulator at the vaporization region, or with a coolant at the condensation region.

The heat-transferring structure of the present invention may be used in anywhere at which transfer of heat is desired. For example, it may preferably be used as a part of woven fabrics, sheets, vests, bath tubs, pillows, helmets, rugs under "kotatsu", headbands, sofas, car sheets, belts, body bands, coolers for electronic products, shoes, carpets, ice sacks, gloves, dustproof clothes and hats.

[Example 1]

An example of the present invention is shown in Fig. 4. In a container 1 made of a ethylene-vinyl alcohol copolymer film, a non-woven fabric 2 is inserted and operating fluid 3 is filled in the container and in the non-woven fabric. With this structure, since the container is made of a material which is light and flexible, the shape of the structure can be conformed to the shape of the human body, so that heat can be taken from the body effectively and without a feeling of incompatibility. Thus, it can give a cool feeling to the human body. Further, since a voluminous vapor space is not formed at the time of not using the structure, the volume of the structure at the time of non-using is much smaller than that of the conventional structure by which heat is transferred by the same principle. Still further, by virtue of the inserted non-woven fabric, the evaporation and circulation of the fluid can be made smoothly.

[Example 2]

A heat-transferring structure of the present invention was made by employing a laminate film of ethylene-vinyl alcohol copolymer and polyethylene as the material of the container, polyester non-woven fabric as the spacer and n-pentane (with boiling point of 36°C under 1 atm) as the operating fluid and by sealing the container after reducing the inner pressure to 450 mmHg.

In this case, at 30°C, 30% of the inner volume of the container is occupied by the liquid and the remainder is the vapor space. Since the ambient temperature was 30°C, the inside of the container is kept at a pressure of not higher than 1 atm. This heat-transferring element was contacted with a palm having a skin temperature of 35°C, and while the inflation of the container was very small, the palm felt very cool. At this time, the skin temperature was kept at 32.2°C.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1 - 3 are sectional views each showing an example of the container employed in the heat-transferring structure of the present invention;

Fig. 4 is a sectional view of an embodiment of the heat-transferring structure of the present invention; and

Fig. 5 is a sectional view of an embodiment of the present invention in which a spacer is inserted in the container.

1: container, 2: woven fabric, 3: operating fluid, 4: spacer

CLAIMS

1. A heat-transferring structure comprising operating fluid and a container sealingly containing the operating fluid, characterized in that the container is filled with the operating fluid at the time of not using the heat-transferring structure, while at the time of operation, the volume of the container is increased due to the vaporization of the operating fluid so that a space filled with the vapor is formed.
2. The flexible heat-transferring structure of claim 1, characterized in that a material having a property to adsorb or capture the operating fluid is inserted in the container.
3. The flexible heat-transferring structure of claim 2, characterized in that the material having a property to adsorb or capture the operating fluid is a fibrous material.
4. The flexible heat-transferring structure of claim 3, characterized in that the fibrous material is a non-woven fabric.
5. The flexible heat-transferring structure of any one of claims 1 - 4, characterized in that the operating fluid has a gas-liquid phase transition point within the temperature range of 20°C to 40°C.
6. The flexible heat-transferring structure of any one of claims 1 - 5, characterized in that the container is made of a sheet comprising a polymer film and/or a

composite film including a polymer material and an inorganic material.

7. The flexible heat-transferring structure of claim 6, characterized in that the operating fluid and a spacer are contained in the sealed container made of a sheet

comprising a polymer film and/or a composite film including a polymer material and an inorganic material, and the pressure in the container is adjusted to not higher than 1 atm.

8. The flexible heat-transferring structure of any one of claims 1 to 7, characterized in that rugged grooves are formed in the inner surface of the container.

9. A process of producing a flexible heat-transferring structure comprising the steps of placing operating fluid and a spacer in a sealed container made of a sheet comprising a polymer film and/or a composite film including a polymer material and an inorganic material, and then reducing the pressure in the container to not higher than 1 atm.

Fig.1.

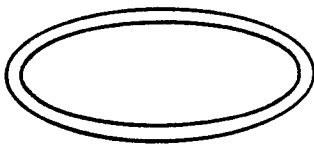


Fig.2.



Fig.3.

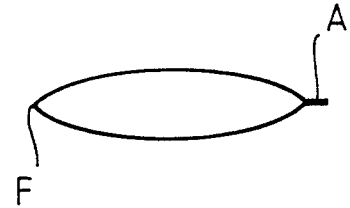


Fig.4.

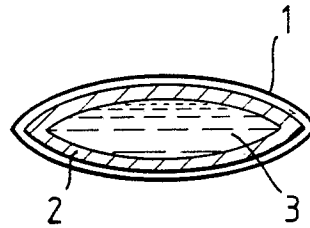
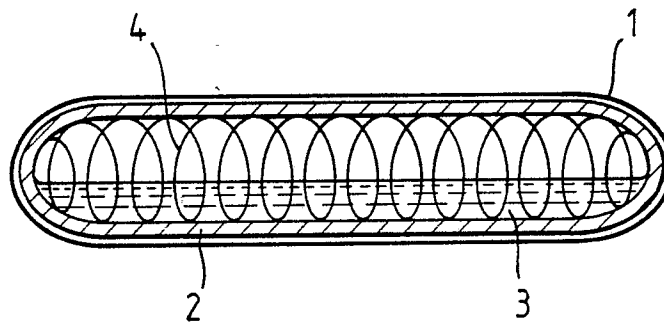


Fig.5.



INTERNATIONAL SEARCH REPORT

00306531

International Application No

PCT/JP87/00963

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ³						
According to International Patent Classification (IPC) or to both National Classification and IPC						
Int.Cl ⁴ F28D15/00, 15/02						
II. FIELDS SEARCHED						
Minimum Documentation Searched ⁴						
Classification System	Classification Symbols					
IPC F28D15/00, 15/02						
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵						
<table style="width: 100%; border: none;"> <tr> <td style="width: 60%;">Jitsuyo Shinan Koho</td> <td style="width: 40%; text-align: right;">1930 - 1987</td> </tr> <tr> <td>Kokai Jitsuyo Shinan Koho</td> <td style="text-align: right;">1971 - 1987</td> </tr> </table>			Jitsuyo Shinan Koho	1930 - 1987	Kokai Jitsuyo Shinan Koho	1971 - 1987
Jitsuyo Shinan Koho	1930 - 1987					
Kokai Jitsuyo Shinan Koho	1971 - 1987					
III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴						
Category ⁶	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁸				
X	JP, A, 58-55644 (Matsushita Electric Works, Ltd.) 2 April 1983 (02. 04. 83) (Family: none)	1-8				
Y	JP, A, 53-28840 (Toshiba Machine Co., Ltd.) 17 March 1978 (17. 03. 78) (Family: none)	9				
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; vertical-align: top;"> ¹⁹ 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 "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed </td> <td style="width: 50%; vertical-align: top;"> "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 "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 "g" document member of the same patent family </td> </tr> </table>			¹⁹ 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 "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "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 "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 "g" document member of the same patent family		
¹⁹ 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 "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "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 "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 "g" document member of the same patent family					
IV. CERTIFICATION						
Date of the Actual Completion of the International Search ²		Date of Mailing of this International Search Report ²				
March 7, 1988 (07. 03. 88)		March 7, 1988 (07. 03. 88)				
International Searching Authority ¹		Signature of Authorized Officer ²⁰				
Japanese Patent Office						