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54 **METHOD OF PRODUCING THIN-FILM EL DEVICE AND COLOR DISPLAY DEVICE USING THIN-FILM EL DEVICE.**

57 According to the production method of a thin-film EL device of the present invention, a step of forming a light-emitting layer comprises a step of forming a mother material layer 1' as a light-emitting mother material and an ion implantation step of implanting a light-emitting center (I) into the mother material layer. Accordingly, the content of the center can be controlled with high controllability and the light emission efficiency can be improved. In the mass production process in which a variety of devices are produced, the light-emitting mother material layers are all formed by using the same target and the kind and amount of the emitting center impurities may be selected in the ion implantation process. Accordingly, the productivity is quite high. According to the production method of a color display device of the present invention, the step of forming the light-emitting layer comprises a step of

forming a plurality of mother material patterns as the light-emitting mother material and an ion implantation step of ion-implanting light-emitting centers of desired colors sequentially and selectively into the mother material layer and forming a plurality of light-emitting layers having desired color patterns. Accordingly, the production is very easy and the positions and colors can be selected freely.

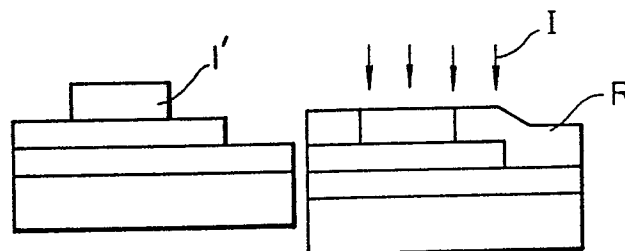


FIG. 2 (c) FIG. 2 (d)

EP 0 331 727 A1

Method of fabricating thin-film EL device and method of fabricating color display device using such EL device

Technical Field:

The present invention relates to a method of fabricating a thin-film electroluminescence (EL) device as well as a method of fabricating a color display device using such an EL device and, more particularly, to a method of forming a luminous layer of such an EL device.

Background Art:

These years, much attention has been focused on a thin-film EL device using a thin-film phosphor layer instead of a dispersion EL device which uses zinc sulfide (ZnS) compound phosphor powder and which has many demerits with respect to luminance thus compelling the inevitable abandonment of its development as an illuminating light source, because the former can provide a high luminance.

The thin-film EL device, in which a luminous layer is made in the form of a thin film to minimize halation or luminous blur caused by the scattering of externally incident light and of light emitted from the interior of the luminous layer and to thereby offer high sharpness and contrast, has been put on the stage as a device for mounting on vehicles, as such a display unit as in a computer terminal, or as an illumination device.

The thin-film EL device, which uses manganese as luminous center material within a ZnS matrix, has essentially a double-dielectric structure in which sequentially stacked on a light-permeable substrate are a transparent electrode made of tin oxide (SnO₂) or the like material, a first dielectric layer, a luminous layer of ZnS:Mn crystalline thin-film made of ZnS matrix material containing manganese luminous center impurity, and a back electrode of a second dielectric layer made of aluminum (Al) or the like material.

And the light emitting process of this thin-film EL device is as follows. First, when a voltage is applied between the aforementioned transparent and back electrodes, electric fields are induced in the luminous layer at the intersections between these electrodes so that electrons so far trapped at the interface level are released therefrom and accelerated, whereby the electrons acquire sufficient energy to be bombarded with orbital electrons of Mn (luminous center) impurities, thereby exciting the orbital electrons. When the thus excited luminous center electrons return to the ground or normal state, they emit light.

With the conventional thin-film EL device, such

a luminous layer made of ZnS:Mn as mentioned above has been formed usually using an electron beam evaporation process or the like (refer to Japanese Patent Publication NOs. 53-10358 and 54-8080).

The electron beam evaporation process is such that, as shown in Fig. 4, ZnS and 0.1-1% of manganese (Mn) were mixed together and sintered to form a pellet 12, and then the pellet 12 is subjected to an irradiation of an electron beam 14 emitted from an electron gun 13 in a vacuum chamber 11 so as to be heated, evaporated and deposited on a substrate 15.

In this case, since the concentration of manganese as the luminous center material greatly affects the luminous efficiency, control of the concentration has been considered important. In such a method, however, it has been so far impossible to achieve sufficient such control.

There has been also suggested a full color EL panel which comprises such different-color thin-film EL devices arranged in a panel form as formed in the aforementioned manner.

However, as shown in Japanese Patent Publication 60-124393 for example, when luminous layers doped with different luminous center materials are to be sequentially formed by the evaporation process, the film forming steps and the patterning steps must respectively correspond in number to the number of sorts in colors to be employed and it is also difficult to arbitrarily select the position of the luminous layer pattern, thus making it impossible to realize a practically full color EL panel.

In view of the above circumstances, it is an object of the present invention to provide a thin-film EL device which can easily be fabricated and offer a high luminous efficiency.

It is another object to provide a color display device which allows its easy fabrication and free selection of color array according to a method of the present invention.

Disclosure of Invention:

In a method of fabricating a thin-film EL device in accordance with the present invention, a process of forming a luminous layer includes a step of forming a pattern of a luminous matrix layer and an ion doping step of injecting into the matrix layer a luminous center material corresponding to a desired color to form the luminous layer of the desired color.

This method is effective, in particular, in a

volume production process of forming many sorts of devices, because a common target can be used in formation of different luminous matrix layers for all the sorts of devices and the sorts and amounts of the luminous center impurities can be selected in the ion doping step, which results in that the fabricating workability can be improved.

According to the color display device fabricating method of the present invention, there can be fabricated a color display device which comprises a plurality of thin-film EL devices arranged in a desired color array, the luminous layers of which EL devices in a desired color array are made by patterning a plurality of luminous matrix layers so as to be arranged in a row and by selectively doping desired luminous center impurities sequentially into the respective matrix layers.

Even it is desired to fabricate a color display device which comprises a plurality of thin-film elements formed respectively as one picture element on an identical substrate and emitting desired different colors, this method requires only one luminous-layer (matrix-layer) forming step and patterning step. And when the luminous center impurities of the different desired colors are sequentially doped into the different luminous layers by an ion implantation process after the patterning step, there can be easily achieved a color display device in which desired colors are arranged in a desired array.

Brief Description of Drawings:

Fig. 1 shows a thin-film EL device in accordance with an embodiment of the present invention;

Figs. 2(a) to 2(e) show different steps of fabricating the same thin-film EL device respectively;

Figs. 3(a) to 3(f) show different steps of fabricating a color display device of a second embodiment of the present invention; and

Fig. 4 shows a prior art method of fabricating a luminous layer.

Best Mode for Carrying Out the Invention:

Embodiments of the present invention will be explained in detail by referring to the accompanying drawings.

As shown in Fig. 1, a thin-film EL device of the invention has a double-dielectric structure in which a luminous layer 1 comprises a 5000Å-thick thin-film layer (which is hereinafter referred to as ZnS:0.4%TbF₃) which contains 0.4% of terbium fluoride (TbF₃) as a luminous center impurity dop-

ed into a luminous matrix of zinc sulfide (ZnS) by an ion implantation process and which emits a green color.

More specifically, this EL device is fabricated by sequentially stacking on a light-permeable 1mm-thick glass substrate 2 a transparent electrode 3 of a 0.3mm-thick tin-oxide (SnO₂) layer or the like, a first dielectric layer 4 of a 0.5μm-thick tantalum-oxide (Ta₂O₅) layer, the aforementioned luminous layer 1, a second dielectric layer 5 of a 0.5μm-thick tantalum-oxide (Ta₂O₅) layer, and a back electrode 6 of a 0.5μm-thick aluminum thick film.

How to fabricate this thin-film EL device will next be explained.

First, as shown in Fig. 2(a) the transparent electrode 3 of the SnO₂ layer is formed on the light-permeable glass substrate 2 by a sputtering process.

The film 3, after formed by the sputtering process, is then subjected to a patterning to the first dielectric layer 4 of the tantalum oxide, as shown in Fig. 2(b).

Subsequently formed on the layer 4 is a ZnS layer 1' as a luminous matrix layer formed by an electron beam evaporation process and then subjected to a patterning, as shown in Fig. 2(c),

Then, as shown in Fig. 2(d), a part of the first dielectric layer 4 not covered with the ZnS layer is covered with a resist R, doped into the luminous matrix layer with TbF₃ of the luminous center material 1 and then subjected to a heat treatment to form the green luminous layer 1.

Further, the resist R is partly removed, subjected to a sputtering for film formation and then subjected to a patterning to form the second dielectric layer 5 of the tantalum oxide layer as shown in Fig. 2(e).

Finally, the second dielectric layer 5 is subjected to a vacuum evaporation to form an aluminum thin film which is then subjected to a patterning to form the back electrode 6.

In this way, such a thin-film EL element as shown in Fig. 1 can be formed highly easily.

This method facilitates the control of the amount of luminous center material to be contained in the luminous layer and accordingly the selection of such content at a proper level, thus enabling the improvement of luminous efficiency.

Explanation will next be made as to how to fabricate a color display device as a second embodiment of the present invention.

This color display device comprises red, green and yellow thin-film EL elements sequentially arranged on a glass substrate 22, and how to fabricate the display device is as follows.

First, a transparent electrode 23 and a first dielectric layer 24 are formed by a usual process

as shown in Fig. 3(a).

The first dielectric layer 24 is then subjected to an electron beam evaporation to form a ZnS which is further subjected to a patterning to form individually divided luminous matrix layer pattern 21, as shown in Fig. 3(b).

Next, as shown in Fig. 3(c), a first resist pattern R1 is formed so that only parts of the pattern corresponding firstly to the red elements are opened, and then the pattern R1 is used as a mask to be subjected to a selective ion doping of luminous center samarium fluoride (SmF_3) to be doped into the luminous matrix layer, thus forming a red luminous layer 21a.

As shown in Fig. 3(d), the first resist pattern is then removed and further a second resist pattern R2 is formed so that only parts of the pattern corresponding to green elements are opened, and the pattern R2 is used as a mask to be subjected to a selective ion doping of luminous center terbium fluoride (TbF_3) to be doped into the luminous matrix layer, thus forming a green luminous layer 21b.

Further, as shown in Fig. 3(e), the second resist pattern is removed and further a third resist pattern R3 is formed so that only parts of the pattern corresponding to yellow elements are opened, and the pattern R3 is used as a mask to be subjected to a selective ion doping of luminous center manganese (Mn) to be doped into the luminous matrix layer, thus forming a yellow luminous layer 21c.

And the thus formed assembly is subjected to a heat treatment to sufficiently diffuse the luminous center materials, followed by the formation of a second dielectric layer 25 and a back electrode 26 by usual processes, thus completing a color display device (refer to Fig. 3(f)).

In accordance with the method of the present invention, the use of only the resist pattern forming step and ion doping step enables the desired color luminous parts to be highly easily formed at desired positions with good controllability.

Though the above explanation has been made in connection with the foregoing embodiments in which the ZnS layer is used as the luminous matrix layer, it goes without saying that the luminous matrix layer may be made of calcium sulfide (CaS), strontium sulfide (SrS) or other suitable substance.

The luminous center material is also not limited to ones used in the foregoing embodiments but may be silver (Ag) copper (Cu) or other material.

The luminous layer has been divided into three zones to repetitively form the red, green and yellow element parts in the foregoing embodiment. However, the luminous layer may be divided into four zones to repetitively form four color element parts consisting of a blue part doped with luminous cen-

ter cerium (Ce) in addition to the aforementioned three color parts.

In addition, this thin-film EL device may be applied not only to the display device but also to various apparatuses including an illuminating apparatus.

Furthermore, only one sort of luminous center impurity has been doped into each one of the luminous layers in the ion doping step, but the present invention is not restricted to the particular example. For example, a first luminous center impurity can be ion-doped into all the luminous matrix layers without using any resist, a second luminous center impurity can next be selectively doped into only ones of the luminous matrix layers corresponding to second and third zones while only one of the luminous matrix layers corresponding to a first zone can be covered with resist, and finally a third luminous center impurity can be selectively doped into only one of the luminous matrix layers corresponding to the third zone while only ones of the luminous matrix layers corresponding to the first and second zones can be covered with resist. In this case, the luminous layer containing the first luminous center impurity is formed in the first zone, the luminous layer containing the first and second luminous center impurities is formed in the second zone, and the luminous layer containing the first, second and third luminous center impurities is formed in the third zone allowing the emission of the three color lights. The related effect accompanied by the use of this method is to allow the number of necessary resist pattern forming steps to be reduced by only one.

Industrial Applicability:

The method of the present invention is effective, in particular, in fabricating a color display device.

According to this method, the content of luminous center impurity can be adjusted with good controllability even not only for a color display device but for a monochromatic display device, thus increasing the luminous efficiency.

Further, when it is desired to form multiple color luminous layers on an identical substrate, the formation can be highly readily realized and the selection of position and color in the layers can be arbitrarily achieved.

Claims

(1) A method of fabricating a thin-film EL device in which a luminous layer is interposed between a transparent electrode and a metallic elec-

trode, said method characterized in that a step of forming said luminous layer includes:
a first step of forming a luminous matrix layer; and
a second step of ion-doping a luminous center impurity into said luminous matrix layer.

(2) A method of fabricating a thin-film EL device as set forth in claim (1), characterized in that said luminous matrix layer is a zinc sulfide (ZnS) layer.

(3) A method of fabricating a thin-film EL device as set forth in claim (1), characterized in that said luminous matrix layer is a calcium sulfide (CaS).

(4) A method of fabricating a thin-film EL device as set forth in claim (1), characterized in that said luminous matrix layer is a strontium sulfide (SrS).

(5) A method of fabricating a color display device in which a plurality of thin-film EL elements each having a desired-color luminous layer interposed between a transparent electrode and a metallic electrode are arranged on an identical substrate to cause desired ones of said thin-film EL elements to emit light in response to picture information, said method characterized in that a step of forming said luminous layers includes:
a matrix layer forming step of forming a pattern of luminous matrix layers; and
an ion doping step of sequentially and selectively ion-doping desired color luminous center materials into said luminous matrix layers so that the respective luminous layers can provide a desired color array.

(6) A method of fabricating a color display device as set forth in claim (5), characterized in that said luminous matrix layer is a zinc sulfide (ZnS) layer.

(7) A method of fabricating a color display device as set forth in claim (5), characterized in that said luminous matrix layer is a calcium sulfide (CaS) layer.

(8) A method of fabricating a color display device as set forth in claim (5), characterized in that said luminous matrix layer is a strontium sulfide (SrS) layer.

(9) A method of fabricating a color display device as set forth in claim (5), characterized in that said luminous center materials to be doped into said respective luminous matrix layers are samarium fluoride (SmF_3) terbium fluoride (TbF_3) and manganese (Mn) respectively and said thin-film EL elements are arranged to provide a repetitive red, green and yellow color array.

(10) A method of fabricating a color display device as set forth in claim (5), characterized in that said luminous center materials to be doped into said respective luminous matrix layers are samarium fluoride (SmF_3), terbium fluoride (TbF_3)

and cerium (Ce) respectively and said thin-film EL elements are arranged to provide a repetitive red, green and blue color array.

(11) A method of fabricating a color display device as set forth in claim (5), characterized in that said luminous center materials to be doped into said respective luminous matrix layers are samarium fluoride (SmF_3) terbium fluoride (TbF_3) manganese (Mn) and cerium (Ce) respectively and said thin-film EL elements are arranged to provide a repetitive red, green, yellow and blue color array.

(12) A method of fabricating a color display device as set forth in claim (5), characterized in that said matrix layer forming step forms a zinc sulfide layer as said luminous matrix layer by an electron beam evaporation process, 3 patterns of the luminous matrix layers correspond to first, second and third zones respectively, and said ion doping step includes:

a first doping step of selectively doping samarium fluoride ions into only one of the luminous matrix layers in said first zone while covering said second and third zones with resist;

a second doping step of selectively doping terbium fluoride ions into only one of the luminous matrix layers in said second zone while covering said third and first zones with resist; and

a third doping step of selectively doping manganese ions into only one of the luminous matrix layers in said third zone while covering said first and second zones with resist.

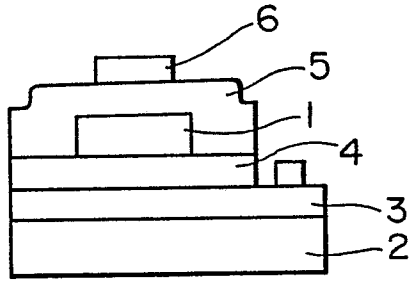
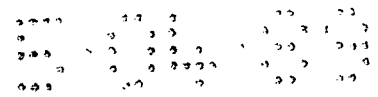


FIG. 1

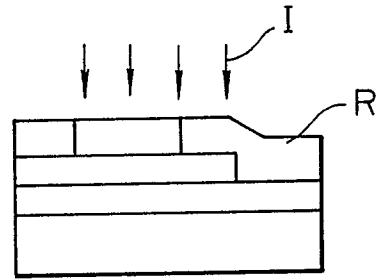


FIG. 2 (d)

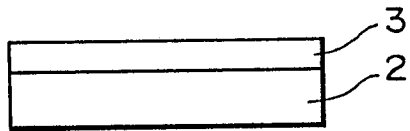


FIG. 2 (a)

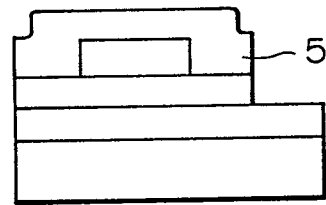


FIG. 2 (e)

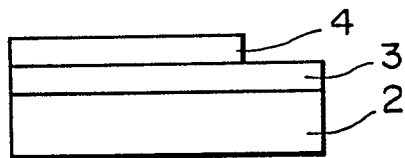


FIG. 2 (b)

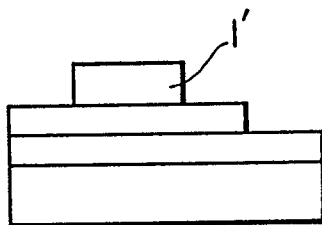


FIG. 2 (c)

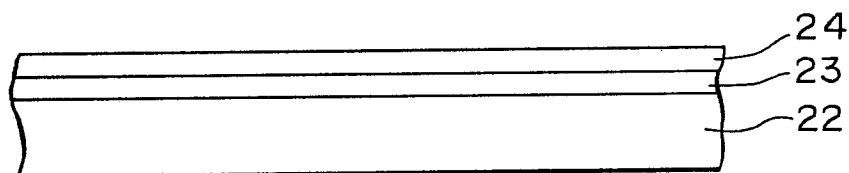


FIG. 3(a)

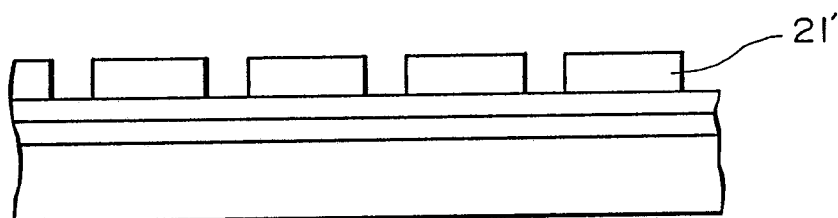


FIG. 3(b)

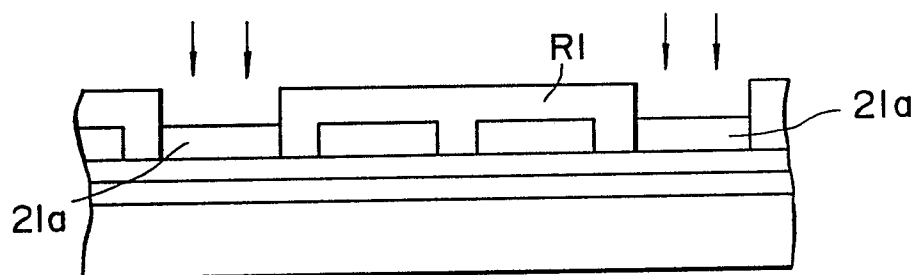


FIG. 3(c)

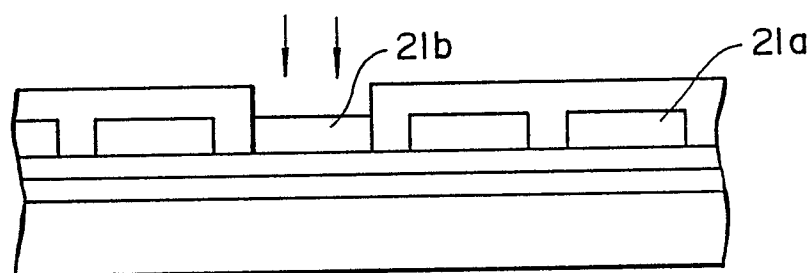


FIG. 3(d)

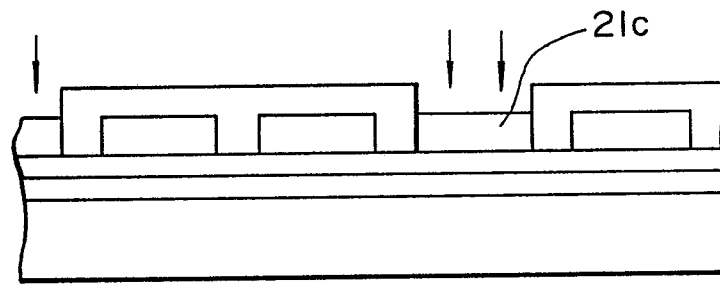
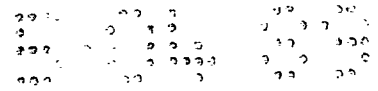


FIG. 3(e)

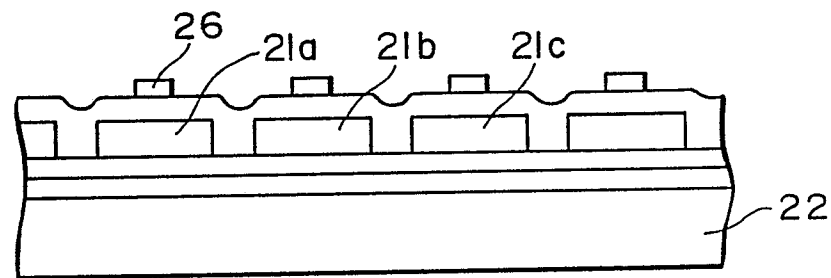


FIG. 3(f)

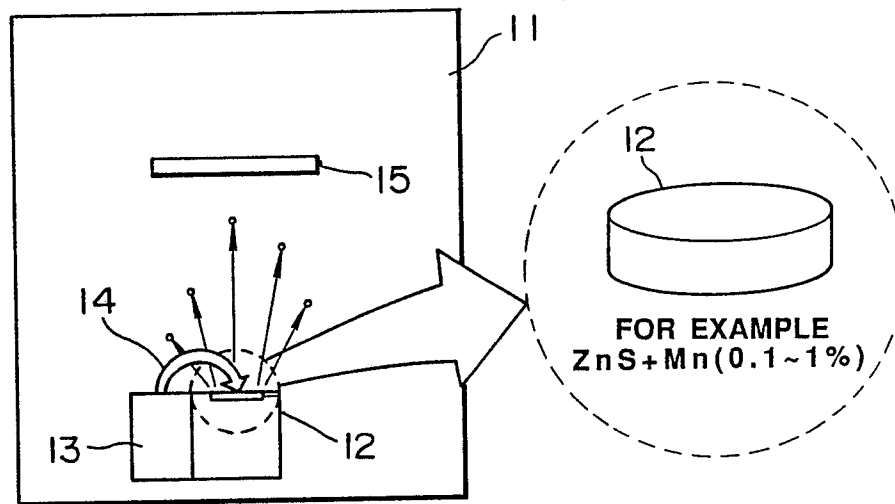


FIG. 4

INTERNATIONAL SEARCH REPORT

International Application No

PCT/JP87/00647

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 G09F9/30		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁴		
Classification System	Classification Symbols	
IPC	G09F9/30	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵		
Jitsuyo Shinan Koho 1926 - 1987 Kokai Jitsuyo Shinan Koho 1971 - 1987		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴		
Category *	Citation of Document, ¹⁵ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁸
X	JP, A, 62-122094 (Alps Electric Co., Ltd.) 3 June 1987 (03. 06. 87) (Family: none)	1-11
X	JP, A, 61-267084 (Brunelchristian and one other) 26 November 1986 (26. 11. 86) (Family: none)	1-11
* Special categories of cited documents: ¹⁶ "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 "&" 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
November 30, 1987 (30.11.87)		December 14, 1987 (14.12.87)
International Searching Authority ¹		Signature of Authorized Officer ²⁰
Japanese Patent Office		