METHOD OF PREVENTING DELAMINATION OF FLAME RETARDING STRUCTURES

Fig. 2

A method of preventing or delaying delamination of a multi-layer structure which is protected against fire. This type of structure is comprised of an inner layer (16), which acts as a body, an outer layer (11) which is arranged at a distance from the inner layer (16), which outer layer (11) comprises a fire retardant film, and an intermediate layer (13,14) which is arranged between the layers and which is attached to the inner layer (16) by means of the first polymer layer (15) and to the outer layer (11) by means of the second polymer layer (12). According to the present invention, a fire retardant is included in at least one polymer layer (12,15), or in the inner layer (16) which is arranged against the first polymer layer (15), in order to prevent or delay delamination of the structure, under conditions in which the outer layer (11) is exposed to a high temperature. The intermediate layer contains a non-woven fabric layer (13), and a thermoplastic polymer film (14), which optionally contains a fire retardant.
Method of preventing delamination of flame retarding structures

The present invention relates to a method of preventing or delaying delamination of a fire protection structure, according to the preamble of Claim 1.

The present invention also relates to a multi-layer board which is used as a fire protection board, according to the preamble of Claim 20, and a use according to Claim 22.

Board structures which are used as fire protection boards are typically comprised of a body layer and a metal layer, for example a metal board or a metal film, which is arranged at a distance from the body layer. During use, the metal layer protects the body layer in case of fire.

Between the metal film and the body layer, there is at least one but often several polymer layers which bind the structure together, but which may also serve as an insulating layer that reduces the heat flux passing through the board.

In wood-based multi-layer structures, the body layer consists of a wood board.

US Patent Specification No. 6,511,730 describes a composite board which is comprised of several layers and which comprises a fire retardant.

Published DE Patent Application No. 2019770 describes a non-combustible laminate which is comprised of 7 layers. The layers are attached to each other by means of adhesive layers.

US Patent Specification No. 4,935,281 describes a board structure which is protected against fire and which is comprised of an inner layer of plywood, an intermediate layer of metal, a glass fibre fabric and adhesive layers.

Prior art structures have good short-term fire protection properties, but at the same time it has been found that multi-layer structures are susceptible to the layers becoming detached, i.e. delamination. This reduces the capacity of the structures for fire protection, because air penetrates between and under the layers.
The present invention is based on the idea that a fire retardant is included in at least one polymer layer of a structure which is comprised of several sub-layers on top of each other, such as a multi-layer board intended to be used as a fire protection board. In addition, or alternatively, the fire retardant can also be included in the inner layer, which is arranged against the first layer, i.e. the innermost polymer layer.

Surprisingly, it has been found that the fire retardants as such do not affect the strength properties of the polymer layer within a temperature range which extends from room temperature up to the manufacturing temperature of the polymer (for example to the melt-processing-temperature). At high temperatures, i.e. above approximately 500 °C, in particular above approximately 800 °C, fire retardants, however, significantly improve the holding together of the structure of the polymer, and thus prevent delamination of the structure, in particular detachment of the fire protection layer from the body board.

More specifically, the method according to the present invention is mainly characterized by what is stated in the characterizing part of Claim 1.

The multi-layer board according to the present invention is, in turn, characterized by what is stated in the characterizing part of Claim 20, and the use according to the present invention, by what is stated in Claim 22.

Considerable advantages are achieved with the present invention. Thus, delaying or preventing delamination can significantly slow down the break-up of the board at high temperatures, because the actual fire protection layer, such as a metal film, remains in place longer and thus protects the other layers.

By using, between the outer and inner layers, such an intermediate layer which is comprised of a non-woven fabric layer and a thermoplastic polymer film, a multi-layer structure that holds together very well is obtained. The thermoplastic polymer film is highly malleable and, when heated, conforms to the adjacent layers, and thus protects them firmly, in particular it protects the inner layer. The non-woven fabric layer of the intermediate layer, in turn, supports the thermoplastic layer. Fire retardant can be easily added to the thermoplastic polymer film, for example, during preparation of the film.
In the following, the present invention will be examined in more detail with the help of a detailed explanation and with reference to the accompanying drawing.

Figure 1 shows a side view of one of the embodiments of the board according to the present technology, and Figure 2 shows a corresponding view of another embodiment according to the present technology.

In the present context, "composite board" refers to any combination board which is composed of layers which are formed of wood-based material, and at least one other material layer.

In the present context, "wood-based material" refers to any material which is composed of any wood material or materials that are based on wood fibres, for example wood veneer, such as softwood or hardwood veneer, or a multi-layer board, plywood or wood board or a similar wood-based material, such as blockboard, chipboard, fibreboard, including MDF and OSB.

In the present context, "adhesive layer" refers to any intermediate layer which joins together the different materials, and which is comprised of adhesive material, which is known per se, for example resin, phenol-formaldehyde adhesive, melamine-formaldehyde adhesive, urea-formaldehyde adhesive and/or polyurethane adhesive or any other adhesive material which is suitable for the purpose.

In the present context, "one-time compression" refers to a method in which all the desired component layers, i.e. material layers and adhesive layers, are stacked at the same time to form a preform, and a board is generated in a one-time compression step.

As described above, the present technology refers in particular to the use of fire retardant in the binder layers of a multi-layer structure, or in such a surface of this kind of structure, in which the metal layer is attached for example by means of the binder layers.

Typically, the film which is used as a fire protection layer, such as a metal film, is thin (thickness approximately 0.005-0.5 mm, in particular 0.005-0.1 mm), in which case it can also be used for protecting 3D shape surfaces and edges, or to protect edges which can be
machined.

However, according to a more preferable embodiment, a solution according to the present invention is used in a multi-layer structure which comprises structural surfaces that are at least essentially laminar. Examples of these are different building boards and similar structures which are essentially stiff and typically self-supporting.

In one embodiment, the structure comprises a body board, such as a wood plate, or the like. At a certain distance from the body board, a fire protection layer is arranged which is comprised of a metal layer or a similar material. Between the layers, there is an intermediate layer which comprises a binder. In at least one binder layer of this multi-layer board structure, or in a non-woven layer or in a combination of these, there is fire retardant, in order to prevent or delay, under conditions of fire, delamination of the multi-layer board structure.

Figure 1 shows a diagram of an embodiment of the multi-layer board structure. In this embodiment, the board structure is comprised of:
- an outer layer 1;
- a first polymer-based adhesive layer 2;
- a non-woven fabric which is comprised of a polymer 3;
- a second polymer-based adhesive layer 4; and
- an inner layer 5.

The body layer of wood-based multi-layer structures is comprised of a wood board or a similar wood-containing board. The outer layer acts in principle as a fire protection layer, and is therefore made of a material which is able to withstand temperatures of above 500 °C, in particular above 750 °C, most suitably above 900 °C, for a period of at least 10 seconds, in particular at least 60 seconds, most suitably at least 120 seconds.

The outer layer 1 is a thin layer or film. Typically, this consists of a metal, such as aluminium, copper or steel, or films or composite materials which comprise metals or metallic substances, or other materials that withstand fire and high temperatures.

In a preferred embodiment, a metal film is used. The thickness of the metal film is
preferably approximately 0.005-3 mm, in particular approximately 0.005-1.5 mm. In addition to the metal layers, in principle it is possible to use ceramic materials, and films and non-woven layers that are impregnated with ceramic materials. The thicknesses of these layers when used as fire protection layers are usually 0.1-15 mm, in particular approximately 0.5-10 mm.

The surface of the outer layer may have a lacquer layer (not shown) or a similar surfacetreated layer, which provides the board structure with a desired finish and, if needed, permits printability.

The inner layer 5 is most suitably a board, in particular a structural board, which is capable of giving the board according to the present technology, desired mechanical properties, such as sufficiently high stiffness, flexural strength and impact strength, or a combination thereof.

Preferably, a board which is wood-based acts as the inner layer which, within the framework of the above mentioned definition - according to the first embodiment of the technology - means that the board is entirely comprised of wood, and according to another preferred embodiment, the board is comprised of wood layers, wood battens, plywood, veneers, fibres, chips or similar wood particles, or these are included in the board. A wood-based frame is for example a wood board, wood-fibre board, or a plywood or composite board that is composed of layers of plywood or veneer on top of each other.

Typically, the wood parts are attached to each other by means of an adhesive, for example, by mixing the wood parts in the adhesive, or by applying adhesive between adjacent wood layers or wood-containing layers, in particular in the form of adhesive layers. In one preferred embodiment, the adhesive layers are uniform. They may be formed of adhesive films. In another embodiment, the adhesive layers are comprised of separate adhesive zones, such as adhesive strips. In other respects, with regard to the adhesive layers, reference can be made to the definition above.

The multi-layer boards are preferably manufactured by using a one-time compression (see above), but it is also possible to generate a multi-layer board by stacking together individual layers, in which case one composition is compressed at a time.
Wood-based multi-layer boards can comprise, besides layers of wood or layers of wood parts, also functional layers. Examples of the properties of such layers are the following: thermal insulation, a moisture barrier, impermeability to air, fire protection, mechanical stress resistance, chemical resistance, weather resistance, and combinations thereof.

With regard to the structures of functional multi-layer boards, and the production and the properties of them, reference can be made to our parallel patent applications nos. WO 2011/101546 and WO 2011/131846.

In a preferred embodiment—the non-woven layer which forms the inner layer is preferably a plywood board, which is typically made of several layers of wood veneer, on top of each other, and which are attached to each other by means of adhesive layers. The thicknesses of the individual wood veneer layers are approximately 0.1-5 mm, for example approximately 0.2-3 mm.

The additional inner layer, i.e. body layer 5, may be made up of wood-based boards, can comprise a mineral material, which may include or consist of silicates or similar silicon oxide materials, or other inorganic, preferably essentially non-combustible materials, such as calcium salts, for example gypsum.

In the embodiment according to Figure 1, reference numerals 2 to 4 together indicate the intermediate layer of the present board. This layer binds together the outer layer and the inner layer.

Most suitably, the intermediate layer comprises a fabric layer, in which case the fabric structure renders to the fabric intermediate layer 3 good mechanical properties. One example of a suitable fabric is the non-woven fabric 3 shown in Figure 1. Typically, the non-woven fabric is an inorganic or organic material, in particular polymer, such as polyester. Examples are poly-terephthalate fabrics.

Furthermore, the intermediate layer also comprises adhesive layers. There is one or more of these. Most suitably, as shown in Figure 1, there is one adhesive layer on each side of the fabric intermediate layer 3 (reference numbers 2 and 4).
The adhesive layers are typically selected from a group which is comprised of thermosetting adhesive or thermoplastic adhesive resins, such as phenol formaldehyde (pf), melamine formaldehyde (mf), urea-formaldehyde (uf), polyurethane (pu), methylene diphenyl diisocyanate (mdi), polymeric methylene diphenyl diisocyanate (pmdi) or water-based methylene diphenyl diisocyanate (emdi) or ethylidenebis(2.5-furandiylmethylene) diisocyanate (edfi) or a mixture thereof. Other particular examples are dispersions of emulsion polymer isocyanate and polyurethane hot-melt adhesives.

In addition to the abovementioned layers, the board in the intermediate layer may also comprise at least one polymer film (in Figure 2) which can be arranged in a desired gap, for example against the outer layer 11, typically between the outer layer 11 and the first adhesive layer 12. Alternatively, the polymer film can be arranged against the inner layer 16, typically between the inner layer 16 and the adhesive layer 15. It is also possible to arrange the polymer film layer against the fabric layer 13, or between the fabric layer 13 and the adjacent adhesive layer 12 or 14. In this figure, it is arranged between the fabric layer 13 and the second adhesive layer 15. There may be several polymer films in the structure.

A suitable polymer film is made of thermoplastic. The thickness of such a thermoplastic film is approximately 0.1-10 mm, in particular approximately 0.5-5 mm. Most suitably, the thermoplastic used is an engineering plastic, such as polyolefin, polyester, polyimide, polyamide, ABS plastic or similar.

Fire retardant is included in at least one layer, which is selected from a group that is comprised of the first and the second adhesive layer and the thermoplastic polymer film.

In another embodiment, fire retardant is included in the inner layer or its surface.

Fire retardant is included in the adhesive layer, the polymer layer and/or the surface of the inner layer, in order to prevent delamination of the structure, particularly to protect the join between the surface layer 1, such as a metal film, and the inner layer, under conditions of fire or more generally under conditions in which the structure is exposed to high temperatures. Most suitably, the present technology prevents, under conditions of fire, detachment of the metal film or the like from the inner layer.
In principle, a fire retardant agent is included in at least one polymer layer, but in one embodiment, a fire retardant is included in at least two layers of a multi-layer board structure, of which layers at least one is a polymer layer.

Typically, a mineral fire retardant or an organohalogen compound or an organophosphorus compound, or a combination thereof, is used as the fire retardant.

In particular, aluminium hydroxide, alkaline earth metal hydroxide, magnesite, wollastonite, talc, antimony oxide, boron compound, such as borate, or inorganic phosphorus compound or organobromine or brominated polymer compound or organophosphate, organophosphonate, or organophosphinate, are used as a fire retardant.

Approximately 0.001-35 %, in particular approximately 0.01-20 % of fire retardant is included in the polymer layer or the surface of the inner layer, in which case the amount of fire retardant is calculated based on the total weight of the layer in which the fire retardant is included.

Mineral fire retardants are most suitably used in a finely divided form, and, typically, mineral fire retardant is used in a particle or granular form.

The average particle size of the powder or the granules is approximately 0.1 μm-10 mm, in particular approximately 0.01 mm-5 mm.

Organic fire retardants can also be used in the form of liquid solutions and suspensions, Water or an organic solvent can be used as an intermediate agent for these solutions or suspensions. Typically, the concentration of fire retardant in the solutions or suspensions is approximately 0.1-99 % by weight, particularly approximately 1-90 % by weight, most suitably approximately 5-75 % by weight, of the total weight of the solution or suspension.

Case specifically, at the temperature at which the organic fire retardants operate they are already in a liquid state.

Compositions which are in the form of a solution or a suspension can be used in
combination with, for example, materials that form adhesive layers by mixir
materials with each other. Thus, in one preferred embodiment, a modified adhesive
composition is generated which is comprised of a dispersion of emulsion polymer
isocyanate, or a polyurethane hot-melt adhesive, which contains a fire retardant. In such a
composition, the fire retardant percentage is in particular approximately 0.001-35 % by
weight, preferably approximately 0.01-20 % by weight, as described above.

Compositions which are in the form of a solution or a suspension can also be used for
treatment of the surface of the inner layer. In this case, the application amounts are for
example approximately 0.1-400 g, in particular approximately 1-100 g, most suitably
approximately 1-50 g of fire retardant per m², depending on the fire retardant used.

When there is a polymer film in the intermediate layer, the fire retardant is preferably
added already during preparation of the film. The film surface can be treated for example
with compositions which comprise compatibilisers, in particular liquid fire retardant
compositions which comprise reactive compatibilisers.

Preferably, the fire retardant is added to the thermoplastic polymer film during melt-
processing. Accordingly, the fire retardant can be included during the compounding
process of the thermoplastic raw material, either as such with the plastic raw material, or
together with the other additives, such as fillers and auxiliary agents. More preferably, the
fire retardant is mixed into a polymer mass which is to be extruded, from which the
polymer layer of the multi-layer board structure is generated. The polymer film can be
extruded directly onto the surface. This significantly speeds up the production of the board.

It is also possible to produce the films by using the blown film or the flat film method and
then separately attaching them to the surface. Typically, the film is attached for example to
the surface of wood by first priming the surface and then adding to the primed layer an
adhesive plastic layer that adheres to the primer. After that, the body plastic and,
optionally, the surface plastic which has functional properties, are attached.

The board structure according to the present invention can be produced all together by using
one-time compression. It is also possible to separately produce the body layer and the outer
layer together with the intermediate layers, which are then attached to each other, for
example, by stacking them into a preform and then pressing them together.

In an example, a multi-layer board is produced which is comprised of
- a lacquer layer;
- aluminium layer;
- an adhesive layer for the aluminium layer;
- a polyethylene film,
- a non-woven layer that is comprised of polyester;
- an adhesive layer for the non-woven layer; and
- a plywood board.

An aluminium film having a thickness of 30 µm acts as the surface layer. The film is attached to the non-woven fabric, which is made of polyester and the grammage of which is approximately 25 g/m². The film is attached by using a binder layer or an adhesive layer which is comprised of polyethylene, and the grammage of which is 23 g/m².

After that, the surface layer is glued to the board by using a weather-resistant polyurethane adhesive, for example a hot-melt adhesive, 60-120 g/m² of which is applied between the plywood board and the surface layer.

Polyurethane hot-melt adhesive gives extremely good results in fire tests.

The non-woven board comprises 1.4 mm birch-veneer layers which are glued together using a weather- and steam-resistant phenolic resin adhesive.

The edges of the board are sealed with acrylic paint.

Reference Numerals List

1: 11 outer layer
2: 12 first adhesive layer
3: 13 non-woven fabric
4: 15 second adhesive layer
14 polymer layer
inner layer

Citations

Patent Literature

5

US 6 511 730
DE 2019770
US 4 935 281
WO 201 1/101546

10 WO 2011/3 1846.
Claims:

1. A method of preventing or delaying delamination of a fire-protected multi-layer structure which comprises

5   - an inner layer (5; 16), which acts as a body;
   - an outer layer (1; 11), which is arranged at a distance from the inner layer, and
   - an intermediate layer (3; 13), which is fitted between these two layers,

the intermediate layer (3; 13) being attached to the inner layer by means of a first polymer layer (4; 15), and to the outer layer (1; 11) by means of a second polymer layer (2; 12), characterized in that

a fire retardant is incorporated into at least one polymer layer (4; 15; 2; 12), or into the inner layer (5; 16) which is arranged against the first polymer layer (4; 15), in order to prevent or delay delamination, under conditions in which the outer layer (1; 11) is exposed to a high temperature, the intermediate layer containing a non-woven fabric layer (13), and a thermoplastic polymer film (14), which optionally contains a fire retardant.

2. The method according to Claim 1, characterized in that the non-woven fabric in the intermediate layer is of inorganic or organic material, in particular polyester, and the thermoplastic polymer film is of polyolefin, polyester or polyamide.

3. A method according to any of Claims 1-2, characterized in that a fire retardant is included in at least two layers of a multi-layer board structure, at least one of which layers is a polymer layer.

4. A method according to any of Claims 1-3, characterized by producing a multi-layer board structure, which is comprises, starting from the outer layer, an outer layer, a second polymer-based adhesive layer, a thermoplastic polymer film, a non-woven fabric which is formed by a polyester, a first polymer-based adhesive layer, and an inner layer, a fire retardant being included in at least one layer which is chosen from the group formed by the first and the second adhesive layer and the thermoplastic polymer film.

5. A method according to any of the preceding claims, characterized in that the fire retardant is mixed into a polymer mass which is to be extruded, and from which mass
the polymer layer of the multi-layer board structure is generated.

6. The method according to Claim 5, characterized in that extrusion is used to prepare the first adhesive layer, the second adhesive layer or the thermoplastic polymer film, or two or more of these.

7. A method according to any of the preceding claims, characterized in that the non-woven layer which forms the inner layer is a wood board, wood-fibre board, or a plywood board or a composite board which is produced from several wood veneer layers on top of each other, which are attached to each other by means of adhesive layers.

8. The method according to Claim 7, characterized in that the thicknesses of the wood veneer layers are approximately 0.1-5 mm, in particular approximately 0.5-2 mm, for example approximately 0.7-1.5 mm.

9. A method according to any of the preceding claims, characterized in that a fire retardant is included on the surface or in the surface layer of the inner layer.

10. A method according to any of the preceding claims, characterized in that the fire retardant film is a metal film of aluminium, copper or steel, or it is of ceramic material or a film or a non-woven layer that is impregnated with a ceramic material.

11. A method according to any of the preceding claims, characterized in that the thickness of the metal film which acts as the fire retardant film is approximately 0.005-3 mm, in particular approximately 0.005-1.5 mm.

12. A method according to any of the preceding claims, characterized in that the thickness of the intermediate layer is approximately 0.1-10 mm, in particular approximately 0.5-5 mm.

13. A method according to any of the preceding claims, characterized in that the multi-layer board structure comprises adhesive layers which are of thermosetting adhesive resin or thermoplastic adhesive resin.
14. The method according to Claim 13, characterized in that the adhesive layers are comprised of phenol formaldehyde (pf), melamine-formaldehyde (mf), urea-formaldehyde (uf), polyurethane (pu), methylene diphenyl diisocyanate (mdi), polymeric methylene diphenyl diisocyanate (pmdi), water-based methylene diphenyl diisocyanate (emdi) or ethylidenebis (2,5-furandiylmethylene) diisocyanate (edfi) or a mixture thereof, which mixture comprises a fire retardant, in particular a dispersion of an emulsion polymer isocyanate or polyurethane-hot melt adhesive, which comprises a fire retardant.

15. A method according to any of the preceding claims, characterized in that the intermediate layer comprises a polyethylene film, which is comprised of a fire retardant that is added into polyethylene before the extrusion.

16. A method according to any of the preceding claims, characterized in that a mineral fire retardant, an organohalogen compound, or an organophosphorus compound, is used as fire retardant.

17. The method according to Claim 16, characterized in that aluminium hydroxide, alkaline earth metal hydroxide, magnesite, antimony oxide, boron compound, such as borate, or inorganic phosphorus compound or organobromine or a brominated polymer compound or organophosphate, organophosphonate, or organophosphinate, is used as fire retardant.

18. A method according to any of the preceding claims, characterized in that approximately 0.001-35 %, in particular approximately 0.01-20 % of fire retardant is included in the polymer layer or on the surface of the inner layer, in which case the amount of fire retardant is calculated based on the total weight of the layer in which the fire retardant is included.

19. A method according to any of the preceding claims, characterized in that a fire retardant is included in the polymer layer or on the surface of the inner layer in order to prevent detaching of the metal film under conditions of fire.

20. A multi-layer board structure intended for use as a fire protection board, which structure comprises
- an inner layer which is formed by a wood board, a wood-fibre board, a plywood or composite board that is formed of wood veneer layers on top of each other;
- an outer layer which is arranged at a distance from the inner layer, which outer layer is comprised of a metal film; and
- an intermediate layer which is fitted between these two layers, the intermediate layer being attached to the inner layer by means of a first polymer layer and the outer layer by means of a second polymer layer,
characterized by the combination that
- a fire retardant is incorporated into at least one polymer layer or into the inner layer which is arranged against the first polymer layer in order to prevent or delay delamination of the board structure under conditions in which the outer layer is exposed to a high temperature, and
- the intermediate layer contains a non-woven fabric layer and a thermoplastic polymer film that possibly comprises a fire retardant.

21. The board structure according to Claim 20, characterized in that it contains, moving from the outer layer to the inner layer
- a lacquer layer;
- an aluminium layer;
- an adhesive layer for the aluminium layer;
- a polyethylene film;
- a non-woven layer which is comprised of polyester;
- an adhesive layer for the non-woven layer; and
- a wood board, a wood-fibre board, a plywood or composite board prepared from wood veneer layers on top of each other;
which are joined to each other.

22. Use of a fire retardant in a binder layer, in an inner layer, or in a combination thereof, of a multi-layer board structure, which comprises an inner layer, a metal layer that is fitted at a distance from the inner layer, and an intermediate layer which is placed between these layers and which comprises a binder, a non-woven fabric layer and a thermoplastic polymer film, in order to prevent or to delay delamination of the multi-layer board structure, under conditions of fire.
23. The use according to Claim 22, characterized in that the inner layer comprises a wood board, a wood-fibre board, and a plywood or composite board made of wood veneer layers on top of each other.
INTERNATIONAL SEARCH REPORT

PCT/FI2013/051200

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: B32B, E04B

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

FI, SE, NO, DK

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

EPO-Internal, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Category*</th>
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<td>US 6890638 B2 (NGUYEN HUY X [US] et al.) 10 May 2005 (10.05.2005) column 3, lines 23-28; column 4, lines 20-25; column 4, line 55 - column 5, line 10; column 20, lines 1-8 and lines 15-17; column 24, lines 44-52</td>
<td>22 1-21, 23</td>
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<td>Y</td>
<td>DE 2019770 A1 (HOKUSAN KK) 04 November 1971 (04.1.1971) page 3, lines 11-22; page 4, lines 3-6; page 5, lines 1-9 and lines 19-26; page 6, lines 1-5 and lines 19-25; claims 1, 2, 3; figure</td>
<td>1-21, 23</td>
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☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

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**INTERNATIONAL SEARCH REPORT**

**Information on patent family members**

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