Title: SOUND ABSORBING STRUCTURES

Abstract: A sound-absorbing structure is provided which comprises a plurality of sound-absorbing tiles or other elements fitted in position, filler cast between the elements so as to provide a substantially flat surface with the elements, and a monolithic rendering which is porous but extends over the substantially flat surface and provides a very smooth surface without significantly reducing the sound-absorbing properties of the elements.
Sound Absorbing Structures

This invention relates to sound absorbing structures such as sound absorbing walls or ceilings.

There are two general methods for providing such structures. The method which gives the best sound absorbing properties generally consists of making preformed sound absorbing panels, tiles or other elements and fitting these preformed elements to the ceiling or wall in such a manner that the elements substantially abut one another. This method has the advantage that the manufacture of the elements can be conducted in such a way that they have very good sound absorbing properties, but it has the disadvantage that the joins between adjacent edges are visible, even when a filler is cast between the joins in an attempt to minimise the appearance of the joins.

The second method involves applying a rendering on to an appropriate substrate, such as a brick or concrete wall or plaster board ceiling, whereby the rendering is formulated so as to provide sound absorbing properties. However these sound absorbing properties are usually significantly inferior compared to those easily achievable using preformed sound absorbing elements. Examples of disclosures of sound absorbing renderings are in US-A-2,921,862 and DE-A-3,607,438.

Various techniques are known for making preformed sound absorbing elements, and these include constructing the basic element in such a way (for instance by orientation of fibres or apertures) to maximise sound absorption properties. Some of the techniques involve applying a sound absorbing coating over a mineral wool substrate. Examples are in DE-A-3,932,472 and EP-A-1,088,800.

The present situation therefore is that the best sound absorbing properties are achieved using preformed elements but these necessarily have joins between the edges of adjacent elements, whereas less satisfactory sound absorbing properties can be obtained with a monolithic surface (i.e., an apparently continuous and uninterrupted surface).

The problem is to be solved in the provision of sound absorbing structures having a monolithic, smooth, surface similar to conventional plaster or plasterboard but which has sound absorbing properties as high as, or almost as high as, are obtainable using sound absorbing elements such as panels or tiles.
If a monolithic surface is provided by applying a conventional plaster rendering over the sound absorbing elements, with or without filler cast between the elements, the sound-absorption properties are seriously reduced and this is unsatisfactory.

WO00/47836 is concerned with the problem of constructing walls from preformed elements, and in particular elements of corrugated sheet material. It proposes that the elements should be rendered with a rendering and that this rendering not only covers the elements but will also seal gaps around the elements. It mentions that the rendering can have sound absorption properties. The system therefore gives a monolithic surface starting from individual elements, but the sound absorption properties will be dictated solely by the sound absorption properties of the rendering. Accordingly, although this is concerned with sound absorption properties starting from preformed elements, and it does give a monolithic surface, the sound absorption properties are not significantly better than those obtained by rendering a conventional concrete or other surface with a sound absorbing rendering.

Sound absorbing renderings usually contain coarse fibrous or other particulate material in order to provide them with the physical structure that results in sound absorption. For instance the rendering may contain mineral fibres, such as the asbestos mentioned in US-A-2,921,862 or, mineral wool fibres instead of the asbestos fibres in that. The application of such a rendering over elements can be capable of giving a monolithic surface which is reasonably flat if a filler has been cast in the joints but it will still not be smooth relative to the conventional smoothness of a plaster or plaster board surface. Accordingly, applying an acoustic, mineral; fibre, rendering would provide a surface which is rough on a microscale and would not satisfy the requirement for a smooth monolithic appearance resembling conventional plaster.

A sound-absorbing structure selected from ceilings and walls is now provided and comprises

- a plurality of substantially abutted, sound-absorbing, elements having an acoustic absorption coefficient $c_w$ of at least 0.7,
- filler which is cast and cured between the elements whereby the filler and the elements provide the structure with a substantially flat surface and
- a physically or chemically cured, porous, monolithic rendering bonded to and extending substantially entirely over the substantially flat surface and which is smooth, and the structure has an acoustic absorption coefficient of at least 0.6.
Preferably the smooth rendering has a surface roughness such that $S_a$ is below 140μm preferably 40 to 140 (e.g., 60-140) μm. Preferably the rendering has a roughness such that $S_q$ is below 170μm preferably 50 to 170 (e.g., 90 to 170) μm. Preferably the rendering has a roughness such that $S_z$ is below 900μm preferably 300 to 900 (e.g., 700 to 900) μm and

The surface roughness values $S_a$ (amplitude parameter), $S_q$ (root mean square deviation) and $S_z$ (extreme amplitude parameter) are determined in conventional manner, for instance as described in Surface Topography, second edition, by Stout and Blunt, published by Pentan Press pages 156 and 166 and in Precision - Handbook of Surface Metrology by Whitehouse published by Rank Taylor Hobson, pages 12 to 14.

A surface having some or all of these values will appear to be truly smooth and will be aesthetically comparable to a conventional plaster or plaster board surface, which is the appearance which is desired in the invention. However these values allow for some microscale roughness in the surface which is grater than in conventional plaster and plasterboard surfaces and this helps to improve the aesthetic appearance of the surface if the filler has not provided a perfectly flat surface.

Preferably the surface complies with at least two of the defined values ($S_a$, $S_q$ and $S_z$) and preferably it complies with all three.

The acoustic absorption coefficient $\alpha_w$ is determined in accordance with I.S.O.354:2003 and is measured 200mm from the surface. $\alpha_w$ of the initial elements is preferably at least 0.8 or 0.85 and often at least 0.9 or 0.95. The sound absorbing elements in the invention are elements which have $\alpha_w$ as high as is reasonably possible, and it is important in the invention that the rendering does not reduce the absorption coefficient too seriously. Generally therefore the absorption coefficient of the substantially flat and smooth monolithic rendering is not more than 0.05, 0.1, or at the most 0.2 units less than the coefficient for the elements. Accordingly $\alpha_w$ of the final structure, carrying the monolithic rendering, is preferably at least 0.7 or 0.8, most preferably at least 0.85 and often at least 0.9 or even 0.95 when the element has a very high $\alpha_w$.

The structure is conveniently made by a process comprising assembling on the surface of a wall or ceiling the plurality of substantially abutted sound-absorbing elements, casting filler between the substantially abutting elements and physically or
chemically curing the cast filler and, if necessary, smoothing the cured cast filler and thereby providing the substantially flat surface,

if necessary applying a primer coat over the cured cast filler to reduce its water absorption,

applying over substantially the entire substantially flat surface an uncured rendering which is a viscous fluid composition containing an aqueous fluid phase in which is suspended insoluble particulate material which consists of particulate material having a maximum dimension below 2mm and wherein the aqueous phase comprises an uncured binder and entrained gas microbubbles, and

physically or chemically curing the binder and thereby forming the smooth, cured, porous monolithic rendering.

In order that the monolithic coating provides the defined smooth monolithic surface it is necessary that the substrate (i.e., the assembly of sound-absorbing elements with filler cast between them) should be as level and as smooth as possible and that the rendering should dry reasonably uniformly after application. It is therefore often desirable to treat parts of the assembly of elements and filler so as to achieve an adequately uniform rate of drying of the fluid rendering. This allows the attainment of substantially uniform bonding of the rendering over the entire surface. However primer is preferably not applied where it is not required for improving drying and bonding, since it can reduce the acoustic properties of the underlying surface.

In particular it can be desirable to apply a primer over the cast filler, but generally not over the sound absorbing elements. This is because cast filler should generally be smoothed by sanding or other conventional method before applying the rendering. Fillers which are capable of being smoothed adequately relatively quickly after initial casting tend to be porous. In particular, optimum fillers, from the point of view of curing and smoothing, are often based on gypsum and such fillers tend to be porous. Accordingly, it is sometimes desirable to apply primer over filler which has been cast, cured and smoothed if the porosity of the filler is then significantly different from the porosity of the remainder of the surface, i.e., the elements.

The primer can be any suitable water-based or other primer paint that will result in the surface having a satisfactorily controlled degree of absorbency.

Preferably the filler which is used is a filler which sets to give a porosity sufficiently similar to the porosity of the panels, tiles or other elements such that the rendering will coat and dry substantially uniformly over the filler and the surfaces of
the other elements without the need to apply primer over the filler. The filler may be fillers based on a hydraulic binder, for instance fillers based on gypsum or cement. Such fillers are generally provided by mixing with water a gypsum powder or other suitable powder containing hydraulic binder, applying the resultant paste, and leaving it to set and dry. However, it is often preferred to use a filler containing an organic binder instead of a hydraulic binder, for instance a filler which is supplied as a paste including a latex or other organic binder. The presence of the organic binder can promote adhesion of the filler to its underlying surface, and can also improve the texture of the surface of the set filler, relative to hydraulic fillers.

It is important in the invention that the rendering must be porous in order that it does not reduce the absorption coefficient too seriously. If the rendering does reduce the absorption coefficient too seriously (relative to the absorption coefficient of the elements underneath the rendering) then the advantages of using these elements is reduced or lost.

Accordingly, in the invention the rendering is preferably not a rendering which would normally be considered as an acoustic rendering. Instead, the rendering is sufficiently porous that the sound reaching the surface of the rendering travels through the pores and is absorbed predominantly by the sound absorbing elements. The pores should therefore be open pores which interconnect between the front surface of the rendering and the surface of the elements on which the rendering is applied. Accordingly the porosity is preferably of the type which is due predominantly to pores created by microbubbles escaping from the rendering after application to the surface but before and during curing of the rendering. Accordingly a foaming agent is preferably included.

The microbubbles can be created by the presence of surfactant (preferably a soap) as foaming agent, combined with vigorous agitation in air. Instead of or in addition to this the rendering is provided by mixing particulate material, binder and water and creating the microbubbles, and optionally larger bubbles, by chemical decomposition within the fluid phase and stirring the resultant fluid composition to distribute the microbubbles uniformly through the composition and to disperse and/or break any larger bubbles into microbubbles.

The microbubbles may be formed by chemical decomposition of a carbonate or bicarbonate in the composition with acid dissolved in the aqueous phase.
However it is not essential to use chemical decomposition in order to generate
the microbubbles and the desired open pore structure. For instance the rendering
may include delayed release microcapsules which will release, during curing of the
rendering, material which either is gaseous or which will react with other components
in the rendering to form gas, in order to provide pores extending through the
rendering.

In order that the final rendered surface is smooth, the particle size distribution
of the particulate material in the rendering should be selected appropriately. The
particles in the rendering are usually bonded by physically or chemically cured bonding
agent wherein the particulate material consists of particulate material having a
maximum dimension below 1mm and a particle size distribution which allows for the
achievement of the defined smoothness.

Pigment such as titanium dioxide is normally included as part of the particulate
material, for instance in amounts of from 0.3 to 10% of the dry render. Fine extender
or filler such as talc can be included as part of the particulate material, for instance in
amounts of from 1 to 20% of the dry render. Hollow fillers such as glass spheres may
be used.

The major components (for instance at least 60 or 70% and preferably at least
80, 90 or 95% by weight of the dry render) are usually conventional, fine, particulate
materials having a maximum size which is below 2mm and is usually below 1mm and
having an average size which is usually below 1mm, preferably below 0.5mm and
most preferably below 0.1 or 0.2mm, and preferably includes very fine material, so as
to promote the formation of a smooth surface. Examples are quartz sand and lime
(calcium carbonate) and dolomite (magnesium, or calcium magnesium carbonate).

Preferably the render is substantially free of rock fibres since the acoustic
benefits they provide to acoustic renderings are not needed in the invention, and such
fibres usually prevent adequate smoothness being obtained. However small amounts
(e.g., below 5% and preferably below 1%) may be included provided they do not
prevent the achievement of the required smoothness. Similarly, appropriately low
amounts of other fibres may be included provided they do not prevent achievement
of the desired smoothness. Examples are synthetic polymeric fibres for instance
acrylic fibres or polyester fibres, typically having a fibre length less than 500μm and
preferably less than 200μm and often less than 100μm. The fibre diameter may be
less than 50μm and preferably less than 20μm and is often around 1 to 10% of the
length. The amount is usually from 1 to 5% based on the dry render. Often the render is free of fibrous material or contains, at most, not more than 5% and often not more than 2%, based on weight of dry render.

The overall combination of particulate material, fibre if present, and other components must be such that the dried and cured rendering has the required surface smoothness, and this necessitates that the rendering does not contain significant amounts of conventional mineral wool fibres.

Typically, the dry content of the rendering comprises 1 to 20% physically or chemically cured binder, 70 to 99% water insoluble particulate material wherein the particulate material has a maximum dimension of 1mm and 0 to 20% water soluble or dispersible additives, such as surfactants.

The viscous fluid composition which is used to form the cured render is usually formed by mixing water insoluble particulate materials as powder or as a preformed aqueous paste with foaming agent and sufficient water to provide the required rheology. The total amount of water is generally about 15 to 55%, often 25 to 45%, by weight of the fluid render. All the necessary ingredients other than water may be in a single powdered mix or paste or the majority may be provided in a powdered mix or paste and a minor amount may be provided either in a separate powdered mix or in a liquid form.

The total ingredients must include binder and viscosifier which is selected to optimise the rheology of the composition during and after application. The same material may serve both purposes but often it is preferred to use different materials, one contributing predominantly to the binder properties and another contributing predominantly to the rheology properties.

The binder cures physically or chemically. Physical curing occurs when, for instance, a film-forming binder dries to form a film. Chemical curing occurs when, for instance, a hydraulic material such as cement or gypsum cures to a solid cured form or when a organic polymer cross links or otherwise cures to form a dried, generally insoluble polymer. It is preferred that the binder and/or the rheology adjusting material (if different) should be film-forming so as to promote the formation of a smooth film surface as the fluid render dries after application.

The binder may be an inorganic hydraulic binder such as cement or gypsum or lime or a mixture thereof but often it comprises an organic polymer. The rheology adjusting material generally comprises organic polymer. Organic polymers which may
be used as binder or rheology adjusting materials (e.g., thickeners) can be selected
from any of the polymers which are conventional for such purposes, including natural
polymers such as cellulosic or modified cellulosic polymers (such as methyl cellulose
or carboxymethyl cellulose), or starches, or synthetic polymeric thickeners or binders
such as homopolymers of acrylamide and/or acrylic acid.

Organic polymer included in the composition may be acidic in order to provide
the acidic conditions which can be utilised to cause the liberation of carbon dioxide.
Instead of, or in addition to this, other acid can be included either in powder form or
as a liquid.

It is generally preferred that the binder is predominantly or wholly organic (for
instance a styrene acrylic or other acrylic emulsion, the thickener is primarily organic
(for instance a cellulosic ether or acrylic thickener) and that any fibres are
predominantly organic, for instance acrylic fibres. Suitable fillers for the composition
are usually inorganic and of very fine particle size, for instance calcium magnesium
carbonate (dolomite), calcium carbonate, quartz or other silica compounds.

It is particularly preferred for the non-aqueous components of the render to
comprise 1 to 20%, preferably 2 to 10% by weight organic water soluble dispersible
materials and 70 to 99% by weight inorganic particulate material provided by, for
instance, 10 to 50% calcium carbonate and a generally larger amount, 30 to 70%, by
weight quartz sand or other sand, with the balance being other inorganic particulate
materials having the desired size distribution.

The rendering may be applied in one or more coats, but generally it is not
necessary to apply more than two coats. The surface of the rendering may have the
required smoothness as a result of merely applying the rendering and allowing it to
cure and set. It is often desirable to smooth the final surface (or an intermediate
surface if more than one coat is applied) by sanding or grinding in order to remove
major blemishes in the surface and to improve its overall smoothness.

In order to construct the sound-absorbing structure comprising the sound-
absorbing elements, the filler and the rendering, it is necessary to provide not only the
elements but also the filler in a form capable of being cast and cured and a powdered
rendering composition for mixing with water, and optionally with other fluid ingredients,
to form a viscous fluid rendering composition.

Several types of sound-absorbing elements having the required high values
of $\alpha_\omega$ (above 0.7 and preferably at least 0.9 or 0.95) and which are in panel or tile form
are well known and can be used in the invention. Suitable elements based on mineral fibres are available under the trade name Rockfon. Other examples are shown in EP-A-0652331 and EP-A-1154087. Elements formed mainly of rock fibres are preferred.

The elements often have a painted fleece covering. They are fitted to the ceiling or wall in conventional manner, either by direct application and adhesion to a solid surface or, more usually, by fitting on to a grid of support elements (such as the Rock Link 24 system supplied by Rockfon Limited of Bridgend, Glamorgan) in which event the sound-absorbent elements are preferably Rockfon Mono Acoustic tiles.

Filler, for instance a gypsum based filler, is then applied into and over the joins between the elements and is cast into and over these joins in conventional manner and allowed to cure. The filler is then sanded, and usually the elements are also lightly sanded to ensure that there are no unwanted particles or other deformations on their surface, to provide an overall surface which is as flat as possible. Nevertheless it is never, in practice, as flat and as smooth as is aesthetically required for a monolithic surface.

The filler not only serves to fill between the elements so as to provide a substantially flat surface but it also serves to promote the security of the fastening of the elements in position and so may eliminate the need for adhesive or other fastening system.

The filler is usually a material optimised for these purposes, such as a cement based filler or, preferably, a gypsum based filler. However with some formulations of the powdered rendering, it is possible to use the same material as filler as is used for the rendering.

The panels, tiles or boards which have been fitted to the wall or ceiling usually already have an external surface which is painted, usually a painted fleece, but if necessary a primer may be applied over the filler only so as to provide substantially uniform absorbency properties throughout, especially when the filler is based on gypsum. The primer can be a conventional primer paint, for instance a water based paint.

The dry composition for forming the viscous fluid rendering composition is then mixed with water, and any other fluid ingredients that are required. This composition comprises physically or chemically curable binder and water insoluble particulate material having the desired particle size range and usually includes materials which
will form an acidic solution which will react with carbonate to form carbon dioxide or will contain some other foaming system.

A suitable composition comprises 1 to 5%, preferably 3 to 4% acrylic or other organic fibres, 1 to 5%, often 1 or 2% up to 3%, of a viscosifier such as a cellulose ether or acrylic thickener, 0.3% to 5% and preferably 2 to 4% (dry weight) organic binder, generally a styrene acrylic or other acrylic emulsion, optionally 0.1 to 0.3% antibacterial and fungal agent, 40 to 70%, often 50 to 70%, fine filler such as calcium magnesium carbonate, calcium carbonate, quartz or other silicon compound, and foaming agent soap (typically 0.05 to 1%, preferably 0.1 to 0.3 or 0.5%), and/or an acid which will react with the filler optionally in larger amounts, and water in an amount of 20 or 25% to 40%.

It is usually convenient to initiate the foaming by mixing some or all of the ingredients which will cause foaming thoroughly before mixing them fully with all the particulate material. Once foaming is well established, the aqueous foaming liquid is then mixed thoroughly with the remainder of the particulate material. Initially it may be seen that there is a non-uniform distribution of gas within the composition but mixing is continued until a uniform texture, similar to stiff whipped cream, exists.

This composition is then sprayed on to the substantially flat surface of filler and sound-absorbing element. The distance between the spray nozzle and the substantially flat surface is often in the range 200 to 1400mm, often 300 to 1000mm, most preferably 400 to 700mm. The amount of render is usually in the range 0.4 to 1.8, preferably 0.6 to 1.6 and most preferably 0.8 to 1.4, litres per minute. The diameter of the spray nozzle is generally 2 to 8mm, preferably 3 to 6mm and most preferably around 4.5 to 7mm, e.g., 6mm.

Preferably around 0.3 to 0.5kg/m² (dry weight) of render is applied in a single application. The surface is then allowed to dry, for instance for at least 8 hours at ambient temperature. A second coat of render is then usually applied and allowed to dry. Sometimes it is desirable to apply a third coat. The rendering may be smoothed by sanding or grinding, as explained above.

The overall amount of render is generally from 0.5 or 1kg to 3kg/m². The total amount of render is usually at least 0.5kg/m² (for instance achieved by application of a single coating of 0.5kg/m²) and it usually extends up to 0.8 or 1kg/m² (for instance 2 layers of 0.5kg/m²). Although it is not usually necessary, it can extend up to 2 or 2.5kg/m² of significant amounts of the render are to be removed by sanding or
grinding, the rate of application may be increased in order to give these quantities in
the final structure after smoothing.

The average thickness of the coating can be as low as 0.3mm but is often at
least 0.5mm. It can be as much as 2mm, but it is preferably not more than 1.5mm.

Accordingly it will be seen that the rendering which is applied in the invention is so
thin, relative to normal acoustic renderings, that it cannot contribute to the sound
absorbing properties. However, as a result of its porosity, it does not reduce
significantly the sound-absorbing properties of the underlying elements.
CLAIMS
1. A sound-absorbing structure selected from ceilings and walls and comprising a plurality of substantially abutted, sound-absorbing, elements having an acoustic absorption coefficient $\alpha_w$ of at least 0.7,
filler which is cast and cured between the elements whereby the filler and the elements provide the structure with a substantially flat surface and a physically or chemically cured, porous, monolithic rendering bonded to and extending substantially entirely over the substantially flat surface and which is smooth and the structure has an acoustic absorption coefficient $\alpha_w$ of at least 0.6.
2. A structure according to claim 1 in which the elements have an acoustic absorption coefficient $\alpha_w$ of at least 0.85 and the structure has a lower acoustic absorption coefficient of at least 0.8.
3. A structure according to claim 1 or claim 2 in which the monolithic rendering has a thickness of not more than 2mm.
4. A structure according to any preceding claim in which the monolithic rendering has a dry weight of up to 2kg/m².
5. A structure according to any preceding claim in which the monolithic rendering has a surface roughness such that $S_a$ is below 140μm, $Sq$ is below 170μm and $Sz$ is below 900μm.
6. A structure according to any preceding claim in which the smooth rendering has a surface roughness such that $S_a$ is 40 to 140μm.
7. A structure according to any preceding claim in which $Sq$ is 50 to 170μm.
8. A structure according to any preceding claim in which $Sz$ is 300 to 900μm.
9. A structure according to any preceding claim in which the cast filler is water absorbent and there is a water absorbency-reducing priming coat between the filler and the rendering to promote bonding of the rendering to the filler.
10. A structure according to any preceding claim in which the porosity of the cured monolithic rendering is due predominantly to pores created by microbubbles escaping from the rendering before and during curing of the rendering.
11. A structure according to any preceding claim in which the cured monolithic rendering comprises particulate material bonded by physically or chemically cured bonding agent wherein the particulate material consists of particulate material having a maximum dimension below 2mm and a particle size distribution which allows for the achievement of the defined smoothness.
12. A structure according to claim 11 in which the binder is a film-forming water soluble or dispersible organic polymeric material cured chemically and/or cured physically by drying the binder while in liquid form.

13. A structure according to any preceding claim in which the cured monolithic rendering is free of inorganic fibres but optionally comprises synthetic polymeric fibres.

14. A structure according to any preceding claim in which the monolithic rendering comprises 1 to 20% physically or chemically cured binder, 70 to 99% water insoluble particulate material wherein the particulate material has a maximum dimension of 2mm and 0 to 20% water soluble or dispersible additives and 0-5% organic fibres.

15. A process for forming a structure according to any of claims 1 to 14 comprising assembling on the surface of a wall or ceiling the plurality of substantially abutted sound-absorbing elements, casting filler between the substantially abutting elements and physically or chemically curing the cast filler and, if necessary, smoothing the cured cast filler and thereby providing the substantially flat surface,

if necessary, applying a primer coat over the cured cast filler to reduce its water absorption,

applying over substantially the entire substantially flat surface an uncured rendering which is a viscous fluid composition containing an aqueous fluid phase in which is suspended insoluble particulate material which consists of particulate material having a maximum dimension below 1mm and wherein the aqueous phase comprises an uncured binder and entrained gas microbubbles, and

physically or chemically curing the binder and thereby forming the smooth, cured, porous monolithic rendering.

16. A process according to claim 15 in which the fluid phase is formed by mixing the particulate material, binder and water and creating the microbubbles, and optionally larger bubbles, by chemical decomposition of a carbonate within the fluid phase and stirring the resultant fluid composition to distribute the microbubbles uniformly through the composition and to disperse and/or break into microbubbles any larger bubbles.
A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 E04B1/82 E04B1/86

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 7 E04B

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>X</td>
<td>EP 0 086 681 A (GACHOT, JEAN) 24 August 1983 (1983-08-24) the whole document</td>
<td>1-16</td>
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<tr>
<td>A</td>
<td>DE 40 32 769 A1 (GUELENPFENNIG, ROLF, DR., 7143 VAIHINGEN, DE; GUELENPFENNIG, ROLF, D) 2 May 1991 (1991-05-02) the whole document</td>
<td>1,15</td>
</tr>
<tr>
<td>A</td>
<td>FR 2 442 808 A (VERRE TECHNIQUE) 27 June 1980 (1980-06-27) the whole document</td>
<td>1-16</td>
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Date of actual completion of the international search: 7 June 2005

Date of mailing of the international search report: 13/06/2005

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<table>
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<tr>
<th>Patent document cited in search report</th>
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<tr>
<td></td>
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<td>AT 12803 T</td>
<td>15-05-1985</td>
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<td>CA 1190376 A1</td>
<td>16-07-1985</td>
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<td>DE 3360118 D1</td>
<td>23-05-1985</td>
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<td>DE 86681 T1</td>
<td>24-11-1983</td>
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<td></td>
<td></td>
<td>EP 0086681 A1</td>
<td>24-08-1983</td>
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<tr>
<td>DE 4032769 A1</td>
<td>02-05-1991</td>
<td>NONE</td>
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<td></td>
<td></td>
<td>JP 55106568 A</td>
<td>15-08-1980</td>
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