Title: ARTIFICIAL GRASS TURF SYSTEM

Abstract: An artificial grass turf carpet (10) comprises a ground structure (11) having an upper surface and upstanding synthetic grass fibres (12) attached to said ground structure, which synthetic grass fibres form a grass surface of said artificial grass turf. The carpet further has upstanding synthetic base layer fibres (15) attached to said ground structure at positions between the upstanding synthetic grass fibres. The base layer fibres have a lower height than said grass fibres. The said base layer fibres are positioned tight against one another and against neighbouring grass fibres, so that a dense base layer (16) is obtained above which the grass fibres extend. An artificial grass turf system includes such a carpet and has preferably a thin, rubber-free infill layer (20) on top of the base layer.
ARTIFICIAL GRASS TURF SYSTEM

The present invention relates to an artificial grass turf carpet and an artificial grass turf system including such a carpet.

From the prior art many artificial grass turf system are known.

Recently the FIFA allowed the use of artificial grass turf systems for soccer. These artificial grass turf systems in general are “third generation” turf systems, having synthetic grass fibres of considerable length, e.g. up to 70 mm, and a thick infill layer on top of the ground structure between the grass fibres. The generally adopted artificial grass turf systems have an infill layer of rubber granules, sometimes mixed with sand.

Many different aspects are related to artificial grass turf systems. These aspects include such things as: ball/surface interaction (vertical ball rebound, ball roll, etc), player/surface interaction (such as deformation, slip resistance, traction, etc) and also shock absorption and energy restitution.

The present invention aims to provide an improved artificial grass turf carpet and an artificial grass turf system including such a carpet.

In particular the present invention aims to provide an artificial grass turf system highly suitable for sports, in particular for soccer.

According to a first aspect thereof the present invention provides an artificial grass turf carpet comprising:

- a ground structure having an upper surface,
- synthetic grass fibres upstanding from said ground structure, which synthetic grass fibres form a grass surface of said artificial grass turf,
- synthetic base layer fibres upstanding from said ground structure at positions between the synthetic grass fibres,
- said base layer fibres having a lower height than said grass fibres,
- wherein said base layer fibres are positioned tight against one another and against neighbouring grass fibres, so that a dense base layer is obtained above which the synthetic grass fibres extent.

In particular the present invention envisages that such a carpet is used in an artificial grass turf system, wherein an infill layer, preferably of one or more particulate materials, is placed on top of said base layer fibres.

The synthetic grass fibres will in general have a resemblance to natural grass and e.g. be of a green colour.

Preferably the grass fibres are bundles of monofilament extruded fibres with a geometry that ensures autonomous resilient behaviour of the grass fibres. In another version e.g. fibrillated tape could be used.

Preferably said synthetic grass fibres are made of polyethylene because of its softness and low coefficient of friction of its surface.

The grass fibres could have a dtex between 6000 and 16000 dtex, preferably between 8000 and 16000 dtex, and are preferably formed of bundles of individual monofilaments that have a dtex between 500 and 2000 dtex. Alternatively single fibres with the same weight (fibrillated tapes) or bundles of slit tapes (so-called mono-tapes) with the same dtex could be used.
The grass fibres could also include co-extruded filaments, e.g. yarns that have two materials in one filament, e.g. nylon in the middle and PE on the outsides.

5 In a preferred embodiment the grass fibres have a thickness of at least 80 microns and a width between 1.3 and 2.0 millimetres.

Preferably the base layer fibres have a solid or monolithic cross-section, not made up from a bundle of filaments as is preferred for the grass fibres, but as a, preferably thick, monofilament.

10 Preferably the base layer fibres are relatively thick, preferably at least significantly thicker than said grass fibres.

15 Preferably a thermoplastic vulcanizate (TPV) is employed for the base layer fibres. This thermoplastic vulcanizate could include EPDM embedded in polypropylene (PP), such as EPDM particles embedded in a PP matrix.

20 As an alternative the base layer fibres are made of a thermoplastic elastomer (TPE) or possible a combination of several thermoplastic elastomers. Also a thermoplastic olefin (TPO) could be used. These materials are known for maintaining their relevant properties over a long time.

25 In a possible embodiment the base layer fibres include EPDM.

Preferably the base layer fibres include an UV-stabilizer.

30 In a possible embodiment the base layer fibres have a sandlike colour.

Preferably the base layer fibres have a minimum cross-sectional dimension of at least 0.7 millimetre, preferably at least 1 millimetre, more preferably at least 1.5 millimetre, most preferably of at least 1.8 millimetre. Preferably said relatively great
thickness is provided a monolithic cross-section of the base layer fibres.

Preferably the base layer fibres have a height between 15 and 35 millimetres, more preferably between 20 and 30 millimetres, e.g. about 25 millimetres.

The infill layer covering said base layer fibres is preferably thin, in particular significantly thinner than prior art infill layers, e.g. within the thickness range of 3-15 millimetres, preferably between 4 and 10 millimetres.

The synthetic grass fibres are of such a length that they extend above said infill layer, e.g. by at least 5, preferably at least 10 millimetres, most preferably within a 15-20 millimetres range.

In an advantageous practical embodiment the base layer fibres have a solid cross-section with a diameter of about 1.8 - 2.8 millimetres, e.g. a circular cross-section.

The inventive carpet and artificial grass turf system including such a carpet are expected to provide an excellent behaviour over a long period of use. This compares favourably to prior art artificial grass turf systems, which suffer from compaction of the infill layer after prolonged use. The compaction results in the hardening of the turf, which negatively affects aspects as "ballbouncing" and "shock absorption" of the turf. It is noted that when a thin infill layer is used on top of the base layer, as is preferred, no detrimental compaction of the thin infill layer will occur.

The dense base layer obtained by the tight packed base layer fibres is considered to behave as a resilient layer, which in general restores after being compressed, e.g. by the players on the turf.

An effect expected to be achieved with the inventive carpet is that the base layer thereof effectively can act as a replacement of (at least most of) the particulate infill material, notably rubber
granules, that is now used for the construction of a artificial grass turf system, in particular third generation turfs.

The dense and resilient base layer of the carpet is expected to produce the effect that the shoe of e.g. a soccer player achieves a grip on the turf essentially equal to the grip on a natural grass turf, primarily by the studs of the shoe penetrating into the turf, under circumstances into the base layer of the turf. This is in particular relevant in situations as when the shoe is rotated on the turf, etc.

This effect is likely to be enhanced when the infill layer covering said base layer is thin as explained before.

The resilient behaviour of the base layer of the carpet is also expected to have an effect on the infill layer on top of the base layer in such a manner that the infill layer does not suffer from undesirable compaction.

It is envisaged that with the carpet according to the invention the need for particulate infill material is significantly reduced as compared to third generation artificial grass turf systems.

It is even envisaged that the carpet according to the invention allows to dispense with rubber granules and the like “resilient infill materials” as are nowadays commonly proposed as infill materials.

It is considered highly advantageous that the infill can be free of rubber granules, as these granules are often environmentally undesirable (e.g. when recycled rubber (SBR) is used) and are likely to cause undesirable high surface temperatures.

A further advantage of the non-use of rubber infill material is that recycling of the turf is easier.
In a preferred embodiment the base layer fibres of the carpet are essentially straight and each have a foot attached to the ground structure and a non-looped upper free end.

In a further preferred embodiment the base layer fibres are upright oriented cut-pile fibres.

In a highly advantageous embodiment the carpet is woven.

Preferably in the woven carpet the base layer fibres are “cut-pile” fibres obtained by the weaving process.

Preferably in the woven carpet the grass fibres and the base layer fibres are woven together with a weft yarn or ground fabric yarn, so as to obtain an integral woven carpet having a ground fabric and grass fibres and base layer fibres extending from the upper surface thereof.

Preferably a woven artificial grass turf carpet is manufactured on a suitable carpet weaving machine, preferably in a single run.

In a possible embodiment the carpet is manufactured using the “face-to-face” carpet weaving technique, wherein two carpets are simultaneously woven face-to-face on a single machine and separated from each other.

By using the weaving technique for the manufacturing of the carpet it is possible to obtain a dense base layer in the carpet.

Also by using the weaving technique a reliable locking can be obtained between the ground structure on the one hand and the base layer fibres and grass fibres on the other hand. This avoids the problem of fibres coming loose from the turf system, as is experienced in prior art tufted artificial grass carpets.
Also by using a suitable weaving technique, such as the "face-to-face" weaving technique, the different heights of the base layer fibres and the grass fibres can be obtained in a single run.

Suitable yarns for in the ground fabric are for instance polypropylene (tape) yarn, (spun) polyester yarn, jute yarn, etc.

The woven part of the ground structure, the ground fabric, is preferably covered on the underside with a coating layer as is known in the carpet finishing technology, such as a latex layer, a polyurethane layer, etc. It can also be envisaged that a further layer, e.g. a glass fibre layer, is fixed against the underside of the woven ground fabric.

In an alternative embodiment the base layer fibres are fusion bonded to said ground structure, e.g. by ultrasonic welding.

Preferably the dense base layer has such a density that the combined cross-sectional area of the grass fibres and base layer fibres — measured at the upper surface of the ground structure — is at least 70%, more preferably at least 80%, most preferably at least 90% per unit of surface area of the carpet.

It might even be possible to achieve a density of about 100%, when the fibres are somewhat elastically compressed by the dense packing in the base layer.

Preferably at least 3 or 4, preferably at least 7, more preferably between 7 and 9, base layer fibres are arranged between neighbouring grass fibres.

Preferably between 30 and 100, preferably between 40 and 70, grass fibres are arranged per metre length of the carpet. When the carpet is woven it is preferred to have this density of grass fibres both in warp and weft direction of the carpet.
Preferably between 300 to 800, preferably between 400 and 600, base layer fibres are arranged per metre length of said carpet. When the carpet is woven it is preferred to have this density of base layer fibres both in warp and weft direction of the carpet.

For instance a carpet has 450 base layer fibres per metre and e.g. 50 grass fibres per metre, wherein the base layer fibres have a thickness of between about 2 mm, preferably with a circular cross-section, whereas the grass fibres are thinner, e.g. 1 mm.

In the above exemplary artificial grass turf carpet the dense base layer has such a density that the combined cross-sectional area of the grass fibres and base layer fibres – measured at the upper surface of the ground structure – is now about 95% per unit of surface area of the carpet.

Preferably said base layer fibres have a greater bending stiffness than said grass fibres.

Preferably the base layer fibres have a non-square cross-section, e.g. a circular or oval cross-section, preferably a circular cross-section. Due to the non-square cross-section narrow "vertical" interstices will be left open between adjacent base layer fibres. A small amount of infill material will enter into these interstices, especially when the turf is compressed, e.g. by a players shoe.

Preferably the grass fibres have a length between 35 to 80 millimetres, preferably between 45 and 75 millimetres, more preferably between 45 and 55 millimetres.

Preferably the base layer fibres are made a thermoplastic material, in particular a thermoplastic elastomer (TPE), or a thermoplastic olefin elastomer (TPO), or a thermoplastic vulcanizate (TPV).

A thermoplastic olefin elastomer (TPO) is e.g. manufactured from polypropylene/EPDM rubber, and is e.g. sold by DOW under the brand name BRANCOM.
A thermoplastic vulcanizite (TPV) is e.g. manufactured by DSM and sold under the brand name Sarlink.

Preferably the grass fibres are essentially made of polyethylene, polypropylene, nylon or a combination of filaments from different materials and/or of filament containing multiple materials. The grass fibres could be fibrillated or mono-filaments. Preferably the grass fibres are preferably straight, but a curled design is also possible.

In an installed artificial grass turf system having an infill layer on the of the base layer fibres grass, it is likely that some infill material will enter into the interstices between the base layer fibres and grass fibres in the zone of the base layer. It is preferred that the density of the fibres in the base layer is such that when considering the volume of the base layer, this base layer volume contains less than 30% of its volume, preferably less than 20%, of infill material.

Preferably the infill layer solely consists of sand, preferably quartz sand.

Preferably the infill layer is free from rubber.

Further artificial grass turf carpets and preferred embodiments thereof according to the invention are described in the appended claims, in particular as in claims 20, 23, 24, 25. It will be appreciated that these carpets can include one or more of the features described above. Also these carpets can be used as part of an artificial grass turf system, wherein an infill layer, e.g. having one or more features as described herein, is used as well.

Although at present the weaving technology is highly preferred for the manufacturing of the carpet, it can be envisaged that the tufting technique could also be used.
The present invention also relates to the manufacturing of the carpet and to a base layer fibre yarn for said carpet.

The invention will now be explained with reference to the drawings.

In the drawings:

Fig. 1 shows highly schematically a side view of a part of an example of an artificial turf system according to the present invention.

The figure 1 shows a part of an artificial grass turf system 1 according to the invention. In actual practice this figure 1 could represent a section of about 10 centimetres of such a system.

The artificial grass turf system 1 is placed on a supporting substrate 2 which is not further described in detail here. This substrate 2 is preferably water permeable, and can include a drainage facility.

The turf system 1 is essentially composed of an artificial grass turf carpet 10 and an infill layer 20 of particulate infill material.

The artificial grass turf carpet 10 is a integrally woven artificial grass turf carpet, made on a carpet weaving machine using suitable yarns.

Preferably said carpet 10 is woven in a single run on such a machine, preferably on a “face-to-face” carpet weaving machine.

The carpet 10 has a ground structure, here embodied as a ground fabric 11, including a weft yarn and having an upper surface.

Synthetic grass fibres 12 are woven integral with said ground structure 11, which synthetic grass fibres 12 extend upward from
said ground structure and form a grass surface of said artificial grass turf.

In this figure 1 the upper ends of the grass fibres 12 are shown in "straight-up" position. It will be appreciated that in actual practice these grass fibres 12 will not be in said position. The filaments of the grass fibres will basically bend and cover (at least partly) the infill layer 20.

The carpet 10 further includes synthetic base layer fibres 15 woven integral with said ground structure 11 at positions between the synthetic grass fibres 12.

Due to the nature of the weaving process in this example the ground fabric 11 is made up by the weft yarn as well as the base layer fibres 15 and the grass fibres 12.

The base layer fibres 15 have a lower height than said grass fibres 12. In this example the length of the grass fibres 12 is about 50 millimetres, and the length of the base layer fibres is about 25 millimetres.

 Preferably the carpet 10 is woven using the face-to-face carpet weaving technique, wherein a bottom carpet and a top carpet are woven at the same time on a machine and the interlaced pile warp ends are cut by a cutting device, e.g. a knife.

This weaving technique is not only highly efficient, but this technique also allows to obtain a dense base layer. It also allows to produce the two different heights of the base layer fibres and the grass fibres, respectively. This can be done by having the knife of the face-to-face carpet weaving machine cut through the base layer fibre yarn in a zone where this yarn is still connecting the two carpets, when the ground fabrics of both carpets are spaced apart at a first distance (e.g. about twice the base layer fibre height), and then move the ground fabrics in this zone further apart to a second distance, greater than said first distance (e.g. about
twice the grass fibre height), and then have the knife cut through the grass fibre yarn.

The base layer fibres 15 are positioned tight against one another and in this example also against neighbouring grass fibres 12, so that a dense base layer 16 or "base zone" of the carpet is obtained thereby. The longer grass fibres 12 extend above this base layer.

In this example the base layer fibres 15 are each of a solid cross section, e.g. a circular cross-section, having a diameter in this example of approximately 2 millimetres.

The grass fibres 12, formed here as bundles of monofilaments, could have a diameter of about 1 millimetre in this example.

In this example it is shown that the carpet has about 450 base layer fibres per metre and e.g. about 50 grass fibres per metre.

In this exemplary artificial turf carpet 10 the dense base layer 16 thus has such a density that the combined cross-sectional area of the grass fibres 12 and base layer fibres 15 – measured at the upper surface of the ground structure 11 – is now about 95% per unit of surface area of the carpet 10.

The infill layer 20 is thin when compared to prior art infill layers. In this example the thickness of the infill layer is about 5 millimetres, measured above the dense base layer 16.

It is noted that the dense base layer 16 essentially consist of the base layer fibres 15 and grass fibres 12. No substantial amount of infill material is present between the upstanding fibres 12, 15 in the base layer 16. Therefor the resilient behaviour of the base layer 16 is governed essentially by said thick and densely packed base layer fibres 15.

With the density shown here the base layer volume contains less than 30% of its volume, preferably less than 20%, of infill material.
The infill layer 20 here solely consists of sand, preferably quartz sand. In particular the infill layer 20 is free from rubber.

As is visible in figure 1 the base layer fibres 15 are essentially straight and each have a foot attached to the ground structure 11 and a non-looped upper free end. As is known in the art of carpet weaving these base layer fibres 15 are upright oriented cut-pile fibres.

In this example the base layer fibres 15 are made of a thermoplastic elastomer (TPE). A thermoplastic vulcanizate (TPV), e.g. including EPDM and PP, could also be used.

The grass fibres 12 are essentially made of a bundle of polyethylene filaments in this example.

The ground structure 11 in practice will not only include the woven fabric part made up by the weft yarn, the base layer fibres and the grass fibres, but also include a coating layer or other secondary layer covering the underside of this woven fabric part. This is common in the carpet finishing practice. E.g. a latex layer or a polyurethane layer is provided.
CLAIMS

1. Artificial grass turf carpet comprising:
   - a ground structure having an upper surface,
   - synthetic grass fibres upstanding from said ground structure, which synthetic grass fibres form a grass surface of said artificial grass turf,
   - synthetic base layer fibres upstanding from said ground structure at positions between the upstanding synthetic grass fibres,
   - said base layer fibres having a lower height than said grass fibres,
   - wherein said base layer fibres are positioned tight against one another and against neighbouring grass fibres, so that a dense base layer is obtained thereby above which the grass fibres extend.

2. Carpet according to claim 1, wherein the base layer fibres are essentially straight and each have a foot attached to the ground and a non-looped upper free end.

3. Carpet according to claim 1 or 2, wherein said base layer fibres are upright oriented cut-pile fibres.

4. Carpet according to any of claims 1-3, wherein said carpet is a woven carpet.

5. Carpet according to claim 4, wherein said carpet is a carpet woven with the face-to-face weaving technique.

6. Carpet according to claim 1 or 2, wherein said base layer fibres are fusion bonded to said ground structure.
7. Carpet according to one or more of the preceding claims, wherein said dense base layer has such a density that the combined cross-sectional area of the grass fibres and base layer fibres measured at the upper surface of the ground structure - is at least 70%, more preferably at least 80%, most preferably at least 90% per unit of surface area of the carpet.

8. Carpet according to one or more of the preceding claims, wherein at least 3 or 4, preferably at least 7, more preferably between 7 and 9, base layer fibres are arranged between neighbouring grass fibres.

9. Carpet according to one or more of the preceding claims, wherein between 30 and 100, preferably between 40 and 70, grass fibres are arranged per metre length of said carpet.

10. Carpet according to one or more of the preceding claims, wherein between 300 to 800, preferably between 400 and 600, base layer fibres are arranged per metre length of said carpet.

11. Carpet according to one or more of the preceding claims, wherein said base layer fibres have a greater bending stiffness than said grass fibres.

12. Carpet according to one or more of the preceding claims, wherein said base layer fibres have a minimum cross-sectional dimension of at least 0.7 millimetre, preferably at least 1 millimetre, more preferably at least 1.5 millimetre, most preferably of at least 1.8 millimetre.

13. Carpet according to one or more of the preceding claims, wherein said base layer fibres have a non square cross-section, e.g. a circular or oval cross-section, preferably a circular cross-section.

14. Carpet according to one or more of the preceding claims, wherein said base layer fibres have a solid cross-section.
15. Carpet according to one or more of the preceding claims, wherein the grass fibres have a length between 35 to 80 millimetres, preferably between 45 and 75 millimetres, more preferably between 45 and 55 millimetres.

16. Carpet according to one or more of the preceding claims, wherein the base layer fibres have a height between 15 and 35 millimetres, preferably between 20 and 30 millimetres.

17. Carpet according to one or more of the preceding claims, wherein the base layer fibres are made of a thermoplastic elastomer (TPE), or a thermoplastic olefin (TPO), or a thermoplastic vulcanizate (TPV).

18. Carpet according to one or more of the preceding claims, wherein the grass fibres are essentially made of polyethylene or polypropylene.

19. Carpet according to one or more of the preceding claims, wherein said carpet is woven and has a ground fabric as ground structure, which is covered on the underside with a coating layer, such as e.g. a latex layer, a polyurethane layer.

20. A woven artificial grass turf carpet comprising:

- a ground fabric including a weft yarn and having an upper surface,

- synthetic grass fibres woven integral with said ground fabric, which synthetic grass fibres form a grass surface of said artificial grass turf,

- synthetic base layer fibres woven integral with said ground fabric at positions between the synthetic grass fibres,
- said base layer fibres having a lower height than said grass fibres.

21. A woven carpet according to claim 20, wherein said base layer fibres are positioned tight against one another and against neighbouring grass fibres, so that a dense base layer is obtained above which the grass fibres extent.

22. A woven carpet according to claim 19 or 20, wherein said base layer fibres are thicker than said grass fibres, e.g. said base layer fibres have a minimum cross-sectional dimension of at least 0.7 millimetre, preferably at least 1 millimetre, more preferably at least 1.5 millimetre, most preferably of at least 1.8 millimetre.

23. Artificial grass turf carpet comprising:

- a ground structure having an upper surface,

- synthetic grass fibres upstanding from said ground structure, which synthetic grass fibres form a grass surface of said artificial grass turf,

- synthetic base layer fibres upstanding from said ground structure at positions between the synthetic grass fibres,

- said base layer fibres having a lower height than said grass fibres,

- wherein said base layer fibres have a minimum cross-sectional dimension of at least 0.7 millimetre, preferably at least 1 millimetre, more preferably at least 1.5 millimetre, most preferably of at least 1.8 millimetre.

24. Artificial grass turf carpet comprising:

- a ground structure having an upper surface,
- synthetic grass fibres extending upward from said ground structure, which synthetic grass fibres form a grass surface of said artificial grass turf,

- synthetic base layer fibres extending upward from said ground structure at positions between the upstanding synthetic grass fibres,

- said base layer fibres having a lower height than said grass fibres,

- wherein said base layer fibres are made of a thermoplastic elastomer, or a thermoplastic olefin, or a thermoplastic vulcanizate.

25. Artificial grass turf carpet comprising:

- a ground structure having an upper surface,

- synthetic grass fibres extending upward from said ground structure, which synthetic grass fibres form a grass surface of said artificial grass turf,

- synthetic base layer fibres extending upward from said ground structure at positions between the upstanding synthetic grass fibres,

- said base layer fibres having a lower height than said grass fibres,

- wherein the combined cross-sectional area of the grass fibres and base layer fibres - measured at the upper surface of the ground structure - is at least 70%, more preferably at least 80%, most preferably at least 90% per unit of surface area of the carpet.
26. An artificial grass turf system including a carpet according to one or more of the preceding claims 1-25, wherein an infill layer, preferably of one or more particulate materials, is placed on top of said base layer fibres, said infill layer covering said base layer fibres, and wherein said grass fibres extend above said infill layer.

27. System according to claim 26, wherein said infill layer has a thickness between 3 and 15 millimetres, preferably between 4 and 10 millimetres.

28. System according to claim 26 or 27, wherein the base layer volume contains less than 30% of its volume, preferably less than 20%, of infill material.

29. System according to one or more of claims 26-28, wherein the infill layer solely consists of sand, preferably quartz sand.

30. System according to one or more of claims 26-29, wherein the infill layer is free from rubber.

31. Use of an artificial turf carpet according to one or more of the preceding claims 1-25 for installing an artificial grass turf system.

32. Method for installing an artificial turf system, wherein a supporting substrate is provided, an artificial turf carpet according to one or more of the preceding claims 1-25 is placed on said supporting substrate, and wherein a infill layer, preferably of one or more particulate materials, is placed on top of said base layer fibres between said upwardly extending grass fibres.

33. Method according to claim 32, wherein said infill layer consists solely of sand.
34. A sports field, such as for soccer, including an artificial grass turf carpet or system according to one or more of the preceding claims.

35. Method for manufacturing an artificial grass turf carpet according to one or more of the preceding claims 1-25, wherein said carpet is integrally woven using a weft yarn in the ground fabric, a base layer fibre yarn for the base layer fibres, and a grass fibre yarn for the grass fibres, e.g. using the face-to-face weaving technology.

36. Method according to claim 35, wherein said base layer fibre yarn is selected from the group of a thermoplastic elastomer, a thermoplastic olefin, or a thermoplastic vulcanizate.

37. Method according to claims 35 or 36, wherein said base layer fibre yarn has a minimum cross-sectional dimension of at least 0.7 millimetre, preferably at least 1 millimetre, more preferably at least 1.5 millimetre, most preferably of at least 1.8 millimetre.

38. A base layer fibre yarn for use in the manufacturing of an artificial grass turf carpet according to one or more of the preceding claims.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 E01C15/08

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 E01C

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>X</td>
<td>PATENT ABSTRACTS OF JAPAN&lt;br&gt;vol. 018, no. 487 (M-1671),&lt;br&gt;12 September 1994 (1994-09-12)&lt;br&gt;&amp; JP 06 158609 A (HAGIWARA KOGYO KK),&lt;br&gt;7 June 1994 (1994-06-07)&lt;br&gt;abstract</td>
<td>1-37</td>
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Further documents are listed in the continuation of box C. Patent family members are listed in annex.

* 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 doubt on priority claim(s) or which could be used 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

**I** 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 when the document is taken alone

**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 of other such documents, such combination being obvious to a person skilled in the art.

**S** document member of the same patent family

Date of the actual completion of the international search: 17 August 2005

Date of mailing of the International search report: 23/08/2005

Name and mailing address of the ISA:
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2290 HV Rijswijk
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Authorized officer: Movadat, R

Form PCT/ISA/210 (second sheet) (January 2004)
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<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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| X        | PATENT ABSTRACTS OF JAPAN  
vol. 1995, no. 09,  
31 October 1995 (1995-10-31)  
& JP 07 145548 A (TORAY IND INC),  
6 June 1995 (1995-06-06)  
abstract | 1, 20,  
23-26,  
31, 32, 34 |
**INTERNATIONAL SEARCH REPORT**

**Box II  Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. □ Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely:

2. ☑ Claims Nos.: 38 because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
   
   see FURTHER INFORMATION sheet PCT/ISA/210

3. □ Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box III  Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

1. □ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. □ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. □ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. □ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (January 2004)
Continuation of Box II.2

Claims Nos.: 38

Lack of technical features, Rule 6.3 (a) PCT

The applicant’s attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.5), should the problems which led to the Article 17(2) declaration be overcome.
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<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
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<tr>
<td>US 2003099787 A1</td>
<td>29-05-2003</td>
<td>NONE</td>
<td></td>
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<td></td>
<td></td>
<td>AU 2716101 A</td>
<td>09-07-2001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP 1238163 A1</td>
<td>11-09-2002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 2003518574 T</td>
<td>10-06-2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 0148322 A1</td>
<td>05-07-2001</td>
</tr>
<tr>
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<td>06-06-1995</td>
<td>NONE</td>
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