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(54) **AN ARRANGEMENT OF DEVICES FOR UNDERGROUND STORAGE OF WATER AND FOR ITS RECOVERY**

(57) An arrangement of devices for underground storage of water and for its recovery, comprising a part of a natural water-permeable layer lying on an impermeable layer, separated by means of at least one closed impermeable anti-filtration barrier with a substantially

vertical inclination, formed from the land surface to a depth below the bottom of the water-permeable layer, as well as comprising a supply installation and a water recovery installation.

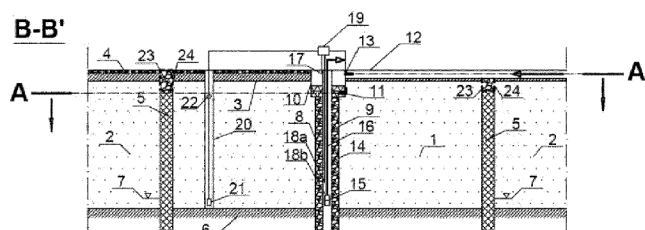


Fig. 2

Description

Technical field

[0001] The object of the invention is an arrangement of devices for underground storage of water and for its recovery, especially useful in areas affected by hydrogeological drought, for retention of water from precipitation, melting, drainage or originating from natural sources for its later use, e.g. in agriculture and horticulture, as well as for water supply in fire protection systems, as backup water abstraction points in the event of an ecological disaster preventing the use of current systems providing water for drinking and for domestic purposes.

Description of prior art

[0002] There are known methods of discharging water from precipitation, melting or drainage to natural permeable layers, involving the use of drain wells or other systems dispersing water in a permeable layer, where the water is not retained for a long time in an aquifer, since it flows to lower drainage areas.

[0003] There are also known systems of accumulating water from precipitation and melting below the ground surface in reservoirs made of various prefabricated elements. For example, the underground rainwater storage disclosed in the American patent application US20140105684A1 constitutes a space filled with an assembly of modular units with a cuboidal shape, in which open walls enable the flow of water between the modules, while external modules have sealing walls in places of contact with the surrounding rock mass. Moreover, selected modules have inspection channels extending to the surface, and the water is supplied to the storage and recovered from it via inflow and outflow spigots formed in the modular elements. A similar modular construction for underground storage of rainwater and other fluids is known from the American patent US10151096B2.

[0004] From the American patent US8074670B2 there is a known underground water reservoir, formed in water-permeable alluvial sediments, sand or gravel, by outlining a part thereof by means of impermeable walls from the surface to a depth lying below the top of an impermeable substratum. The water level maintained in the reservoir is higher than in the surrounding layer, such that water is supplied to the reservoir from the surrounding aquifer via a supply system provided with a pump and a valve on the side of a higher groundwater table level, and its surplus can be discharged to the aquifer via an overflow discharge system on the side of a lower groundwater table level. In the area of the reservoir there are drilled vertical recovery openings, usually reaching to the bottom of the reservoir, by means of which water is acquired from the reservoir. Similar constructions of underground water retention ponds in the areas of alluvial plains have been disclosed in other American patents: US6840710B2 and US7192218B2.

Summary of the invention

[0005] The invention solves the technical problem of underground storage of large volumes of water, especially rainwater and meltwater, upon its prior purification from mechanical contaminants, preventing siltation of the reservoir, as well as its management in areas poor in natural water sources.

[0006] The essence of the arrangement of devices for underground storage of water and for its recovery, comprising an underground retention pond, constituting the volume of a natural water-permeable layer lying on an impermeable substratum, separated from the water-permeable layer by means of an impermeable anti-filtration barrier, formed from the land surface to a depth below the bottom of the water-permeable layer, with a substantially vertical inclination of the walls, forming a closed shape in a horizontal cross-section, as well as comprising a supply installation and a water recovery installation, is in that the water supply installation is constituted by at least one slot trench, formed inside the underground retention pond, filled with a water-permeable material, on which there is a water distribution collector, made of modular boxes with perforated bottoms, filled in the near-bottom part with a filtration material, resting on a deposit of the water-permeable material, so that their perforated bottoms abut the deposit of the water-permeable material, and having perforations in walls abutting the neighbouring boxes. Moreover, the essence of the invention is in that the water distribution collector is connected to a water supply collector via an controllable water inflow adjustment element, while the water recovery installation constitutes at least one recovery well, situated in the slot trench, in which recovery well there is a recovery pump connected to a recovery pipeline and having a signal connection in a wired manner to a control and measurement apparatus, which also has a signal connection in a wired or wireless manner to a controllable water inflow adjustment element and a maximum water level probe placed in the water distribution collector. The essence of the invention is also in that in the area of the underground retention pond there is at least one piezometer well, provided with a submersible pressure gage and a permitted water level probe, which also have a signal connection in a wired or wireless manner to the control and measurement apparatus, which also has a signal connection in a wired or wireless manner to probes monitoring the water level in the recovery well.

[0007] It is preferable when the separated volume of the natural water-permeable layer constituting the underground retention pond has the shape of a circle or an ellipse in a horizontal cross-section.

[0008] It is also preferable when the natural water-permeable layer is constituted by sand or gravel.

[0009] It is further preferable when the slot trench is formed inside the underground retention pond, along its diameter.

[0010] It is preferable when the water-permeable ma-

terial filling the slot trench constitutes gravel, expanded clay or synthetic granules made of polyvinyl chloride (PVC), polypropylene (PP), polyethylene (PE) or glass. It is preferable when the piezometer well is located on the axial direction of the supply collector.

[0011] Moreover, it is preferable when the distance of the piezometer well from the anti-filtration barrier is no less than 1/3 of the distance of the anti-filtration barrier from the recovery well.

[0012] Under the conditions of a poorly permeable or impermeable layer lying on the natural water-permeable layer, it is preferable when the underground retention pond comprises additional bleeding and venting elements, and it is especially preferable when the bleeding and venting elements are constituted by a layer of a natural permeable material, which constitutes gravel, or a layer of synthetic granules made of polyvinyl chloride (PVC), polypropylene (PP), polyethylene (PE), expanded clay or glass, surrounded by a geotextile, situated in segments in the upper part of the anti-filtration barrier, constituting a ventilation connection of the underground retention pond with the atmosphere, or when the bleeding and venting elements constitute openings extending through the poorly permeable or impermeable layer, forming a ventilation connection of the underground retention pond to the atmosphere.

[0013] It is preferable when the area of surface above the underground retention pond is covered by a soil layer, which allows for ensuring the biological function of this area.

[0014] It is preferable when the filtration material constitutes a sponge or a geotextile or a coir mat, arranged in layers on the whole bottom surface of the boxes forming the water distribution collector.

Brief description of drawings

[0015] The object of the invention is presented in an embodiment in the drawing, in which fig. 1 presents a schematic view of the underground retention pond in a broken horizontal cross-section AA', while fig. 2 - in a vertical cross-section B-B'.

Detailed description of the invention

Embodiment 1

[0016] The arrangement of devices for underground storage of water and for its recovery comprises an underground water retention pond 1, formed in a natural water-permeable layer 2 with average thickness of 20 metres, which is constituted by coarse sand, lying on an impermeable substratum 6 and placed under a natural poorly permeable or impermeable layer 3, which is constituted by tills with a soil layer 4 lying thereon. The underground water retention pond 1 constitutes a volume of pore spaces formed between sand grains, separated in the permeable layer 2 by a vertical anti-filtration barrier

5 in the shape of a ring with a diameter of 60 m, so that in a horizontal cross-section the underground retention pond 1 has the shape of a circle. The anti-filtration barrier 5 is formed in the water-permeable layer 2, and it is sunk by approx. 1 m into an impermeable substratum 6. In the natural water-permeable layer 2 there is a groundwater table 7, during a hydrogeological drought placed in the lower part of this layer. Inside the underground retention pond 1 there is a slot trench 8 with a width of 0.8 m, formed along the diameter of the retention pond 1 from the top surface of the water-permeable layer 2 to its bottom. The slot trench 8 is filled with a water-permeable material 9 which constitutes a gravel deposit. Surrounding the partially perforated casing string of a recovery well 14, situated in the central part of the underground retention pond 1, a part of the gravel deposit is sunk 1 m into the impermeable substratum 6. In the upper part of the slot trench 8, directly above the gravel deposit, there is a water distribution collector 10, made of modular boxes with perforated bottoms, resting on the water-permeable material 9, and with perforated walls in the part abutting other boxes. The boxes of the water distribution collector 10 in the near-bottom part are filled with a filtration material 11, which is constituted by plates of filtration sponge, stacked one above the other and covering the entire bottom surface of the boxes. The water distribution collector 10 is connected to a supply collector 12 via an inflow adjustment element 13, which constitutes a moving weir, provided with a controllable mechanism adjusting the inflow of water into the collector. In the slot trench 8 there is a partially perforated casing string of a recovery well 14, in which a recovery pump 15 is placed and connected to a recovery pipeline 16. In the water distribution collector 10 there is a maximum water level probe 17, and inside the perforated casing string of the recovery well 14 there is a multi-core cable with probes 18a and 18b monitoring the water level in the recovery well 14, connected to a control and measurement apparatus 19 on the surface, which is further connected by means of signal wires to a mechanism adjusting the height of the moving weir, being the water inflow adjustment element 13, and to the recovery pump 15. At a distance of 1/3 of the radius from the vertical anti-filtration barrier 5, on the axial direction of the supply collector 12 there is a piezometer well 20, provided with a submersible pressure gage 21 and provided with a permitted water level probe 22. In the upper part of the vertical anti-filtration barrier 5 there are bleeding and venting elements 23, which are constituted by gravel with layer thickness of 0.5 m, surrounded by a geotextile 24, providing a ventilation connection of the underground pond 1 to the atmosphere through the poorly permeable or impermeable layer 3 and the soil layer 4.

Embodiment 2

[0017] In another embodiment, the water retention pond 1 has been delimited in a natural water-permeable

layer 2, which is constituted by a 5 m layer of a mixture of gravel with coarse sand and a 20-metre layer of fine sand lying thereon, on which in turn lies a poorly permeable or impermeable layer 3, which is constituted by tills, covered by a soil layer 4 on the surface. The underground retention pond 1 with a horizontal cross-section in the shape of an ellipse has two perpendicular slot trenches, formed to a depth of 4 metres, partially sunk into the gravel and sand layer, filled with a water-permeable material 9, which is constituted by synthetic granules, constituting a mixture of polypropylene PP and glass granules. The slot trenches are provided at the top with modular boxes with perforated bottoms and perforated walls in the part abutting each other, in the near-bottom part filled with a filtration material 11, which is constituted by alternating layers of sponge and coir mat, additionally reinforced from the outside by a geotextile. A water supply collector 12 and a piezometer well 20 are situated on the direction of the bisector between the directions of perpendicular slot trenches 8. Moreover, an element 13 adjusting the inflow of water into the water distribution collector 10 constitutes a controllable valve having a signal connection in a wired manner to a control and measurement apparatus 19.

Embodiment 3

[0018] In yet another embodiment of the invention, an underground retention pond 1 has been formed in a water-permeable layer 2 of sand, on which lie poorly permeable and impermeable layers 3. Under these conditions, the underground retention pond 1 in its upper part additionally comprises bleeding and venting elements 23, which are constituted by a natural permeable material in the form of a gravel layer, surrounded by a geotextile 24, lying in segments on an anti-filtration barrier 5. The retention pond 1 comprises three columns of partially perforated casing strings of a recovery well 14, also being provided with recovery pumps 15 connected to a recovery pipeline 16, as well as with probes 18a and 18b monitoring the water level of the recovery well 14. A slot trench 8 is filled with a water-permeable material 9, which is constituted by a mixture of expanded clay and polyethylene granules.

Embodiment 4

[0019] In other embodiment of the invention, the permeable material is constituted by a mixture of synthetic granules of PCV and PP with glass, surrounded by a geotextile 24, and moreover the bleeding and venting element is constituted by a grid of wells extending through natural poorly permeable and impermeable layers 3, lying above a natural water-permeable layer 2, which wells constitute a ventilation connection of the underground retention pond 1 to the atmosphere.

Embodiment 5

[0020] In yet another embodiment of the invention, the slot trench 8 is filled with a water-permeable material 9, which is constituted by a mixture of PVC granules and expanded clay, while a permeable material 23, serving the function of a bleeding and venting element, surrounded by a geotextile 24, constituting a mixture of polyethylene and expanded clay granules, lies in the upper part of a vertical anti-filtration barrier 5.

Further description of the invention

[0021] The operation of the arrangement of devices for underground storage of water and for its recovery according to the invention involves supplying water purified from mechanical contaminants by a supply collector 12 to a water distribution collector 10, in which it is ultimately filtered on a filtration material 11, which constitutes the final element of trapping mechanical contaminants, preventing the process of siltation of the gravel deposit. In the water distribution collector 10 there is a maximum water level probe 17, and inside the perforated casing string of a recovery well 15 there is a multi-core cable with water level probes 18a, 18b, cooperating with a control and measurement apparatus 19, which controls the water level in the water distribution collector 10 and, if needed, controls an inflow adjustment element 13 so as to increase or decrease the inflow of water into the water distribution collector 10, and moreover controls a recovery pump 15 during the process of recovering water from the underground retention pond 1. A submersible pressure gage 21 in a piezometer well 20 enables tracing the water level in the underground retention pond 1 being filled, and a permitted water level probe 22 placed in the piezometer well 20 prevents overfilling the underground retention pond 1. The anti-filtration barrier 5 prevents the stored water from spreading, and maintains it at a level higher than the groundwater level 7 in the natural water-permeable layer 2, while a permeable material, surrounded by a geotextile 24, in the upper part of the anti-filtration barrier 5 enables the flow and exchange of air between the pore space in the soil and the atmosphere when filling and emptying the underground water retention pond 1.

Key to reference numerals in fig. 1 and fig. 2:

[0022]

- | | |
|----|---|
| 1. | underground pond |
| 2. | natural water-permeable layer |
| 3. | natural poorly permeable or impermeable layer |
| 4. | soil layer |
| 5. | vertical anti-filtration barrier |
| 6. | impermeable substratum |
| 7. | groundwater table |
| 8. | slot trench |

- 9. water-permeable material
- 10. distribution collector
- 11. filtration material
- 12. supply collector
- 13. inflow adjustment element
- 14. recovery well
- 15. recovery pump
- 16. recovery pipeline
- 17. maximum water level probe
- 18. (18a, 18b) probes
- 19. control and measurement apparatus
- 20. piezometer well
- 21. submersible pressure gage
- 22. permitted water level probe
- 23. bleeding and venting element
- 24. geotextile

Claims

1. An arrangement of devices for underground storage of water and for its recovery, comprising an underground retention pond, constituting the volume of a natural water-permeable layer, lying on an impermeable substratum, separated from the water-permeable layer by means of an impermeable anti-filtration barrier, made from the ground surface to a depth below the bottom of the water-permeable layer, with a substantially vertical inclination of the walls, forming a closed shape in a horizontal cross-section, as well as comprising a supply installation and a water recovery installation, **characterised in that** the water supply installation is constituted by at least one slot trench (8), formed inside the underground retention pond (1) and filled with a water-permeable material (9), on which there is a water distribution collector (10), made of modular boxes with perforated bottoms, filled in the near-bottom part with a filtration material (11), lying on a deposit of the water-permeable material (9), so that their perforated bottoms abut the deposit of the water-permeable material (9), and having perforations in walls abutting the neighbouring boxes, and moreover the water distribution collector (10) is connected to a water supply collector (12) via a controllable water inflow adjustment element (13), while the water recovery installation constitutes at least one recovery well (14), situated in the slot trench (8), in which there is a recovery pump (15), connected to a recovery pipeline (16) and having a signal connection in a wired manner to a control and measurement apparatus (19), which also has a signal connection in a wired or wireless manner to the controllable water inflow adjustment element (13) and a maximum water level probe (17), located in the water distribution collector (10), and moreover, in the area of the underground retention pond (1), there is at least one piezometer well (20), provided with a submersible pressure gage (21) and a permit-

ted water level probe (22), which also have a signal connection in a wired or wireless manner to the control and measurement apparatus (19), which also has a signal connection in a wired or wireless manner to probes (18a and 18b) monitoring the water level in the recovery well (14).

2. The arrangement of devices according to claim 1, **characterised in that** a separated volume of the natural water-permeable layer (2) constituting the underground retention pond (1) has the shape of a circle or an ellipse in a horizontal cross-section.
3. The arrangement of devices according to claim 1, **characterised in that** the natural water-permeable layer (2) is constituted by sand or gravel.
4. The arrangement of devices according to claim 1, **characterised in that** the slot trench (8) is formed inside the underground retention pond (1), along its diameter.
5. The arrangement of devices according to claim 1, **characterised in that** the water-permeable material (9) filling the slot trench (8) constitutes gravel, expanded clay or synthetic granules made of PCV, PP, PE or glass.
6. The arrangement of devices according to claim 1, **characterised in that** the piezometer well (20) is located on the axial direction of the supply collector (12).
7. The arrangement of devices according to claim 1, **characterised in that** the distance of the piezometer well (20) from the anti-filtration barrier (5) is no less than 1/3 of the distance of the anti-filtration barrier (5) from the recovery well (14).
8. The arrangement of devices according to claim 1, **characterised in that** under the conditions of a poorly permeable or impermeable layer (3) lying on the natural water-permeable layer (2), the underground retention pond (1) comprises additional bleeding and venting elements (23).
9. The arrangement of devices according to claim 8, **characterised in that** the bleeding and venting elements (23) are constituted by a layer of a natural permeable material, which constitutes gravel, or a layer of synthetic granules made of PCV, PP, PE, expanded clay or glass, surrounded by a geotextile (24), situated in segments in the upper part of the anti-filtration barrier (5), constituting a ventilation connection of the underground retention pond (1) to the atmosphere.
10. The arrangement of devices according to claim 8,

characterised in that the bleeding and venting elements (23) constitute openings, extending through the poorly permeable or impermeable layer (3), constituting a ventilation connection of the underground retention pond (1) to the atmosphere.

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11. The arrangement of devices according to claim 1, **characterised in that** the area of surface above the underground retention pond (1) is covered by a soil layer (4).

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12. The arrangement of devices according to claim 1, **characterised in that** the filtration material (11) constitutes a sponge or a geotextile or a coir mat, arranged in layers on the whole bottom surface of the boxes forming the water distribution collector (10).

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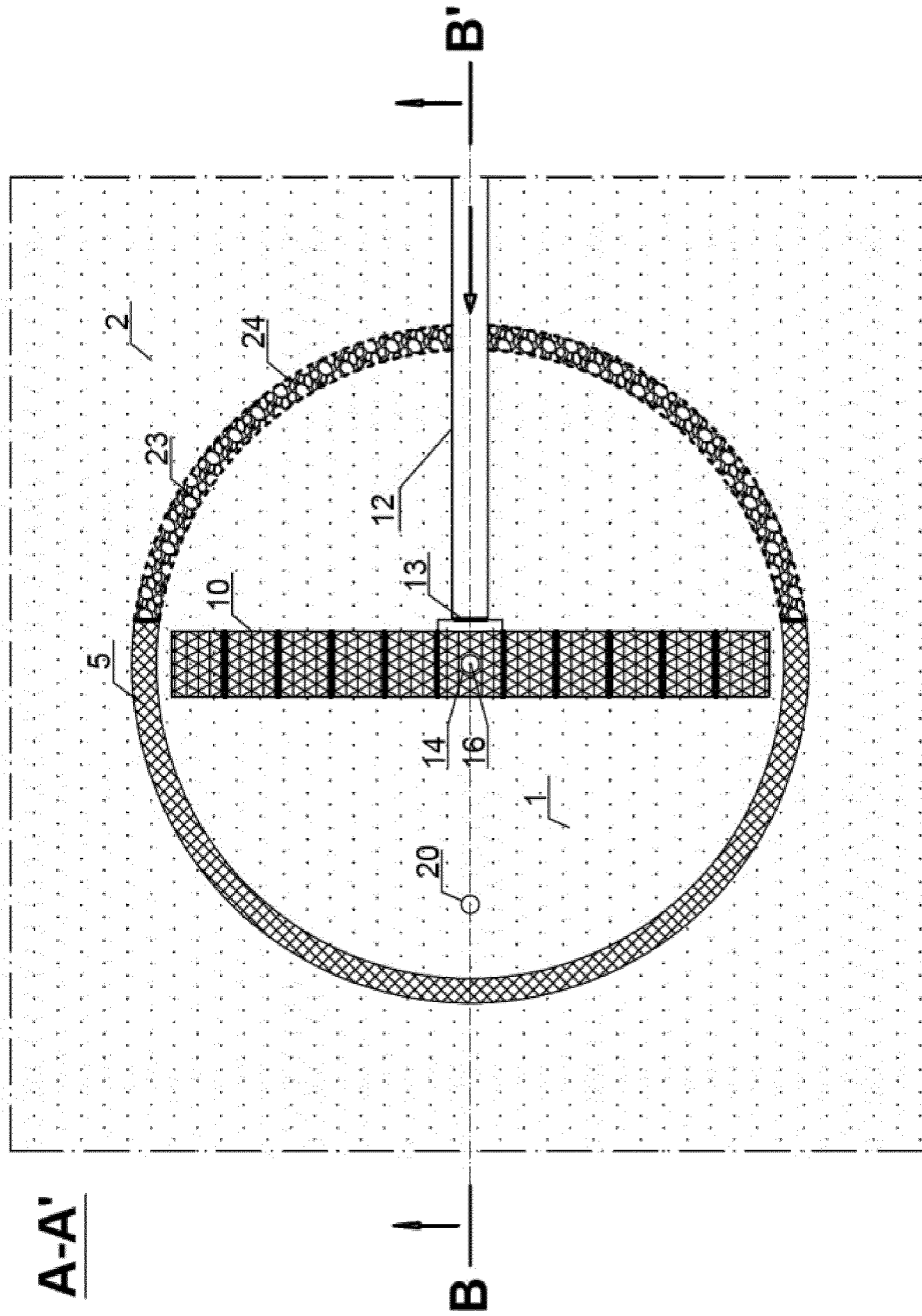


Fig. 1

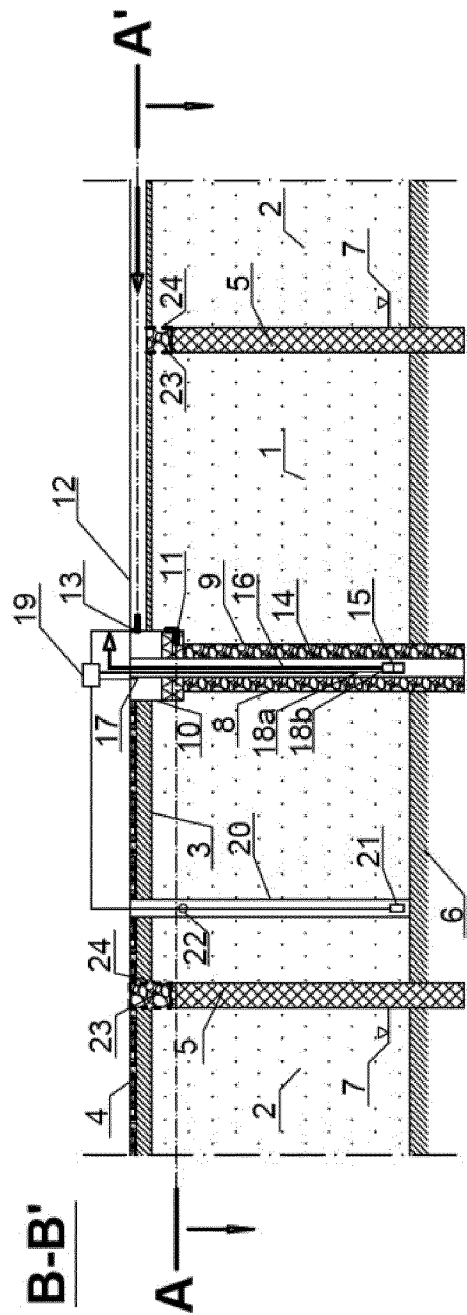


Fig. 2



EUROPEAN SEARCH REPORT

Application Number

EP 22 16 3933

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EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2009/173142 A1 (PETERS STANLEY R [US] ET AL) 9 July 2009 (2009-07-09) * page 1, paragraph 2 * * page 1, paragraph 18 * * page 2, paragraph 24 - page 3, paragraph 29 * * page 3, paragraph 33 - page 4, paragraph 40 * * page 4, paragraph 44 - paragraph 47; figures 1, 2, 4-6, 8 *	1-12	INV. E03B3/40 B65G5/00 E02B3/00 E03B11/14 E03F5/10 A01G25/00 A62C3/00 ADD. E03B3/02 E03B3/03 E03B3/30
A,D	US 2008/072968 A1 (PETERS STANLEY R [US] ET AL) 27 March 2008 (2008-03-27) * page 2, paragraph 23 - page 6, paragraph 46; figures *	1-12	
A	US 2008/073087 A1 (PETERS STANLEY R [US] ET AL) 27 March 2008 (2008-03-27) * page 2, paragraph 19 - page 3, paragraph 28; figures *	1	
			TECHNICAL FIELDS SEARCHED (IPC)
			E03B E02C B65G E02B E03F A01G A62C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 6 September 2022	Examiner Fajárnés Jessen, A
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 22 16 3933

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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06-09-2022

10	Patent document cited in search report	Publication date	Patent family member(s)	Publication date
	US 2009173142 A1	09-07-2009	NONE	
15	US 2008072968 A1	27-03-2008	NONE	
	US 2008073087 A1	27-03-2008	NONE	
20				
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EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 20140105684 A1 **[0003]**
- US 10151096 B2 **[0003]**
- US 8074670 B2 **[0004]**
- US 6840710 B2 **[0004]**
- US 7192218 B2 **[0004]**