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(72) Feltaláló(k):
Taafel, Klaus, 76767 Hagenbach (DE)
Bauer, Irmgard, 76337 Waldbronn (DE)
Kettner, Christiane, 78580 Bärenthal (DE)
Weidemann, Thomas, 87634 Obergünzburg (DE)

(73) Jogosult(ak):
Ritter Energie- und Umwelttechnik GmbH & Co. KG, 72135 Dettenhausen (DE)

(74) Képviselő:
Danubia Szabadalmi és Jogi Iroda Kft., Budapest

(54) **Napelemes berendezés**

Solar array

The invention relates to a solar array with a solar collector, comprising at least one collector tube with a cladding tube, in which a register engages, wherein between the cladding tube and the register an interior cavity that is connected to the atmosphere is formed, and wherein the register is connected to a feed line and a discharge line, by means of which a heat transfer medium can be fed to and discharged from the register respectively.

Such a solar array produced by the applicant is known from practice. It has proved itself in a multitude of applications especially since the cladding tube is configured as vacuum tube and therefore makes possible a highly effective thermal insulation of the register with respect to the surroundings of the solar collector. Because of this, the sunlight can be effectively converted into heat even with low ambient temperatures in order to heat the heat transfer medium conducted through the register. In order to make possible as long as possible a lifespan and to a large extent freedom of maintenance of the solar collectors which are mostly installed in locations with difficult access for example on roofs of houses, the vacuum tubes are produced from borosilicate glass and the register from a rustproof metal such as stainless steel and copper. The register produced from these metals durably withstands the high temperatures that occur during the operation of the solar array and the pressures in the heat transfer medium accompanied by this. However it is disadvantageous that the raw material prices for stainless steel and copper are quite high. For this reason, the solar array is still relatively expensive.

From CN 201 593 877 U a solar array with a solar collector is known, furthermore, which comprises at least one collector tube with a cladding tube, in which a register engages. Between the cladding tube and the register, an internal cavity is formed, which for the heat insulation of the register is evacuated. The register is connected to a feed line and a discharge line, by means of which a heat transfer medium can be fed to and removed from the register respectively. The register consists of non-rust proof, heat and pressure-resistant aluminium.

The object of the invention is to create a solar array of the type mentioned at the outset which is cost-effectively producible yet makes possible a long lifespan and a largely maintenance-free operation.

This object is solved with the features of Claim 1. In an advantageous manner, the register is thus produced from cost-effectively available non-rustproof temperature and pressure resistant steel. Because of this, the solar collector or its register can be very cost-effectively produced. Since through the protective device the formation of condensate on the outer surface of the register is prevented, the register is always kept dry on its outer surface during the operation of the solar array. Because of this, despite the non-rustproof register material, harmful corrosion on the register is nevertheless avoided over a long service life so that the required pressure resistance of the register over the entire lifespan of the solar array is ensured.

With a preferred embodiment of the invention, the protective device comprises a heating device for the register, an ambient temperature sensor for detecting the ambient temperature of the solar collector and a collector outlet temperature sensor for detecting the collector temperature at the discharge line of the solar collector, the ambient temperature sensor and the collector outlet temperature sensor being connected to the heating device via a control and/or regulating device. The heating device can for example comprise a fuel-fired boiler by means of which the heat transfer medium conducted through the register can be heated if required in order to avoid condensate formation on the register with falling outside temperatures. As heat transfer medium, water is preferably used. In an advantageous manner, a separation between the heat transfer medium for the solar collector and the heat transfer medium for the boiler can thereby be omitted, i.e. a uniform heat transfer medium for the entire solar array can be used. The heat transfer medium in this case can flow through the solar collector, the boiler and at least one heating element of a household heater. This renders the solar array cost-effective.

With an advantageous configuration of the invention, the heating device comprises a heat storage unit, which via the feed line and the discharge line is connected to the solar collector to form a heat transfer medium circuit, wherein in the heat transfer medium circuit a pump is arranged, and wherein the ambient temperature sensor and the collector outlet temperature sensor are connected to the pump via the control and/or regulating device. Here, with adequate solar irradiation, heat energy can be stored in the heat storage unit and for example be removed from the heat storage unit at night on cold days for heating the register. The control and/or regulating device in this case is preferably configured in such a manner that it is brought into a frost protection operating state when the ambient temperature of the solar collector falls below a predetermined first temperature value of for example 3°C. In this operating state, heat transfer medium that is so warm that the temperature of the heat transfer medium, which is present in a line portion of the feed line that runs in the open or in a frost-threatened region does not fall below a predetermined second temperature value that is smaller than the first temperature value and greater than 0°C is pumped into the feed line with the help of the pump. The second temperature value preferentially is 1°C. The frost protection operating state is deactivated when the ambient temperature of the solar collector exceeds a third temperature value that is greater than the second temperature value and for example be 4°C, for a predetermined period of time, which can for example be 12 hours. Through the frost protection operating state it is prevented that the heat transfer medium that is present in the line portion of the feed line running in the open in ambient temperatures that are below the first temperature value, cools down to the extent that when it is transported into the solar collector after the pump has been switched on, it cools down said solar collector. Thus, after the pump has been switched on, the formation of condensate on the outer surface of the register and a corrosion hazard accompanied by this are avoided. In addition, the solar collector is protected through the frost protecting operating state from freezing.

It is advantageous when the control and/or regulating device is configured in such a manner that the collector outlet temperature does not fall below the ambient temperature. The air that is present in the interior cavity of the cladding tube cannot then cool down on the register in normal operating conditions so that no condensate can form there.

With a practical configuration of the invention, the control and/or regulating device is configured in such a manner that the collector temperature on the discharge line of the solar collector does not fall below a predetermined minimum value. The minimum value can for example be between 3 and 5°C, in particular

4°C. Because of this, the formation of condensate on the register can be suppressed even more effectively.

In a further development of the invention, the control and/or regulating device comprises a storage unit in which thermal characteristic variables for the solar collector, the feed line, the discharge line and the heat transfer medium are stored, wherein the protective device comprises a volume flow rate sensor for detecting the heat transfer medium volume flow rate fed to the solar collector, an advance temperature sensor for detecting the advance temperature of the heat transfer medium that is present in the discharge line and a return temperature sensor for detecting the return temperature of the heat transfer medium that is present in the feed line, and wherein the control and/or regulating device comprises a microprocessor that is connected to the storage unit, wherein in the storage unit an operating program that can be executed on the microprocessor is stored, by means of which from the characteristic variables and measurement signals for the volume flow rate, the return temperature, the ambient temperature and the collector temperature on the discharge line of the solar collector a pumping rate is determined through a real-time simulation of the temperatures in the feed line and a calculation of the cooling-down speed of the array components of the solar array that are located in the open or in the frost region, with which the pump can be activated by means of the control and/or regulating device in such a manner that the temperature on the outer surface of the register and in the feed line does not fall below a defined limit value above the ambient temperature. By way of this measure, the temperature on the outer surface of the register can be determined with great precision and held above the ambient temperature without a temperature sensor having to be present on the outer surface.

It is advantageous when the heat storage unit is arranged in a building and the solar collector in the open, and when the characteristic variables comprise characteristic values for

- the length and the content of a line portion of the feed line that is present within the building,
- the length and the content of a line portion of the feed line that is present in the open,
- the length and the content of a line portion of the discharge line that is present within the building,
- the length and the content of a line portion of the discharge line that is present in the open, and
- the size of the solar collector.

With the help of these characteristic variables, the temperature on the outer surface of the register can be calculated in advance in a simple manner from the measurement signals for the volume flow rate, the advance temperature, the return temperature and the ambient temperature. Here it is even possible that solar array can be switched over between a first operating state, in which the calculation using the characteristic variables is carried out, and a second operating state, in which the characteristic variables are learned. For learning the characteristic variables, warm heat transfer medium can be conducted out of the heat storage unit and/or the boiler through the heat transfer medium circuit, wherein with the sensors the chronological sequence of the volume flow rate, of the advance temperature, of the return temperature and of the ambient temperature is recorded. From the course of these measurement values, the characteristic variables can be determined with the help of a mathematical model of the solar array.

A primary energy-saving operation of the solar array is made possible in that the control and/or regulating device is configured in such a manner that the pump can be operated in intermittent mode. While the protective device is active, the intervals can preferably be dimensioned short and can for example be a few seconds.

The mild steel, from which the register or at least a portion of the register is produced, is preferably a pressure-resistant steel which is preferentially normalized. Such a steel is traded under the steel type designation P195GH.

The cladding tube is preferentially configured as vacuum tube with an outer wall and an inner wall spaced from the former, between which an evacuated intermediate space is arranged. Because of this, a highly effective thermal insulation of the register against the surroundings of the solar collector and thus a correspondingly high efficiency of the solar array is made possible.

In the following, an exemplary embodiment of the invention is explained in more detail with the help of the drawing. There:

Fig. 1 shows a schematic representation of a solar array,

Fig. 2 shows a front view of a solar collector with three collector tubes, wherein in the case of the left collector tube only the register and in the case of the middle collector tube the vacuum tube and a heat conduction plate located therein are only partially shown, and

Fig. 3 shows a longitudinal section through the solar collector.

A solar array that in Fig. 1 is designated with 1 as a whole has a solar collector 2 with a holder 3, on which multiple collector tubes 4 are arranged. The collector tubes 4 are orientated parallel to one another in a plane and laterally spaced from one another through intermediate spaces.

As is evident in Fig. 2 and 3, the collector tubes 4 each comprise a cladding tube 6, in which a register 5 engages. The cladding tubes 6 are each configured as double-walled vacuum tube with a substantially cylindrical outer wall 7 and a cylindrical inner wall 8 that is arranged concentrically thereto. The outer wall 7 and the inner wall 8 consist of glass and are each closed at their one axial end by an approximately semi-spherically shaped wall portion 9, 10. At its other axial end, the outer wall 7 and the inner wall 8 are fused. In the radial direction, the outer wall 7 and the inner wall 8 are spaced from one another by an evacuated intermediate space 11. The cladding tubes 6 serve as heat insulation, which thermally insulated the portions of the register 5 that are present within the cladding tube 6 against the surroundings of the solar collector 1.

Between the inner wall 8 and the register 5 of each collector tube 4, an interior cavity 12 each is formed, which at the end of the cladding tube 6 that is distant from the semi-spherical wall regions 9, 10 is connected to the atmosphere via a ventilation opening that is not shown in more detail in the drawing. By way of the ventilation opening, possible air pressure fluctuations between the interior cavity 12 and the atmosphere can be offset.

In order to render the solar energy better utilizable, an absorption layer which is not shown in more detail in the drawing is applied to the outside of the inner wall 8 facing the intermediate space 11 and of the semi-spherical wall region 10, which has a low emission and a high absorption. Between the inner wall 8 and the register 5, a heat conduction plate 13 is arranged, which connects the inner wall 8 with the register 5 in a heat-conducting manner.

Between the back sides of the collector tubes 4 and the holder 3, a reflector 14 is arranged, which for each collector tube 4 has a parabolic cylindrical reflector surface each, which projects the absorption layer of the collector tube 4 concerned onto the sunlight impinging on it.

The register 5 consists of a non-rustproof heat and pressure-resistant steel. The portions of the register 5 running within the cladding tube 6 each have an approximately U-shaped course with two U-legs arranged parallel to the longitudinal extension of the cladding tubes 6 and an arc-shaped tube section connecting these to one another. However, other configurations of the register 5 are also conceivable. Accordingly, instead of the U-shaped portions, tube portions can also be provided which have an inner and outer tube element, which are arranged coaxially to one another and at their the semi circular-shaped wall region 10 are connected to one another.

In Fig. 2 it is evident that the portions of the register 5 running within the cladding tubes 6 are connected in series and are connected to one another by connecting portions 15, which run transversely to the U-legs.

A U-leg which is arranged within a cladding tube 6 of a first collector tube 4 (left in Fig. 2) is connected to a discharge line 19 via a discharge portion 18 of the register 5, by means of which the heat transfer medium can be removed from the register 5. At its free end, the discharge portion 18 has a first connecting piece 51 that can be releasably connected to the discharge line 19 and is arranged in the open, which consists of a rustproof metal material such as for example copper or stainless steel. A U-leg of the register 5 which is arranged within a cladding tube 6 of a last collector tube 4 (right in Fig. 2) is connected to a second connecting piece 54 via a feed line portion 16, a pipe bend 52 and a connecting line 53. The pipe bend 52, the connecting line 53 and the second connecting piece 54 consists of a rustproof metal material such as for example copper or stainless steel. The portions of the register 5, running within the cladding tubes 6, the connecting portions 15, the feed line portion 16 and the discharge line portion 18 consists of a non-rustproof heat and pressure-resistant steel and can be unitarily connected to one another. The feed line portion 16, the connecting portions 15, the discharge line portion 18 and the connecting line 53 are surrounded by a heat insulation 55, which is arranged between a covering 56 provided on the holder 3. The covering 56, the pipe bend 52, the connecting pieces 51, 54 and the cladding tubes 3 seal the register 5 against access ingress of rainwater and dirt.

In order to prevent that during the operation of the solar array 1 on the register 5 which consists of non-rustproof heat and pressure-resistant steel, corrosion is formed, the solar array 1 comprises a protective device by means of which the register 5 can be heated when required in such a manner that the formation of condensate on the outer surface of the register 5 facing away from the heat transfer medium is prevented.

For this purpose, the protective device comprises a heating device with a heat storage unit 20 and a boiler 21. The heat storage unit 20 has an advance connection 22 and a return connection 23, which are connected to a heat exchanger 24, which is thermally coupled to a water reservoir 25 that is located in the interior of the heat storage unit 20. For introducing cold water into the water reservoir 25, the same comprises a cold water connection 26, which is connected to a cold water line of a water supply network. For removing warm water, the water reservoir 25 comprises a warm water connection 27 above the cold water connection 26, to which a warm water line is connected. The warm water line and the cold water line are connected to a water removal device which is not shown in more detail in the drawing by way of a mixing battery 28, such as a water tap or a shower.

The return connection 23 of the heat storage unit 20 is connected to the feed line 17 for the solar collector 2 and a first line 30 via a first branch 29, which leads to an inlet connection 31 of the boiler 21. The advance connection 22 of the heat storage unit 20 is connected to the discharge line 19 of the solar collector 2 and a second line 33 by way of a second branch 32, which leads to an outlet connection 34 of the boiler 21. In the feed line 17, the discharge line 19, the first line 30 and the second line 33, a shut-off valve 35, 36, 37, 38 each is arranged.

For delivering the heat transfer medium through the solar collector 2, a first pump 39 is arranged in the feed line 17. The delivery direction of the first pump 39 is selected so that the heat transfer medium is transported via the discharge line 19 from the discharge portion 18 of the solar collector 2 to the advance connection 22 of the heat storage unit 20 when the valves 35, 36 are opened.

A second pump 40 which is arranged in the second line 33 serves for conducting the heat transfer medium through the boiler 21. The delivery direction of the second pump 40 is selected so that the heat transfer medium is transported via the second line 33 from the outlet connection 34 of the boiler 21 to the advance connection 22 of the heat storage unit 20 when the valves 37, 38 are opened.

In Fig. 1 it is evident that the heat storage unit 20 and the boiler 21 are arranged in the frost-protected interior of a heatable building 41 and the solar collector 2 outside the building 41 in the open. The feed line 17 comprises a first feed portion running in the open and a second feed portion running in the interior of the building 41. In corresponding manner, the discharge line 19 comprises a first line portion running in the open and a second discharge portion running in the interior of the building 41.

The protective device comprises multiple temperature sensors. For detecting the ambient temperature of the solar collector 2, an ambient temperature sensor 42 is arranged in the open in the immediate vicinity of the solar collector 2. At the outlet of the solar collector 2, a collector outlet temperature sensor 43 is provided for detecting the collector temperature at the line portion 18. For measuring the advance temperature of the heat transfer medium, an advance temperature 44 is arranged on the second line portion located within the building 41. For measuring the return temperature of the heat transfer medium, a return temperature sensor 45 is provided, which is arranged on the second feed line portion located within the building 41. For detecting the storage unit temperature of the water reservoir 25 located in the heat storage unit 20, the protective device furthermore comprises a storage unit temperature sensor 46.

As is evident in Fig. 1, the protective device additionally comprises a volume flow rate sensor 47 for detecting the heat transfer medium volume flow rate fed to the solar collector 2. The volume flow rate sensor 47 is likewise arranged in the second feed line portion.

The ambient temperature sensor 42, the collector outlet temperature sensor 43, the advance temperature sensor 44, the return temperature sensor 45, the storage unit temperature sensor 46 and the volume flow rate sensor 47 are each connected to a control and/or regulating device 48 via signal lines for transmitting the measurement signals detected by them. For controlling the heat transfer medium volume flow rate in the solar collector 2, the control and/or regulating device 48 is connected to the first pump 39 via a further line.

The control and/or regulating device 48 comprises an electronic memory 49 and a microprocessor 50 interacting with the same. In the memory 49, thermal characteristic variables for the solar collector, the feed line, the discharge line and the heat transfer medium are stored. The characteristic variables comprise characteristic values for

- the length and the content of the line portion of the feed line located within the building,
- the length and the content of the line portion of the feed line located outside the building,
- the length and the content of the line portion of the discharge line located within the building,
- the length and the content of the line portion of the discharge line located outside the building,
- the material cross section of these lines,
- the heat capacity of the materials, from which these lines are made and
- the size of the solar collector.

The characteristic variables can be calculated from the known geometry of the register 5 and the portions of the feed line 17 and of the discharge line 19 located within and without the building 41, and from material characteristic variables of the heat transfer medium and of the materials from which the aforementioned parts are made. Preferably, the thermal characteristic variables however can be experimentally determined, in particular in that the control and/or regulating device 48 is put into an operating mode in which the characteristic variables are learned and stored in the memory 49.

When the first pump 39 delivers the heat transfer medium through the solar collector 2, the heat output produced by the solar collector 2 is calculated by means of an operating program running on the microprocessor 50 by way of the measurement signals for the advance temperature, the return temperature and the volume flow rate and a characteristic variable for the heat capacity of the heat transfer medium stored in the memory 49. When sufficient heat energy is produced and the temperature in the heat storage unit does not exceed a predetermined maximum value, the generated solar heat is transferred into the heat storage unit 20 via the heat exchanger 24.

The operating program of the control and/or regulating device comprises a simulation program, by means of which a simulation value for the temperature on the outer surface of the register 5 is determined from the characteristic variables stored in the memory 49 and measurement signals for the volume flow rate, the advance temperature and the return temperature and the ambient temperature with the help of the microprocessor 50. The first pump 39 is activated by means of the control and/or regulating device in such a manner as a function of the simulation value and the measurement signal of the ambient temperature sensor that the temperature on the outer surface of the register 5 does not fall below the measurement value for the ambient temperature.

When the temperature on the outer surface of the register 5 falls below a predetermined limit value, warm heat transfer medium is pumped out of the heat storage unit 20 and/or the boiler 21 into the solar collector 2. Here, the first pump 39 is operated at short intervals which for example can have an interval period of four to 16 seconds.

The mean volume flow rate of the heat transfer medium delivered into the solar collector 2 is dependent on the ambient temperature, the temperature on the outer surface of the register 5, the size or heat capacity of the solar collector 2 and of the advance temperature.

Napelemes berendezés

Szabadalmi igénypontok

1. Napelemes berendezés (1) napkollektorral, amely legalább egy, burkolócsöves (6) kollektorcsővel rendelkezik, mely burkolócsőbe egy regiszter (5) nyúlik bele, ahol a burkolócső (6) és a regiszter (5) között egy a környezettel összeköttetésben álló belső üreg (12) van kialakítva, és ahol a regiszter (5) egy hozzávezetéssel (17) és egy elvezetéssel (19) áll összeköttetésben, amelyekkel a regiszterbe (5) hőátadó közeg vezethető, illetve a regiszterből hőátadó közeg vételezhető, *azzal jellemezve*, hogy a regiszter (5) legalább szakaszosan egy nem rozsdamentes, hő- és nyomásálló acélból áll, és hogy a napelemes berendezés (1) egy védőberendezéssel rendelkezik, amely úgy van kialakítva, hogy megakadályozza kondenzvíz képződését a regiszter (5) hőátadó közeggel ellentétes külső felületén.

2. Az 1. igénypont szerinti napelemes berendezés (1), *azzal jellemezve*, hogy a védőberendezés tartalmaz egy fűtőberendezést a regiszter (5) számára, egy környezeti hőmérséklet érzékelőt (42) a napkollektor (2) környezeti hőmérsékletének érzékelésére, és egy kollektor kimeneti hőmérséklet érzékelőt (43) a kollektor hőmérsékletének érzékelésére a napkollektor (2) elvezetésénél (19), és hogy a környezeti hőmérséklet érzékelő (42) és a kollektor kimeneti hőmérséklet érzékelő (43) egy vezérlő és/vagy szabályozó berendezésen (48) keresztül a fűtőberendezéssel áll összeköttetésben.

3. A 2. igénypont szerinti napelemes berendezés (1), *azzal jellemezve*, hogy a fűtőberendezésnek hőtárolója (20) van, amely a hozzávezetésen (17) és az elvezetésen (19) keresztül a napkollektorral (2) egy hőátadó közeg körré van összekötve, hogy a hőátadó közeg körben egy szivattyú (39, 40) van elrendezve, és hogy a környezeti hőmérséklet érzékelő (42) és a kollektor kimeneti hőmérséklet érzékelő (43) a vezérlő- és/vagy szabályozó berendezésen (48) keresztül a szivattyúval (39, 40) áll összeköttetésben.

4. A 2. vagy 3. igénypont szerinti napelemes berendezés (1), *azzal jellemezve*, hogy a vezérlő- és/vagy szabályozó berendezés (48) úgy van kialakítva, hogy a kollektor kimeneti hőmérséklet nem csökken a környezeti hőmérséklet alá.

5. A 2-4. igénypontok bármelyike szerinti napelemes berendezés (1), *azzal jellemezve*, hogy a vezérlő- és/vagy szabályozó berendezés (48) úgy van kialakítva, hogy a kollektor hőmérséklet a napkollektor (2) elvezetésénél (19) nem csökken egy előre meghatározott legkisebb érték alá.

6. A 3-5. igénypontok bármelyike szerinti napelemes berendezés (1), *azzal jellemezve*, hogy a vezérlő- és/vagy szabályozó berendezés (48) egy tárolót (49) tartalmaz, amelyben a napkollektorra (2), a hozzávezetésre (17), az elvezetésre (19) és a hőátadó közegre vonatkozó termikus paraméterek vannak eltárolva, hogy a védőberendezésnek egy térfogatáram érzékelője (47) van a napkollektorhoz (2) vezetett hőátadó közeg térfogatáram mérésére, egy előremenő hőmérséklet érzékelője (44) van az elvezetésben (19) található hőátadó közeg előremenő hőmérsékletének mérésére, és egy visszatérő hőmérséklet érzékelője (45) van a hozzávezetésben (17) található hőátadó közeg visszatérő hőmérsékletének mérésére, és hogy a vezérlő- és/vagy szabályozó berendezésnek (48) egy a tárolóval (49) összekötött mikroprocesszora (50) van, hogy a tárolóban (49) egy a mikroprocesszoron (50) futtatható üzemi program van eltárolva, amellyel a térfogatáramra, a visszatérő hőmérsékletre, a környezeti hőmérsékletre és a napkollektor (2) elvezetésénél (18) a kollektor hőmérsékletre vonatkozó paraméterekből és mérési jelekből kiszámítható a hozzávezetésben (17) fennálló hőmérsékletek valós idejű szimulációja, és a szabadon fekvő berendezés részek kihűlési sebességének kiszámítása révén meghatározunk egy szivattyúsebességet, amellyel a szivattyút (39, 40) a vezérlő- és/vagy szabályozó berendezéssel úgy vezérelhetjük, hogy a hőmérséklet a regiszter (5) külső felületén és a hozzávezetésben (5) ne csökkenjen egy a környezeti hőmérséklet fölötti meghatározott határérték alá.

7. A 6. igénypont szerinti napelemes berendezés (1), *azzal jellemezve*, hogy a hőtároló (20) egy épületben (41), a napkollektor (2) a szabadban van elrendezve, és hogy a paraméterek a következőkre vonatkozó mérési értékeket tartalmaznak:

– a hozzávezetés (17) egy az épületen (41) belül található vezetékszakaszának hossza és tartalma,

– a hozzávezetés (17) egy a szabadban található vezetékszakaszának hossza és tartalma,

– az elvezetés (19) egy az épületen (17) belül található vezetékszakaszának hossza és tartalma,

– az elvezetés (19) egy a szabadban található vezetékszakaszának hossza és tartalma, és

– a napkollektor (2) mérete.

8. A 3-7. igénypontok bármelyike szerinti napelemes berendezés (1), *azzal jellemezve*, hogy a vezérlő- és/vagy szabályozó berendezés úgy van kialakítva, hogy a szivattyú (39, 40) szakaszos üzemben működtethető.

9. Az 1-8. igénypontok bármelyike szerinti napelemes berendezés (1), *azzal jellemezve*, hogy a nem rozsdamentes, hő- és nyomásálló acél normalizáló izzításnak alávetett acél.

10. Az 1-9. igénypontok bármelyike szerinti napelemes berendezés (1), *azzal jellemezve*, hogy a burkolócső (5) vákuumcsőként van kialakítva külső fallal (7) és egy attól távközzel elválasztott belső fallal (8), melyek között légritkított közbenső tér (11) van elrendezve.

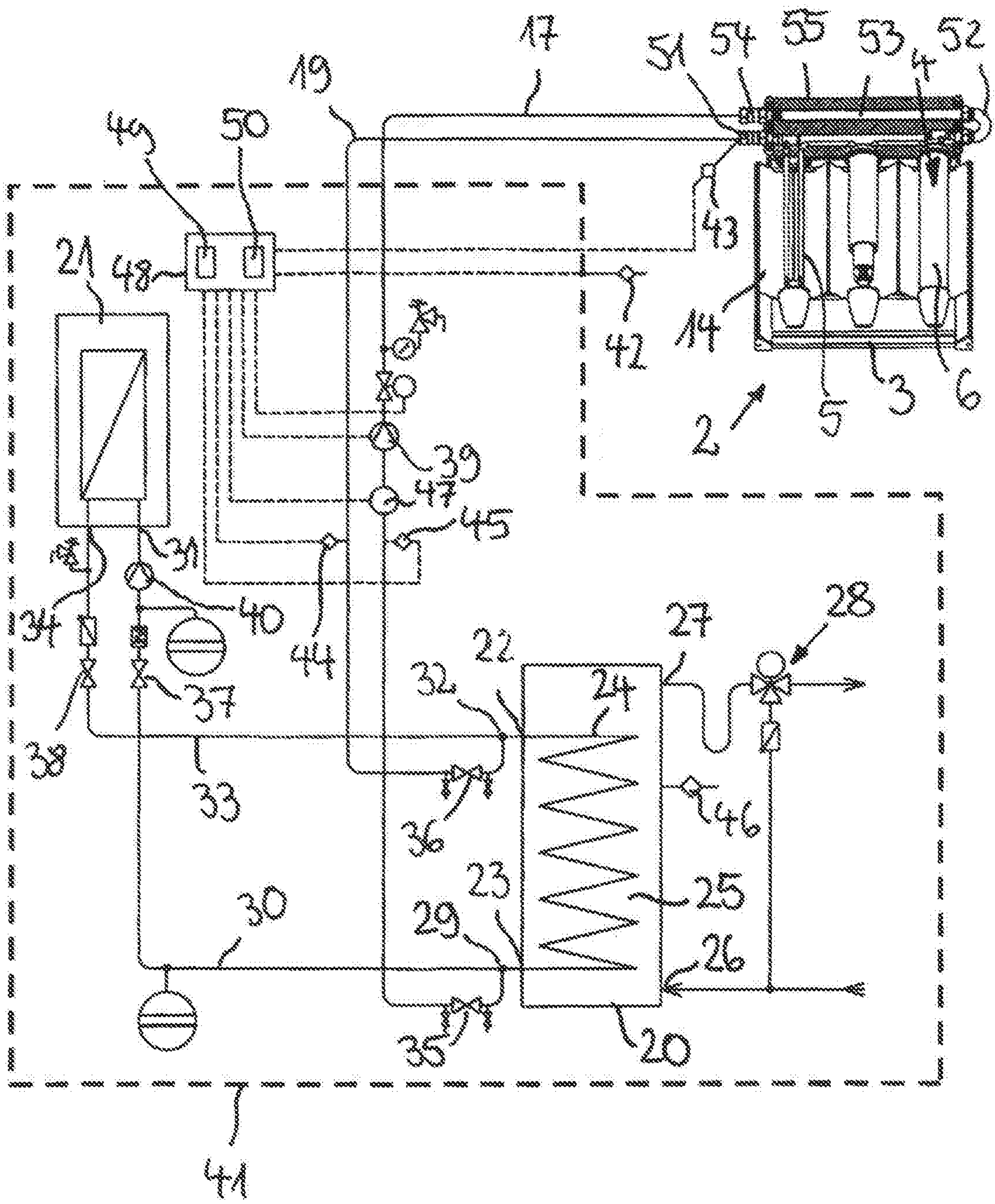
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Fig. 1

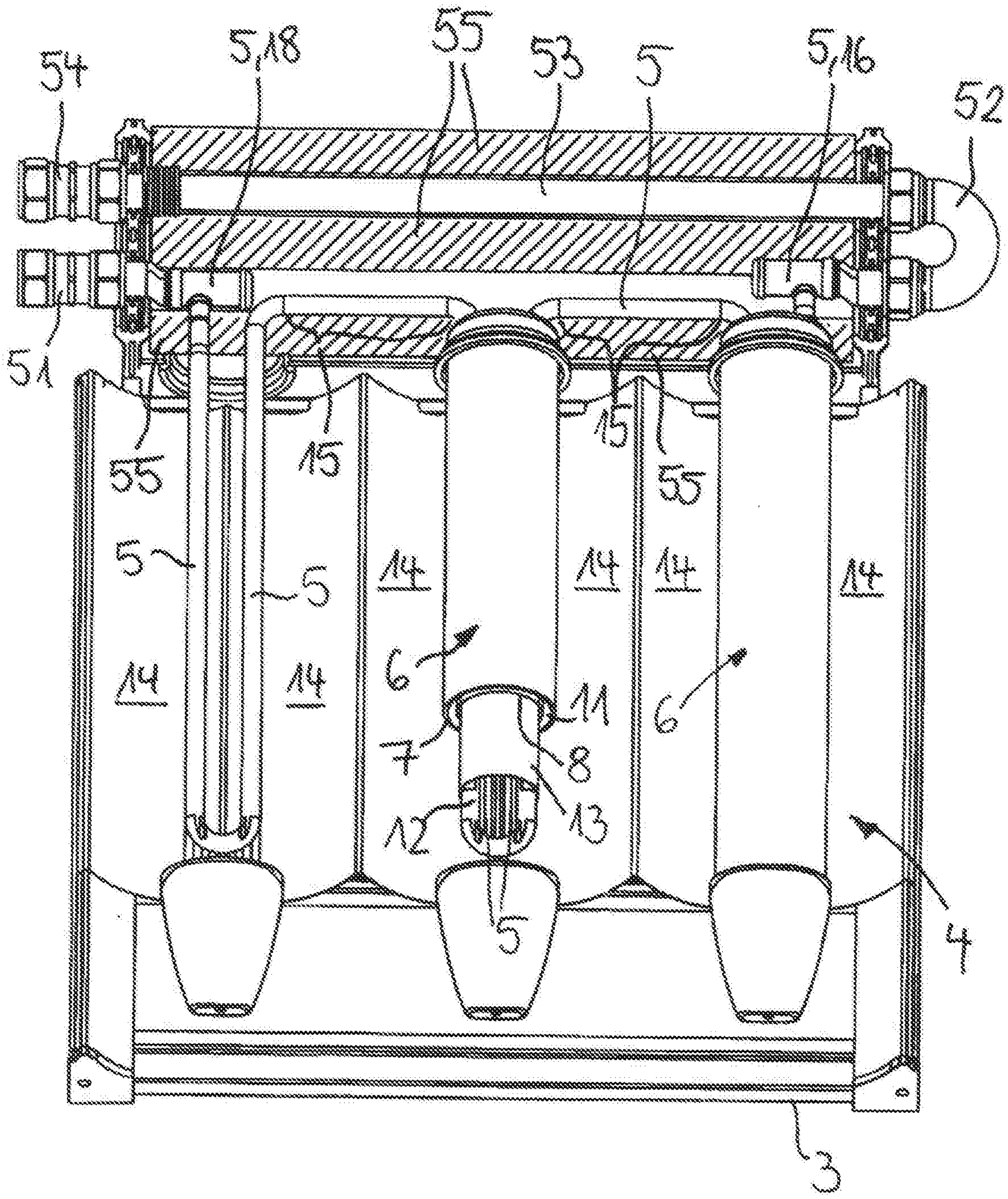
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Fig. 2

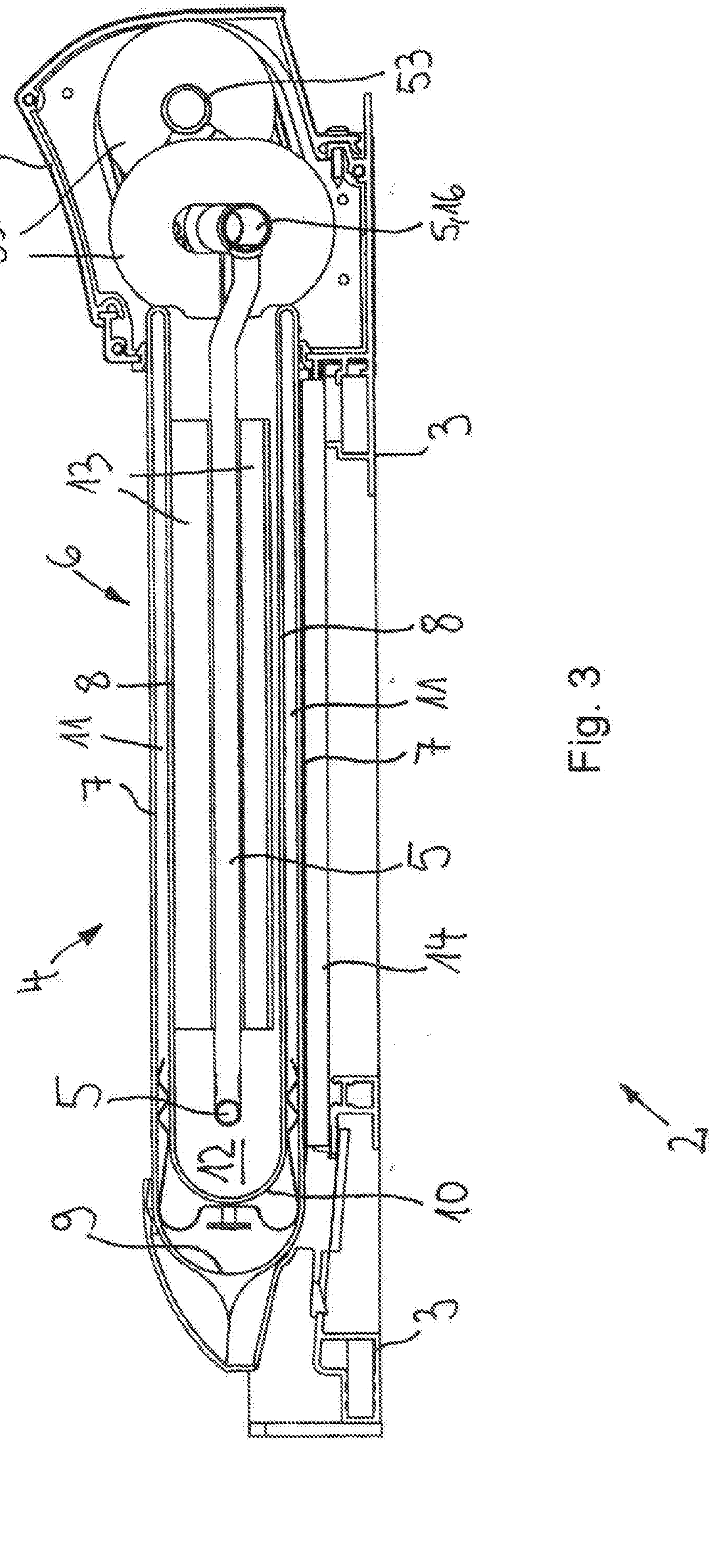

Fig. 3