(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 671 090 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
**05.04.2023 Bulletin 2023/14**

(21) Application number: **19216451.5**

(22) Date of filing: **16.12.2019**

(51) International Patent Classification (IPC):
***F28D 5/02*** *(2006.01)* ***F28D 3/02*** *(2006.01)*
***F28F 27/00*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
**F28D 5/02; F28D 3/02; F28F 27/003**

(54) **IMPROVED COOLING PROCESS AND APPARATUS FOR IMPLEMENTING SAID PROCESS**

VERBESSERTES KÜHLVERFAHREN UND VORRICHTUNG ZUR IMPLEMENTIERUNG DES BESAGTEN VERFAHRENS

PROCÉDÉ DE REFROIDISSEMENT AMÉLIORÉ ET APPAREIL POUR LA MISE EN UVRE DUDIT PROCÉDÉ

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**

(30) Priority: **17.12.2018 IT 201800011172**

(43) Date of publication of application:
**24.06.2020 Bulletin 2020/26**

(73) Proprietor: **LU-VE S.P.A.**
**21100 VARESE (IT)**

(72) Inventors:
- **MERLO, Umberto**
  **21040 Uboldo (VA) (IT)**
- **FILIPPINI, Stefano**
  **21040 Uboldo (VA) (IT)**

(74) Representative: **Rastelli, Franco**
**Dott. Franco Cicogna & C. SRL**
**Via Visconti di Modrone, 14/A**
**20122 Milano (IT)**

(56) References cited:
**EP-A1- 3 306 247**
**WO-A1-2015/173767**
**US-A1- 2018 231 264**



EP 3 671 090 B1

## Description

### BACKGROUND OF THE INVENTION

**[0001]** The present invention concerns an improved cooling process and the related cooling apparatus.

**[0002]** The field of the invention is that of systems for cooling single-phase or two-phase fluids, in turn used in refrigerating or conditioning systems, or in industrial heat exchange systems.

**[0003]** The systems to which the invention refers are in particular of the type provided with ducts for the fluid to be cooled, which enters a heat exchange pack where it is cooled by means of an air circulation provided by respective fans and by means of adiabatic panels that pre-cool air sucked by fans through the heat exchange pack, and by means of spray nozzles wetting the surface of the heat exchange pack with water.

**[0004]** In the prior art relative to exchangers described here (EP3306247A1), the above-mentioned components are activated only as a function of the exchange power required. This has the drawback of keeping constantly in operation the same initial cooling area of the exchanger, in which the corresponding adiabatic pack is the one that receives the spraying action for the longest period of time. As a result, the adiabatic pack where the initial cooling takes place is subjected to the highest number of working hours and is therefore more liable to malfunctions and requires more frequent maintenance to remove residues (limescale and similar) left by the cooling water.

### SUMMARY OF THE INVENTION

**[0005]** The main aim of the invention is to provide a cooling process, and the related apparatus, adapted to avoid the above-mentioned drawbacks.

**[0006]** This aim is achieved by the process and apparatus of claims 1 and 5, respectively. Preferred embodiments of the invention are disclosed in the remaining claims.

**[0007]** According to the invention, the spray nozzles for cooling the adiabatic packs are activated alternately, namely in a rotation cycle sequence in which the spray nozzles operate in alternate phases. In this way, while in a first phase some spray nozzles are active and others are at rest, in the subsequent phases this operating state is varied or exchanged between the spray nozzles within the overall cooling system.

**[0008]** In the process and apparatus according to the invention, the components that perform the cooling are therefore no longer activated only as a function of the exchange power required, but also taking into account the operating time of the spray nozzles. In this way there is an exchange between different zones or cooling areas of the apparatus according to the invention, which are therefore each subjected to a shorter period of use, with evident advantages in terms of maintenance and good overall operation of the system.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0009]** This and other objects are achieved by the process and apparatus of the present invention, illustrated by way of non-limiting example in the figures of the attached drawings, wherein:

- Figure 1 schematically illustrates an example of a cooling apparatus according to the invention,
- Figure 2 schematically illustrates the operating principle of the cooling system provided on the apparatus of Figure 1;
- Figure 3 illustrates the dry operation diagram of the system in Figure 2;
- Figure 4 illustrates the diagram of Figure 2, in a dry operation state in combination with pre-cooling of air on both the adiabatic panels;
- Figures 5A, 5B illustrate the diagram of Figure 2, in operation with fans, in combination with one single adiabatic panel on one side of the cooling apparatus and with one and two spraying units, respectively, on the opposite side;
- Figures 6 and 7 illustrate the operation diagram of Figure 2, with rotating operation of two spraying units on both sides of the apparatus;
- Figures 8 and 9 illustrate the diagram of Figure 2, with rotating operation of three spraying units; and
- Figure 10 illustrates the diagram of Figure 2 with full operation of the cooling system (fans, plus adiabatic panels, plus all the spraying units).

### DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0010]** The apparatus according to the invention, illustrated in Figure 1, comprises a framework 10 above which a fan assembly 1 is mounted which sucks cooling air (arrow F in Figure 1) through adiabatic panels 2a and 2b. The fluid to be cooled in the heat exchange packs (not shown in the figures) enters through inlets 5a, 5b of the apparatus of Figure 1 and exits through outlets 6a, 6b.

**[0011]** The diagram of the cooling system of the heat exchange packs illustrated in Figure 2 comprises said fans 1, which pre-cool air sucked by the fans by contact with the wet surface of said packs. Spraying units are also provided, consisting of pipes 3a,3b,3c,3d which bear respective spraying nozzles for spraying water to cool the heat exchange packs. Respective valves 4a,4b,4c, 4d control the water delivery to the cited spraying units 3a, 3b, 3c, 3d. It should be noted that the invention is not limited to the four spraying units shown in the figures, since the number of these units can vary from two or more.

**[0012]** Cooling water is supplied through an inlet 5 and is split into a branch 6, conveying cooling water to the valves 4a-4d, and a branch 7 conveying water to the ad-

iabatic panels 2.

**[0013]** In a first cooling mode of the heat exchange packs of the apparatus in Figure 1, the cooling is carried out in a dry condition, namely by circulation of air by the fans 1 only (Figure 3).

**[0014]** In a second mode, cooling by passage of water through the adiabatic panels 2a, 2b is added to the circulation of air by the fans 1 (Figure 4).

**[0015]** In the cooling mode illustrated in Figures 5A and 5B, with the cooling apparatus split into two sides or parts 9a, 9b separated by a centre line 8, the cooling action performed by the spraying unit 3a located on the side 9a of the cooling apparatus (Figure 5A) or by both the spraying units 3a, 3b located on the same side 9a, by opening of the respective valves 4a and 4b (Figure 5B), is added to the cooling action of the fans 1 and the single adiabatic panel 2b located on the side 9b of the apparatus. The principle is to obtain a higher cooling level than that illustrated in Figure 4, by introducing the operation of one or two spraying units on one side of the cooling apparatus, while maintaining on the opposite side the cooling action due to the respective adiabatic panel.

**[0016]** More specifically, the operating sequence with rotation cycle of said spraying units 3a, 3b, 3c, 3d is performed in such a way that, when only one adiabatic panel is operating, at least one spraying unit 3a, 3b, 3c, 3d is simultaneously activated on the side of the apparatus opposite to the side on which said adiabatic panel is located.

**[0017]** In the cooling mode illustrated in Figures 6 and 7, the cooling action due to the activation of a spraying unit on both sides 9a, 9b of the apparatus, i.e. the unit 3b on the side 9a and the unit 3c or the unit 3d on the side 9b of the same cooling apparatus, respectively, is added to the cooling action of the fans 1 and both the adiabatic panels 2a, 2b. The rotation between said two operating modes of Figures 6 and 7 described above is obtained by opening the valves 4b, 4c and 4b, 4d, respectively.

**[0018]** In this phase, therefore, the spraying unit 3a, which in the preceding phases was in operating state, is now kept turned off, while the remaining units 3c, 3d operate in a mutually alternating way or in rotation.

**[0019]** In the operating modes illustrated in Figures 8 and 9, the cooling action of the fans 1 and the adiabatic panels 2a, 2b is integrated with the action performed by three spraying units, i.e. the units 3b, 3c, 3d, respectively, in the version illustrated in Figure 8, and the units 3a, 3c, 3d in the version of Figure 9. Also in this case, and according to the invention, the operating modes illustrated in said Figures 8 and 9 are rotated by opening the valves 4b, 4c, 4d and 4a, 4c, 4d, respectively.

**[0020]** The most complete or highest cooling level is obtained in the mode illustrated in Figure 10, where the cooling is provided together by the fans 1, the adiabatic panels 2a, 2b and all the spraying units 3a, 3b, 3c, 3d.

**[0021]** The intervention of the different cooling modes described above can be determined as a function of the specific requirements of the cooling system, based on the overall operating time of the spraying units, or also based on the modes required for the specific intended use of the system.

**[0022]** Modifications can be made to the invention, as described above and illustrated in the figures of the attached drawings, in order to provide variations, which anyway fall within the protective scope defined in the appended claims.

**[0023]** Thus, for example, the number of spraying units and related valves could be different. Furthermore, the presence of the adiabatic panels, for example, is not necessary since the cooling system according to the invention can achieve the claimed effects also through the spraying units 3a-3d only, operating in rotation.

**[0024]** It is furthermore possible to provide for rotation of only one single spraying unit, moving it between the various sectors. Thus, for example, it is possible to cool by individually activating the spraying units 3a, 3b, 3c, 3d, namely each one independently of the others.

**[0025]** Finally, a system (not illustrated) can be provided for controlling the duration times of the described operating modes of the apparatus, in particular of said spraying units, adjusted based on the required cooling needs.

## Claims

1. A process for cooling a fluid with an apparatus comprising spraying units (3) controlled by respective supply valves (4) for supplying a heat-carrier fluid, **characterized in that** said spraying units (3) are activated in a mutually alternating way according to an operation sequence with a rotation cycle between them and **in that** said spraying units (3) are activated with alternating operation between individual spraying units and/or sets of two or more spraying units.

2. The process according to claim 1, **characterized in that** said apparatus further comprises cooling air circulation fans (1) and adiabatic panels (2), **characterized in that** it provides for the activation of said fans (1) and said panels (2) in combination with said spraying units (3) with an alternating operation sequence or according to a rotation cycle between them.

3. The process according to claim 2, **characterized in that** said operation sequence of said spraying units (3) according to a rotation cycle operates in such a way that, divided the cooling apparatus into two sides (9a, 9b) separated by a centre line (8), when only one adiabatic panel (2) on one of said sides (9a) or (9b) is operating, at least one spraying unit (3) is simultaneously activated on the other side of the apparatus, opposite to the side on which said adiabatic panel (2) is located.

4. A cooling apparatus for implementing the process according to one or more of the preceding claims, comprising fans (1), adiabatic panels (2), and spraying units (3), controlled by respective valves (4), for spraying water on the heat-exchange packs of said apparatus, wherein said panels (2) are located distributed on the parts (9a, 9b) of said apparatus, **characterized in that** it provides a control system for the duration times of said operating modes according to a rotation cycle of said spraying units, adjusted based on the required cooling needs, wherein said spraying units (3) are activated with alternating operation between individual spraying units and/or sets of two or more spraying units.

**Patentansprüche**

1. Verfahren zum Kühlen eines Fluids mit einer Vorrichtung, die Sprüheinheiten (3) umfasst, die durch jeweilige Zufuhrventile (4) zum Zuführen eines Wärmeträgerfluids gesteuert werden, **dadurch gekennzeichnet, dass** die Sprüheinheiten (3) auf eine gegenseitig abwechselnde Weise gemäß einer Betriebsabfolge mit einem Rotationszyklus zwischen ihnen aktiviert werden, und dadurch, dass die Sprüheinheiten (3) mit abwechselndem Betrieb zwischen einzelnen Sprüheinheiten und/oder Sätzen aus zwei oder mehr Sprüheinheiten aktiviert werden.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** die Vorrichtung ferner Kühlluft-Umluftgebläse (1) und adiabatische Platten (2) umfasst, **dadurch gekennzeichnet, dass** sie für die Aktivierung der Gebläse (1) und der Platten (2) in Kombination mit den Sprüheinheiten (3) mit einer abwechselnden Betriebsabfolge oder gemäß einem Rotationszyklus zwischen ihnen sorgt.

3. Verfahren nach Anspruch 2, **dadurch gekennzeichnet, dass** die Betriebsabfolge der Sprüheinheiten (3) gemäß einem Rotationszyklus derart operiert, dass, wenn die Kühlvorrichtung in zwei durch eine Mittellinie (8) getrennte Seiten (9a, 9b) geteilt wird und nur eine adiabatische Platte (2) auf einer der Seiten (9a) oder (9b) in Betrieb ist, mindestens eine Sprüheinheit (3) gleichzeitig auf der anderen Seite der Vorrichtung gegenüber der Seite aktiviert wird, auf der sich die adiabatische Platte (2) befindet.

4. Kühlvorrichtung zum Implementieren des Verfahrens nach einem oder mehreren der vorhergehenden Ansprüche, umfassend Gebläse (1), adiabatische Platten (2) und Sprüheinheiten (3), die durch jeweilige Ventile (4) gesteuert werden, zum Sprühen von Wasser auf die Wärmetauscheraggregate der Vorrichtung, wobei die Platten (2) verteilt auf den Teilen (9a, 9b) der Vorrichtung angeordnet sind, **dadurch gekennzeichnet, dass** sie ein Steuersystem für die Zeitdauern der Betriebsmodi gemäß einem Rotationszyklus der Sprüheinheiten bereitstellt, das basierend auf dem erforderlichen Kühlbedarf eingestellt ist, wobei die Sprüheinheiten (3) mit abwechselndem Betrieb zwischen einzelnen Sprüheinheiten und/oder Sätzen von zwei oder mehr Sprüheinheiten aktiviert werden.

**Revendications**

1. Procédé de refroidissement d'un fluide avec un appareil comprenant des unités de pulvérisation (3) commandées par des vannes d'alimentation respectives (4) pour alimenter un fluide caloporteur, **caractérisé en ce que** lesdites unités de pulvérisation (3) sont activées de manière alternée entre elles selon une séquence de fonctionnement avec un cycle de rotation entre elles et **en ce que** lesdites unités de pulvérisation (3) sont activées avec un fonctionnement alterné entre des unités de pulvérisation individuelles et/ou des ensembles de deux ou plusieurs unités de pulvérisation.

2. Procédé selon la revendication 1, **caractérisé en ce que** ledit appareil comprend en outre des ventilateurs de circulation d'air de refroidissement (1) et des panneaux adiabatiques (2), **caractérisé en ce qu'**il prévoit l'activation desdits ventilateurs (1) et desdits panneaux (2) en combinaison avec lesdites unités de pulvérisation (3) avec une séquence de fonctionnement alternée ou selon un cycle de rotation entre elles.

3. Procédé selon la revendication 2, **caractérisé en ce que** ladite séquence de fonctionnement desdites unités de pulvérisation (3) selon un cycle de rotation fonctionne de telle manière que, divisé l'appareil de refroidissement en deux côtés (9a, 9b) séparés par une ligne centrale (8), lorsqu'un seul panneau adiabatique (2) d'un desdits côtés (9a) ou (9b) est en fonctionnement, au moins une unité de pulvérisation (3) est activée simultanément de l'autre côté de l'appareil, opposé au côté sur lequel ledit panneau adiabatique (2) est situé.

4. Appareil de refroidissement pour la mise en œuvre du procédé selon une ou plusieurs des revendications précédentes, comprenant des ventilateurs (1), des panneaux adiabatiques (2), et des unités de pulvérisation (3), commandées par des vannes respectives (4), à des fins de pulvérisation d'eau sur les packs d'échange de chaleur dudit appareil, dans lequel lesdits panneaux (2) sont situés en étant répartis sur les parties (9a, 9b) dudit appareil, **caractérisé en ce qu'**il fournit un système de commande des durées desdits modes de fonctionnement selon un

cycle de rotation desdites unités de pulvérisation, ajusté sur la base des besoins de refroidissement requis, dans lequel lesdites unités de pulvérisation (3) sont activées avec un fonctionnement alterné entre des unités de pulvérisation individuelles et/ou des ensembles de deux ou plusieurs unités de pulvérisation.

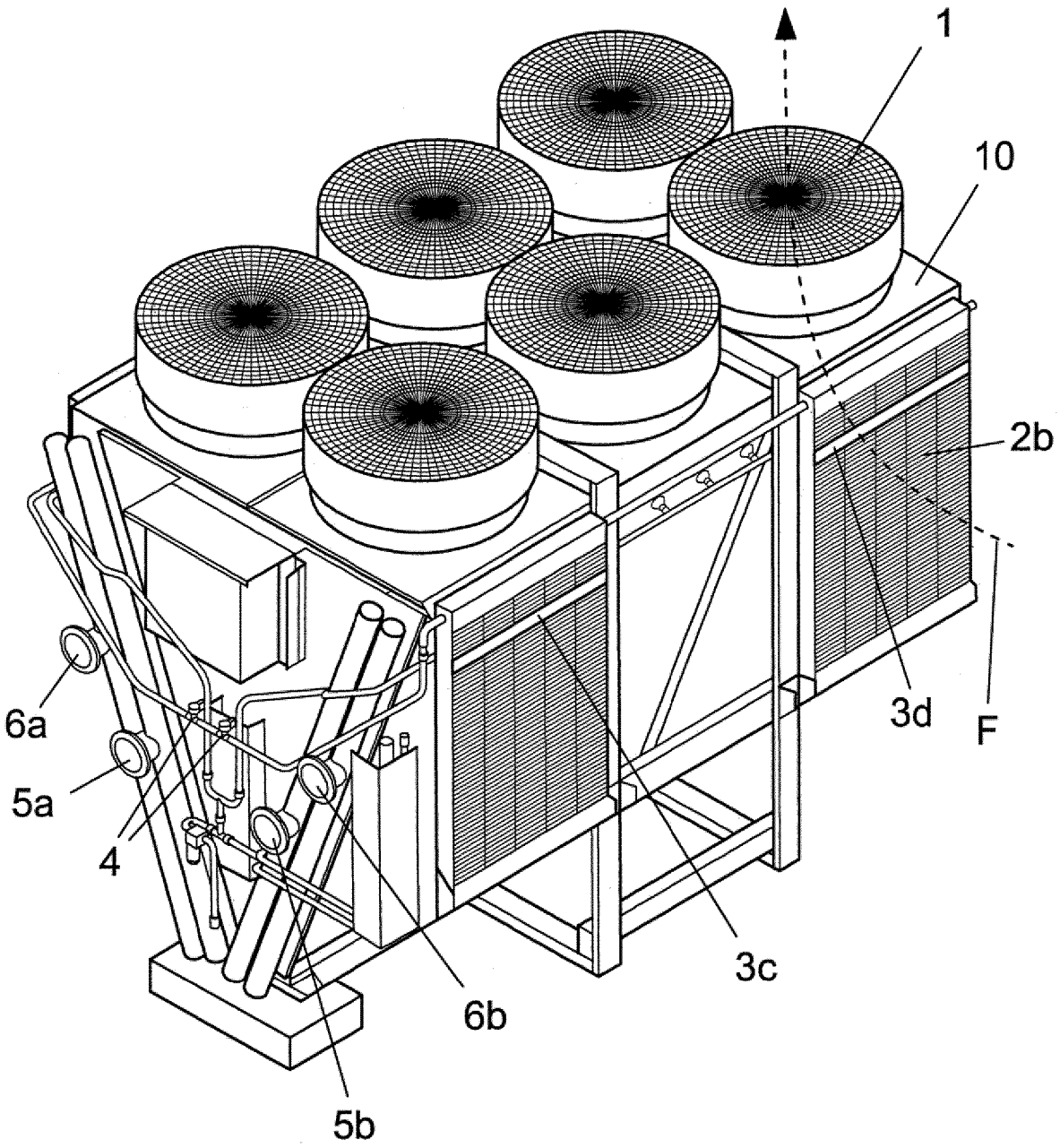


FIG. 1

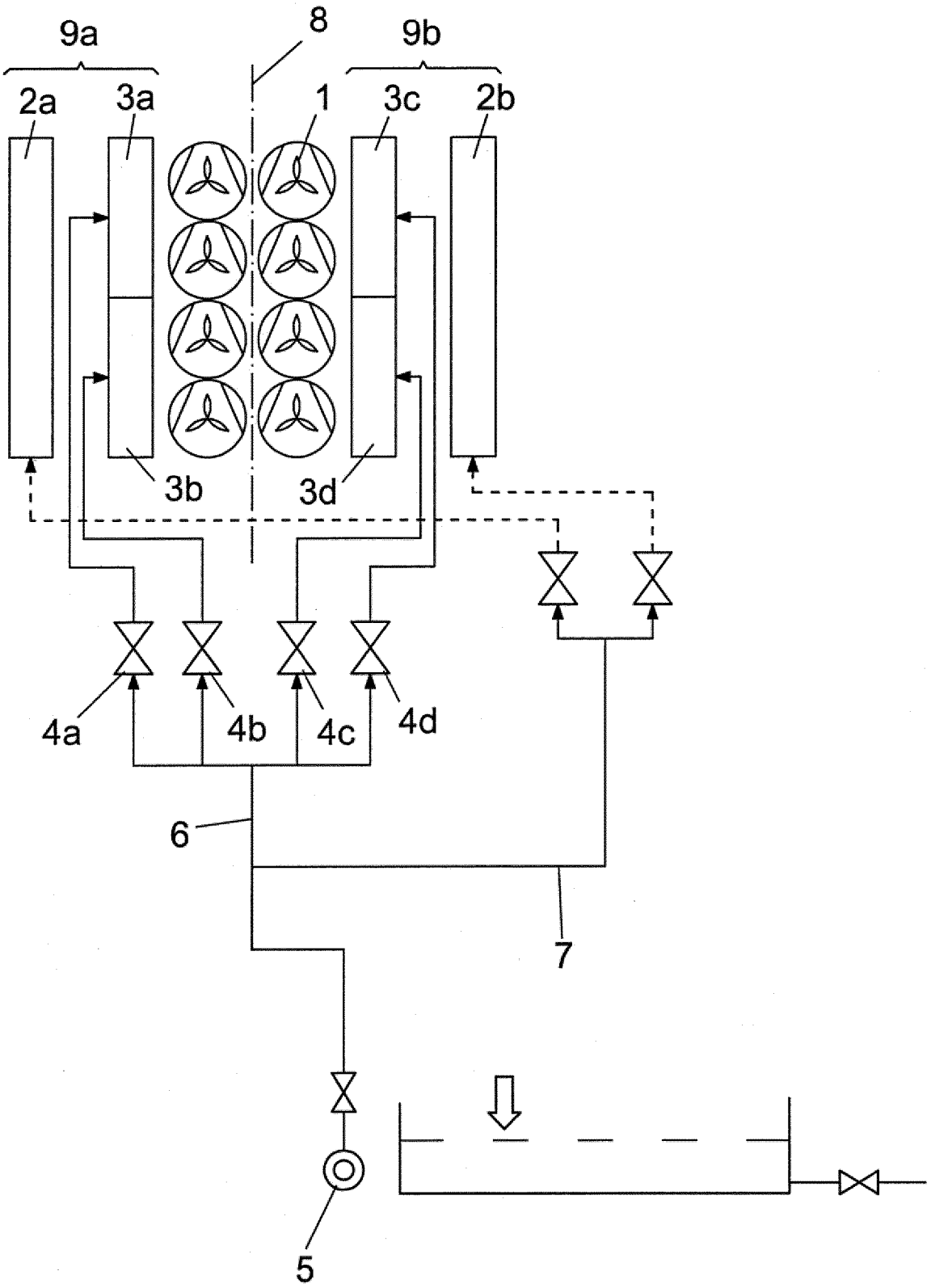


FIG. 2

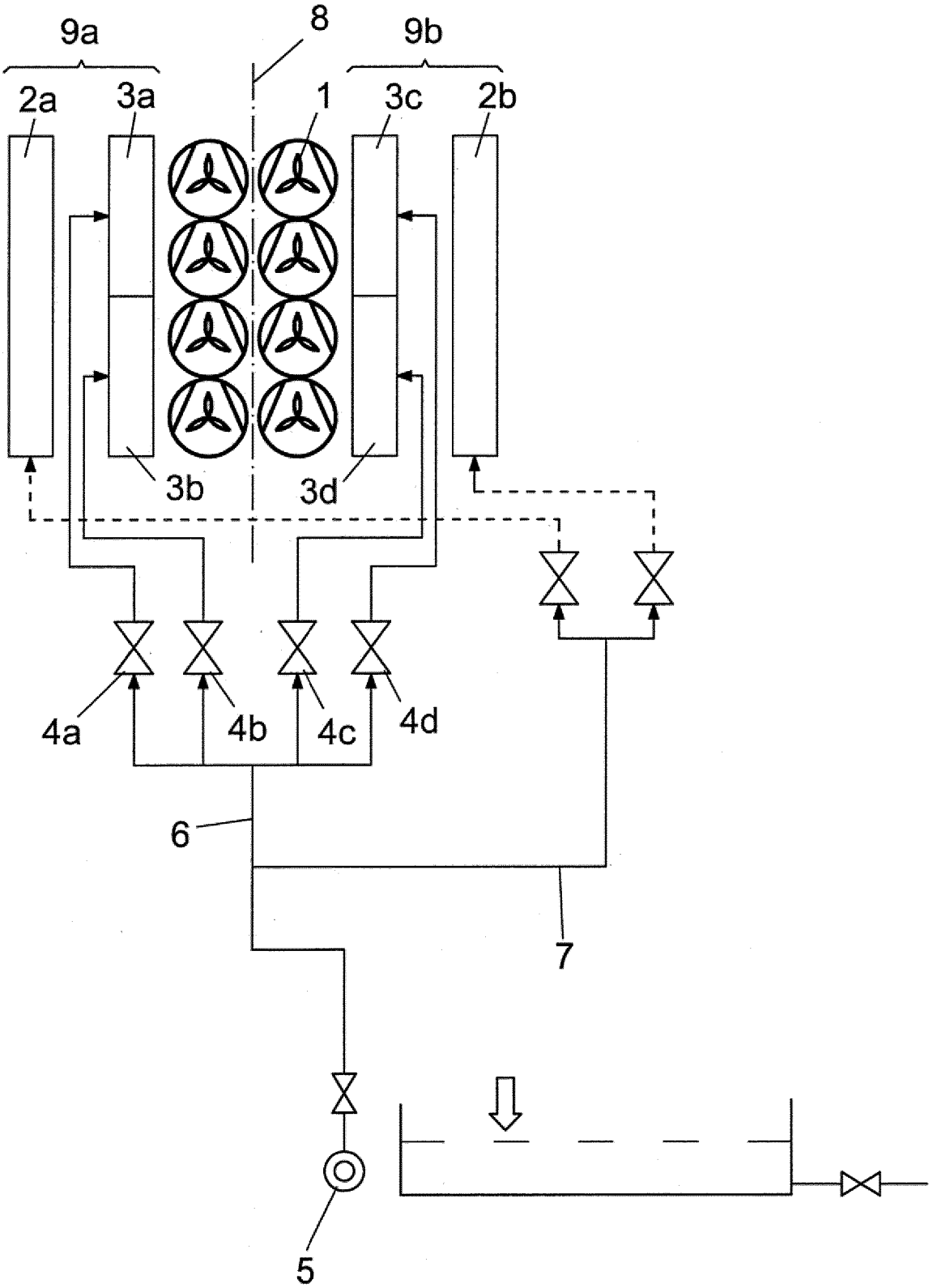


FIG. 3

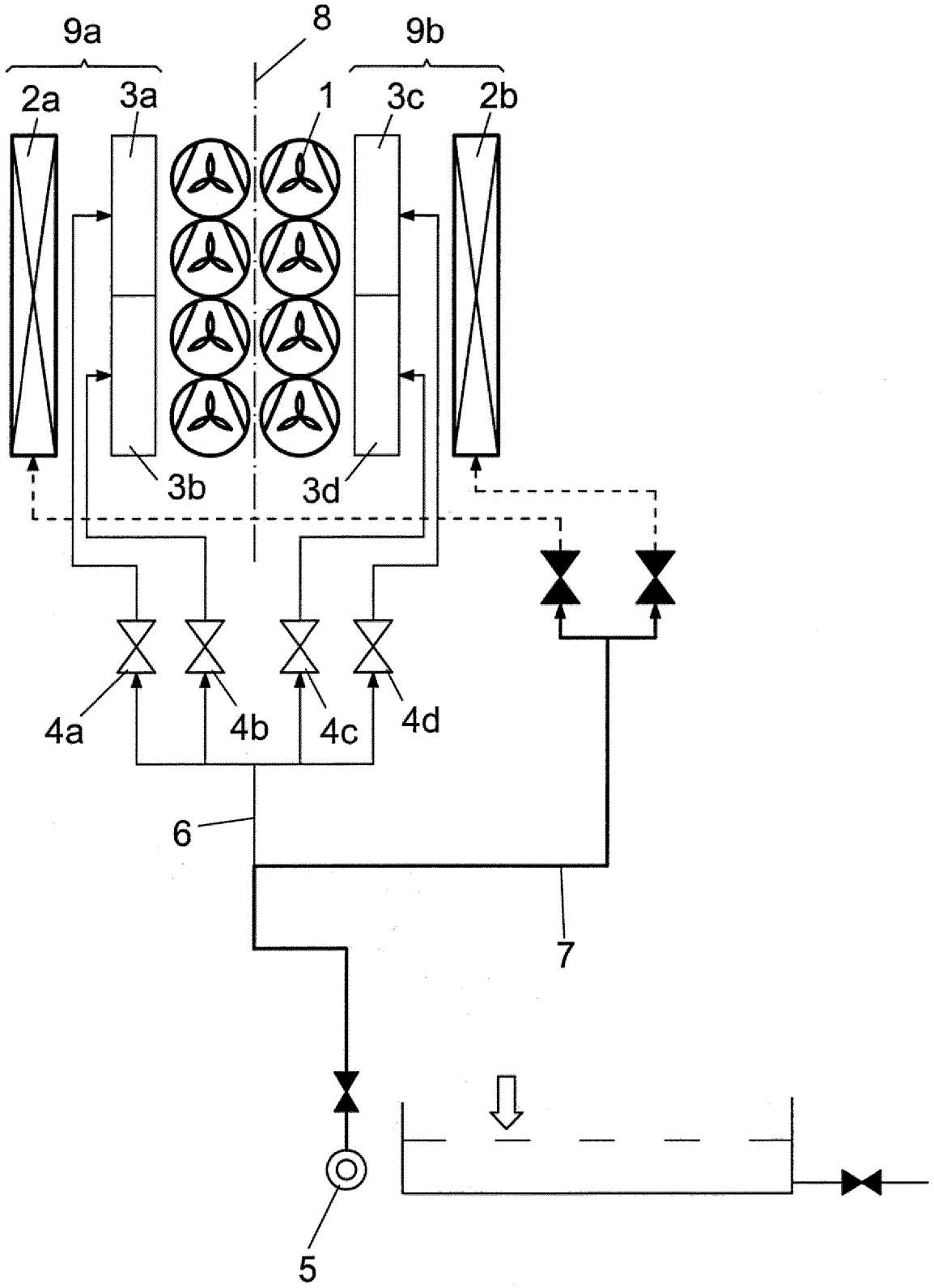


FIG. 4

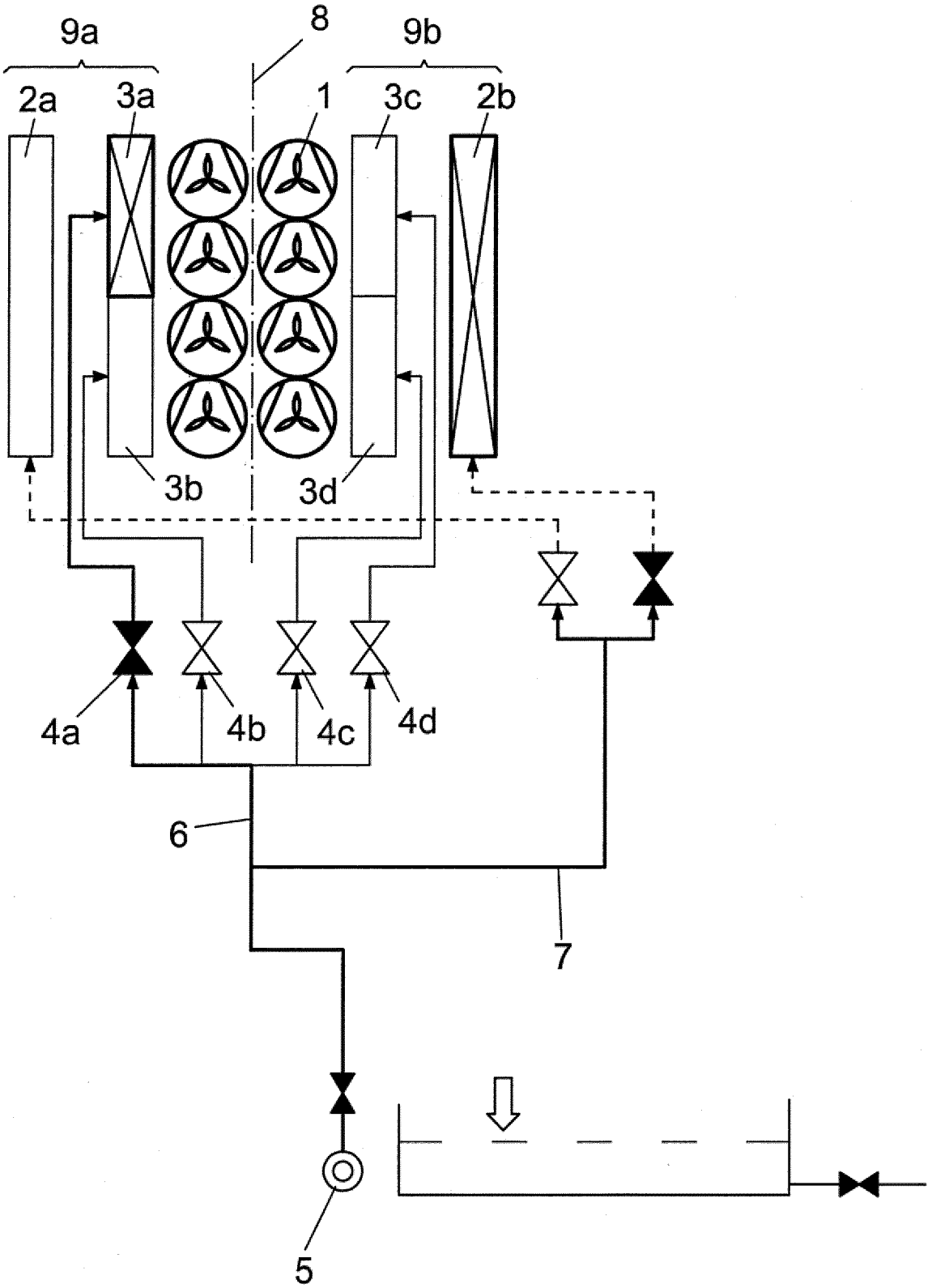


FIG. 5A

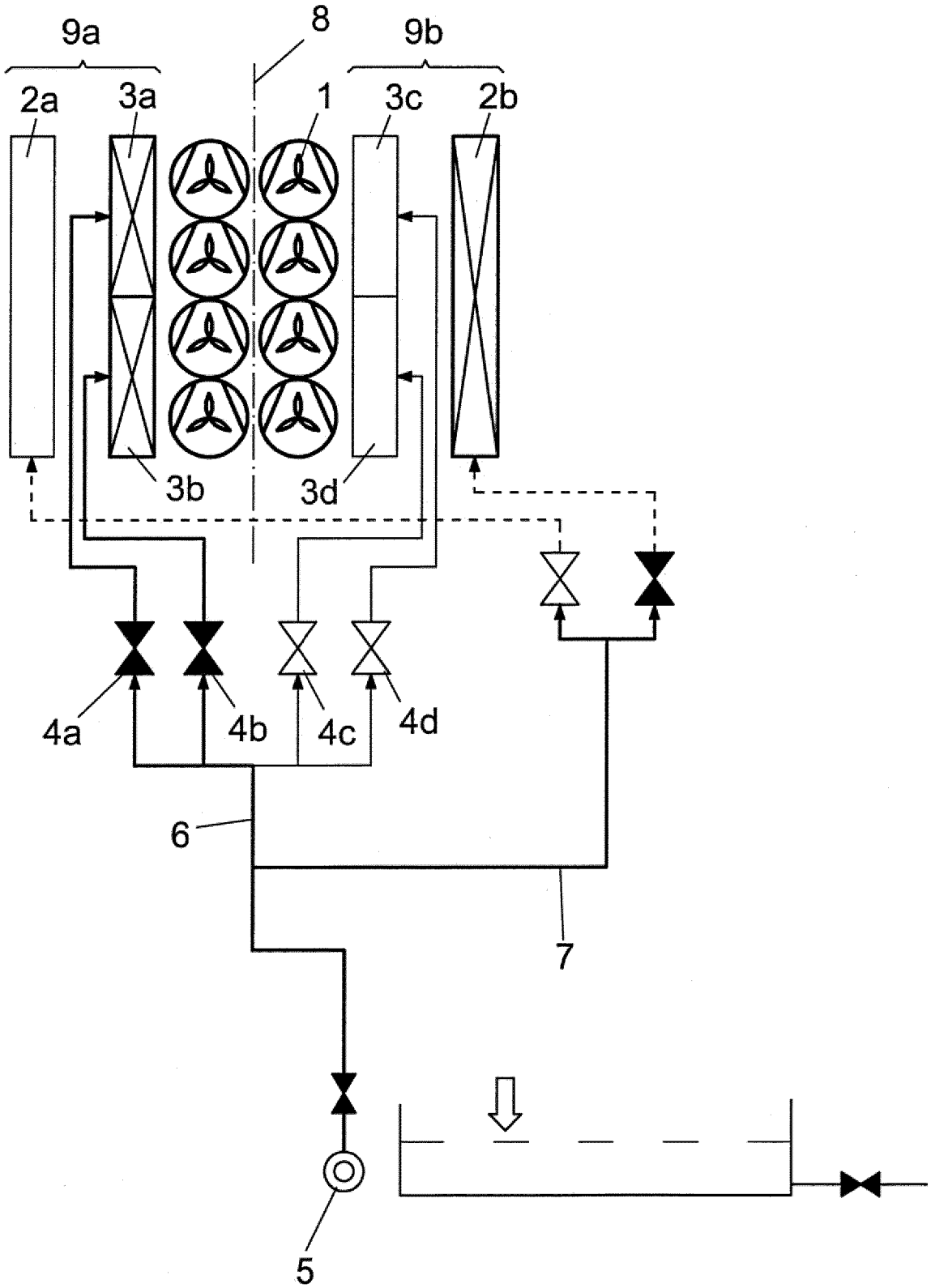


FIG. 5B

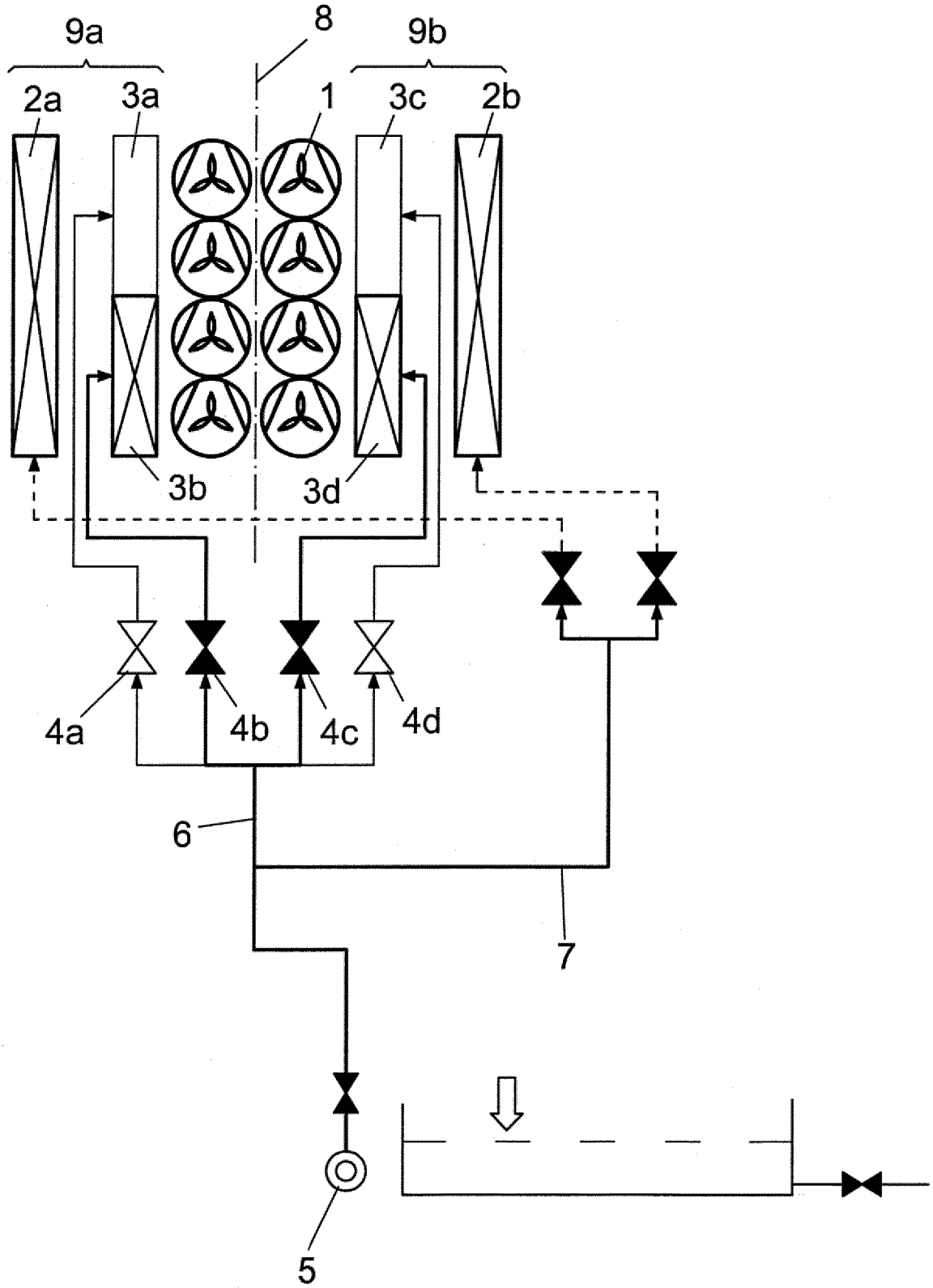


FIG. 6

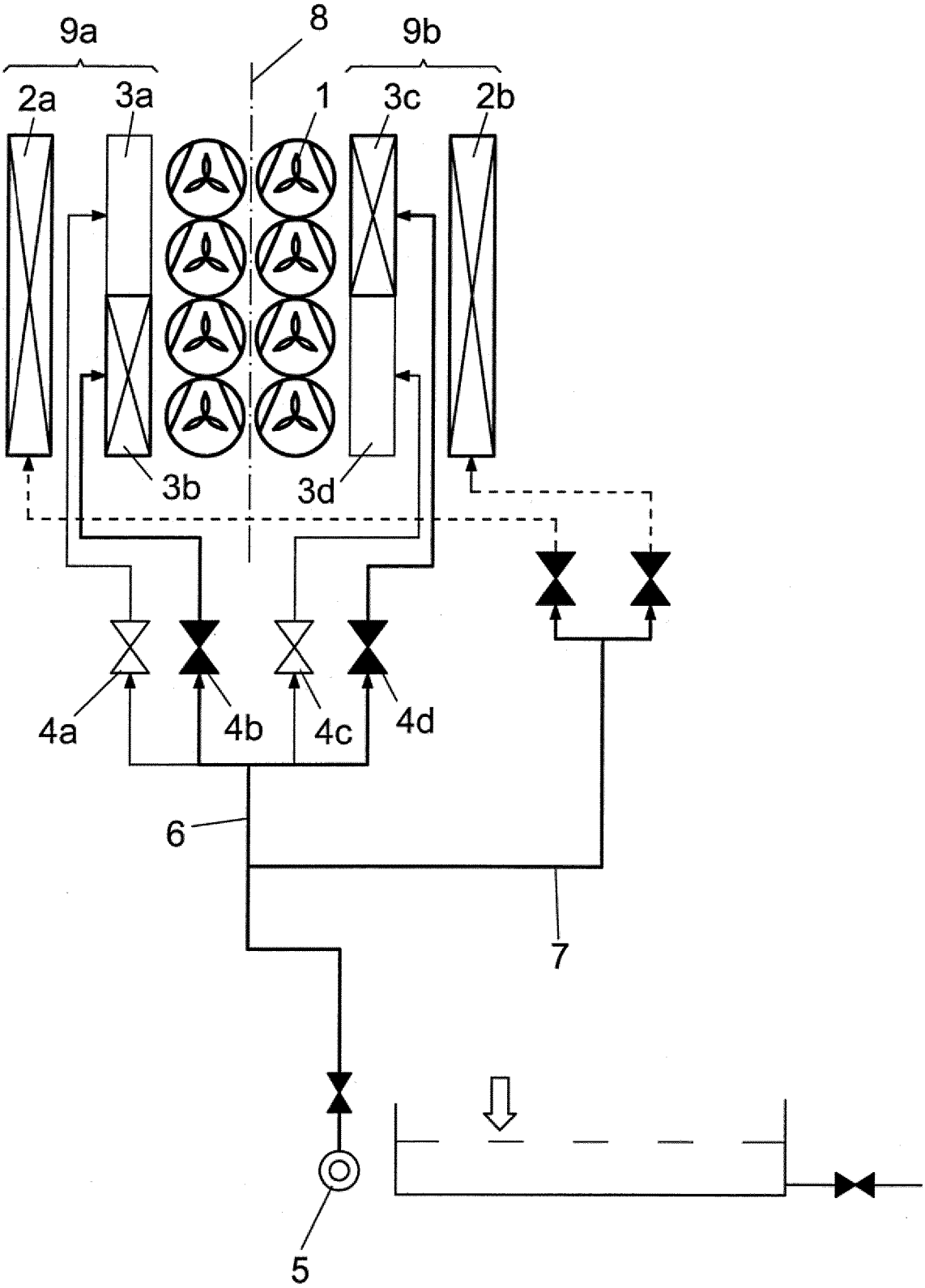


FIG. 7

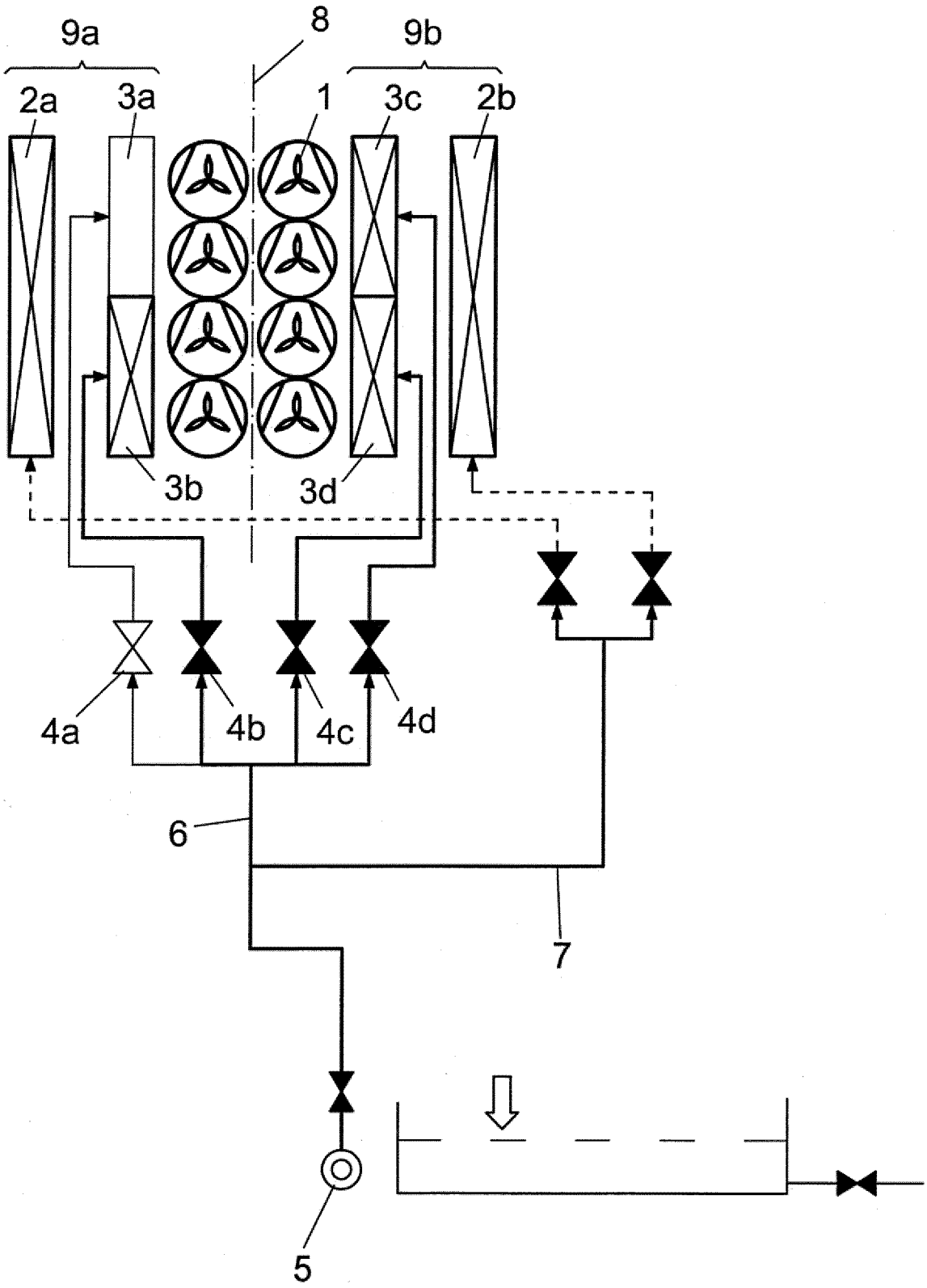


FIG. 8

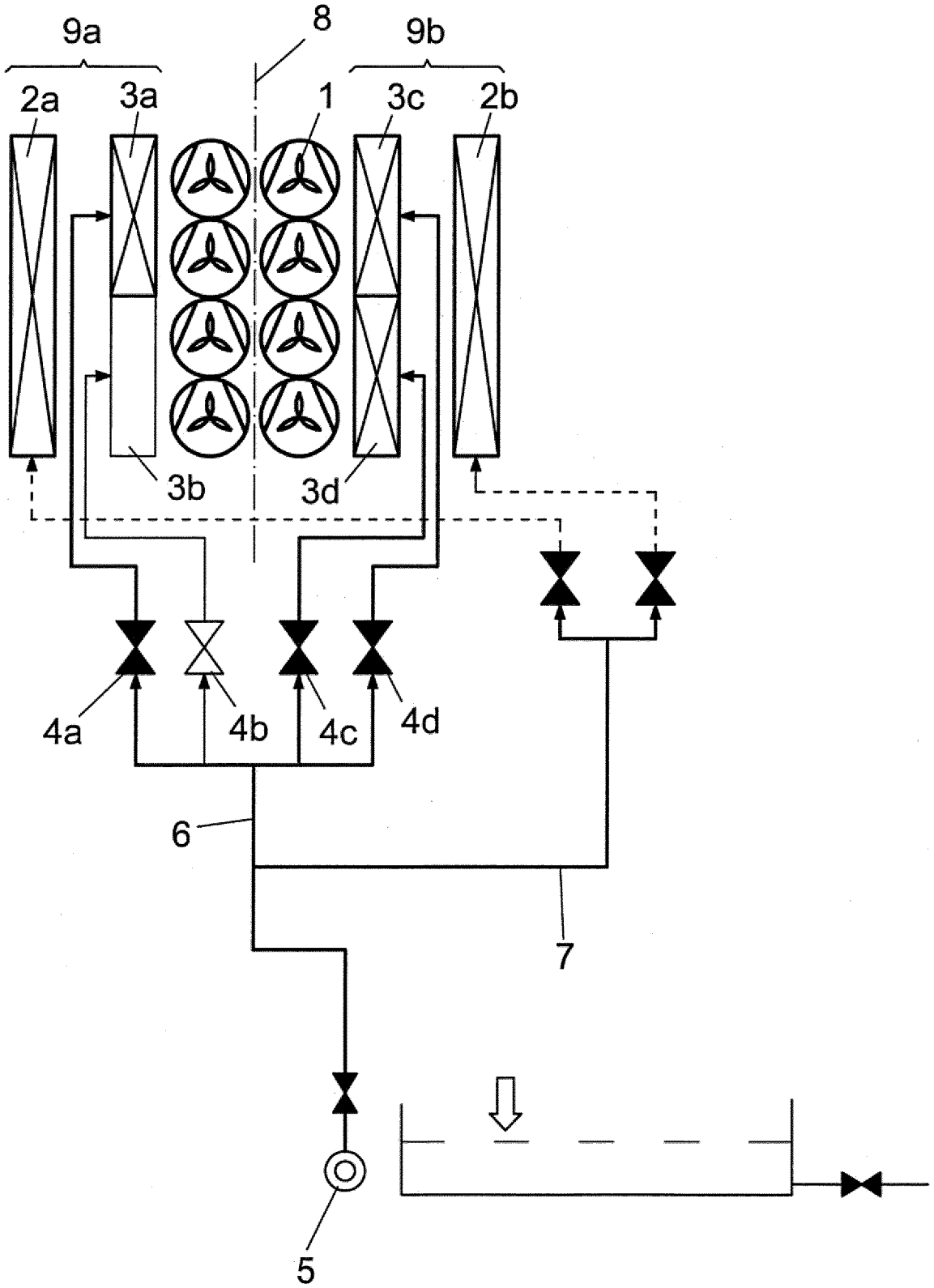


FIG. 9

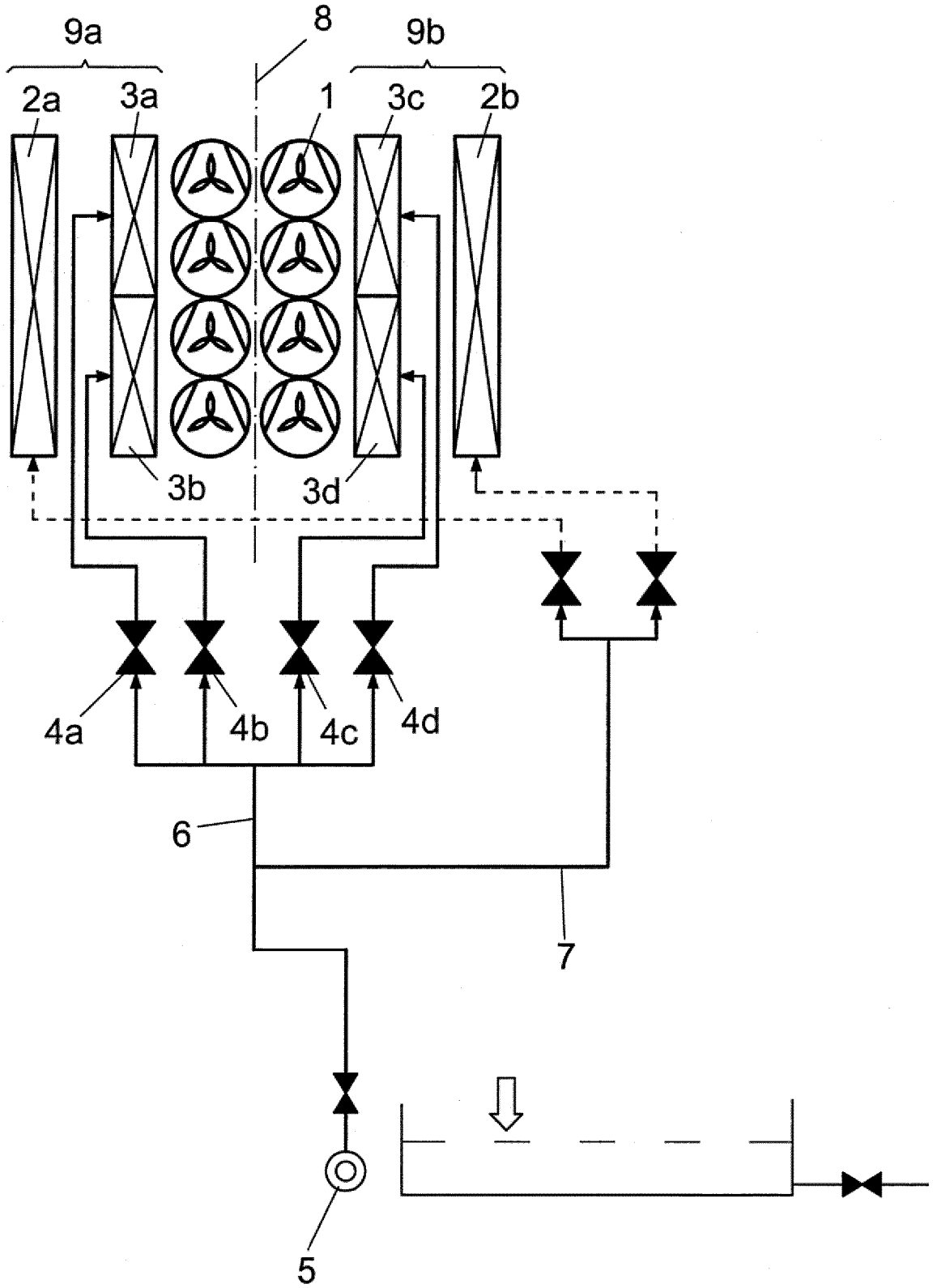


FIG. 10

## REFERENCES CITED IN THE DESCRIPTION

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

### Patent documents cited in the description


- EP 3306247 A1 **[0004]**