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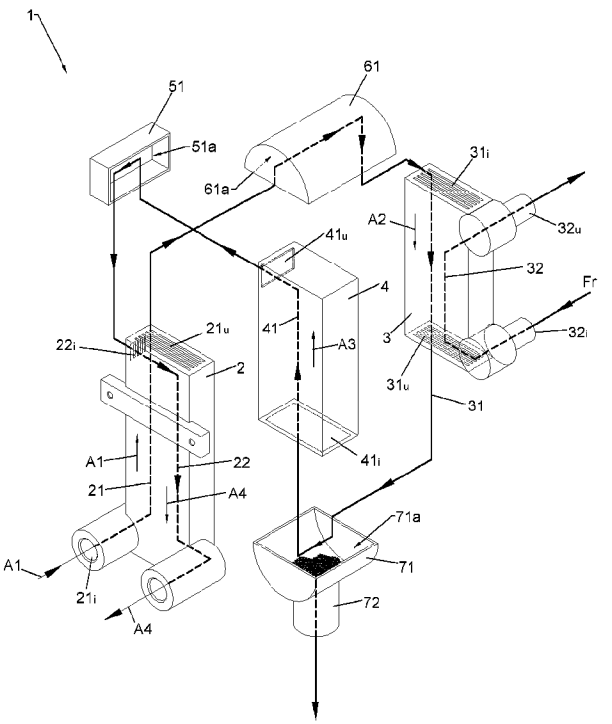
(54) Titre : ECHANGEUR DE CHALEUR PERFECTIONNE ET SYSTEME DE SECHAGE A L'AIR UTILISANT LEDIT ECHANGEUR DE CHALEUR

(54) Title: PERFECTED HEAT EXCHANGER AND AIR DRYING SYSTEM USING THE AFORESAID HEAT EXCHANGER



(57) Abrégé/Abstract:
A heat exchanger (1) comprising: a cooler/heater (2), an evaporator (3) and a condensate separator (4), provided with inlet lines (21i, 22i; 31i, 32i; 41i) and outlet lines (21u, 22u; 31u, 32u; 41u) through which flows develop in countercurrent to each other for

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(57) Abrégé(suite)/Abstract(continued):
obtaining through the cooler/heater (2) an incoming flow of hot and humid air (A1) and an outgoing flow of cooled cold air (A4). The cooler/heater (2), the evaporator (3) and the condensate separator (4) are independent units from each other joined by connection means (8) for defining a single-block body (11) on whose outer surface (12) inlet lines (21i, 22i; 31i, 32i; 41i) and outlet lines (21u, 22u; 31u, 32u; 41u) are provided. A first conduit (5) places in communication the outlet line (41u) with the second inlet line (22i); a second conduit (6) places in communication the first outlet line (21u) with the first inlet line (31i); and a third conduit (7) places in communication the first outlet line (31u) with the first inlet line (41i). The conduits (5, 6, 7) project from the outer surface (12) that delimits the single-block body (11).

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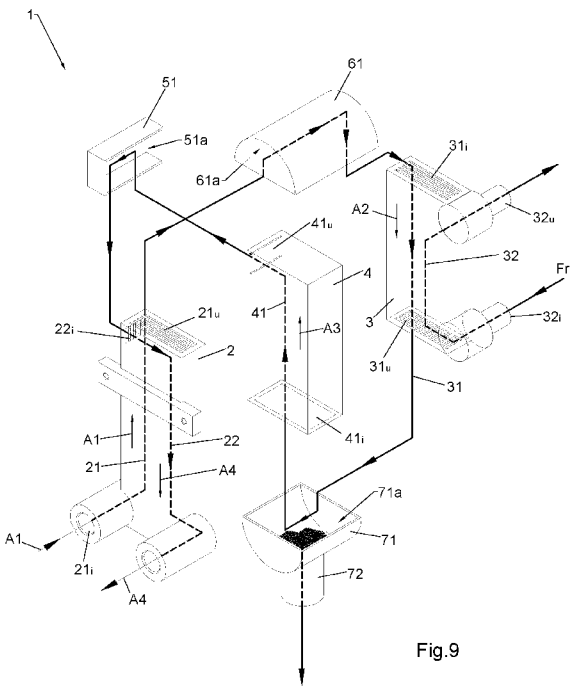

Fig.9

(57) Abstract: A heat exchanger (1) comprising: a cooler/heater (2), an evaporator (3) and a condensate separator (4), provided with inlet lines (21i, 22i; 31i, 32i; 41i) and outlet lines (21u, 22u; 31u, 32u; 41u) through which flows develop in countercurrent to each other for obtaining through the cooler/heater (2) an incoming flow of hot and humid air (A1) and an outgoing flow of cooled cold air (A4). The cooler/heater (2), the evaporator (3) and the condensate separator (4) are independent units from each other joined by connection means (8) for defining a single-block body (11) on whose outer surface (12) inlet lines (21i, 22i; 31i, 32i; 41i) and outlet lines (21u, 22u; 31u, 32u; 41u) are provided. A first conduit (5) places in communication the outlet line (41u) with the second inlet line (22i); a second conduit (6) places in communication the first outlet line (21u) with the first inlet line (31i); and a third conduit (7) places in communication the first outlet line (31u) with the first inlet line (41i). The conduits (5, 6, 7) project from the outer surface (12) that delimits the single-block body (11).

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PERFECTED HEAT EXCHANGER AND AIR DRYING SYSTEM USING THE AFORESAID HEAT EXCHANGER.

DESCRIPTION

The invention relates to a countercurrent heat exchanger and preferably but not exclusively of the finned pack type, particularly adapted for drying compressed air.

The invention also relates to a compressed air drying system that uses the heat exchanger of the invention.

As is known, in compressed air production systems the air that exits from the compressor must be appropriately dehumidified to prevent, during the adiabatic decompression that it undergoes when it is used, the humidity contained therein from condensing.

For that purpose, continuously operating, direct expansion cooling cycle dryers are used which substantially comprise a countercurrent heat exchanger, in which the hot and humid compressed air coming from the compressor is cooled and dehumidified before being sent to the users.

According to the prior art, heat exchangers of the type described are comprised of two heat exchange units and a condensate separator unit that operatively interact and that comprise:

- a cooler/heater;
- a cooling evaporator of the air coming from the cooler/heater;
- a condensate separator in which the humidity contained in the air coming from the evaporator condenses in the form of large drops and is removed.

In particular, the heater/cooler considerably pre-cools the hot and humid compressed air that comes from the delivery pipe of the compressor by countercurrent heat exchange with the cold and dehumidified compressed air that comes from the condensate separator.

The evaporator in turn receives at the inlet the pre-cooled air exiting from the cooler/heater and cools it to the desired dew point, through heat exchange with a coolant fluid that circulates in countercurrent in the evaporator itself.

In this way the pre-cooled air, as well as the further cooling process, also undergoes a dehumidification process.

Finally, the cold air enters the condensate separator in which the minuscule drops of water that have formed in the evaporator collect on the bottom in the form of water.

The dehumidified cold air then enters the cooler/heater where, as has been mentioned above, it considerably pre-cools the hot and humid compressed air that reaches the delivery pipe of the compressor.

The cold and dried air then exits from the cooler/heater and can be conveyed to the users.

Heat exchangers of the known type described, although being able to supply cooled and dehumidified air in conditions adapted to satisfy users' requirements, do however have some recognised disadvantages and limitations.

First of all, according to the prior art, the functional elements that form the heat exchanger and that, as has been mentioned, comprise a cooler/heater, an evaporator and a condensate separator, are made in a single block and all the conduits and passage lines that place the cooler/heater, the evaporator and the condensate separator in communication with each other are therefore internal to the block.

Therefore, the quality of the connections and seals may only be verified once the assembly is complete.

Furthermore, as once the assembly is complete, the exchanger is presented as a single functional block, it will be impossible to identify in which one or ones of the functional elements that comprise it the possible leak or seal defect is situated.

Finally, a possible repair intervention will be very complex and therefore expensive as the operator must intervene on the completely assembled exchanger and this implies that in the case of leaks it is preferable to scrap the whole exchanger.

The present invention intends to overcome the listed drawbacks and limitations.

In particular, it is a first object of the invention to realise a heat exchanger comprising functional elements, each of which constitutes an independent element, realised independently from the others according to its own processing cycle.

It is another aim that the exchanger according to the invention is realised following the construction of the various functional elements that comprise it, by mechanical assembly of the functional elements themselves.

It is a further object that also the conduits that place the passage lines of

the different functional elements in communication are realised following the assembly of the functional elements themselves.

In accordance with one embodiment of the present invention there is provided a heat exchanger particularly adapted for cooling and dehumidifying air, which includes a cooler/heater provided with heat exchange surfaces configured so as to define between them two countercurrent paths that comprise: a first path for a flow of hot and humid air, which extends between a first inlet line and a first outlet line; and a second path for a flow of cold dehumidified air, which extends between a second inlet line and a second outlet line. An evaporator provided with heat exchange surfaces is configured so as to define between them two countercurrent paths that comprise: a first path for a flow of partially cooled humid air, coming from the first outlet line of the cooler/heater, which extends between a first inlet line and a first outlet line; and a second path for a coolant fluid, coming from an external source, which extends between a second inlet line and a second outlet line. A condensate separator, in which condenser surfaces are provided, is configured so as to define between them a path for cooled humid air coming from the first outlet line of the evaporator, which extends between an inlet line and an outlet line. The cooler/heater, the evaporator and the condensate separator are independent units from each other joined by connection means for defining a single-block body on whose outer surface the inlet lines and the outlet lines are provided. A first conduit places in communication the outlet line of the condensate separator with the second inlet line of the cooler/heater. A second conduit places in communication the first outlet line of the cooler/heater with the first inlet line of the evaporator. A third conduit places in communication the first outlet line of the evaporator with the first inlet line of the condensate separator. The conduits are arranged projecting externally from the outer surface that delimits the single-block body.

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Advantageously, the heat exchanger of the invention is easier and more rational to construct with respect to analogous heat exchangers of the prior art as it first envisages the construction of the functional elements, each one independent from the other, and only subsequently the assembly thereof for realising the entire exchanger.

Furthermore, advantageously, each functional element can be tested individually prior to assembly; in this way it is possible to intervene with any repairs, thus reducing waste.

In a further advantageous way, a more reliable product is obtained which improves the possibility of obtaining the constructional, functional and qualitative repetitiveness of the heat exchanger.

Finally, the modularity of the functional elements and the fact that they can be tested before and after assembly enable control of the entire production cycle with an improvement in the quality of the final product.

The aims and advantages listed will be highlighted better during the description of the exchanger of the invention which is provided below by way of non-limiting example with reference to the appended tables of the drawings in which:

- fig. 1 represents an axonometric view of the exchanger of the invention;
- fig. 2 represents a lateral view of fig. 1;
- fig. 3 represents a partially exploded view of fig.1;
- fig. 4 represents another lateral view of fig. 1;
- fig. 5 represents another partially exploded view of fig. 1;
- fig. 6 represents a further view of fig. 1;
- fig. 7 represents a partially sectioned view of fig. 6;
- fig. 8 represents a partially exploded view of fig. 6;
- fig. 9 represents a schematic axonometric view of the exchanger of the invention exploded in the parts that comprise it;
- fig. 10 represents a partial decomposition of the exchanger of the invention

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in another axonometric view;

- fig. 11 represents a partial decomposition of the axonometric view of fig. 1.

The heat exchanger according to the invention is represented in figures 1 to 11 where it is indicated overall with **1**.

With particular reference to figures 1 and 9, it is observed that it comprises three functional elements and more particularly a cooler/heater indicated overall with **2**, an evaporator indicated overall with **3** and a condensate separator indicated overall with **4**, which are mechanically connected to each other and are operatively connected as will be described below.

In relation to the cooler/heater **2**, it is provided internally with heat exchange surfaces that are configured so as to define between them two countercurrent paths that comprise a first path **21** for a flow of hot-humid air **A1** that extends between a first inlet line **21i** and a first outlet line **21u** and a second path **22** for a flow of dehumidified cold air **A4** that extends between a second inlet line **22i** and a second outlet line **22u**.

In relation to the evaporator **3**, it is also provided internally with heat exchange surfaces that are configured so as to define between them two countercurrent paths that comprise a first path **31** for a flow of partially cooled humid air **A2** that comes from the first outlet line **21u** of the cooler/heater **2** and that extends between a first inlet line **31i** and a first outlet line **31u** and a second path **32** for a coolant fluid **Fr** coming from an external source that extends between a second inlet line **32i** and a second outlet line **32u**.

Finally, in relation to the condensate separator **4**, condenser surfaces are provided therein, configured so as to define between them a path **41** for cooled humid air **A3** that comes from the first outlet line **31u** of the evaporator **3** and that extends between an inlet line **41i** and an outlet line **41u**.

It is appropriate to specify that, in relation to the cooler/heater **2** and the evaporator **3**, both are of the finned pack type with countercurrent flows of the known type per se.

For this reason, their internal construction will not be described below as it refers to structures that are known per se.

The same can be said in relation to the condensate separator **4** which is of the known coalescence type.

It is however to be understood that the heat exchange surfaces of the cooler/heater **2** and of the evaporator **3** and the condensing surfaces of the

condenser **4** may be of any type according to the prior art.

According to the invention, the cooler/heater **2**, the evaporator **3** and the condensate separator **4** are independent units from each other and are joined together by connection means **8** for defining a single-block body **11** on whose outer surface **12** inlet lines **21i**, **22i**; **31i**, **32i**; **41i** and outlet lines **21u**, **22u**; **31u**, **32u**; **41u** are provided.

It is observed, with particular reference to figures 2 to 8, that in the heat exchanger **1** there is a first conduit **5** that places in communication the outlet line **41u** of the condensate separator **4** with the second inlet line **22i** of the cooler/heater **2**.

A second conduit **6** is also provided, which places in communication the first outlet line **21u** of the cooler/heater **2** with the first inlet line **31i** of the evaporator **3**.

Finally, a third conduit **7** is provided, which places in communication the first outlet line **31u** of the evaporator **3** with the first inlet line **41i** of the condensate separator **4**.

As can be noted, the conduits **5**, **6**, **7** project from the outer surface **12** that delimits the single-block body **11** and each of them is defined between the outer surface **12** of the single-block body **11** and a respective cover **51**, **61**, **71**.

It is observed that each cover has a concave profile **51a**, **61a**, **71a** delimited by a perimeter edge **51b**, **61b**, **71b** that is fixed in a sealed way to the outer surface **12** of the single-block body **11** and externally to the perimeter of each pair of lines **22i**, **41u**; **21u**, **31i**; **31u**, **41i** through connection means **8**.

On this point, it is specified that the connection means **8** of the covers **51**, **61**, **71** to the surface **12** of the single-block body **11** and of the cooler/heater **2**, of the evaporator **3** and of the condensate separator **4** between them are comprised of weldings **81**.

In another embodiment that is not described herein, the connection means may possibly be comprised of flanged junctions, also possibly joined by means of welding or bolting.

In relation to the covers **51**, **61**, **71** it is observed that they comprise:

- a first cover **51** that is applied on the second inlet line **22i** of the cooler/heater **2** and on the first outlet line **41u** of the condensate separator **4** for defining the first conduit **5**;
- a second cover **61** that is applied on the first outlet line **21u** of the

cooler/heater **2** and on the first inlet line **31i** of the evaporator **3** for defining the second conduit **6**;

- a third cover **71** that is applied on the first outlet line **31u** of the evaporator **3** and on the first inlet line **41i** of the condensate separator **4** for defining the third conduit **7**.

It is also observed that the second inlet line **22i** and the second outlet line **22u** of the cooler/heater **2**, together with the second inlet line **32i** and the second outlet line **32u** of the evaporator **3**, each communicate with a junction sleeve **9** that is fixed, preferably but not necessarily, by welding respectively to the cooler/heater **2** and to the evaporator **3**.

Each junction sleeve **9** can therefore be used for connecting the cooler/heater **2** and the evaporator **3** to external pipes.

It is also observed that the third cover **71** is provided with a perforated sleeve **72**, which can support a drain tap not shown, which places in communication the third conduit **7** with the external environment for draining via gravity the water that forms by coalescence in the condensate separator **4**.

For this purpose, it is observed in the figures that the heat exchanger **1** is provided with a bracket **15** having connection holes to a support surface so as to be arranged in a vertical position which conveys by gravity the condensate water onto the bottom of the third cover **71**.

Operatively, the circulation of the air in the heat exchanger of the invention is now described with particular reference to the exploded axonometric representation of figure 9.

It is observed that a flow of hot and humid air **A1** that comes from the delivery pipe of a compressor, not shown in the figures, enters the cooler/heater **2** through the first inlet line **21i** and travels along it according to the first path **21** until reaching the first outlet line **21u**.

During such path which, as can be observed, takes place travelling along the cooler/heater **2** in the vertical upwards direction, the flow **A1** of hot and humid air meets in countercurrent a flow of cold dehumidified air **A4** that comes from the first outlet mouth **41u** of the condensate separator **4** and travels along the cooler/heater **2** downwards between the second inlet line **22i** and the second outlet line **22u**.

Along the cooler/heater **2** the flows of air **A1** and **A4** flow, as mentioned, in countercurrent and without mixing so that the flow of hot and humid air **A1** is

cooled, yielding heat to the flow of cold dehumidified air **A4**.

Therefore, in the cooler/heater **2** the initial part of the heat exchange takes place as from the first outlet line **21u** of the cooler/heater **2** a flow of partially cooled humid air **A2** exits, which crosses the second conduit **6**, delimited by the first cover **61**, is conveyed into the evaporator **3**, while the flow of dehumidified cold air **A4** which exits from the second outlet line **22u** of the cooler/heater **2** can be conveyed to be used.

The flow of partially cooled humid air **A2** enters into the evaporator **3** through its first inlet line **31i** and crosses it downwards, undergoing a cooling and dehumidifying process by heat exchange in countercurrent with the cooling fluid **Fr** which is comprised of a coolant fluid that evaporates and crosses the evaporator **3** entering from the second inlet line **32i** and exits through the second outlet line **32u**.

The coolant fluid can come from an external source in the liquid-vapour two-phase condition and flows into the evaporator **3** upwards, being aspirated by a cooling compressor.

The coolant fluid evaporates thanks to the latent and sensitive heat that it absorbs from the compressed air that is thus cooled.

A flow of cooled humid air **A3** therefore exits from the first outlet line **31u** of the evaporator **3**, which, through the third conduit **7** delimited by the third cover **71**, enters into the condensate separator **4** through the inlet line **41i**.

The water vapour contained in the cooled humid air **A3** starts to condense in the third conduit **7**, continues the condensation rising into the condensate separator **4** and is finally collected by dropping in the form of condensate water into the third cover **71** from which it is removed through the drain sleeve **72**.

Through the outlet line **41u** the flow of dehumidified cold air **A4** therefore exits from the condensate separator **4** and through the first conduit **5** delimited by the first cover **51** it is conveyed into the second inlet line **22i** of the cooler/heater **2** in which the cycle is concluded.

As mentioned in the introductory part, the invention also relates to a drying system of the compressed air produced by a compressor, and such drying system comprises at least one perfected exchanger of the invention.

Based on the description, it is understood that the exchanger of the invention reaches all the aims and all the advantages listed in the introductory part.

First of all, the object of the invention to realise a heat exchanger comprising

independent functional elements, each of which constitutes an independent element, realised independently from the others according to its own processing cycle, is reached.

Furthermore, the conduits that place the passage lines of the different functional elements in communication are realised following the assembly of the functional elements themselves.

This is made possible as the passage lines of the fluids through the functional elements of the exchanger are all realised on the outer surfaces of the functional block comprised of the functional elements when they are connected to each other.

Furthermore, such lines communicate with each other through the aforesaid channels that are obtained by applying, above and perimetrally to the lines that need to communicate with each other, appropriate concave covers fixed to the outside of the functional block comprising the functional elements connected to each other.

Advantageously, the heat exchanger of the invention is therefore easier and more rational to construct with respect to analogous heat exchangers of the prior art as it first envisages the construction of the functional elements, each one independent from the other, and only subsequently the assembly thereof for realising the entire exchanger.

Again advantageously, this particular type of construction enables each functional element to be tested individually prior to assembly and this enables any faulty functional elements to be identified so as to be able to repair or possibly eliminate them.

This, as already mentioned, is not possible in heat exchangers of the known type.

During the operation stage, modifications and variations not mentioned in the description and also not shown in the drawings may be made to the heat exchanger of the invention.

However, it is to be understood that should such modifications and variations fall within the following claims, they are all to be considered protected by the present patent.

The embodiments of the present invention for which an exclusive property or privilege is claimed are defined as follows:

1. A heat exchanger particularly adapted for cooling and dehumidifying air, comprising:

a cooler/heater provided with heat exchange surfaces configured so as to define between them two countercurrent paths that comprise:

a first path for a flow of hot and humid air, which extends between a first inlet line and a first outlet line;

a second path for a flow of cold dehumidified air, which extends between a second inlet line and a second outlet line;

an evaporator provided with heat exchange surfaces configured so as to define between them two countercurrent paths that comprise:

a first path for a flow of partially cooled humid air, coming from said first outlet line of said cooler/heater, which extends between a first inlet line and a first outlet line;

a second path for a coolant fluid, coming from an external source, which extends between a second inlet line and a second outlet line;

a condensate separator, in which condenser surfaces are provided, configured so as to define between them a path for cooled humid air coming from said first outlet line of said evaporator, which extends between an inlet line and an outlet line,

said cooler/heater, said evaporator and said condensate separator being independent units from each other joined by connection means for defining a single-block body on whose outer surface said inlet lines and said outlet lines are provided, wherein it comprises:

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a first conduit that places in communication said outlet line of said condensate separator with said second inlet line of said cooler/heater;

a second conduit that places in communication said first outlet line of said cooler/heater with said first inlet line of said evaporator;

a third conduit that places in communication said first outlet line of said evaporator with said first inlet line of said condensate separator,

said conduits being arranged projecting externally from said outer surface that delimits said single-block body.

2. The heat exchanger according to claim 1, wherein said first, second and third conduits are defined between said outer surface of said single-block body and covers with a concave profile, each of which has a perimeter edge which is sealingly fixed to said outer surface of said single-block body and externally to the perimeter of each pair of said lines, through said connection means.

3. The heat exchanger according to claim 2, wherein said covers comprise:

a first cover that is applied to said second inlet line of said cooler/heater and to said outlet line of said condensate separator for defining said first conduit;

a second cover that is applied to said first outlet line of said cooler/heater and to said first inlet line of said evaporator for defining said second conduit;

a third cover that is applied to said first outlet line of said evaporator and to said first inlet line of said condensate separator for defining said third conduit.

4. The heat exchanger according to any one of claims 1 to 3, wherein said second inlet line and said second outlet line of said cooler/heater and said second inlet line and said second outlet line of said evaporator each communicate with a junction sleeve adapted for connection with a corresponding inlet or outlet pipe.

5. The heat exchanger according to claim 4, wherein in said third cover a perforated sleeve is provided, for draining the condensate.

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6. The heat exchanger according to any one of claims 1 to 5, wherein said cooler/heater, said evaporator and said condensate separator are of the finned pack type with countercurrent flow.

7. The heat exchanger according to any one of claims 1 to 6, wherein said condensate separator is of the coalescence type.

8. The heat exchanger according to claim 1 or 2, wherein said connection means are weldings.

9. The heat exchanger according to claim 1 or 2, wherein said connection means are flanged junctions.

10. A compressed air drying system comprising at least one heat exchanger for cooling and drying the compressed air produced by a compressor unit, wherein said heat exchanger is realised according to any one of claims 1 to 9.

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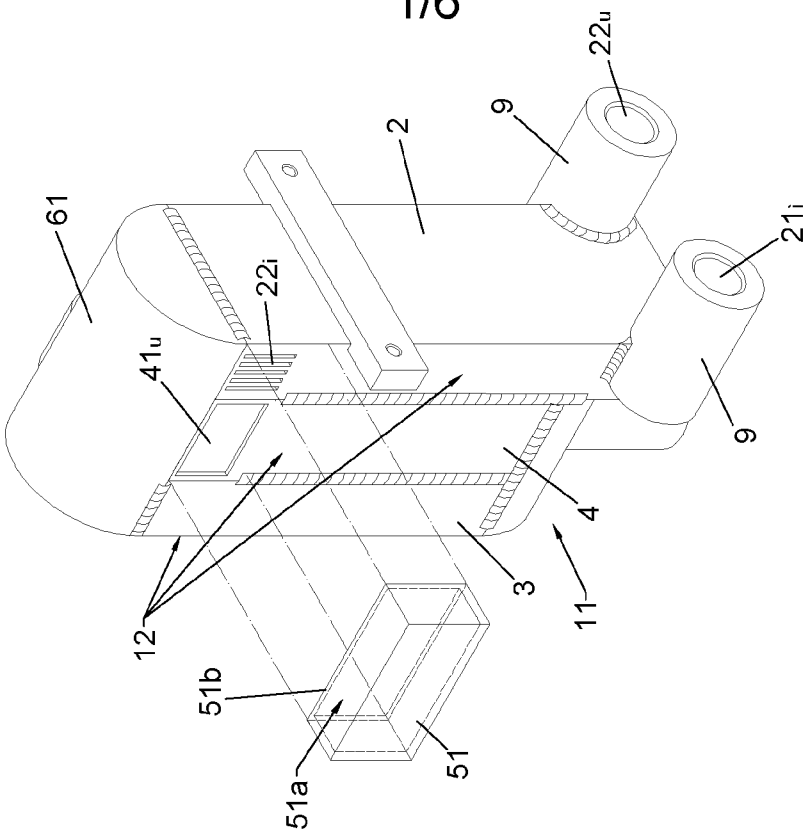


Fig.3

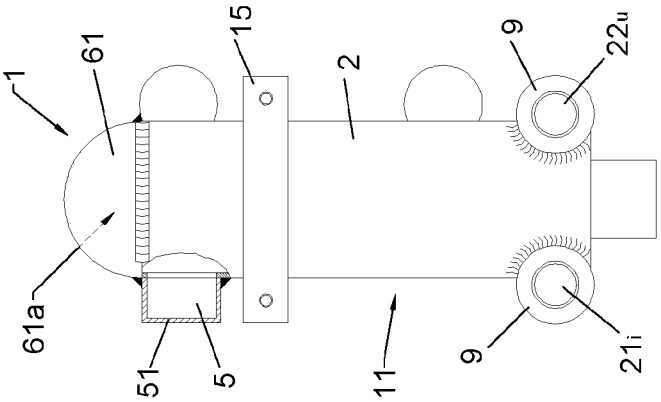


Fig.2

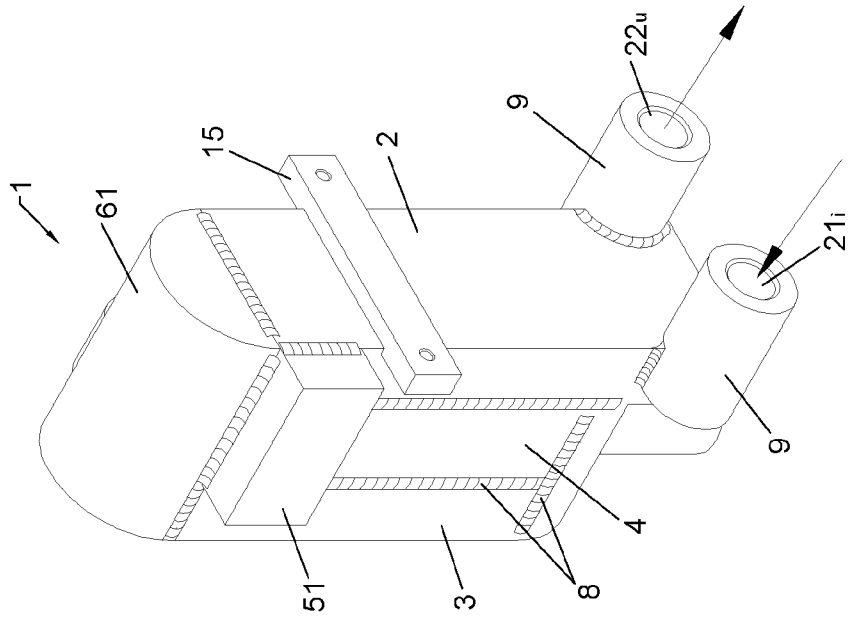


Fig.1

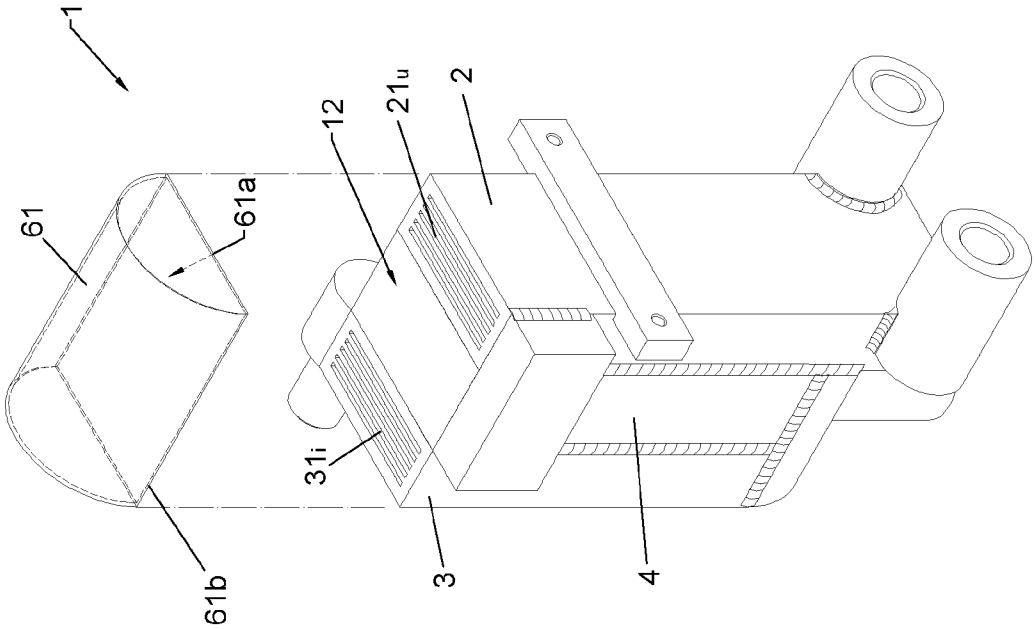


Fig.5

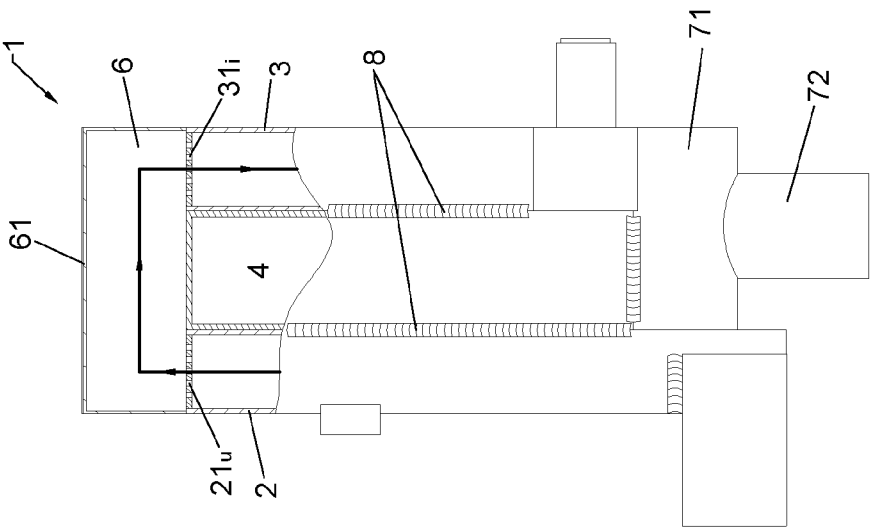


Fig.4

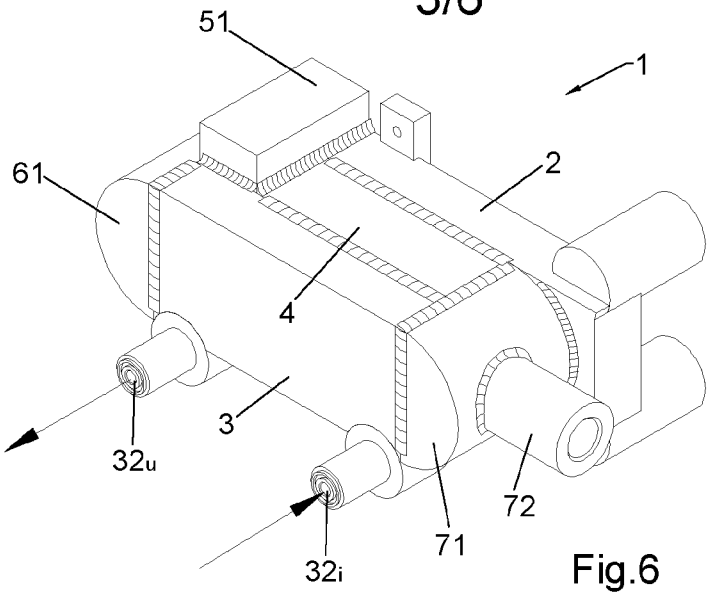


Fig.6

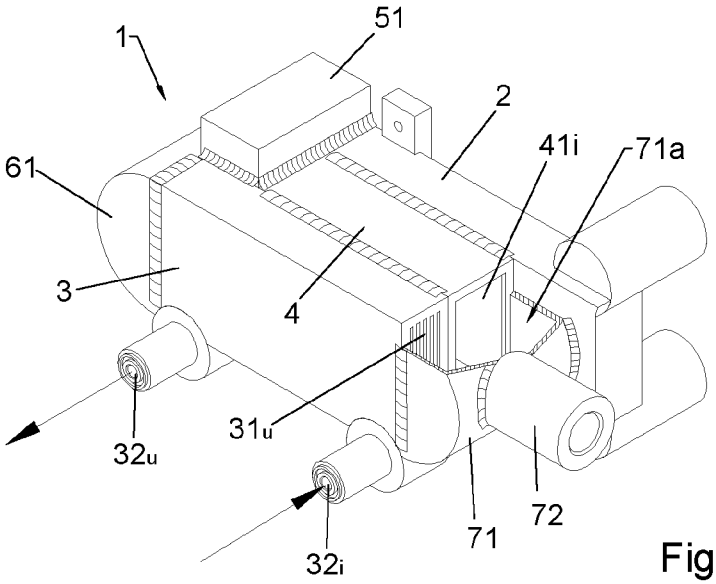


Fig.7

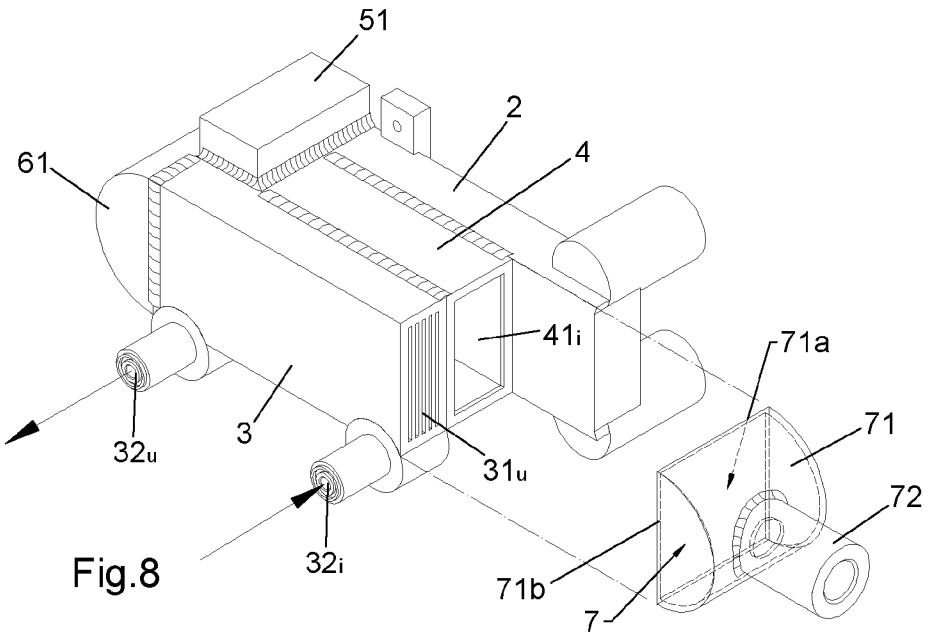
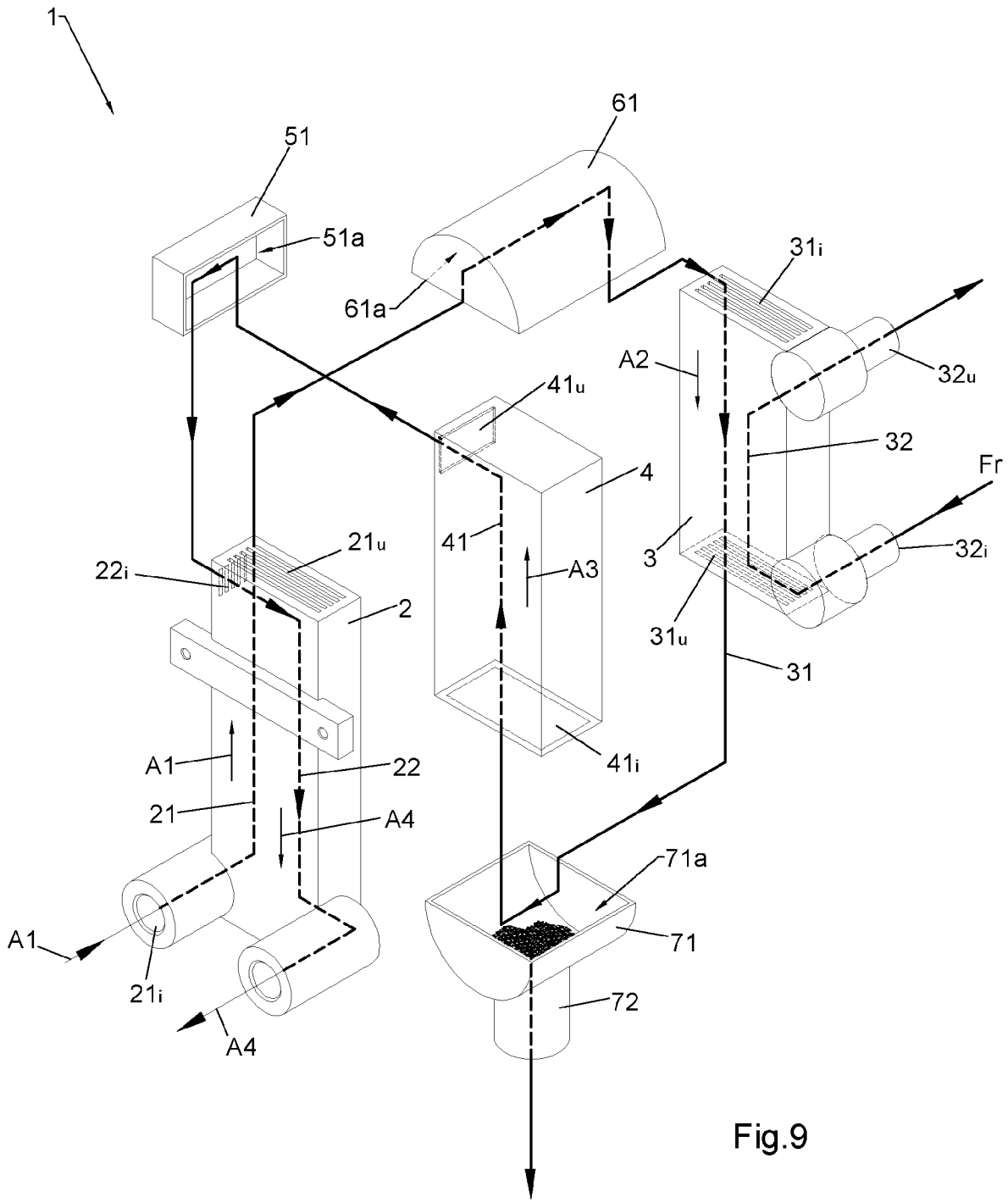


Fig.8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A3
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31
41i
A1
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A4
71a
A1
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21i
72
A4

Fig.9

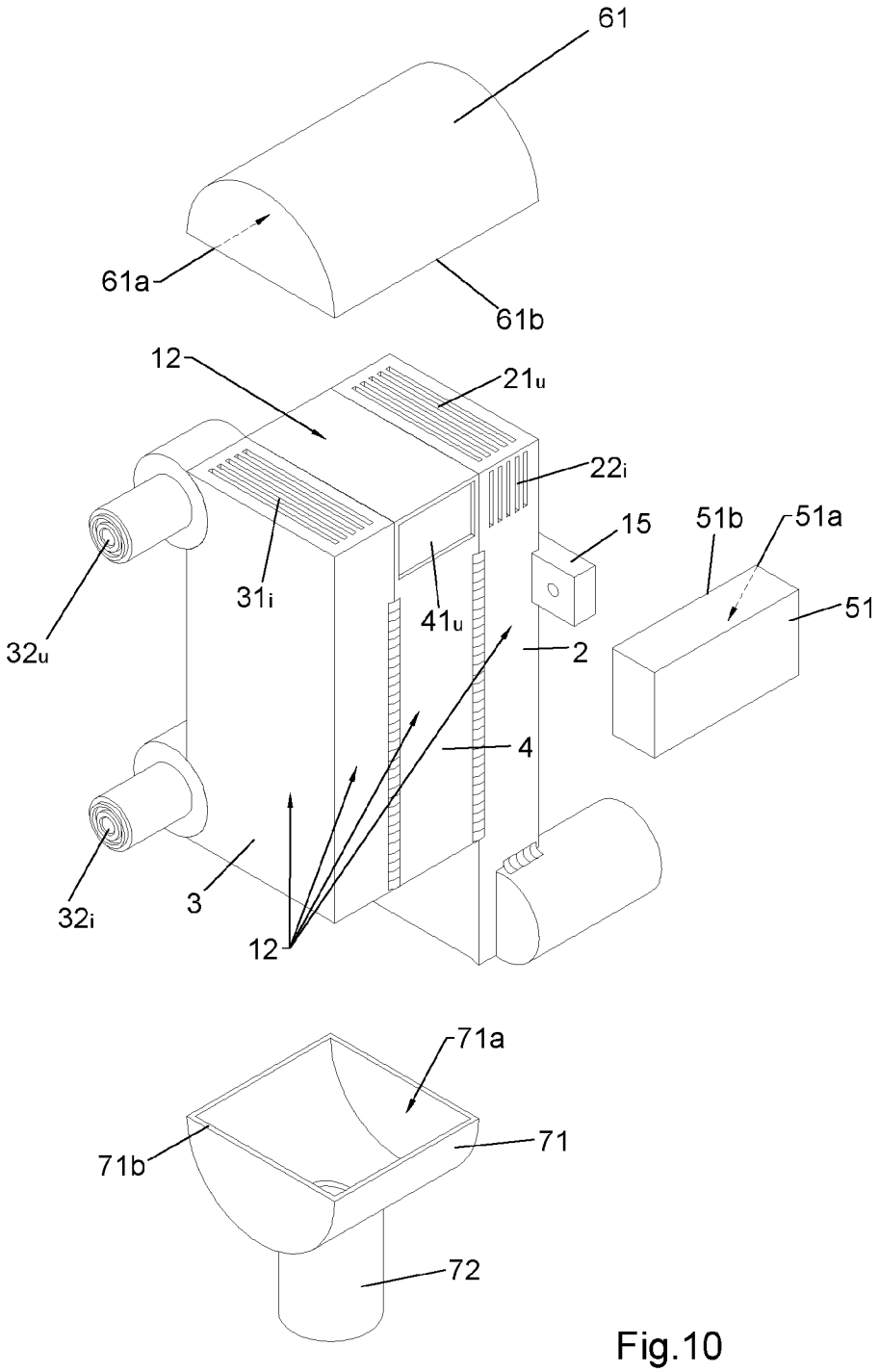
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Fig.10

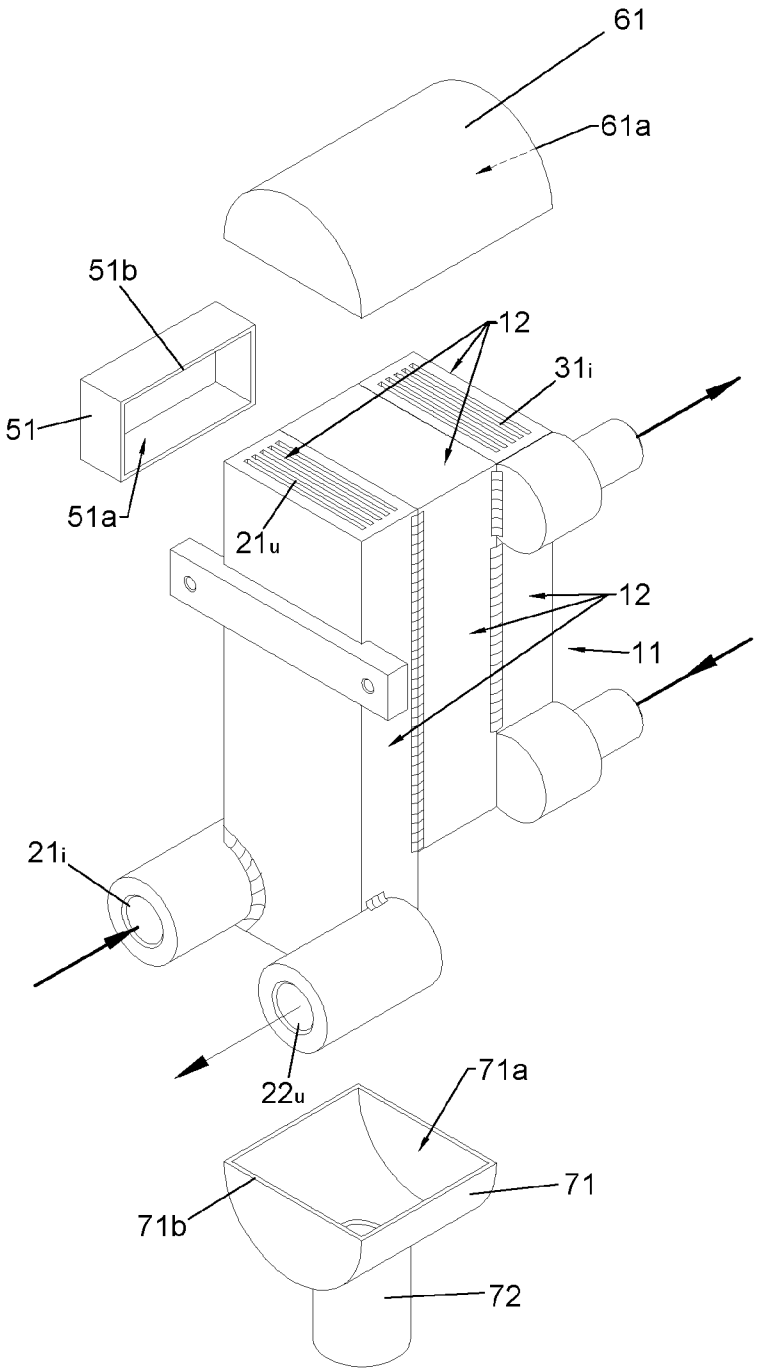
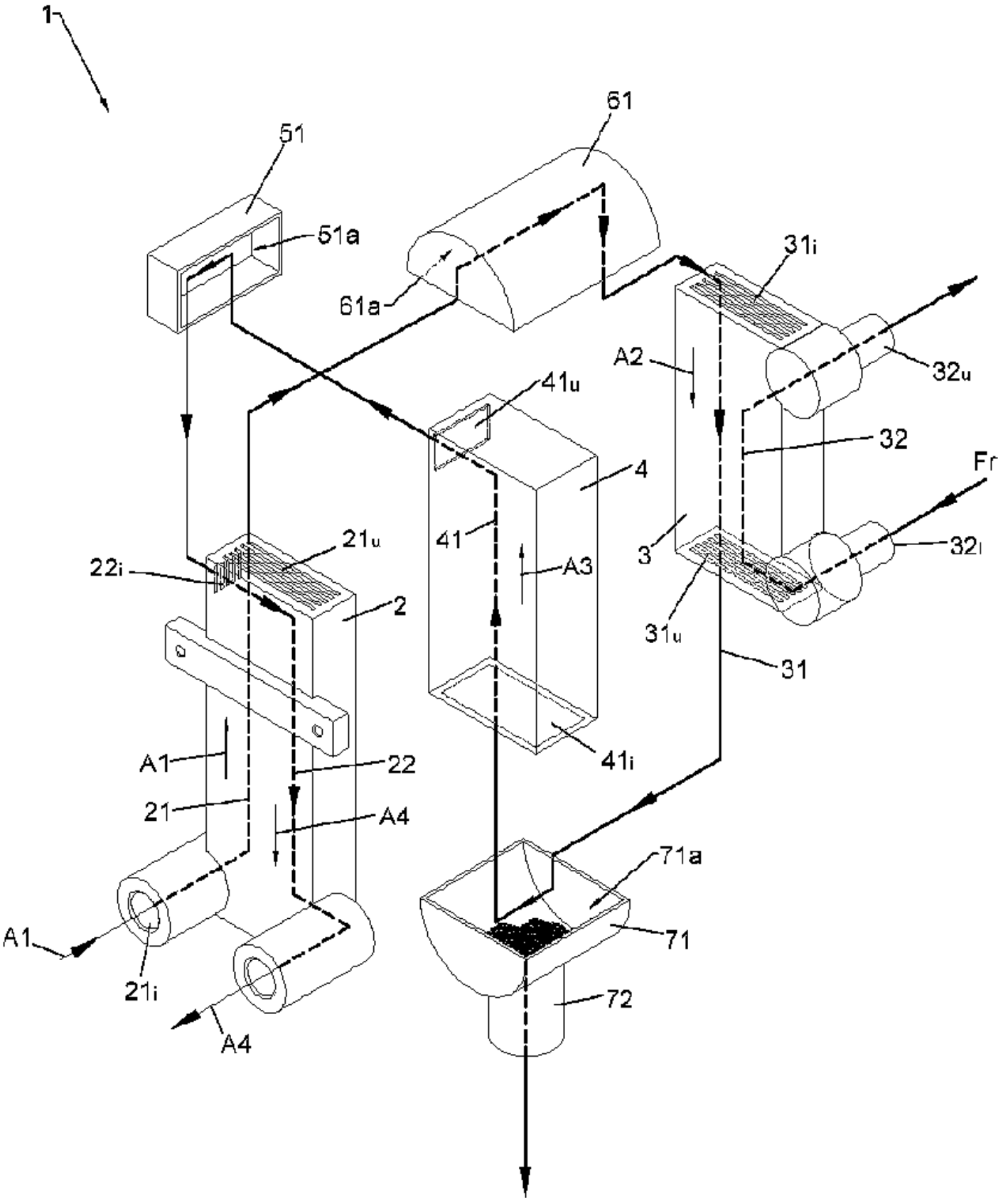


Fig.11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