



(86) Date de dépôt PCT/PCT Filing Date: 2014/02/25  
(87) Date publication PCT/PCT Publication Date: 2014/08/28  
(85) Entrée phase nationale/National Entry: 2015/08/07  
(86) N° demande PCT/PCT Application No.: CA 2014/050132  
(87) N° publication PCT/PCT Publication No.: 2014/127488  
(30) Priorités/Priorities: 2013/02/25 (US61/768,835);  
2013/04/09 (US61/809,997)

(51) Cl.Int./Int.Cl. *F28D 7/10* (2006.01),  
*F28D 7/02* (2006.01), *F28F 1/00* (2006.01),  
*F28F 27/00* (2006.01)  
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(54) Titre : PROCEDE ET DISPOSITIF POUR TRANSFERER DE LA CHALEUR  
(54) Title: METHOD AND DEVICE FOR TRANSFERRING HEAT

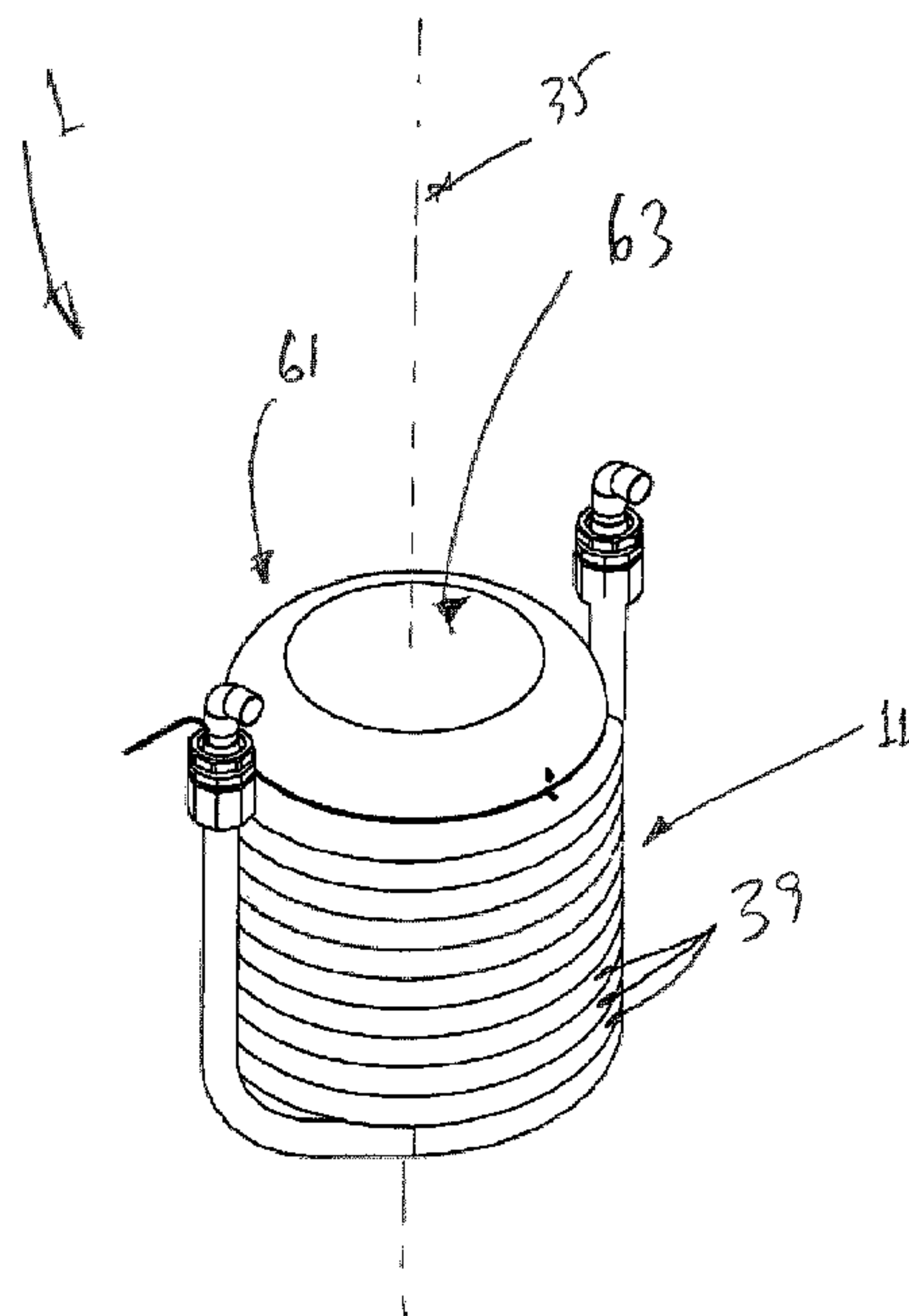
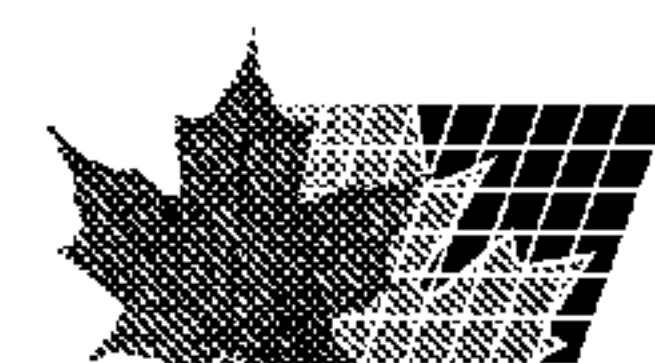


FIG. 13

(57) Abrégé/Abstract:

A method and corresponding device for transferring heat between a discharge fluid (3) of a first system (5) and a second system (7). The discharge fluid (3) from the first system (5) is received and conveyed to a given location (9). There is provided at least one non-vertical elongated member (11) being positioned, shaped and sized so as to define an array of stacked cross-sectional profiles (13) extending within at least one wall segment (15), said at least one wall segment (15) being operatively connectable to the second system (7). The discharge fluid (3) is allowed to free-flow (ex. free-fall, cascade, etc.) over said at least one wall segment (15) of stacked cross-sectional profiles (13) so as to allow a heat exchange between the discharge fluid (3) and the array of stacked cross-sectional profiles.



(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property  
Organization  
International Bureau



(10) International Publication Number  
**WO 2014/127488 A1**

(43) International Publication Date  
28 August 2014 (28.08.2014)

## (51) International Patent Classification:

*F28D 7/10* (2006.01) *F28F 1/00* (2006.01)  
*F28D 7/02* (2006.01) *F28F 27/00* (2006.01)

## (21) International Application Number:

PCT/CA2014/050132

## (22) International Filing Date:

25 February 2014 (25.02.2014)

## (25) Filing Language:

English

## (26) Publication Language:

English

## (30) Priority Data:

61/768,835 25 February 2013 (25.02.2013) US  
61/809,997 9 April 2013 (09.04.2013) US

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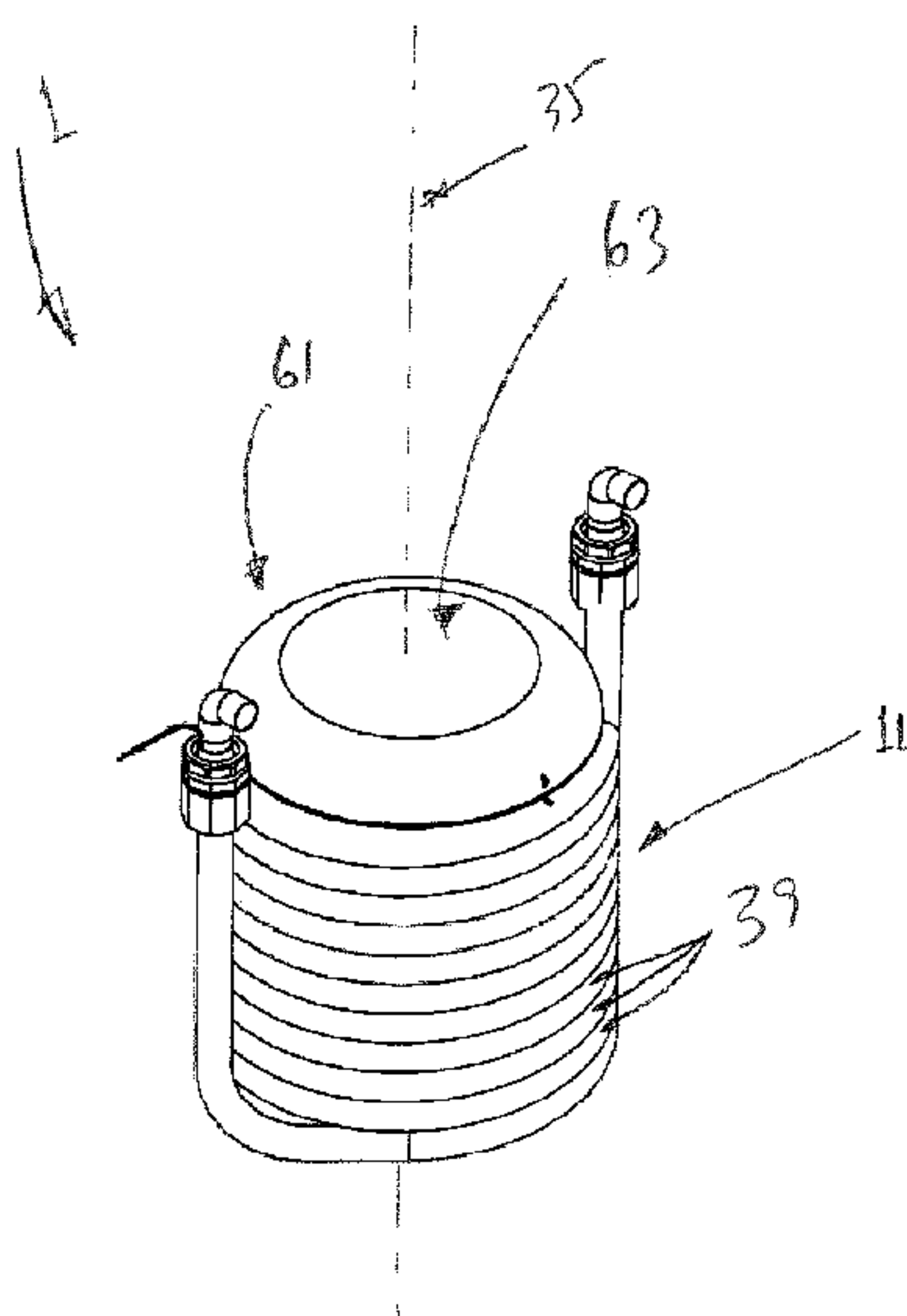
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Floor, 1001 Square-Victoria, Montreal, Québec H2Z 2B7  
(CA).

(81) Designated States (*unless otherwise indicated, for every  
kind of national protection available*): AE, AG, AL, AM,  
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,  
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,  
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,  
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,  
KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,  
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,  
OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,  
SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM,  
TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM,  
ZW.

(84) Designated States (*unless otherwise indicated, for every  
kind of regional protection available*): ARIPO (BW, GH,  
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ,  
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,  
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,  
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,  
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,  
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,  
KM, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: METHOD AND DEVICE FOR TRANSFERRING HEAT

FIG. 13

(57) Abstract: A method and corresponding device for transferring heat between a discharge fluid (3) of a first system (5) and a second system (7). The discharge fluid (3) from the first system (5) is received and conveyed to a given location (9). There is provided at least one non-vertical elongated member (11) being positioned, shaped and sized so as to define an array of stacked cross-sectional profiles (13) extending within at least one wall segment (15), said at least one wall segment (15) being operatively connectable to the second system (7). The discharge fluid (3) is allowed to free-flow (ex. free-fall, cascade, etc.) over said at least one wall segment (15) of stacked cross-sectional profiles (13) so as to allow a heat exchange between the discharge fluid (3) and the array of stacked cross-sectional profiles.

WO 2014/127488 A1

**WO 2014/127488 A1**



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**Published:**

— *with international search report (Art. 21(3))*

## METHOD AND DEVICE FOR TRANSFERRING HEAT

### **Field of the invention:**

5           The present invention relates to the field of heat exchanging technologies. More particularly, the present invention relates to a method and to a device for transferring heat between a discharge fluid of a first system and a second system. The present application claims the priority of US provisional patent application No. 61/768,835 dated February 25<sup>th</sup>, 2013, and that of US provisional patent  
10       application No. 61/809,997 dated April 9<sup>th</sup>, 2013, the contents of which are both incorporated herein by reference.

### **Background:**

15           In many instances, it is desirable to capture waste energy (ex. heat, etc.) so that it can be recuperated, or be transferred from one fluid to another, and put to productive use. One example of such energy recovery and reuse occurs with sources of heated effluent, an example of which includes the discharge from appliances like dishwashers, washing machines, or other sources of industrial effluents. Indeed, the  
20       heated effluent can be any fluids, that can be charged or not with particulate matter, and whose temperature is suitable for heat exchange with another fluid.

          It is known to use "falling-film" heat exchangers to recover energy from an effluent heat source. Such heat exchangers can produce important heat transfer  
25       rates, and the falling-film heat exchanger can thus be an ideal device for effluent heat recovery.

          Typically, falling-film heat exchangers are used in relatively large industrial configurations which can consist of bundles of vertical straight tubes which carry a  
30       liquid to be heated. A separate, heated liquid is allowed to fall on the tubes, thereby

achieving a transfer of energy from the heated liquid to the liquid carried by the tubes. A further characteristic of such falling-film heat exchangers is that they allow for a more continuous operation because the presence of impurities in the effluent such as debris, particulate or other contaminants does not tend to clog the heat exchange process because such impurities are removed from the tubes by the falling-film of effluent.

Another type of heat exchanger is the coiled heat exchanger, which is often submerged or used as a tube in a tube heat exchange apparatus. The immersed coil is generally used in reservoir heat exchangers by being immersed in a larger body of contained or circulated water. These heat exchangers often cannot achieve the desired efficiencies for many applications, are not very compact, and can be sensible to fouling.

Another frequent technique used for heat transfer is the counter-flow coiled "tube in a tube", also known as a coaxial heat exchanger. Such a heat exchanger is largely used in refrigerant/water cooled systems, such as heat pumps, air conditioners, and the like. In these systems, water flow and refrigerant flow circulate in opposite directions in coaxial tube heat exchanger. However, because of the small distance between the co-axial tubes, these heat exchangers can be susceptible to fouling and clogging.

Known to the Applicant are following patents and patent applications related to heat-transfer systems, and other devices:

AT 397114 B; and AU 2011216275 A1;

CA 1225987 A1; CA 1236088 A1; CA 2563969 A1; and 2,600,265 A1;

CN 1576766 A; CN 2474976 Y; and CN 102155854 A;

DE 4238450 A1; DE 29915788 U1; DE 102008021698 A1; and DE 102008022890 A1;

5 EP 0000192 A1; EP 0797065 A2; EP 1469269 A1; EP 1864603 A2; and EP 2292136 A1;

JP 6277171 A; JP 8219663 A1; JP 9014870 A; JP 2000283662 A1; JP 2002062063 A1; JP 2010019537 A1; and JP 2011089755 A1;

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KR 100843515 B1; KR 100843516 B1; and KR 20100082555 A;

US 3332469 A; US 3371709 A; US 3437124 A1; US 3502140 A1; US 4202406; US 4326551 A; US 4529032 A; US 4531572 A; US 4532985; US 4572287; 15 US 4619311; US 4764254; US 4857144; US 5195578-1; US 5660193 A1; US 5709264 A; US 5953924 A; US 5971061 A; US 6089312; US 6241010 B1; US 8176926 B2; US 8226777 B2; US 2008283099 A1; US 2009120465 A1; and US 2011155179 A1; and

20 WO 0017594 A1; WO 2009009341 A2; and WO 2009016650 A1.

The Applicant is also aware of the following disadvantages associated with some of these known systems: a) many do not resist fouling which results from the presence of impurities in the effluent, and which leads to many systems slowly being 25 corrupted over time, in that their heat transfer coefficient lowers, and/or the fluid flow path is reduced or blocked, which leads to process interruption and maintenance costs which are detrimental to the process efficiency for the client; b) many cannot be visually inspected without a thorough dismantling of the system by trained practitioners, which increases labour costs associated with maintenance and 30 inspection; c) some of the immersed heat exchangers have a poor external

convection coefficient due to the nature of the flow pattern; d) many are not readily adaptable to existing sources of hot effluent and thus cannot be used with these sources unless a specific engineering design is realised on each situation, which is costly and not likely to result in an optimum solution; e) many are not suitable for  
5 premises where a low-cost-installation, rapid payback and/or ease-of-operation solution is required; f) etc.

Hence, in light of the aforementioned, there is a need for an improved device or method which would be able to overcome or at least minimize some of the  
10 aforementioned prior art disadvantages.

### **Summary of the invention:**

An object of the present invention is to provide a method which, by virtue of its design and features, satisfies some of the above-mentioned needs and which is thus  
15 an improvement over other related conventional heat-exchanging/transferring methods.

In accordance with the present invention, the above object is achieved, as will  
20 be easily understood from the present description, with a method such as the one briefly described herein and such as the one exemplified in the accompanying drawings. Also described is a corresponding device for carrying out the method.

According to one aspect of the present invention, there is provided a method of  
25 transferring heat between a discharge fluid of a first system and a second system, the method comprising the steps of:

- a) receiving the discharge fluid from the first system;
- b) conveying the discharge fluid to a given location;
- c) providing at least one non-vertical elongated member being positioned,  
30 shaped and sized so as to define an array of stacked cross-sectional

profiles extending within at least one wall segment, said at least one wall segment being operatively connectable to the second system; and

d) allowing the discharge fluid to free-flow over said at least one wall segment of stacked cross-sectional profiles so as to allow a heat exchange between

5 the discharge fluid and the array of stacked cross-sectional profiles.

The above-mentioned method is innovative and advantageous in that with the action of gravity, the free-falling fluid will spread itself on the profile resulting in a very thin layer of fluid, in a manner which is also dictated by the profile, the viscosity and

10 the flow rate of the fluid. This thin layer exhibits enhanced heat transfer coefficient for laminar flow and has the further advantage of exposing heat transfer surface for easy maintenance, allows debris to fall upon without altering flow rate, etc.

According to another aspect of the present invention, there is also provided a

15 device for carrying out the above-mentioned method.

For example, according to another aspect of the present invention, there is also provided a device for transferring heat between a discharge fluid of a first system and a second system, the device including:

20 a conveying assembly for conveying the discharge fluid from the first system to a given location;

a heat exchanger assembly operatively connectable to the conveying assembly, the heat exchanger assembly including at least one non-vertical elongated member being positioned, shaped and sized so as to define an array of stacked

25 cross-sectional profiles extending within at least one wall segment, said at least one wall segment being operatively connectable to the second system; and

a distributing assembly for allowing discharge fluid provided by the conveying assembly to free-flow over a part of the array of cross-sectional profiles so as to allow a heat exchange between the discharge fluid and the array of cross-sectional profiles.

The device may comprise a housing which may consist of a "casing", for example, intended to include one or several of the conveying assembly, the heat exchanger assembly and the distributing assembly, as well as other possible components, as exemplified in the accompanying drawings. Alternatively, in the context of the present description, housing may also simply refer to the room, plant, treatment factory and/or infrastructure, whether opened, partially opened, partially closed, or closed, cooperating with one or several components of the device, and thus, the term "housing" in the context of the present description is obviously not limited to "casing" *per se* and/or other similar components.

According to another aspect of the present invention, there is provided a device for exchanging thermal energy between a first fluid and second fluid, the device comprising:

a housing providing a closed volume and comprising at least one fluid intake and at least one fluid exit, the housing further comprising a fluid receptacle disposed at the bottom of the housing for collecting fluid;

a closed circuit mountable within the housing and coiling about a vertical axis from an inlet to an outlet, the closed circuit comprising an outer circuit surface and configured for conveying the second fluid from the inlet to the outlet; and

a distributor mountable above the closed circuit, the distributor configured for distributing the first fluid along the outer circuit surface of the closed circuit such that the first fluid substantially coats the outer circuit surface before collecting in the fluid receptacle, thereby allowing thermal energy to be exchanged between the first fluid and the second fluid via the outer circuit surface of the closed circuit.

In some optional embodiments, the closed circuit can take on a circular, loop, helical, etc. configuration, although other non-cylindrical configurations are possible. The closed circuit can consist of a singular tube coiling about a vertical axis, or can consist of a plurality of such tubes that collect to a common piping system at the

beginning and the end of the closed circuit, such as double-tubing, for example. Optionally, the tubes can be co-axial, or allow for reverse and/or opposing flows.

5 In some optional embodiments, the closed circuit can be a singular tube forming an elongated coil, which can be used in series or parallel, or which can include a plurality of modular components so as to form a heat exchanger, for example.

10 In some optional embodiments, the distributor consists of a diffusion geometry which distributes the first fluid evenly over the top of the outer circuit surfaces.

Further optionally, at least one of the fluid intakes of the housing can be equipped with an apparatus, which in its nature and position, acts as a filter for filtering the first fluid of impurities and/or debris.

15

According to one aspect of the present invention, there is provided a device for exchanging thermal energy between a first fluid and second fluid, the device comprising:

20 a circuit coiling about a vertical axis from an inlet to an outlet, the circuit comprising an outer circuit surface and configured for conveying the second fluid from the inlet to the outlet; and

at least one fluid distributor system, mountable above the closed circuit, the at least one distributor configured for equally distributing by descent or by pressure the first fluid along the outer circuit surface of the closed circuit such that the first fluid  
25 substantially coats the outer circuit surface before collecting in a fluid receptacle, thereby allowing thermal energy to be exchanged between the first fluid and the second fluid via the outer circuit surface of the closed circuit.

According to another aspect of the present invention, there is also provided an appliance, such as a dishwasher, for example, equipped with the above-mentioned device(s).

5        According to another aspect of the present invention, there is also provided a kit with components for assembling the above-mentioned device(s) and/or appliance.

According to yet another aspect of the present invention, there is also provided a set of components for interchanging with components of the above-mentioned kit.

10

According to yet another aspect of the present invention, there is also provided a method of assembling components of the above-mentioned device(s), appliance, kit and/or set.

15        According to yet another aspect of the present invention, there is also provided a method of operating the above-mentioned device(s), appliance, kit and/or set.

According to yet another aspect of the present invention, there is also provided a method of doing business with the above-mentioned device(s), appliance, kit, set  
20 and/or method(s).

Certain objects, advantages, and other features of the present invention will become more apparent upon reading of the following non-restrictive description of possible embodiments thereof, given for the purpose of exemplification only, with  
25 reference to the accompanying drawings.

#### **Brief description of the drawings:**

Figure 1 is a front perspective view of a heat-transferring device according to a  
30 possible embodiment of the present invention.

Figure 2 is another front perspective view of what is shown in Figure 1, the device being now shown with a top lid of its outer casing in an exploded relationship with respect to a bottom portion of the casing to better illustrate inner components of the device according to a possible embodiment.

Figure 3 is another front perspective view of what is shown in Figure 1, the device being now shown with its outer shell being completely removed to better illustrate inner components of the device according to a possible embodiment.

Figure 4 is a rear perspective view of what is shown in Figure 3.

Figure 5 is a left perspective view of what is shown in Figure 3.

Figure 6 is a right perspective view of what is shown in Figure 3.

Figure 7 is a front elevational view of what is shown in Figure 3.

Figure 8 is a rear elevational view of what is shown in Figure 3.

Figure 9 is a left elevational view of what is shown in Figure 3.

Figure 10 is a right elevational view of what is shown in Figure 3.

Figure 11 is a top plan view of what is shown in Figure 3.

Figure 12 is a bottom plan view of what is shown in Figure 3.

Figure 13 is a perspective view of at least one elongated non-vertical member (ex. coil) being positioned, shaped and sized so as to define an array of stacked

cross-sectional profiles extending within at least one wall segment and cooperating with a distributing assembly (ex. diffusion plate) according to a possible embodiment of the present invention

5           Figure 14 is a schematic cross-sectional view of a heat-transferring device according to a possible embodiment of the present invention, this view illustrating an example of possible way in which the discharge fluid can be distributed over the at least one wall segment of stack cross-sectional profiles.

10           Figure 15 is a schematic cross-sectional view of a heat-transferring device according to another possible embodiment of the present invention, this view illustrating another example of possible way in which the discharge fluid can be distributed over the at least one wall segment of stack cross-sectional profiles.

15           Figure 16 is a schematic cross-sectional view of a heat-transferring device according to another possible embodiment of the present invention, this view illustrating yet another example of possible way in which the discharge fluid can be distributed over the at least one wall segment of stack cross-sectional profiles.

20           Figure 17 is a schematic cross-sectional view of a heat-transferring device according to yet another possible embodiment of the present invention, this view illustrating another example of possible way in which the discharge fluid can be distributed over the at least one wall segment of stack cross-sectional profiles.

25           Figure 18 is a schematic elevational view of a heat-transferring device according to another possible embodiment of the present invention, this view better illustrating an example of possible falling-fluid-film being created with the discharge fluid over the at least one wall segment of stack cross-sectional profiles.

30           Figure 19 is a top plan view of what is shown in Figure 18.

Figure 20 is a schematic cross-sectional view of at least one wall segment of stacked cross-sectional profiles according to a possible embodiment of the present invention, the at least one wall segment being shown interacting with a falling-fluid-film of discharge fluid free-flowing (ex. free-falling) over said at least one wall segment.

Figure 21 is an enlarged view of a portion of what is shown in Figure 20.

10 Figure 22 is a schematic cross-sectional view of at least one wall segment of stacked cross-sectional profiles according to a possible embodiment of the present invention.

15 Figure 23 is a schematic cross-sectional view of at least one wall segment of stacked cross-sectional profiles according to another possible embodiment of the present invention.

20 Figure 24 is a schematic cross-sectional view of at least one wall segment of stacked cross-sectional profiles according to another possible embodiment of the present invention.

Figures 25a-25f are examples of possible cross-sectional profiles to be used according to possible embodiments of the present invention.

25 Figures 26a-26d are examples of possible fluid path patterns according to possible embodiments of the present invention.

Figure 27 is a front view of a coil pattern and distributor assembly according to a possible embodiment of the present invention.

Figure 28 is a top view of what is shown in Figure 27.

Figure 29 is a side elevational view of a closed circuit having single tubing according to a possible embodiment of the present invention.

5

Figure 30 is a side elevational view of a closed circuit having multiple tubing according to a possible embodiment of the present invention.

Figure 31 is schematic cross-sectional view of a leak detecting mechanism according to a possible embodiment of the present invention.

10

Figure 32 is schematic cross-sectional view of a leak detecting mechanism according to another possible embodiment of the present invention.

15

Figure 33 is a schematic cross-sectional view of a device for transferring heat from one system to another according to a possible embodiment of the present invention.

20

Figure 34 is a schematic cross-sectional view of a device for transferring heat from one system to another according to another possible embodiment of the present invention.

25

Figure 35 is a perspective view of a filtering apparatus (ex. inside strainer) for filtering discharge fluid according to a possible embodiment of the present invention.

Figure 36 is a top plan view of what is shown in Figure 35.

Figure 37 is a partial sectional view of a portion of what is shown in Figure 35.

30

Figure 38 is an enlarged front view of a portion of what is shown in Figure 37.

Figure 39 is a perspective view of a filtering apparatus (ex. external strainer) for filtering discharge fluid according to a possible embodiment of the present invention, the external strainer being shown in a closed configuration.

5

Figure 40 is another perspective view of what is shown in Figure 39, the filtering apparatus (ex. external strainer) being now shown in an open configuration.

Figure 41 is another perspective view of what is shown in Figure 39, the filtering apparatus (ex. external strainer) being now shown connected to a heat-transferring device according to a possible embodiment of the present invention.

10

Figure 42 is a side elevational view of a filtering apparatus according to another possible embodiment of the present invention.

15

Figure 43 is a cut-away top view of what is shown in Figure 42.

Figure 44 is a cross-sectional view taken along line A-A of Figure 43.

20

Figure 45 is a cross-sectional view of an alternate rectangular design taken along line A-A of Figure 43.

25

Figures 46-56 provide schematics of a heat-transferring device being used in different applications, according to different possible embodiments of the present invention.

Figure 57 is a schematic view of a heat-transferring device being used with a hot water make-up device according to a possible embodiment of the present invention.

30

Figure 58 is an enlarged view of the hot water make-up device shown in Figure 57.

Figure 59 is a schematic view of a heat-transferring device being used in another different application according to a possible embodiment of the present invention.

Figure 60 is an enlarged view of the heat-transferring device shown in Figure 59.

#### **Detailed description of optional embodiments:**

In the following description, the same numerical references refer to similar elements. Furthermore, for the sake of simplicity and clarity, namely so as to not unduly burden the figures with several references numbers, not all figures contain references to all the components and features, and references to some components and features may be found in only one figure, and components and features of the present disclosure which are illustrated in other figures can be easily inferred therefrom. The embodiments, geometrical configurations, materials mentioned and/or dimensions shown in the figures are optional, and are given for exemplification purposes only.

Furthermore, although the present heat-transferring method and/or device was primarily designed to be used with an appliance, such as a dishwasher for example, in order to recuperate heat from the discharge fluid thereof (also for example), it may be used with other objects and/or in other types of applications, as apparent to a person skilled in the art. For this reason, expressions such as "appliance", "dishwasher", "recuperate", "heat", "discharge fluid", etc. as used herein should not be taken as to limit the scope of the present invention and include all other kinds of

objects, applications and/or purposes with which the present invention could be used and may be useful, as can be easily understood by a person skilled in the art.

Indeed, the use of the term "vertical" herein to describe the structure does not  
5 limit the device to being used only with structures being "perpendicular" to the surface. For this reason, expressions such as "upright", "straight", "erect", "raised", "inclined", "slanted", etc. can be used interchangeably with the term "vertical".

Moreover, in the context of the present invention, the expressions "system",  
10 "kit", "assembly", "device", "heat exchanger", "module", "product", "unit" and "appliance", as well as any other equivalent expressions and/or compounds word thereof known in the art will be used interchangeably, as apparent to a person skilled in the art. This applies also for any other mutually equivalent expressions, such as, for example: a) "exchanging", "transferring", "conveying", etc.; b) "energy", "thermal  
15 energy", "heat", etc.; c) "recovering", "recuperating", "extracting", "reusing", "storing", etc.; d) "discharge", "effluent", "waste cleaning water", etc.; e) "fluid", "gas", "liquid", "water", etc.; f) "free-falling", "flowing", "circulating", "travelling", "passing", "cascading", etc.; g) "inlet", "intake", etc.; h) "outlet", "exit", etc.; h) "distributing", "spreading", "diffusing", etc.; i) "discharge fluid", "first fluid", etc.; j) "working fluid",  
20 "second fluid", etc.; k) "path", "circuit", "conduit", "tube", "tubing", "pipe", etc.; l) "filtering", "screening", "straining", etc.; m) "adjacent", "consecutive", "neighboring", etc.; n) "panel", "door", "lid", etc.; o) "housing", "shell", "body", "casing", "room", "plant", "treatment factory", "infrastructure", etc.; p) "providing", "defining", etc.; as well  
25 as for any other mutually equivalent expressions, pertaining to the aforementioned expressions and/or to any other structural and/or functional aspects of the present invention, as also apparent to a person skilled in the art.

Furthermore, in the context of the present description, it will be considered that  
all elongated objects will have an implicit "longitudinal axis" or "centerline", such as  
30 the longitudinal axis of an pipe for example (whether "hollow" or "full"), or the

centerline of a bore, for example, and that expressions such as "connected" and "connectable", or "mounted" and "mountable", may be interchangeable, in that the present invention also relates to a kit with corresponding components for assembling a resulting fully assembled and operational heat-transferring device and/or resulting  
 5 assembly including the same.

In addition, although the optional configurations as illustrated in the accompanying drawings comprise various components and although the optional configurations of the method, device and corresponding assembly as shown may consist of certain geometrical configurations and/or dimensions as explained and  
 10 illustrated herein, not all of these components, geometries and/or dimensions are essential and thus should not be taken in their restrictive sense, i.e. should not be taken as to limit the scope of the present invention. It is to be understood that other suitable components and cooperations thereinbetween, as well as other suitable geometrical configurations and/or dimensions may be used for the  
 15 method/device/assembly, and corresponding parts, as briefly explained and as can be easily inferred herefrom, without departing from the scope of the invention.

List of numerical references for some of the corresponding possible components illustrated in the accompanying drawings:

20

1. device
3. discharge fluid (or "first" fluid) (of first system)
- 3f. falling-fluid-film
5. first system
- 25 7. second system
9. given location
11. elongated member
13. cross-sectional profile
- 13a. first cross-sectional profile (ex. "upper" cross-sectional profile)

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- 13b. second cross-sectional profile (ex. "lower" cross-sectional profile)
- 13c. outer surface (of cross-sectional profile)
- 15. wall segment
- 15a. first side (ex. "front" side) (of wall segment)
- 5 15b. second side (ex. "rear" side) (of wall segment)
- 17. fluid circuit
- 19. pump
- 21. tube
- 23. fluid path (for working fluid or second fluid)
- 10 23a. inner wall (of fluid path)
- 23b. outer wall (of fluid path)
- 25. working fluid (or "second" fluid) (of second system)
- 25'. heat-containing fluid
- 27. air
- 15 29. leak-detecting mechanism
- 31. recess (of leak-detecting mechanism)
- 33. flow direction (of discharge fluid)
- 33a. first flow direction (of discharge fluid)
- 33b. second flow direction (of discharge fluid)
- 20 35. vertical axis
- 37. housing
- 39. loop(s)
- 41. flow equalizing surface
- 43. gap (between adjacent cross-sectional profiles)
- 25 45. fluid circuit (for working fluid or second fluid)
- 45a. inlet (of closed fluid circuit)
- 45b. outlet (of closed fluid circuit)
- 45c. outer surface (of fluid circuit)
- 47. debris (of discharge fluid)
- 30 49. cleaning product

## 18

- 51. cleaning solution
- 53. control system (or simply "controller")
- 55. conveying assembly
- 57. heat exchanging assembly
- 5 59. distributing assembly (or simply "distributor")
- 61. flow equalizer
- 63. diffusion plate (of flow equalizer)
- 65. channel (of flow equalizer)
- 67. access panel (of housing)
- 10 69. vent (of housing)
- 71. fluid intake
- 71a. first fluid intake
- 71b. second fluid intake
- 73. fluid exit
- 15 73a. first fluid exit
- 73b. second fluid exit
- 75. fluid receptacle
- 77. filtering apparatus
- 77a. perforated tube (of filtering apparatus)
- 20 77b. cylindrical screen (of filtering apparatus)
- 77d. perforated pipe (of filtering apparatus)
- 77e. filter screen (of filtering apparatus)
- 77f. gasket (of filtering apparatus)
- 77g. screwable cap (of filtering apparatus)
- 25 79. tank
- 81. detector
- 83. drainage channel (of leak-detecting mechanism)
- 85. sprayer
- 87. suction assembly
- 30 89. evacuation pump

- 91. hot water make-up assembly (or simply "make-up device")
- 91a. storage tank (of hot water make-up assembly)
- 91b. control valve (of hot water make-up assembly)
- 91c. circulation pump (of hot water make-up assembly)
- 5 91d. control module (of hot water make-up assembly)
- 91e. temperature sensor (of hot water make-up assembly)
- 93. display (of device)
- 95. bio-hazard control system
- 97. cleaning system
- 10 99. kit (for assembling device)
- 101. assembly (including device)
- 103. transmission system (for wired or wireless data transmission)

Broadly stated, the present disclosure relates to a method and device for  
 15 exchanging energy between two systems, and according to one possible  
 embodiment, between two fluids, or more. The expression "exchanging energy" as  
 used herein refers to the transfer of energy, in all its forms, from one fluid (such as a  
 "first fluid" of a first system, hereinafter referred to also as "discharge fluid") to another  
 system, and/or fluid thereof. One possible example of such a transfer occurs between  
 20 a refrigerant and air, such as in air conditioners. Another example of such a transfer  
 occurs within heat exchangers, where energy in the form of thermal energy (i.e. heat)  
 is transferred from one fluid (i.e. a hot fluid) to another (i.e. a colder fluid), thereby  
 allowing for the heat exchanger to transfer the energy of the hot fluid so as to heat the  
 cool fluid, for example. Such heat exchangers can be used for heat recovery with  
 25 dishwashers, washing machines, industrial effluents, and many other applications. In  
 the present disclosure, the device will be described as being used in conjunction with  
 an industrial application, such as recovering energy from waste cleaning water, but  
 the device is not limited to such use, nor is it limited to being used only for heat  
 recovery. Similarly, it is understood that the term "fluid" is not limited to liquids, and

includes gases as well, of any density and/or volume and includes brines, refrigerants, pure elements and mixtures of different fluids and/or gas.

Referring to Figures 1-34, and according to different one possible embodiment, the device 1 is used for exchanging energy between a first fluid 3 and a second fluid 25. The first and second fluids 3,25 can be any liquid or gas. Moreover, the device 1 is not limited to exchanging energy between only two fluids, and can facilitate the exchange of energy between more than two fluids, if desired. Also, it can be understood that the device 1 could ultimately be used for facilitating the exchange of heat from one fluid of a first given system to at least one non-vertical elongated member of another second system, said non-vertical elongated being positioned, shaped and sized so as to define an array of stacked cross-sectional profiles extending within at least one wall segment, said at least one wall segment being operatively connectable to the second system, wherein the at least one non-vertical elongated member could be "full" instead of having a second fluid 25 circulating along a "hollow" fluid path or circuit of the second system, etc. In this configuration, the first fluid 3 would exchange energy with a "solid" elongated member of different temperature.

In one optional configuration, as exemplified in the accompanying drawings, the second fluid 25 is relatively cold water which requires preheating, and the first fluid 3 is the relatively hot effluent from the industrial process, such as wash water. The device 1 can be used to transfer heat from the effluent first fluid 3 to the cold water second fluid 25. Alternatively, the device 1 can be used to draw heat from the first fluid 3 so as to cool it down for further use. It is thus apparent that the exchange of energy can go from either the first fluid 3 to the second fluid 25, and/or vice versa.

The device 1 can include a casing or a housing 37. The housing 37 can be any reservoir, tank, vessel, container, etc. which provides an interior having a volume for containing the fluids 3,25, the closed circuit, and optionally the distributor. In most

embodiments, the housing 37 is considered "closed" because it does not allow for the unintentional escape of energy and/or fluids, with the exception of air/or fluid through a vent 69 specifically designed for such a purpose. The vent 69 can permit the free circulation of air and/or fluids from inside the device 1 to atmosphere. As such, an  
5 unrestricted passage between the internal atmosphere of the housing 37 and the external environment can be created, which permits fluid movement out of the housing 37, and thus avoiding the creation of suction or pressure which can result from the change in fluid height inside the device 1.

10 The housing 37 can have multiple fluid intakes 71, and multiple fluid exits 73 through which the fluids 3,25 enter and exit the housing 37, respectively. In one possible configuration, the housing 37 is provided with two fluid intakes 71a, 71b – a first fluid intake 71a through which the heated effluent first fluid 3 enters the housing 37, and a second fluid intake 71b through which the cold water second fluid 25 enters  
15 the housing 37. In such a configuration, the housing 37 can also include two fluid exits 73a, 73b – one for releasing the heat-depleted first fluid 3, and the other one for releasing the heated second fluid 25. The dispositions of the fluid intakes 71 and fluid exits 73 are not limited to the optional embodiment illustrated in the accompanying figures.

20 The housing 37 can also include a fluid receptacle 75 disposed at the bottom of the housing 37. The receptacle 75 collects fluids, and it can therefore take any suitable shape or configuration, examples of which include a pan, tray, vessel, receptacle, etc. In most embodiments, the receptacle 75 collects the first fluid 3 after  
25 it has coated the last of the outer circuit surface of the closed circuit. Optionally, the receptacle 75 can be inclined towards a central pump and/or drain so as to facilitate drainage and/or disposal of the first fluid 3 which collects thereon. The spent flow of the first fluid 3 is recovered with the receptacle 75 and thus can be discharged outside the reservoir. The housing 37 can also include a pump 19 which can be  
30 disposed at a low point in the housing 37, such as at the base of the receptacle 26, so

as to circulate and/or recirculate fluids. Optionally, the pump 19 can be used to pump spent first fluid 3 from the bottom of the housing 37 to the distributor, as further explained below. The pump 19 can be protected by a grill and/or screen so as to prevent impurities from entering therein.

5

In some optional embodiments, the housing 37 can include a filtering apparatus 77 mounted to at least one of the fluid intakes 71. In the example where the first fluid 3 is hot effluent from a dishwasher, it may be necessary to filter the first fluid 3 before exchanging energy so as to remove any debris 47. Such retention of undesirable particles can advantageously protect the pump and coil from clogging. The filtering apparatus 77 performs such a function by removing debris, solid matter, gunk, impurities, etc., often from the heated effluent first fluid 3. This advantageously allows for the heated first fluid 3 to be pumped, conveyed, etc. without risking that debris 47 therein contaminates or corrupts equipment used to move the first fluid 3. The filtering apparatus 77 can take many different forms, as illustrated in Figures 35-45, for example.

Indeed, as shown in these figures, the filtering apparatus 77 can consist of an elongated perforated tube 77a, into which can be inserted a substantially cylindrical screen 77b. As the first fluid 3 enters the filtering apparatus 77, it first encounters the screen 77b, which can be finer than the perforated tube 77a. This first encounter removes many of the problematic impurities from the first fluid 3, which is then allowed to leave the screen 77b and to enter the housing 37 via the perforations in the tube 77a. Advantageously, the housing 37 can be equipped with an access door or panel 67 which allows a user or maintenance technician to easily access the screen 77b and/or tube 77a, and to clean the same so as to prevent blocking. In some optional embodiments, the filtering apparatus 77 can be automatically cleaned by the action of a water jet wash and/or sprayers 85.

Another example of a form for the filtering apparatus 77 is provided in Figures 42-45. The filtering apparatus 77 can be provided with a perforated pipe 77d into which can be inserted a removable filter screen 77e. The operation of such a filtering apparatus 77 is similar to the one described in the preceding paragraph. The filtering apparatus 77 can be provided with a gasket 77f for providing a suitable seal. The filtering apparatus 77 can also be provided with a screwable cap 77g so as to provide a watertight seal with the housing 37. The shape, configuration, form, etc. of the filtering apparatus 77 can vary, and it is understood that it is not limited to tubular and/or circular configurations.

The device 1 can also include a fluid path 23 (hereinafter referred to also as fluid "circuit" 45), which can take on the form of a closed circuit 45, an example of which is provided in Figures 1-19. The use of the term "closed" to describe the circuit 45 means that the fluid carried within the circuit 45 is not exposed nor mixed with the first fluid 3, and is conveyed by the circuit 45. The term "circuit" can refer to the periodical path travelled by the fluid therein. In some embodiments, the circuit 45 consists of a helical, twisted, wound, etc. route along which the fluid (e.g. the second fluid 25) travels, and whereby the fluid returns to the direction from whence it came. In some optional embodiments, the circuit 45 is mounted within the housing 37 and coils about a vertical axis from an inlet 45a to an outlet 45b of the circuit 45. Although the circuit 45 is shown in some figures as being incorporated into the housing 37, the circuit 45 can also be used independently of the housing 37, in another device, as desired. This optional configuration is shown in Figures 27 and 28, where the device 1 can include a circuit 45 and a distributing assembly 59 which operate independently of the housing. Figure 27 also illustrates an example of a flow equalizer 61 for equalizing and repartitioning the flow of first fluid 3 on the closed circuit 45.

The term "coil" as used herein refers to the fact that the fluid and/or the circuit 45 moves in a winding path so as to form a series of upwardly-extending, interconnectable loops or a bended hollow tube geometry. As such, the circuit 45 can

take the form of a helix, twist, spiral, etc., but can also take any other non-circular forms such as a rectangular coil, a triangular coil, or another polygonal coil. In this regard, reference is made to Figure 26, which shows examples of various coil patterns that the circuit 45 can take. For example, the circuit 45 can have a  
5 serpentine coil, as shown in configuration "A". The circuit 45 can also have a circular or "round" coil, as shown in configuration "B". Further optionally, the circuit 45 can have an elongated or oblong coil, as shown in configuration "C". The circuit 45 can also have an elliptical or oval coil, as shown in configuration "D". The possible coil patterns that can be taken by the circuit 45 are not limited to those shown in Figure 26  
10 or elsewhere. Indeed, the choice of coil pattern for the circuit 45 can depend upon numerous factors, such as: the available space or volume for the circuit 30, the fluid being used for exchanging energy, the desired energy exchange rate, the material being used for the circuit 30, etc. The coiled circuit 45 can be coiled at any angle or orientation, provided that the circuit 45 is directed substantially perpendicular to the  
15 direction of the falling first fluid 3 flow.

Indeed, a considerable advantage resulting from the present system is that it meant to have a working fluid 25 travel along a "longest" path as possible between two vertical points (for example, between an inlet 45a and an outlet 45b of the fluid  
20 circuit 45, or fluid path 23), that is, via the longest "at least one non-vertical elongated member" 11 possible, so that the working fluid 25 can be exposed with the desired heat exchange surface to the discharge fluid 3 flowing (ex. free-falling, free-flowing, etc.) over the at least one wall segment 15 of stacked cross-sectional profiles 13 defined by the aforementioned "at least one non-vertical elongated member" 11, in  
25 order to optimize and/or maximize heat transfer between the first fluid 3 and the second fluid 25.

In some optional embodiments, examples of which are shown in Figures 31 and 32, the coiled circuit 45 is composed of two or more tubes 21 that are arranged to

provide a void space in their middle, which can advantageously assist in providing a leak detection technique as further explained below.

Returning back to Figures 1-31, the coiled circuit 45 includes an outer circuit  
5 surface 37. The surface 45c consists of the exterior of the circuit 30, and can thus take many different forms. In one possible example of the form the surface 45c can take, and considering the example where the circuit 45 is made up of a plurality of coiled tubings, of any suitable cross-section geometry, the surface 45c can be the outer surface of the tubes 21. The surface 45c is thus the portion of the circuit 45 that  
10 is exposed to the volume of the housing 37 and/or to the first fluid 3 falling thereon, as further explained below.

It can thus be appreciated that the coiled circuit 45 conveys (e.g. transports, takes, brings, pumps, etc.) the second fluid 25 from the inlet 45a to the outlet 45b,  
15 whether the circuit 45 is incorporated within the housing 37, or used independently thereof. In the optional configuration provided in Figure 14, the dispositions of the inlet 45a and the outlet 45b advantageously allow the second fluid 25 to exchange energy with the first fluid 3, the temperature of which increases as it advances higher within the coiled circuit 45. It is of course understood that the dispositions of the inlet 45a  
20 and the outlet 45b are not limited to the optional configuration illustrated in Figure 14. Indeed, in an example of one possible alternative configuration, the inlet 45a can be disposed near the top of the housing 37 and the outlet 45b near the bottom of the housing 37. In such a configuration, the second fluid 25 can be conveyed under gravity through the coiled circuit 30, and such a flow of second fluid 25 can enable a  
25 heat exchange approaching a "parallel" heat exchange.

In some optional embodiments, an example of which is provided in Figures 2-32, the coiled circuit 45 can consist of a plurality of tubing where the second fluid 25 is distributed equally in individual tubes 21. The tubing can be made of any heat-  
30 conduction material, such as metal alloys. Such tubing can be a pair of individual

tubes 21, and can also be a coil composed of three tubes 21. In such a configuration, the source of the second fluid 25 can flow through both tubes 21. Such a flow can be uni-directional or bi-directional, as required. Advantageously, such a configuration of tubing can allow for a greater volume and/or flow rate of second fluid 25 to be  
5 exposed to energy exchange without the associated penalty of pressure losses of increased flow rate. Of course, more or fewer individual tubes 21 can be used, depending on numerous factors such as: the volume or flow rate of second fluid 25, the volume of first fluid 3, space constraints, etc. The distance separating the tubing can vary provided that a "falling film" of first fluid 3 can still be produced, as further  
10 explained below. Therefore, the tubing can be wound vertically by leaving an interval between adjacent tubing in such a manner that the surfaces of the next revolution are close enough together so as to maintain a continuous flow of first fluid 3 over the outer circuit surface 45c (i.e. not inducing a separation of the flow). As such, spacers can be used to precisely calibrate the space between the tubes 21.

15 In other optional embodiments, the coiled circuit 45 can consist of a single tube 21. Such a tube 21 can coil upwardly about a vertical axis. Optionally, the coiled circuit 45 can be made of two or more concentric tubes 21 which together form the fluid path 21. These concentric tubes 21 can consist of an outer tube or wall 21b  
20 being press-fitted very closely to an inner tube or wall 21a. The purpose of such double coiling is to provide means for detecting leaks within the coiled circuit 30, as exemplified in Figures 31 and 32.

In such an embodiment, a drainage channel 83 can be created between inner  
25 and outer walls 23a, 23b of the fluid path 23. The drainage channel 83 can consist of a spacing or cavity which allows for leak detection. In some optional embodiments, the drainage channel 83 can be located on the outer wall 23b. The drainage channel 83 can also be located on the inner tube wall 23a. In the optional configuration where the drainage channel 83 is located on the inner wall 23a, this allows for any leaks in the  
30 inner tube 21 to remain within the outer tube 21, and thus prevents potential

contamination as well as indicates to the user the rupture of the inner wall 23a.. This may also, in some cases, advantageously allow for energy exchange to continue without hindrance. In some optional embodiments, the drainage channel 83 consists of a notched inner passage which is press fitted into the outer tube 21. If a leak is  
5 detected in the tube of the drainage channel 83, the leaked second fluid 25 will collect in the drainage channel 83 and will be prevented from escaping or being corrupted by the first fluid 3 outside of the circuit 45 because it is blocked by the outer tube 21 (i.e. the outer wall 23b of fluid path 23). The outer tube 21 can be configured for leak detection so that the leak becomes apparent to the user. Such leak detection can be  
10 performed visually, or with a suitable device or instrument.

Other optional embodiments of the circuit 45 include: a) the tubing can be made with a simple wall, a double wall, a double wall with ventilation separation, etc. - two tubings can be fitted together with the interior or exterior tubing being deformed  
15 as to create a cavity where the ruptured wall fluid can be detected, as exemplified in Figures 31 and 32; b) the interior tubing can be fabricated with surface enhancing properties or turbulence flow enhancer so as to augment the efficiency of the interior heat transfer; c) the tubing can be provided with heat transfer surface enhancement devices, such as fins, grooves, dimples; d) the tubing can be of any cross-sectional  
20 geometry, such as oval, square, rectangular or any form, some of which are shown in Figure 25; e) the external tubing surface can be treated with a surface treatment method such as dipping, galvanizing, annealing, etc. in order to enhance surface properties for corrosion resistance, capillarity, self-cleaning, fouling, bio-hazard control, to name but a few properties; and f) the outer circuit surface 45c can be  
25 covered by a very thin material such as a polymer or thin film coating in order to seal any gaps and enhance surface properties for corrosion resistance, capillarity, self-cleaning, fouling, bio-hazard control, etc., as exemplified in Figures 20 and 21.

As mentioned earlier, the device 1 also includes a distributing assembly 59  
30 (hereinafter referred to also simply as a "distributor" 59), an example of which is

provided in Figure 14. The distributor 59 controls the distribution of fluid, typically but not exclusively the first fluid 3, onto the outer circuit surface 45c of the circuit 30, thereby achieving the exchange of energy between the first fluid 3 and the second fluid 25. The distributor 59 can be used to evenly distribute the flow of the first fluid 3, thereby advantageously assuring a more even exchange of energy. The distributor 59 can be mounted about the housing 37, and advantageously above the circuit 45 such that it can distribute by "descent" (i.e. by gravity or under pressure) the first fluid 3 onto the circuit. The distributor 59 can be mounted elsewhere provided that it can control the rate of distribution of the first fluid 3 over the circuit 45.

In another possible embodiment, the first or second fluid 3,25 can be sprayed upon the outer circuit surface 45c of the coiled circuit 45. This can advantageously create an equal film around the coiled circuit 45. The amount of fluid sprayed, as well as the position of the spray nozzle, can be varied so as to control or optimise the energy exchange process.

Figures 14-19 provide examples of some of the many different forms that the distributor 59 may take. Figure 15 shows a distributor 59 which draws the first fluid 3 from a bottom of the housing 37, such as the fluid receptacle 75, where the first fluid 3 collects. The distributor 59 then pumps the first fluid 3 up through the middle of the coiled circuit 45 and into a diffusion plate 63. The diffusion plate 63 can take many different forms. In one possible example, the diffusion plate 63 can have a conical geometry. This geometry can be aligned with a horizontal plane, upon which the first fluid 3, directed from the center of the conical diffusion plate 63, is equally repartitioned by the effect of gravity. The geometry of the diffusion plate 63 can vary, and can possess groves, cuts, embossing, holes, etc. The goal of such geometry is to ensure that the first fluid 3 is equally repartitioned before falling by gravity upon the circuit 45 located below the diffusion plate 63. Indeed, the flow equalizer 61 can be a diffusion plate 63, a diffusion ring and/or any geometric apparatus permitting diffusion of flow of the first fluid 3 over the array of cross-sectional profiles 13.

In one possible embodiment, an example of which is provided in Figure 15, the diffusion plate 63 can be a downwardly sloped circular pan. As shown, the first fluid 3 is pumped into the diffusion plate 63 and exits, under pressure or not, from outlets on the periphery of the diffusion plate 63 so as to fall onto the outer circuit surface 45c of the coil 45. Alternatively, the first fluid 3 can be forced under pressure to impinge the distributor 59 at a certain velocity. By these velocity forces impacting on the distributor 59, the first fluid 3 is repartitioned equally around the surface on which it is impinged. In the optional embodiment shown in Figure 16, the diffusion plate 63 is a downwardly-sloping circular pan or "overflow" type. The first fluid 3 is pumped above the middle of the diffusion plate 63 with the first fluid 3 fluid vertically emerging as a fountain to fall upon the diffusion plate 63 by gravity flow. The first fluid 3 eventually drains via gravity towards the periphery of the diffusion plate 63 so as to eventually free-fall over the outer circuit surface 45c. In yet another alternative, the first fluid 3 could be sprayed on the coiled circuit 45 directly.

In the optional embodiment shown in Figure 17, the first fluid 3 is brought (under pressure or not) to a point above the diffusion plate 63, which can again consist of a circular downwardly-sloping pan. Once released onto the diffusion plate 63, the first fluid 3 can flow under pressure or freely over the periphery of the diffusion plate 63 and onto the outer circuit surface 45c. Figure 19 provides a top schematic view of the diffusion plate 63, and of the distribution of the first fluid 3 by the diffusion plate 63 over the coiled circuit 45. Optionally as well, the distributor 59 may consist of a plurality of spouts 44 radially interspersed about the vertical axis at the middle of the coil 45. The first fluid 3 can thus be distributed via the spouts 44 onto the outer circuit surface 45c. Optionally, the distributor 59 can include dispersers 46 provided near the outlet of the spouts 44 so as to widely disperse the first fluid 3 over the outer circuit surface 45c.

Having now described some of the features of the device 1, an example of a typical operation of the device will be discussed.

The first fluid 3, such as external heated effluent from a dishwasher, for example, enters the housing 37. Before entering, the first fluid 3 is filtered by the filtering apparatus 77, which can be removed and cleaned manually or automatically by a wash cycle. After passing through the filtering apparatus 77, the first fluid 3 collects at the bottom of the housing 37, such as in the fluid receptacle 75. Once a sufficient volume of first fluid 3 has collected, a centrifugal pump 19 can be used to pump the collected first fluid 3 upward and onto the distributor 59 so as to generate a "waterfall" upon the circuit 45 and the outer circuit surface 45c.

Referring to Figure 19, the distributor 59 controls the distribution of the first fluid 3 onto the circuit 30, and provides a substantially equal repartition around the circuit 45. This control can be achieved through some of the following non-limitative features of the distributor 59: the downward slope, the flow rate of first fluid 3 over the periphery of the distributor 59, the form of the distributor 59, etc. Once it leaves the distributor 59, the flow of first fluid 3 is equally repartitioned around the outer circuit surface 45c. Such a flow of first fluid 3 can be characterized by the very thin fluid thickness, or "film", on the surface 30c, which advantageously helps to achieve a significant exchange of energy. This efficient exchange occurs because with such a thin film 3f, the effects of capillarity are observed, and the flow of the first fluid 3 over the surface 45c can thus remain attached to the tubes 21 of the coil 30, and this, for each descending level of tubes 21. The flow of first fluid 3 can thus be prevented from separating from tube to tube, and the distributor 59 thus allows the first fluid 3 to substantially "coat" the outer circuit surface 45c with a thin film 3f of first fluid 3. A "falling-film" flow of first fluid 3 is therefore achieved on the surface 45c of the coiled tubing, resulting in a high heat transfer coefficient for this first fluid 3. An inner convection flow can be induced inside the coiled tubing of the circuit 30, where the

second fluid 25 is flowing, to enhance the heat transfer coefficient of the second fluid 25 and optimize heat transfer between the two fluids 3,25.

5 The flow of first fluid 3 thus flows down the coiled tubing in a cascading manner, ensuring that the tubing of the circuit 45 is covered in heated fluid, for example. The heat transfer can be enhanced by the use of the falling film, which is characterized by the thinness of the first fluid 3 upon the outside circuit surface 37. At the bottom of the circuit 30, the first fluid 3 is either discarded by gravity (i.e. falling to the bottom of the housing 37, in a channel, etc.) or captured. The flow of the second  
10 fluid 25 can be induced in either a counter-current flow/heat-exchange or a parallel flow/heat-exchange dependent upon the direction of the gravity falling first fluid 3. It can thus be appreciated that an exchange of energy from the first fluid 3 to the second fluid 25, in the form of thermal energy, is achieved.

15 In some optional embodiments, the device 1 includes an electronic control system (i.e. controller 53) for controlling the exchange of energy, and which can measure such exchange. The control system can monitor the pump 19 so that it can pump more or less depending on the efficiency of the device measured in real time. Such control of the pump can be achieved by using temperature sensors, of resistive  
20 or other type, which are installed on the inlet 45a and outlet 45b of the circuit 45. The control system can also detect flow rates for the fluids, and in particular, the second fluid 25, so as to allow for operating the device 1 accordingly. The control system can also detect changes in the volume of first fluid 3 accumulating in the housing 37, and adjust the pump 19 accordingly. The control system 53 can also be fitted with a  
25 transmission module 103, in order to transmit the data by means of wireless or connected capacity.

Moreover, the control system 53 can calculate the energy exchanged and/or recovered according to the flow rate of the second fluid 25 and the difference in  
30 temperature from the inlet 45a to the outlet 45b. To detect the flow rate, a pressure

loss sensor can be used which can determine the coiled circuit 45 pressure drop versus flow rate. The control system can also initiate a purge procedure according to the number of cycles of the device 1. Similarly, the control system 55 can initiate a self-cleaning procedure by either not performing energy exchange, by augmenting the  
5 flow rate, and/or by heating the coiled circuit 45 with electric tape resistance. Furthermore, the control system 53 can advise the operator of all these measurements and parameters, and can suggest maintenance based on the previous performance of system maintenance. All the data from energy measuring, maintenance, etc. can be transmitted or received by means of a data transfer system  
10 103 in order to realise an "intelligent" system that can interact with other control systems.

In some optional embodiments, the device 1 includes a bio-hazard control system 95, an example of which is provided in Figure 33. The bio-hazard control  
15 system can control the water quality of the first or second fluids 3,25, either before or after circulation in the device 1. The bio-hazard control system 48 can employ various techniques, and take different configurations, so as to achieve the above-described functionality. Examples of these include, but are not limited to: UV lamp, electric heating, chemical dilution, ozone generation, application of an antibio-hazard agent,  
20 copper/silver ion control, etc. The bio-hazard control system 95 can be one of, or a combination of these, and can further be controlled manually, automatically, or at pre-set intervals.

In some optional embodiments, the device 1 includes a cleaning system 97, an  
25 example of which is shown in Figure 33. The cleaning system 97 can project, spray, wash, etc. cold, hot or lukewarm water and/or a mixture of water and cleaning agent, onto the outer circuit surface 45c in order to clean the outer surface 45c of possible debris, grease, biological film or other accumulation of material detrimental to the operation of the device 1.

In some optional embodiments, a suction apparatus 87 can be provided and attached either to the device 1 or a source of heated effluent. The suction apparatus can allow for capturing drainage effluent without disturbing the drainage system of the source. The suction apparatus can be fitted on the drain line of the source, such as a dishwasher, and a fluid tubing can then connect to the device 1 so as to collect and/or suck the first fluid 3 passing by. Further optionally, the device 1 can include an evacuation pump 89, which can be used to evacuate the first fluid 3 under pressure, instead of using the sole forces of gravity flow. Further optionally, the device 1 can be used to feed a heat pump or can be integrated with a heat pump system so as to reclaim and heat to a better temperature the preheated amount of second fluid 25, such as shown in Figure 56.

In some optional embodiments, and example of which is shown in Figures 57 and 58, an intermittent hot water make-up device 91 can be integrated within the device 1, or used externally as a complementary module whenever required. The make-up device 91 can be used to complement energy exchange in the device 1 when said device 1 is not able to supply the required flow or temperature needs. In the particular application where heat energy is recovered from a commercial dishwasher, for example, the make-up device 91 allows for the installation of the device 1 without the need to connect it to the hot water heater. The make-up device 91 therefore allows a water supply at the correct flow and temperature requirements to be constantly available to the appliance being served, and this, whether or not the device 1 has recovered a sufficient amount of energy for the appliance in question. One possible technique by which the make-up device 91 accomplishes this is by allowing for an automatic selection of the source of water. Another possible technique is the incorporation of auxiliary source of energy for completing the heating process. Auxiliary equipment such as an electric hot water heater, gas water heater and/or other type of water heater can be incorporated and/or externally connected to the unit.

In one possible configuration, the make-up device 91 consists of a water storage volume, such as piping or tank, 91a, two flow control valves 91b (such as solenoid acting valves, for example), a circulation pump 91c, and a control module 91a with temperature sensors 91e. The make-up device 91 can be used to  
5 complement the device 1, which in this example is used to supply and/or pre-heat a hot water supply to a commercial dishwasher. The solenoid valves can be controlled such that when one is opened, the other is closed (i.e. inverse operation). By default, the hot water from the building's hot water distribution system valve can be opened. The device 1 is connected to said system and recirculates recovered energy through  
10 the storage tank of the make-up device 91 via its circulation pump 91c. When the temperature of the tank 91a attains a preset value, the temperature sensor 91e can activate a sequence whereby the hot water valve is closed and the recovered water valve is opened. The recovered energy water can then be supplied to the appliance for use during the appliance's water-use cycle, until the temperature in the tank  
15 attains a preset value. When this value is attained, the hot water valve opens, the recovered energy valve closes, and the water is then again supplied by the building's hot water system, until enough energy has been reclaimed and the cycle begins again.

20 In some optional embodiments, the device 1 can be used to feed an instantaneous water heater, and/or electric, gas and/or other energy source, or can be integrated with such a heater as a single system. In such a configuration, the device 1 can assist in providing heated second fluid 25 at a predefined temperature such as, but not restricted to, about 140°F to about 180°F.

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The device 1 can be integrated with, or attached to, various devices and/or appliances. Some non-limiting examples of such integration and attachment are provided in Figures 46-59. In Figures 46 and 47, the device 1 receives heated effluent from a dishwasher via a drain-water entrance. The device 1 is provided with an  
30 internal storage volume of second fluid 25. A pump can be used to pump the second

fluid 25 from the storage volume to the circuit 45. The housing 37 consists of an external casing, and is equipped with a display which can be used to display important information to the user/technician. The energy-depleted first fluid 3 can exit the housing via the drain water exit.

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In Figure 48, the device 1 can be used to preheat the second fluid 25 before it is used in a conventional hot water heater. The device 1 is similar to the one shown in Figure 46 or 47. The output of second fluid 25 from the device 1 is directed to a water storage tank, from where it can be drawn by the hot water heater as required.

10 Advantageously, this configuration can reduce the energy required to heat the second fluid 25 in the hot water heater.

In Figure 49, the device 1 is similar to the ones described in Figures 46-48. The device 1 in this configuration can be used to preheat the relatively cold second fluid 25 before it is sent to the dishwasher requiring hot water for cleaning purposes. The device 1 can be used to preheat the second fluid 25, and can store this preheated second fluid 25 in the storage tank. The preheated second fluid 25 can then be drawn from the storage tank to the hot water heater integrated within the dishwasher. Advantageously, this configuration can reduce the energy required to  
20 heat the second fluid 25 in the hot water heater of the dishwasher.

In Figure 50, multiple devices 10 are shown being used, in series or in parallel, to preheat the second fluid 25 before it is used in the dishwasher.

25 In Figure 51, the device 1 is being shown used in conjunction with a storage system, which may be suitable for evacuation of high-flow loads from the dishwasher. The dishwasher may discharge the heated effluent first fluid 3 through an external filtration and catch basin located on the drainage side of the dishwasher. After being filtered, the first fluid 3 can be pumped, or flow under gravity, to the storage system,  
30 which can include a supplemental pump to evacuate high-flow loads from the

dishwasher. From the storage system, the first fluid 3 can be fed slowly (i.e. via gravity) to the device 1. The heated second fluid 25 can then be run back to the dishwasher for use.

5 In Figure 50, the device 1 is shown integrated within the dishwasher, as a component of the dishwasher. Relatively cold second fluid 25 can be preheated by the device 1 via the heated effluent first fluid 3. This preheated second fluid 25 can be stored in the storage tank of the device 1, and from there can be drawn to the hot water heater of the dishwasher.

10 In Figure 53, the device 1 and the storage system of Figure 51 are shown integrated within the dishwasher.

15 In Figure 54, the device 1 is shown positioned beneath a dishwasher, and can be fed hot water effluent (i.e. first fluid 3) by gravity drainage from the dishwasher. The device 1 can be used to pre-heat cold second fluid 25 for use in the dishwasher.

20 In Figure 55, the device 1 is shown positioned beneath a dishwasher, as in Figure 54. Here, the pre-heated second fluid 25 can be used to supply a detachable jet faucet and/or spray valve which is commonly used in restaurant kitchens for cleaning and/or rinsing off dishes before they enter the dishwasher. The amount of heat needed to supply the jet can thus be reduced, advantageously saving energy costs. Indeed, such a configuration can use the residual heat of dishwasher effluent to reduce the amount of hot water used by the spray valve.

25 In Figures 57 and 58, the device 1 is shown associated with an intermittent heat recovery make-up device 91. Here, the recovered energy from device 1 can be stored and discharged in an intermittent way with the help of the make-up device 91. When enough recovered energy is available, full recovered energy is supplied to the dishwasher. When not enough flow is available, the hot water from the existing hot

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water supply system can be used to supply the dishwasher. Optionally, hot water can be blended with the recovered energy water.

As can now be better appreciated in reference to the heat-transferring device described hereinabove, as exemplified in the accompanying drawings, the present invention relates to a method of transferring heat between a discharge fluid 3 of a first system 5 and a second system 7, the method comprising the steps of: a) receiving the discharge fluid 3 from the first system 5; b) conveying the discharge fluid 3 to a given location 9; c) providing at least one non-vertical elongated member 11 being positioned, shaped and sized so as to define an array of stacked cross-sectional profiles 13 extending within at least one wall segment 15, said at least one wall segment 15 being operatively connectable to the second system 7; and d) allowing the discharge fluid 3 to flow (ex. free-fall, free-flow, etc.) over said at least one wall segment 15 of stacked cross-sectional profiles 13 so as to allow a heat exchange between the discharge fluid 3 and the array of stacked cross-sectional profiles.

According to different possible embodiments having been discussed, step a) may comprise: i) the step of filtering debris 47 from the discharge fluid 3 prior to carrying out step b); ii) the step of storing the discharge fluid 3 prior to carrying out step b); and iii) the step of detecting a presence of the discharge fluid 3 in a given location prior to carrying out step b).

According to other possible embodiments having been discussed, step b) may comprise: i) the step of conveying the discharge fluid 3 along an upwardly extending fluid circuit 17; and ii) the step of using a corresponding pump 19 to adjustably control a flow rate of the discharge fluid 3. However, as previously explained, the discharge fluid 3 could be naturally conveyed, via the effect of gravity for example, onto and/or into the device 1, and more particularly, its heat exchanger (i.e. the at least one wall segment 15 of stacked cross-sectional profiles 13, etc.).

According to other possible embodiments having been discussed, step c) may comprise: i) the step of providing at least one hollow tube 21 so as to define a fluid path 23 along which a working fluid 25 of the second system 7 is allowed to travel; ii) the step of providing a plurality of hollow tubes 21 being interconnectable to one another so as to define a fluid path 23 along which a working fluid 25 of the second system is allowed to travel; iii) the step of providing a closed fluid path 23; iv) the step of providing a single-wall fluid path 23; and v) the step of providing a double-wall fluid path 23 having an inner wall 23a and an outer wall 23b, a working fluid 25 of the second system 7 being configured for travelling within the inner wall 23a) of the fluid path 23 and air 27 being provided between the inner wall 23a and the outer wall 23b.

As also discussed hereinabove, step c) may also comprise the step of providing a leak-detecting mechanism 29, and according to one possible embodiment, the step of providing a leak-detecting mechanism 29 comprises the step of defining a recess 31 within one wall of a pair of inner and outer walls 23a, 23b, as better shown in Figures 31 and 32, wherein in these particular examples, the inner and outer walls 23a, 23b are shown concentric with respect to one another.

According to a particular given embodiment, step c) comprises the step of conveying a working fluid 25 of the second system 7 along a fluid path 23 extending within the at least one wall segment 15 of cross-sectional profiles 13 so as to allow a heat transfer between said working fluid 25 of the second system 7 and the discharge fluid 3 of the first system 5 free-falling over said the at least one wall segment 15 of stacked cross-sectional profiles 13. The working fluid 25 of the second system 7 may be water, for example, although other types of suitable working fluids (ex. refrigerants, etc.) could also be used with the present system.

Step c) can also comprise the step of selecting at least one flow direction 33 for the working fluid 25 of the second system 7 along the fluid path 23 so as adjustably select a type of heat exchange between the discharge fluid 3 and the

working fluid 25 via the at least one wall segment 15 of stacked cross-sectional profiles 13, and according to a possible embodiment, step c) comprises the step of selectively conveying the working fluid 25 between opposite first and second flow directions 33a,33b along the fluid path 23. Namely, flow direction and flow rate of the working fluid 25 can be adjustably selected so that a heat exchange between the discharge fluid 3 and the working fluid 25 via the at least one wall segment 15 of stacked cross-sectional profiles 13 adjustably ranges between a parallel heat exchange and a counter-current heat exchange, as discussed hereinabove.

According to other possible embodiments, step c) comprises the step of conveying the working fluid 25 along the fluid path 23 in a pressurized manner.

Step c) can also comprise the step of extending the fluid path 23 in a substantially coiled manner about a vertical axis 35 and within a given confined housing 37. The fluid path 23 can comprise a plurality of upwardly-extending loops 39 or a bended hollow tube geometry.

In applications where the working fluid 25 of the second system 7 is a fluid having a temperature less than that of the discharge fluid 3 of the first system 5 so that heat is transferred from the first system 5 to the second system 7, the method can be used for cooling the discharge fluid 3 of the first system 5 prior to effluence into a given system. The method can also be used for recuperating heat from the discharge fluid 3 of the first system 5 so as to employ said heat as workable heat for a given system.

In applications where the working fluid 25 of the second system 7 is a fluid having a temperature higher than that of the discharge fluid 25 of the first system 5 so that heat is transferred from the second system 7 to the first system 5, the method can be used for cooling the working fluid 25 of the second system 7 prior to effluence into a given system. The method can also be used for recuperating heat from the

working fluid 25 of the first system 5 so as to employ said heat as workable heat for a given system.

As was discussed in reference to Figures 46-59, and depending on the given applications and the desired end results, the above-mentioned given system can be either the first system 5, the second system 7 and/or another separate system. Indeed, the method further can comprise the step of storing working fluid 25 having extracted heat from the discharge fluid 3 back as a source of usable heat-containing fluid 25', for any of the above-mentioned systems. For instance, the method can comprise the step of redirecting working fluid 25 having extracted heat from the discharge fluid 3 back into the first system 5 as a source of usable heat-containing fluid 25' for said first system 5. Alternatively, the method can comprise the step of redirecting working fluid 25 having extracted heat from the discharge fluid 3 into another different system as a source of usable heat-containing fluid 25' for said different system.

According to other possible embodiments, step d) may comprise: i) the step of exposing the discharge fluid 3 to atmospheric pressure; ii) the step of diffusing the discharge fluid 3 over a flow equalizing surface 41; iii) the step of allowing the discharge fluid 3 to free-fall via gravity in a substantially transversal manner with respect to a longitudinal disposition of the stacked cross-sectional profiles 13 contained within the at least one wall segment 15; iv) the step of allowing the discharge fluid 3 to free-fall over opposite front and rear sides 15a,15b of the at least one wall segment 15 of stacked cross-sectional profiles 13; v) the step of providing a gap 43 between adjacent cross-sectional profiles 13a,13b so as to allow free-falling discharge fluid 3 to pass from one side 15a,15b of the at least one wall segment 15 of stacked cross-sectional profiles 13 to another opposite side 15b,15a of said at least one wall segment 15, which enables to improve the lateral liquid dispersion on the wall segment, etc.; vi) the step of allowing the discharge fluid 3 to free-fall directly over outer peripheral surfaces 13c of stacked cross-sectional profiles 13; vii) the step

of adjusting flow rate parameters to ensure that the discharge fluid 3 free-falling directly over outer peripheral surfaces 13c of stacked cross-sectional profiles 13 creates a falling-fluid-film 3f which coats said stacked cross-sectional profiles 13 via a capillary action of the discharge fluid 3 travelling over said stacked cross-sectional profiles 13, etc.

Depending on particular application and desired end results, dimensional values of stacked cross-sectional profiles 13 may differ between adjacent stacked cross-sectional profiles 13a,13b. For example, a given upper cross-sectional profile 13a within the array of stacked cross-sectional profiles 13 may be bigger than a subsequent lower cross-sectional profile 13b within said array of stacked cross-sectional profiles 13, as shown in Figure 23. Alternatively, a given upper cross-sectional profile 13a) within the array of stacked cross-sectional profiles 13 may be smaller than a subsequent lower cross-sectional profile 13b) within said array of stacked cross-sectional profiles, as shown in Figure 24. This provides a way of controlling different parameters, such as debris accumulation, flow repartition, etc. The stacked profiles 13 can also be offset and/or staggered in order to control the falling flow characteristics and thus control and/or optimize heat transfer or debris filtration.

According to a particular embodiment, dimensional values of stacked cross-sectional profiles 13 are substantially the same between adjacent stacked cross-sectional profiles 13a,13b, as shown in Figure 22. Also, the array of stacked cross-sectional profiles 13 extending within the at least one wall segment 15 can be an array of stacked hollow tubes 21 which define a fluid path 23 along which a working fluid 25 of the second system 7 is allowed to travel.

Stacked hollow tubes 21 of the at least one wall segment 15 of stacked tubes 21 can be cylindrical tubes 21, and according to another possible embodiment, diameters of stacked tubes 21 may be substantially the same throughout the at least one wall segment 15 of stacked tubes 21. However, it is worth mentioning that the

stacked hollow tubes 21 of the at least one wall segment 15 of stacked tubes 21 may be tubes having varied cross-sectional profiles 13, such as, for example: a triangular cross-sectional profile 13, a rectangular cross-sectional profile 13, a square cross-sectional profile 13, a polygonal cross-sectional profile 13, an elliptical cross-sectional profile 13 and a circular cross-sectional profile 13, as shown in Figure 25.

According to other possible embodiments, step d) may also comprises at least one step selected from the group consisting of: i) controlling an energy exchange between the discharge fluid 3 and the least one wall segment 15 of cross-sectional profiles 13, ii) controlling a pumping flow rate of the discharge fluid 3 free-falling over said at least one wall segment 15 of stacked cross-sectional profiles 13, and iii) controlling a temperature difference between two different points of the at least one non-vertical elongated member 11.

Step d) may also comprise at least one step selected from the group consisting of: iv) controlling a temperature difference between working fluid 25 of the second system 7 travelling at two different locations along a fluid path 23, v) controlling a flow rate of working fluid 25 travelling between said two different locations, vi) controlling bio-hazard quality of the discharge fluid 3, and vii) controlling bio-hazard quality of the working fluid 25.

Bio-hazard control can be carried out using a component selected from the group consisting of UV lamp, electric heating, chemical dilution, ozone generation, application of an antibio-hazard agent and copper/silver ion control.

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As explained therein, the method can comprise the step of carrying out steps a), b), c) and d) within a same housing 37 being configured for retrofitting onto a conventional system (i.e. an appliance, such as a dishwasher, for example, etc.). Alternatively, the method may comprise the step of carrying out steps a), b), c) and d) in an integrated manner within said conventional system.

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According to other possible embodiments, the method may comprise the step of e) recuperating discharge fluid 3 after having free-fallen over said at least one wall segment 15 of stacked cross-sectional profiles 13. Step e) may further comprise the step of evacuating discharge fluid 3.

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According to other possible embodiments, the method may comprise the step of f) cleaning discharge fluid debris 47 off from stacked cross-sectional profiles 13 of the at least one wall segment 15 of stacked cross-sectional profiles 13.

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Step f) comprises the step of spraying cleaning product 49 within the housing 37 and onto the stacked cross-sectional profiles 13 of the at least one wall segment 15 of stacked cross-sectional profiles 13 so as to remove discharge fluid debris 47 from said stacked cross-sectional profiles 13. Alternatively and/or in combination with this first option, step f) may also comprise the step of soaking the stacked cross-sectional profiles 13 of the at least one wall segment 15 of stacked cross-sectional profiles 13 within the housing 37 with a cleaning solution 51 so as to remove discharge fluid 47 debris from said stacked cross-sectional profiles 13.

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Different combinations of the different steps and sub-steps of the method are contemplated. For example, steps a), b), c) and d) could be carried out in parallel. Alternatively, the method can comprise the step of carrying out steps a), b), c) and d) in series. According to a given embodiment, steps of the method, including a cleaning step, are carried out in an automated manner via a controller 53.

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According to another aspect of the present invention, there is provided an assembly being provided with such a device. In the examples given, the assembly has been shown as a dishwasher, wherein the discharge fluid 3 is hot discharge fluid from the dishwasher, and wherein the device 1 is used for recuperating heat from the hot discharge fluid of the dishwasher. However, as can be easily understood, the assembly can be any assembly with which the present device could be used and may

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be useful, such as, for example, a washing machine, a system for processing discharge fluid from an industrial process, a system for processing discharge fluid from a cooling process, a system for processing residential discharge fluid, a system for processing commercial discharge fluid, a system for processing sewer discharge fluid, a system conveying a natural water stream, etc.

As previous explained, and according to another aspect of the present invention, there is provided a kit with corresponding components for assembling a device 1 (and/or resulting assembly including the same) such as the one described and illustrated herein. Similarly, an appliance (i.e. dishwasher, air conditioner, washing machine, etc.), or a process of an industrial or residential nature, can be provided with any and/or all of the components of the device 1 described above.

Numerous modifications can be made to the present heat-transferring device 1, without departing from the scope of the present disclosure. For example, and as previously explained, the at least one non-vertical elongated member 11 being positioned, shaped and sized so as to define an array of stacked cross-sectional profiles 13 extending within at least one wall segment 15, is not necessarily limited to being disposed about a "coiled" pattern extending about a vertical axis 35 within a housing 37, and may take on various other geometrical dispositions within various other types of environments, depending on the particular application(s) for which the heat-transferring device 1 is intended for, and the desired end result(s).

Furthermore, although the at least one elongated member 11 has been exemplified as being possibly a "tube" 21 along which a working fluid 25, such a fluid of a second system 7, is meant to interact with the first fluid 3 of a first system 5, it is worth mentioning that said at least non-vertical elongated member 11 does not necessarily need to be "hollow", and that ultimately, the at least one non-vertical elongated member 11 being positioned, shaped and sized so as to define an array of stacked cross-sectional profiles 13 extending with at least one wall segment 15 could

be "full", so that the at least one wall segment 15 of stacked cross-sectional profiles 13 would be at least one wall segment of "full" cross-sectional profiles 13, which would have a temperature different from that of the first fluid 3 of the first system 5 with which the heat-transferring device 1 could be used, so as to ensure a corresponding heat transfer between this first fluid 3 and the at least one wall segment 15 of "full" cross-sectional profiles 13, being operatively connected to the second system 7.

Also, and as previously explained, depending on the particular application(s) for which the heat-transferring device 1 would be intended for, and the desired end result(s), the at least one wall segment 15 of "full" cross-sectional profiles 13, which could be or not provided with corresponding gaps 43, as discussed hereinabove, could be varied in temperature, with a corresponding temperature-regulation component, so as to vary an extent of heat transfer between the first fluid 3 of the first system 5 and the second system 7 operatively connected to such a wall segment 15 of "full" cross-sectional profiles 13.

It is also worth mentioning also that the disposition of the cross-sectional profiles 13 is not limited to be substantially "horizontal" disposition within the at least one wall segment 15, in that, various other suitable and/or varied dispositions, such as "slanted" for example, could be envisioned and used for the present heat-transferring device 1, depending on the particular application(s) for which it is intended for, and the desired end result(s), and also, even though the at least one wall segment 15 has been shown as being partially "curved" due to the fact that a coil pattern has been exemplified in the accompanying drawings for a possible at least one non-vertical member 11, it is worth mentioning that said at least one wall segment 15 of stacked cross-sectional profiles 13 could have various other geometrical configurations. For example, the at least one wall segment 15 could simply be a "straight" wall segment 15 wherein the stacked cross-sectional profiles 13

extend therein along various other suitable positional and/or geometrical configurations.

As can be appreciated in light of the preceding, the device 1 offers advantages over the prior art in that, by virtue of its design and components, the device 1 simultaneously enables an exchange of energy between the fluids 3,25 so as to meet the energy recovery requirements, while being resistant to fouling and remaining relatively inexpensive to produce.

Indeed, in many known heat transfer applications, the presence of impurities such as debris, particulates or other contaminants are detrimental to the continuous operation of the heat exchange process. The device 1 advantageously overcomes this drawback because of the "falling film" of first fluid 3 over the coiled circuit 30, which flushes the debris with the flow. Also, in the event of any debris still remain on the coiled circuit 30, these debris can be easily cleaned because the coiled circuit 30 is meant to be selectively "exposed" (ex. by accessing to the inside housing by removing panels, etc., if such a housing is being used with the device 1, etc.).

Furthermore, the device 1 is advantageously suited for the particular exemplary use with a dishwasher because of the significant heat transfer rates that the device 1 can provide. In addition, the device 1 can be produced compactly, which can increase operational efficiencies and further facilitate its use and/or integration with an appliance. The device 1 addresses at least some of the problems associated with heat recovery from a hot, intermittent effluent source for preheating cold water. The use of a pump and filter provides a complete energy exchange solution.

The following non-limitative list of advantages may also be associated with the device 1:

- energy recovery of effluent to heat hot water consumption;
- use of recovered energy for cooling purposes;
- capture and disposal of food waste from dishwater effluent with manual or

automatic straining device;

- relatively small footprint;
- hot fluid entrance can be placed as low to the ground as possible;
- self diagnostic electronic control;
- 5      - continuous and real-time measurement of energy efficiency;
- relatively low production costs;
- self-cleaning through the "falling film" flow;
- self-cleaning through an automatic spray system;
- smooth surfaces prevent the trapping of contaminants;
- 10      - relatively easy visual inspection of the device 1 and/or its features;
- relatively easy to service, either by a lay person or by a technician;
- bio-hazard control via a dedicated, automated system; and
- installation as a stand-alone hot water/recovered water supply system with the use of components of a make-up device.

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The following performance indicators were estimated for a given device 1 having a height of about 16 to 36 in., a width of about 16 to 30 in., and a length of about 10 to 30 in. It is of course understood that the device 1 can be scaled either up or down as required.

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- Heat recovery power: 5 to 30 kW
- Heat recovery efficiency: 50 % to 70 %
- Preheated second fluid 25 flow rate/pump capacity 1 to 10 usgpm (variable speed)

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- First fluid 3 pump capacity: 1 to 20 usgpm (variable speed)

- Drain rate capacity from dishwasher: 0 to 50 usgpm
- Internal volume of the housing 37: 1 to 20 gallons

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- First fluid entrance temperature (from dishwasher): 120 to 180 F
- Second fluid exit (i.e. preheated) temperature: 60 F to 140 F

- Material: Stainless steel
- (external), PVC, copper

- Electric voltage: 48 VDC, 120 V AC

- External pump flow rate: 40 to 100 usgpm

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- Storage volume: 10 to 30 usg

The following performance indicators were estimated for a given device 1 consisting of a single wall about 20 mm diameter copper tube vertically wound in a circular coil pattern for 10 revolutions, and having a total height of about 250 mm and a coil diameter of about 250 mm. It is of course understood that the device 1 can be scaled either up or down as required, to adapt for heat exchange capacity ranging from about 100 W to about 1 MW.

|    |                             |                                                                |
|----|-----------------------------|----------------------------------------------------------------|
| 10 | - Heat recovery power:      | up to 40 kW                                                    |
|    | - Heat recovery efficiency: | 50 % to 80 %                                                   |
|    | - Second fluid 25 flow rate | 1 to 7 usgpm                                                   |
|    | - First fluid 3 flow rate:  | 1 to 7 usgpm                                                   |
| 15 | Material:                   | Stainless steel (external),<br>PVC, copper, aluminium,<br>etc. |

In ending, the scope of the claims should not be limited by the possible embodiments set forth in the examples, but should be given the broadest interpretation consistent with the description as a whole.

## CLAIMS:

1. A method of transferring heat between a discharge fluid (3) of a first system (5) and a second system (7), the method comprising the steps of:

5 e) receiving the discharge fluid (3) from the first system (5);

f) conveying the discharge fluid (3) to a given location (9);

g) providing at least one non-vertical elongated member (11) being positioned, shaped and sized so as to define an array of stacked cross-sectional profiles (13) extending within at least one wall segment (15), said at least  
10 one wall segment (15) being operatively connectable to the second system (7); and

h) allowing the discharge fluid (3) to free-flow over said at least one wall segment (15) of stacked cross-sectional profiles (13) so as to allow a heat exchange between the discharge fluid (3) and the array of stacked cross-  
15 sectional profiles.

2. Method according to claim 1, wherein step a) comprises the step of filtering debris (47) from the discharge fluid (3) prior to carrying out step b).

20 3. Method according to claim 1 or 2, wherein step a) comprises the step of storing the discharge fluid (3) prior to carrying out step b).

4. Method according to any one of claims 1-3, wherein step a) comprises the step of detecting a presence of the discharge fluid (3) in a given location prior to  
25 carrying out step b).

5. Method according to any one of claims 1-4, wherein step b) comprises the step of conveying the discharge fluid (3) along an upwardly extending fluid circuit (17).

6. Method according to any one of claims 1-5, wherein step b) comprises the step of using a corresponding pump (19) to adjustably control a flow rate of the discharge fluid (3).

5 7. Method according to any one of claims 1-6, wherein step c) comprises the step of providing at least one hollow tube (21) so as to define a fluid path (23) along which a working fluid (25) of the second system (7) is allowed to travel.

10 8. Method according to any one of claims 1-6, wherein step c) comprises the step of providing a plurality of hollow tubes (21) being interconnectable to one another so as to define a fluid path (23) along which a working fluid (25) of the second system is allowed to travel.

15 9. Method according to any one of claims 1-8, wherein step c) comprises the step of providing a closed fluid path (23).

10. Method according to any one of claims 1-9, wherein step c) comprises the step of providing a single-wall fluid path (23).

20 11. Method according to any one of claims 1-9, wherein step c) comprises the step of providing a double-wall fluid path (23) having an inner wall (23a) and an outer wall (23b), a working fluid (25) of the second system (7) being configured for travelling within the inner wall (23a) of the fluid path (23) and air (27) being provided between the inner wall (23a) and the outer wall (23b).

25 12. Method according to any one of claims 1-11, wherein step c) comprises the step of providing a leak-detecting mechanism (29).

30 13. Method according to claim 12, wherein the step of providing a leak-detecting mechanism (29) comprises the step of defining a recess (31) within one wall of a pair of inner and outer walls (23a,23b).

14. Method according to claim 13, wherein the inner and outer walls (23a, 23b) are concentric with respect to one another.

15. Method according to any one of claims 1-14, wherein step c) comprises the step of conveying a working fluid (25) of the second system (7) along a fluid path (23) extending within the at least one wall segment (15) of cross-sectional profiles (13) so as to allow a heat transfer between said working fluid (25) of the second system (7) and the discharge fluid (3) of the first system (5) free-falling over said the at least one wall segment (15) of stacked cross-sectional profiles (13).

16. Method according to claim 15, wherein step c) comprises the step of selecting at least one flow direction (33) for the working fluid (25) of the second system (7) along the fluid path (23) so as adjustably select a type of heat exchange between the discharge fluid (3) and the working fluid (25) via the at least one wall segment (15) of stacked cross-sectional profiles (13).

17. Method according to claim 14 or 16, wherein step c) comprises the step of selectively conveying the working fluid (25) between opposite first and second flow directions (33a,33b) along the fluid path (23).

18. Method according to any one of claims 15-17, wherein flow direction and flow rate of the working fluid (25) are adjustably selected so that a heat exchange between the discharge fluid (3) and the working fluid (25) via the at least one wall segment (15) of stacked cross-sectional profiles (13) adjustably ranges between a parallel heat exchange and a counter-current heat exchange.

19. Method according to any one of claims 15-18, wherein step c) comprises the step of conveying the working fluid (25) along the fluid path (23) in a pressurized manner.

20. Method according to any one of claims 15-19, wherein step c) comprises the step of extending the fluid path (23) in a substantially coiled manner about a vertical axis (35) and within a given confined housing (37).

5 21. Method according to any one of claims 15-20 wherein the fluid path (23) comprises a plurality of upwardly-extending loops (39).

22. Method according to any one of claims 15-20, wherein the working fluid (25) of the second system (7) is a fluid having a temperature less than that of the  
10 discharge fluid (3) of the first system (5) so that heat is transferred from the first system (5) to the second system (7).

23. Method according to any one of claims 1-22, wherein the method is used for cooling the discharge fluid (3) of the first system (5) prior to effluence into a  
15 given system.

24. Method according to any one of claims 1-23, wherein the method is used for recuperating heat from the discharge fluid (3) of the first system (5) so as to employ said heat as workable heat for a given system.

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25. Method according to any one of claims 15-20, wherein the working fluid (25) of the second system (7) is a fluid having a temperature higher than that of the discharge fluid (25) of the first system (5) so that heat is transferred from the second system (7) to the first system (5).

25

26. Method according to any one of claims 1-25, wherein the method is used for cooling the working fluid (25) of the second system (7) prior to effluence into a given system.

30

27. Method according to any one of claims 1-26, wherein the method is used for recuperating heat from the working fluid (25) of the first system (5) so as to employ said heat as workable heat for a given system.

28. Method according to any one of claims 23, 24, 26 or 27, wherein the given system is selected from the group consisting of the first system (5), the second system (7) and another separate system.

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29. Method according to any one of claims 15-28, wherein the working fluid (25) of the second system (7) is water.

30. Method according to any one of claims 1-29, wherein the method further comprises the step of storing working fluid (25) having extracted heat from the discharge fluid (3) back as a source of usable heat-containing fluid (25').

31. Method according to any one of claims 25-30, wherein the method further comprises the step of redirecting working fluid (25) having extracted heat from the discharge fluid (3) back into the first system (5) as a source of usable heat-containing fluid (25') for said first system (5).

32. Method according to any one of claims 25-31, wherein the method further comprises the step of redirecting working fluid (25) having extracted heat from the discharge fluid (3) into another different system as a source of usable heat-containing fluid (25') for said different system.

33. Method according to any one of claims 1-32, wherein step d) comprises the step of exposing the discharge fluid (3) to atmospheric pressure.

25

34. Method according to any one of claims 1-33, wherein step d) comprises the step of diffusing the discharge fluid (3) over a flow equalizing surface (41).

35. Method according to any one of claims 1-34, wherein step d) comprises the step of allowing the discharge fluid (3) to free-fall via gravity in a substantially transversal manner with respect to a longitudinal disposition of the stacked cross-sectional profiles (13) contained within the at least one wall segment (15).

30

36. Method according to any one of claims 1-35, wherein step d) comprises the step of allowing the discharge fluid (3) to free-fall over opposite front and rear sides (15a,15b) of the at least one wall segment (15) of stacked cross-sectional profiles (13).  
5

37. Method according to any one of claims 1-36, wherein step d) comprises the step of providing a gap (43) between adjacent cross-sectional profiles (13a,13b) so as to allow free-falling discharge fluid (3) to pass from one side (15a,15b) of the at least one wall segment (15) of stacked cross-sectional profiles (13) to another opposite side (15b,15a) of said at least one wall segment (15).  
10

38. Method according to any one of claims 1-37, wherein step d) comprises the step of allowing the discharge fluid (3) to free-fall directly over outer peripheral surfaces (13c) of stacked cross-sectional profiles (13).  
15

39. Method according to any one of claims 1-38, wherein step d) comprises the step of adjusting flow rate parameters to ensure that the discharge fluid (3) free-falling directly over outer peripheral surfaces (13c) of stacked cross-sectional profiles (13) creates a falling-fluid-film (3f) which coats said stacked cross-sectional profiles (13) via a capillary action of the discharge fluid (3) travelling over said stacked cross-sectional profiles (13).  
20

40. Method according to any one of claims 1-39, wherein dimensional values of stacked cross-sectional profiles (13) differ between adjacent stacked cross-sectional profiles (13a,13b).  
25

41. Method according to any one of claims 1-40, wherein a given upper cross-sectional profile (13a) within the array of stacked cross-sectional profiles (13) is bigger than a subsequent lower cross-sectional profile (13b) within said array of stacked cross-sectional profiles (13).  
30

42. Method according to any one of claims 1-40, wherein a given upper cross-sectional profile (13a) within the array of stacked cross-sectional profiles (13) is smaller than a subsequent lower cross-sectional profile (13b) within said array of stacked cross-sectional profiles.

5

43. Method according to any one of claims 1-40, wherein dimensional values of stacked cross-sectional profiles (13) are substantially the same between adjacent stacked cross-sectional profiles (13a, 13b).

10

44. Method according to any one of claims 1-43, wherein the array of stacked cross-sectional profiles (13) extending within the at least one wall segment (15) is an array of stacked hollow tubes (21) which define a fluid path (23) along which a working fluid (25) of the second system (7) is allowed to travel.

15

45. Method according to claim 44, wherein stacked hollow tubes (21) of the at least one wall segment (15) of stacked tubes (21) are tubes having a cross-sectional profile (13) selected from the group consisting of triangular cross-sectional profile (13), rectangular cross-sectional profile (13), square cross-sectional profile (13), polygonal cross-sectional profile (13), elliptical cross-sectional profile (13) and  
20 circular cross-sectional profile (13).

25

46. Method according to claim 44 or 45, wherein stacked hollow tubes (21) of the at least one wall segment (15) of stacked tubes (21) are cylindrical tubes (21).

47. Method according to any one of claims 44-46, wherein diameters of stacked tubes (21) are substantially the same throughout the at least one wall segment (15) of stacked tubes (21).

30

48. Method according to any one of claims 1-47, wherein step d) comprises at least one additional step selected from the group consisting of: i) controlling an energy exchange between the discharge fluid (3) and the least one wall segment (15)

of cross-sectional profiles (13), ii) controlling a pumping flow rate of the discharge fluid (3) free-falling over said at least one wall segment (15) of stacked cross-sectional profiles (13), and iii) controlling a temperature difference between two different points of the at least one non-vertical elongated member (11).

5

49. Method according to any one of claims 1-48, wherein step d) comprises at least one additional step selected from the group consisting of: iv) controlling a temperature difference between working fluid (25) of the second system (7) travelling at two different locations along a fluid path (23), v) controlling a flow rate of working  
10 fluid (25) travelling between said two different locations, vi) controlling bio-hazard quality of the discharge fluid (3), and vii) controlling bio-hazard quality of the working fluid (25).

50. Method according to claim 49, wherein bio-hazard control is carried out  
15 using a component selected from the group consisting of UV lamp, electric heating, chemical dilution, ozone generation, application of an antibio-hazard agent and copper/silver ion control.

51. Method according to any one of claims 1-50, wherein the method  
20 comprises the step of carrying out steps a), b), c) and d) within a same housing (37) being configured for retrofitting onto a conventional system.

52. Method according to any one of claims 1-50, wherein the method  
25 comprises the step of carrying out steps a), b), c) and d) in an integrated manner within a conventional system.

53. Method according to any one of claims 1-52, wherein the method comprises the step of venting the housing (37).

57

54. Method according to any one of claims 1-53, wherein the method comprises the step of e) recuperating discharge fluid (3) after having free-fallen over said at least one wall segment (15) of stacked cross-sectional profiles (13).

5 55. Method according to claim 54, wherein step e) further comprises the step of evacuating discharge fluid (3).

56. Method according to any one of claims 1-55, wherein the method comprises the step of f) cleaning discharge fluid debris (47) off from stacked cross-sectional profiles (13) of the at least one wall segment (15) of stacked cross-sectional profiles (13).

10

57. Method according to claim 56, wherein step f) comprises the step of spraying cleaning product (49) within the housing (37) and onto the stacked cross-sectional profiles (13) of the at least one wall segment (15) of stacked cross-sectional profiles (13) so as to remove discharge fluid debris (47) from said stacked cross-sectional profiles (13).

15

58. Method according to claim 56 or 57, wherein step f) comprises the step of soaking the stacked cross-sectional profiles (13) of the at least one wall segment (15) of stacked cross-sectional profiles (13) within the housing (37) with a cleaning solution (51) so as to remove discharge fluid (47) debris from said stacked cross-sectional profiles (13).

20

25 59. Method according to any one of claims 1-58, wherein the method comprises the step of carrying out steps a), b), c) and d) in parallel.

60. Method according to any one of claims 1-58, wherein the method comprises the step of carrying out steps a), b), c) and d) in series.

30

61. Method according to any one of claims 1-60, wherein steps of the method, including a cleaning step, are carried out in an automated manner via a controller (53).

5 62. A device (1) for carrying out a method according to any one of claims 1-61, for transferring heat between a discharge fluid (3) of a first system (5) and a second system (7), the device (1) including:

a housing (37);

10 a conveying assembly (55) for conveying the discharge fluid (3) from the first system (5) to a given location (9);

a heat exchanger assembly (57) operatively connectable to the conveying assembly, the heat exchanger assembly (57) including at least one non-vertical elongated member (11) being positioned, shaped and sized so as to define an array of stacked cross-sectional profiles (13) extending within at least one wall segment (15), said at least one wall segment (15) being operatively connectable to the second system (7); and

15 a distributing assembly (59) for allowing discharge fluid (3) provided by the conveying assembly (55) to free-flow over a part of the array of cross-sectional profiles (13) so as to allow a heat exchange between the discharge fluid (3) and the array of cross-sectional profiles (13).

63. Device (1) according to claim 62, wherein the conveying assembly (55) is contained within the housing (37).

25 64. Device (1) according to claim 62 or 63, wherein the heat exchanger assembly (57) is contained within the housing (37).

65. Device (1) according to any one of claims 62-64, wherein the heat exchanger assembly (57) is provided with a gap (43) between adjacent cross-sectional profiles (13a,13b) so as to allow free-falling discharge fluid (3) to pass from

30

one side (15a,15b) of the at least one wall segment (15) of stacked cross-sectional profiles (13) to another opposite side (15b,15a) of said at least one wall segment (15).

66. Device (1) according to any one of claims 62-65, wherein dimensional  
5 values of stacked cross-sectional profiles (13) differ between adjacent stacked cross-sectional profiles (13a,13b).

67. Device (1) according to any one of claims 62-66, wherein a given upper  
cross-sectional profile (13a) within the array of stacked cross-sectional profiles (13) is  
10 bigger than a subsequent lower cross-sectional profile (13b) within said array of stacked cross-sectional profiles (13).

68. Device (1) according to any one of claims 62-66, wherein a given upper  
cross-sectional profile (13a) within the array of stacked cross-sectional profiles (13) is  
15 smaller than a subsequent lower cross-sectional profile (13b) within said array of stacked cross-sectional profiles (13).

69. Device (1) according to any one of claims 62-66, wherein dimensional  
values of stacked cross-sectional profiles (13) are substantially the same between  
20 adjacent stacked cross-sectional profiles (13a,13b).

70. Device (1) according to any one of claims 62-69, wherein the array of  
stacked cross-sectional profiles (13) extending within the at least one wall segment  
(15) is an array of stacked hollow tubes (21) which define a fluid path (23) along  
25 which a working fluid (25) of the second system (7) is allowed to travel.

71. Device (1) according to claim 70, wherein stacked hollow tubes (21) of  
the at least one wall segment (15) of stacked tubes (21) are tubes (21) having a  
cross-sectional profile (23) selected from the group consisting of triangular cross-  
30 sectional profile (13), rectangular cross-sectional profile (13), square cross-sectional

60

profile (13), polygonal cross-sectional profile (13), elliptical cross-sectional profile (13) and circular cross-sectional profile (13).

72. Device (1) according to claim 70 or 71, wherein stacked hollow tubes  
5 (21) of the at least one wall segment (15) of stacked tubes (21) are cylindrical tubes (21).

73. Device (1) according to any one of claims 70-72, wherein diameters of  
10 stacked tubes (21) are substantially the same throughout the at least one wall segment (15) of stacked tubes (21).

74. Device (1) according to any one of claims 62-73, wherein outer surfaces  
15 (13c) of the stacked cross-sectional profiles (13) are surface-treated with a method selected from the group consisting of dipping, galvanizing, annealing and coating.

75. Device (1) according to any one of claims 62-74, wherein the distributing  
assembly (59) includes a flow equalizer (61) for repartitioning a flow of discharge fluid  
(3) to free-fall over the array of cross-sectional profiles (3).

20 76. Device (1) according to claim 75, wherein the flow equalizer (61) includes a diffusion plate (63).

77. Device (1) according to claim 76, wherein the diffusion plate (63) is a  
downwardly-sloping circular pan.

25 78. Device (1) according to claim 75 or 76, wherein the flow the equalizer (61) includes at least one fluid flow channel (65) selected from the group consisting of groove, embossment, hole, spout, dispenser and tubing.

30 79. Device (1) according to any one of claims 62-78, wherein the distributing assembly (59) is contained within the housing (37).

## 61

80. Device (1) according to any one of claims 62-79, wherein the distributing assembly (59) is located above the heat exchanger assembly (57).

5 81. Device (1) according to any one of claims 62-80, wherein the housing (37) includes at least one access panel (67) for accessing components of the device contained within the housing (37).

82. Device (1) according to any one of claims 62-81, wherein the housing (37) includes a vent (69).

10

83. Device (1) according to any one of claims 62-82, wherein the device (1) includes at least one fluid intake (71).

15 84. Device (1) according to any one of claims 62-83, wherein the device (1) includes a first fluid intake (71a) for receiving a first fluid from the first system (5), and a second fluid intake (71b) for receiving a second fluid from the second system (7).

85. Device (1) according to any one of claims 62-84, wherein the device (1) includes at least one fluid exit (73).

20

86. Device (1) according to any one of claims 62-85, wherein the device (1) includes a first fluid exit (73a) for releasing a first fluid from the first system (5), and a second fluid exit (73b) for releasing a second fluid from the second system (7).

25 87. Device (1) according to any one of claims 62-86, wherein the housing (37) includes a fluid receptacle (75) for collecting discharge fluid (3) from the first system (5).

30 88. Device (1) according to claim 87, wherein the fluid receptacle (75) is located at a bottom portion of the housing (37).

89. Device (1) according to any one of claims 62-88, wherein the device (1) includes at least one pump (19) for use with the conveying assembly (55).

## 62

90. Device (1) according to claim 89, wherein the at least one pump (19) is at least one variable-speed pump (19) for adjustably controlling a flow rate of the discharge fluid (3) along the conveying assembly (55).

5

91. Device (1) according to any one of claims 62-90, wherein the device (1) includes a filtering apparatus (77) for filtering debris (47) from the discharge fluid (3).

92. Device (1) according to any one of claims 62-91, wherein the device (1) includes a tank (79) for storing the discharge fluid (3) prior to heat exchange with a second fluid of the second system (7).

10

93. Device (1) according to any one of claims 62-92, wherein the device (1) includes a detector (81) for detecting a presence of fluid in a given location.

15

94. Device (1) according to any one of claims 62-93, wherein the conveying assembly (55) includes an upwardly extending fluid circuit (17).

20

95. Device (1) according to any one of claims 62-94, wherein the array of stacked cross-sectional profiles (13) includes at least one hollow tube (21) so as to define a fluid path (23) along which a working fluid (25) of the second system (7) is allowed to travel.

25

96. Device (1) according to any one of claims 62-95, wherein the array of stacked cross-sectional profiles (13) includes a plurality of hollow tubes (21) being interconnectable to one another so as to define a fluid path (23) along which a working fluid (25) of the second system (7) is allowed to travel.

30

97. Device (1) according to claim 96, wherein the fluid path (23) is a closed fluid path (23).

98. Device (1) according to claim 96 or 97, wherein the fluid path (23) is a single-wall fluid path (23).

99. Device (1) according to claim 96 or 97, wherein the fluid path (23) is a double-wall fluid path (23) having an inner wall (23a) and an outer wall (23b), a working fluid (25) of the second system (7) being configured for travelling within the inner wall (23a) of the fluid path (23) and air (27) being provided between the inner wall (23a) and the outer wall (23b).

100. Device (1) according to any one of claims 96-99, wherein the fluid path (23) extends in a substantially coiled manner about a vertical axis (35) and within the housing (37).

101. Device (1) according to any one of claims 96-100, wherein the fluid path (23) includes a plurality of upwardly-extending interconnectable loops (39).

102. Device (1) according to any one of claims 62-101, wherein the device (1) includes a leak-detecting mechanism (29).

103. Device (1) according to claim 102, wherein the leak-detecting mechanism (29) includes a drainage channel (83).

104. Device (1) according to claim 102 or 103, wherein the leak-detecting mechanism (29) includes a recess (31) defined within one wall of a pair of inner and outer walls (23a,23b).

105. Device (1) according to any one of claims 62-104, wherein the device (1) includes a controller (53) for adjusting flow rate parameters to ensure that the discharge fluid (3) free-falling directly over outer peripheral surfaces (13c) of stacked cross-sectional profiles (13) creates a falling-fluid-film (3f) which coats said stacked cross-sectional profiles (13) via a capillary action of the discharge fluid (3) travelling over said stacked cross-sectional profiles (13).

106. Device (1) according to claim 105, wherein the controller (53) is further configured for controlling at least one of the following: i) an energy exchange between the discharge fluid (3) and the least one wall segment (15) of cross-sectional profiles (13), ii) a pumping rate of the discharge fluid (3) free-falling over said at least one wall segment (15) of stacked cross-sectional profiles (13), and iii) a temperature difference  
5 between two different points of the at least one non-vertical elongated member (11).

107. Device (1) according to claim 105 or 106, wherein the controller (53) is further configured for controlling at least one of the following: iv) a temperature  
10 difference between working fluid (25) of the second system (7) travelling at two different locations along a fluid path, v) a flow rate of working fluid (25) travelling between said two different locations, vi) a bio-hazard quality of the discharge fluid (3), and vii) a bio-hazard quality of the working fluid (25).

108. Device (1) according to any one of claims 105-107, wherein the controller (53) is further configured for initiating a purge procedure of the device (1).  
15

109. Device (1) according to any one of claims 105-108, wherein the controller (53) is further configured for initiating a self-cleaning procedure of the  
20 device (1).

110. Device (1) according to any one of claims 62-109, wherein the device includes internal sprayers (85) for spraying cleaning product (49) within the housing (37) and onto the stacked cross-sectional profiles (13) of the at least one wall segment (15) of stacked cross-sectional profiles (13) so as to remove discharge fluid debris (47) from said stacked cross-sectional profiles (13).  
25

111. Device (1) according to any one of claims 62-110, wherein the housing (37) of the device (1) is configured for receiving a filling-up of cleaning solution (51) in  
30 order to selectively soak the stacked cross-sectional profiles (13) of the at least one wall segment (15) of stacked cross-sectional profiles (13) in the cleaning solution (51)

65

provided within the housing (37) so as to remove discharge fluid debris (47) from said stacked cross-sectional profiles (13).

112. Device (1) according to any one of claims 62-111, wherein the device  
5 (1) includes a suction assembly (87) for sucking fluid out from the housing (37).

113. Device (1) according to claim 112, wherein the suction assembly (87) includes an evacuation pump (89).

10 114. Device (1) according to any one of claims 62-113, wherein the device (1) includes a hot water make-up assembly (91).

115. Device (1) according to claim 114, wherein the hot water make-up assembly (91) includes a storage tank (91a), a pair of control valves (91b), a  
15 circulation pump (91c) and a control module (91d) with temperature sensors (91e).

116. Device (1) according to claim 115, wherein the control valves (91b) are solenoid valves.

20 117. Device (1) according to any one of claims 114-117, wherein the hot water make-up assembly (91) is contained with the housing (37).

118. Device (1) according to any one of claims 62-117, wherein the device (1) includes a display (93) for displaying information pertaining to operational  
25 parameters of the device (1).

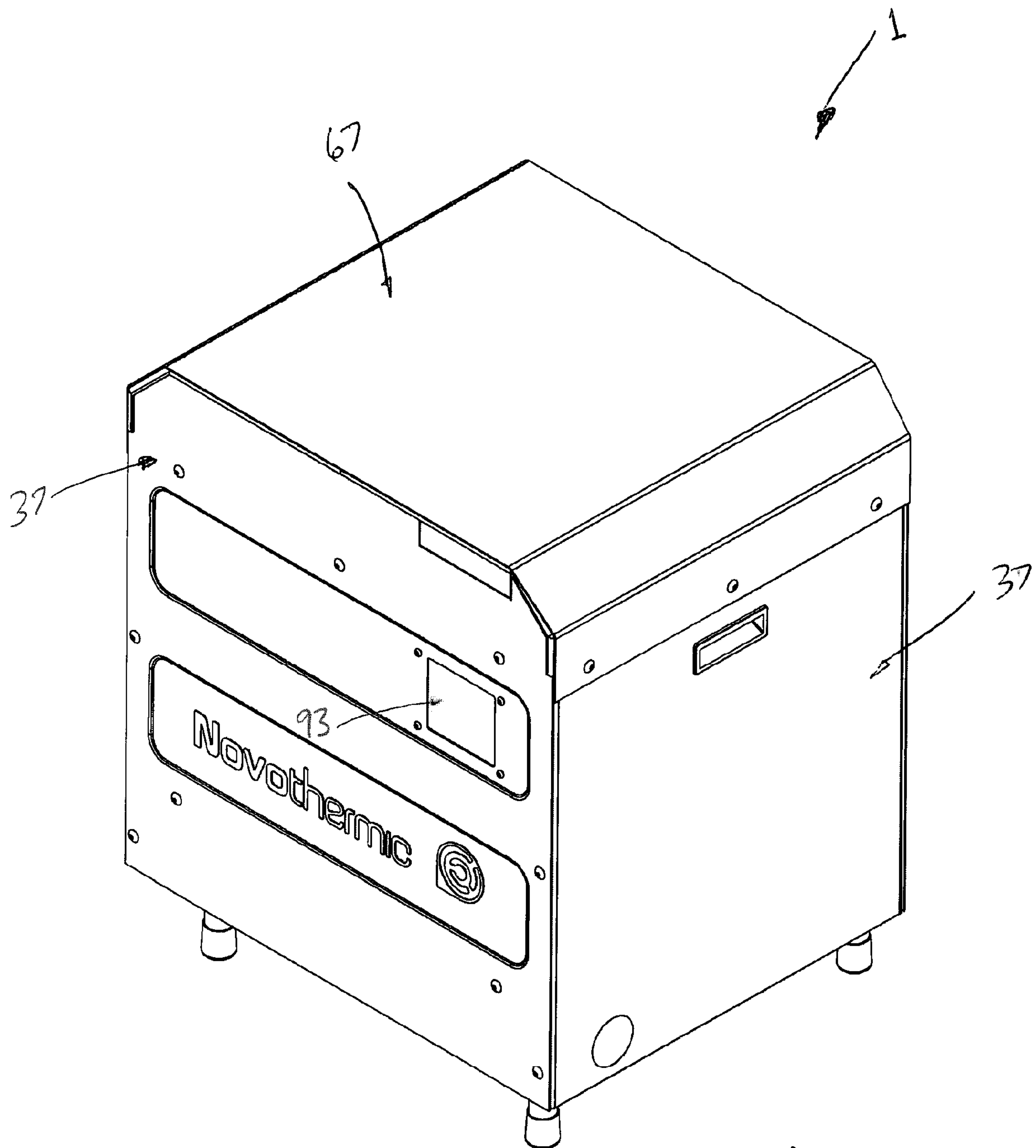
119. Device (1) according to claim 118, wherein the display (1) is configured for displaying an amount of saved energy.

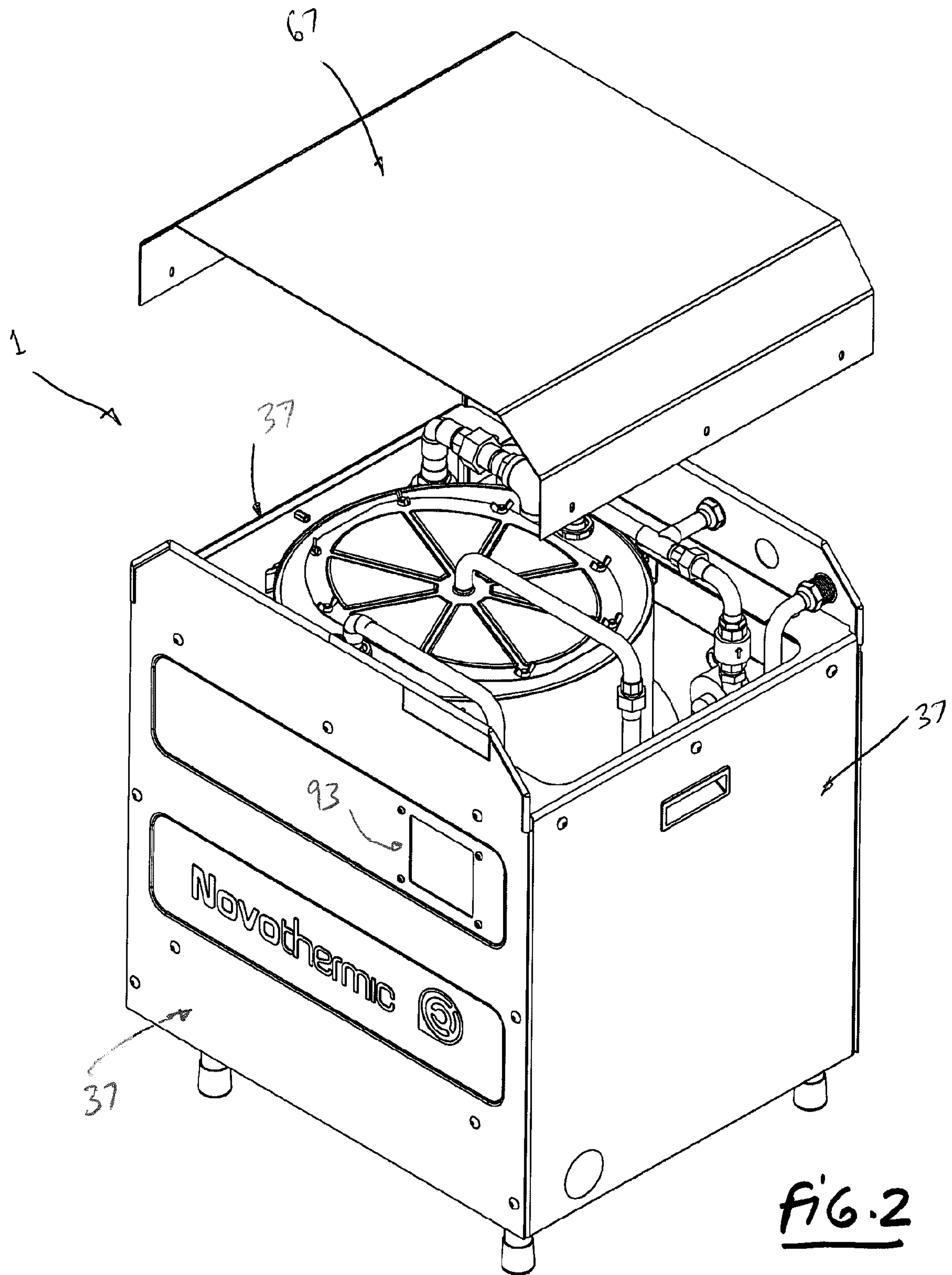
30 120. A kit with corresponding components for assembling a device (1) according to any one of claims 62-119.

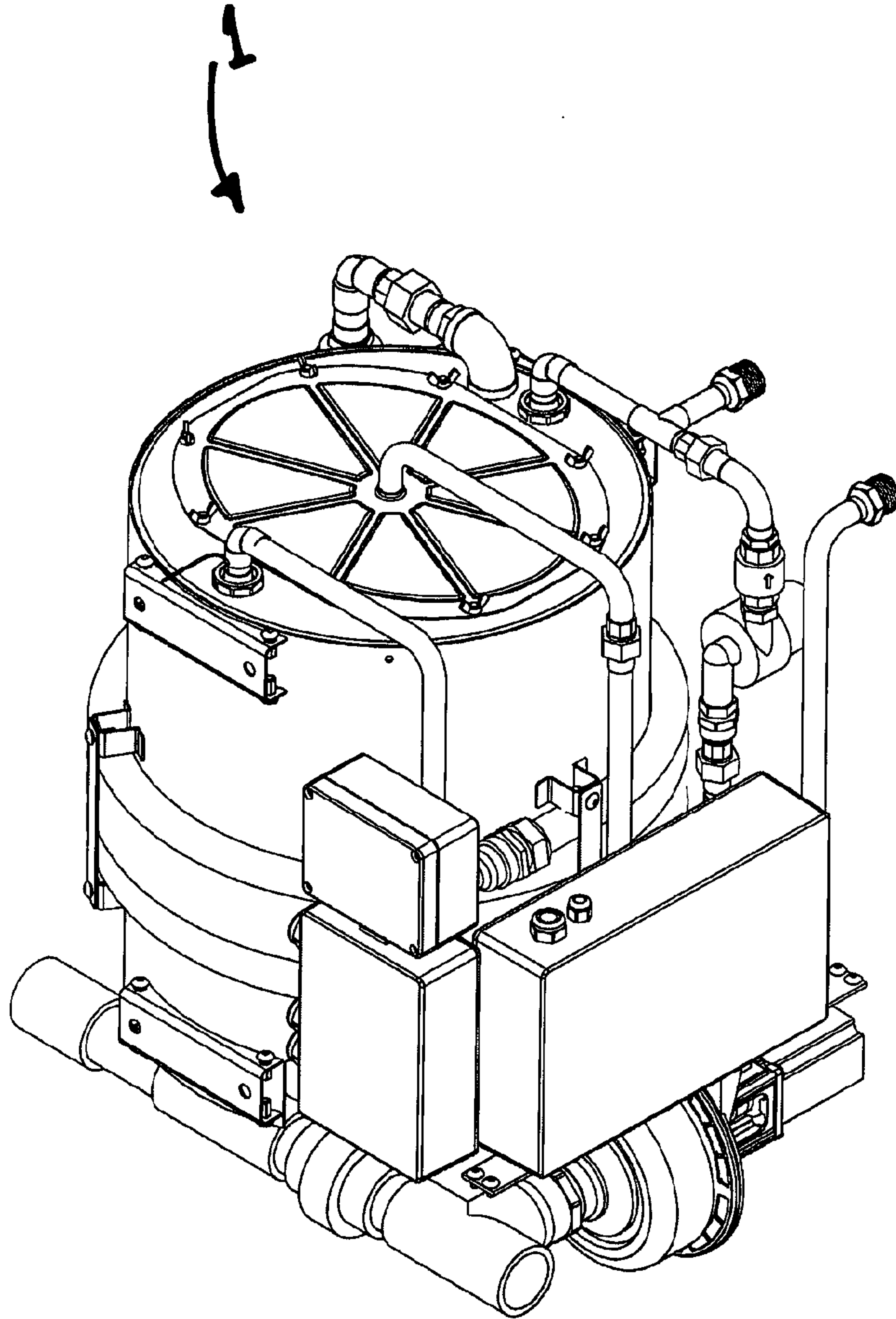
121. An assembly being provided with a device (1) according to any one of claims 62-119.

122. Assembly according to claim 121, wherein the assembly is an assembly  
5 selected from the group consisting of a dishwasher, a washing machine, a system for processing discharge fluid from an industrial process, a system for processing discharge fluid from a cooling process, a system for processing residential discharge fluid, a system for processing commercial discharge fluid, a system for processing sewer discharge fluid, and a system conveying a natural water stream.

10 123. Assembly according to claim 122, wherein the assembly is a dishwasher, wherein the discharge fluid (3) is hot discharge fluid from the dishwasher, and wherein the device (1) is used for recuperating heat from the hot discharge fluid of the dishwasher.

FIG. 1



FIG. 3

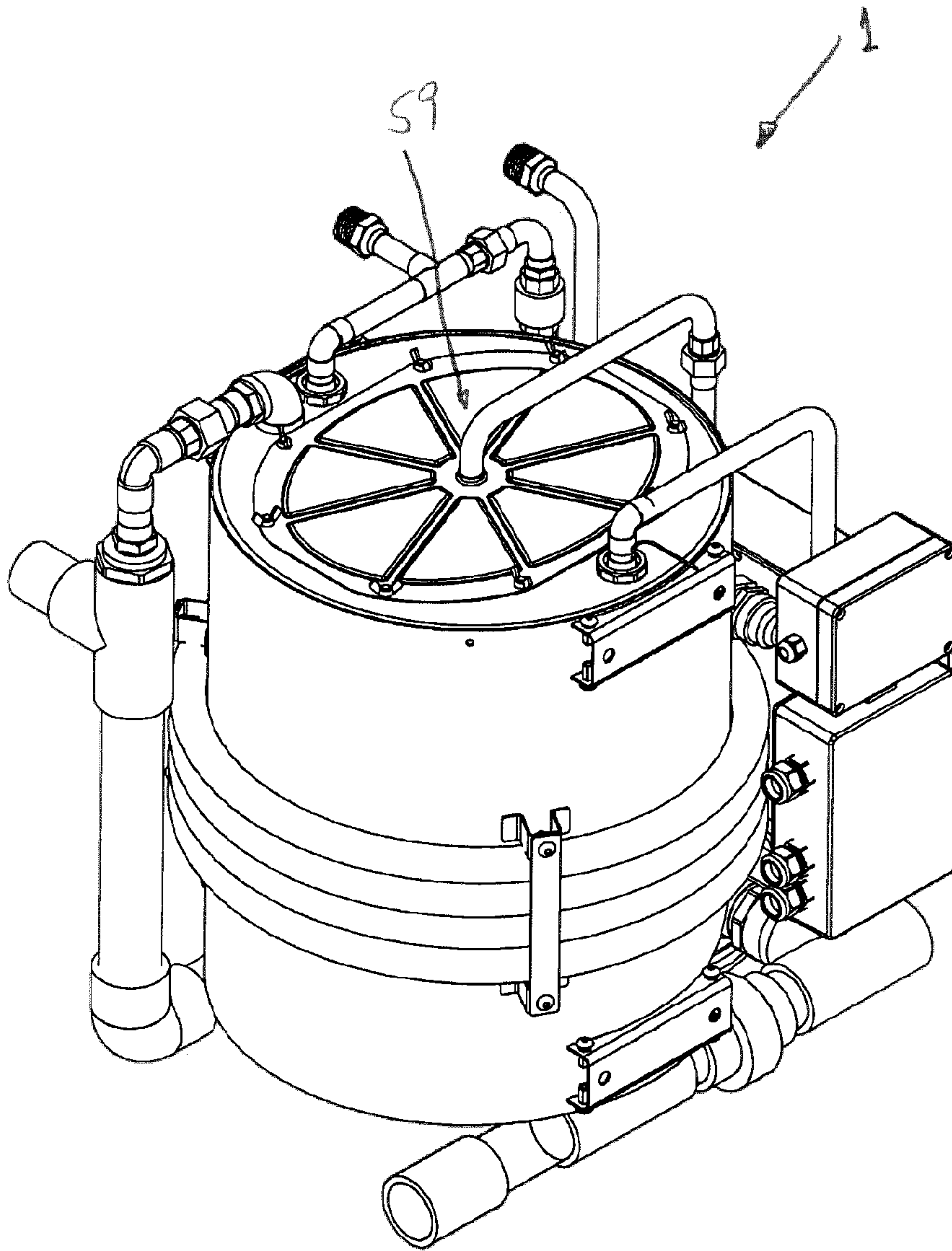
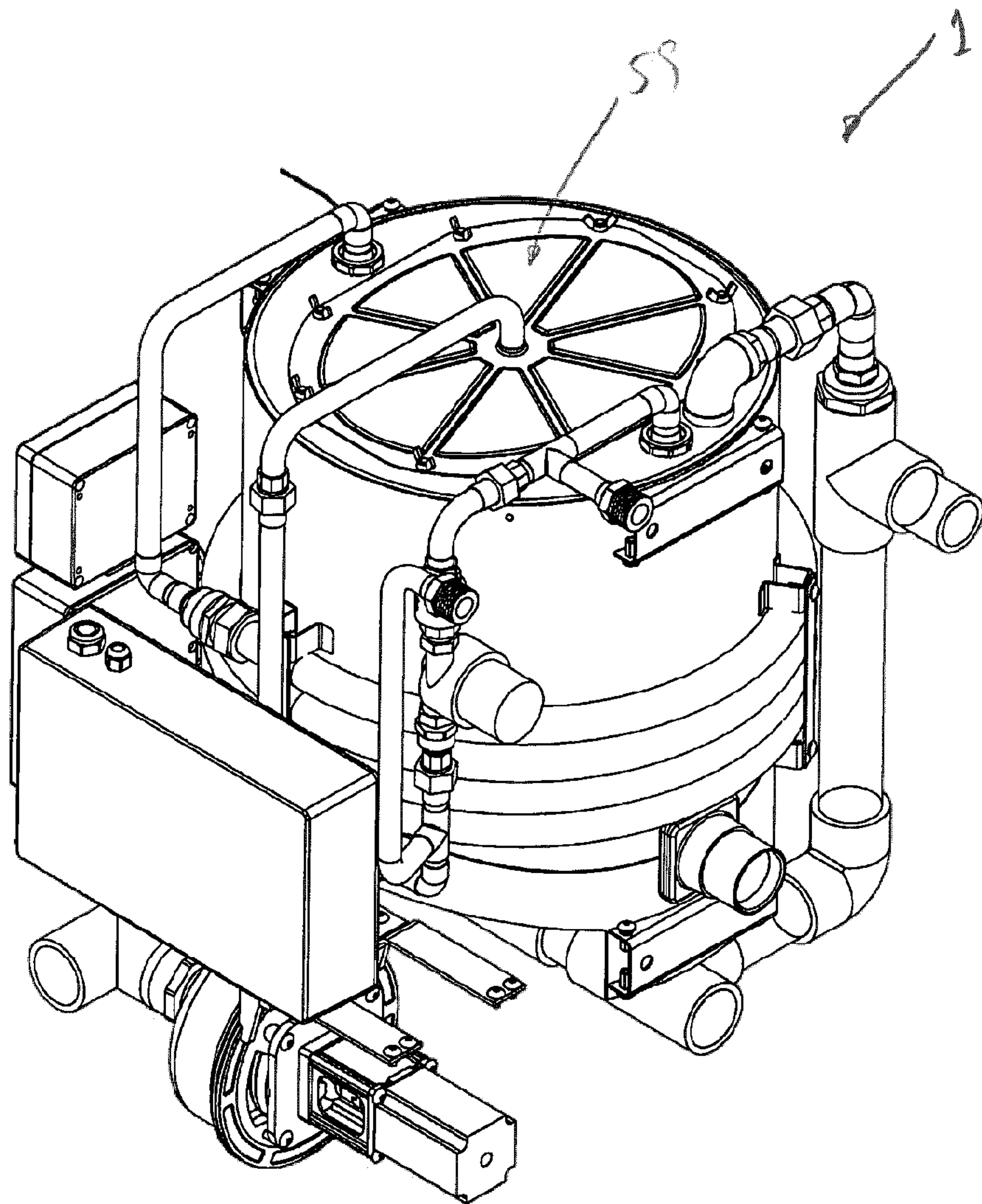


FIG. 4



Fig. 5

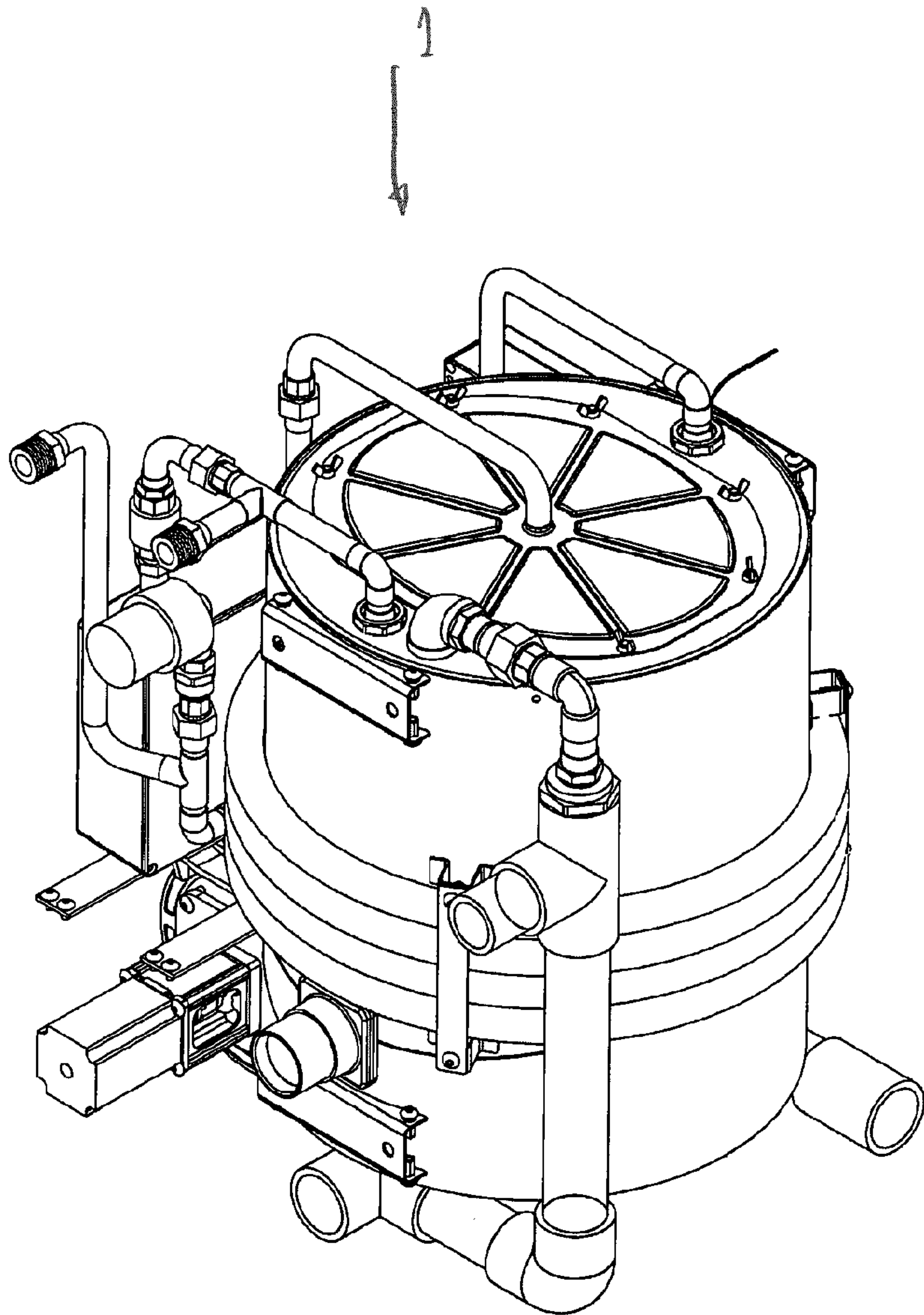
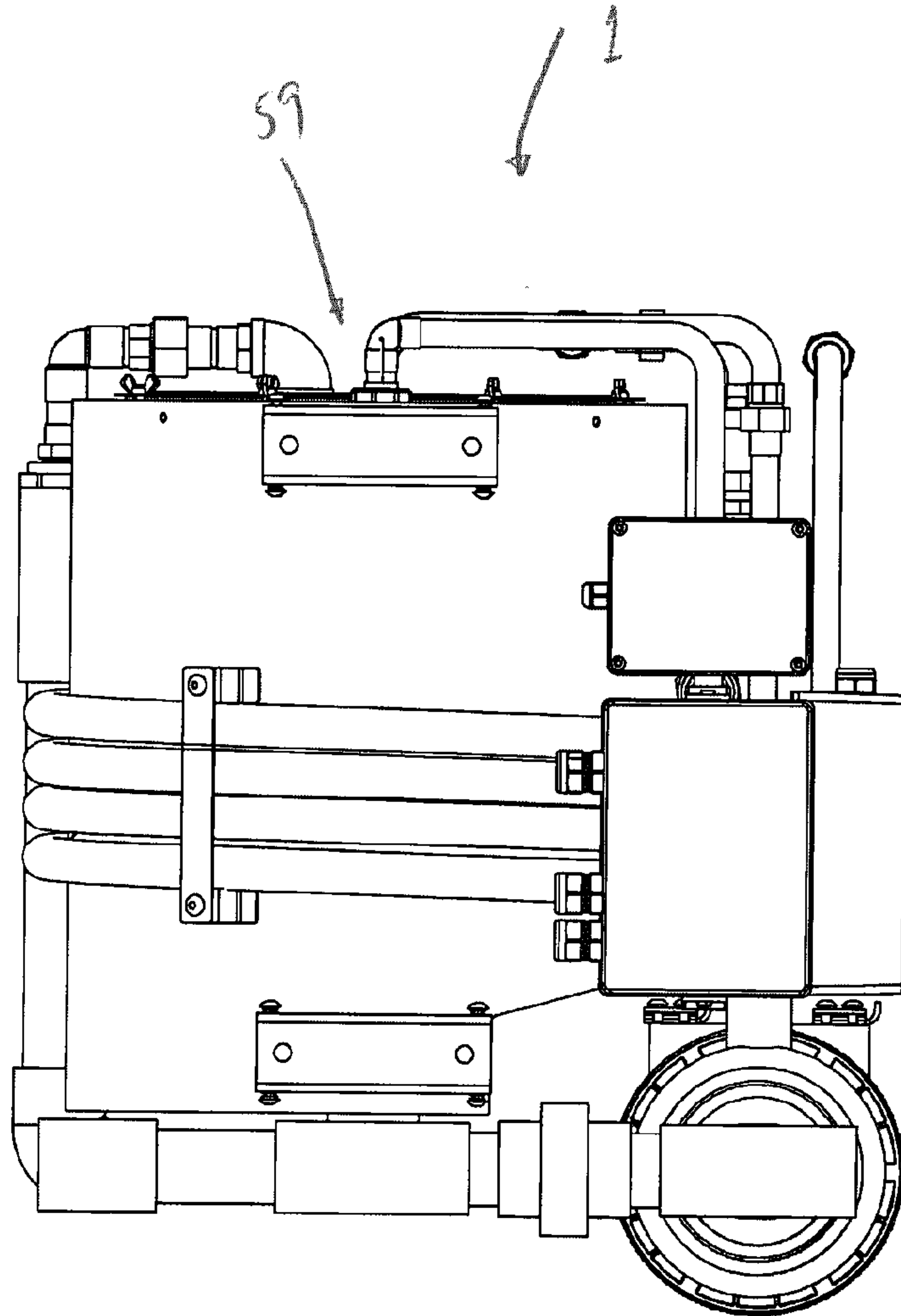
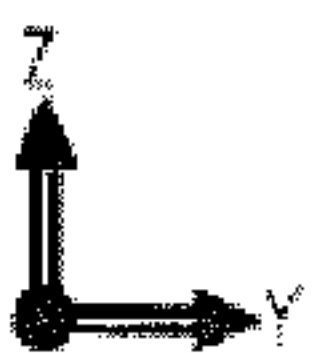
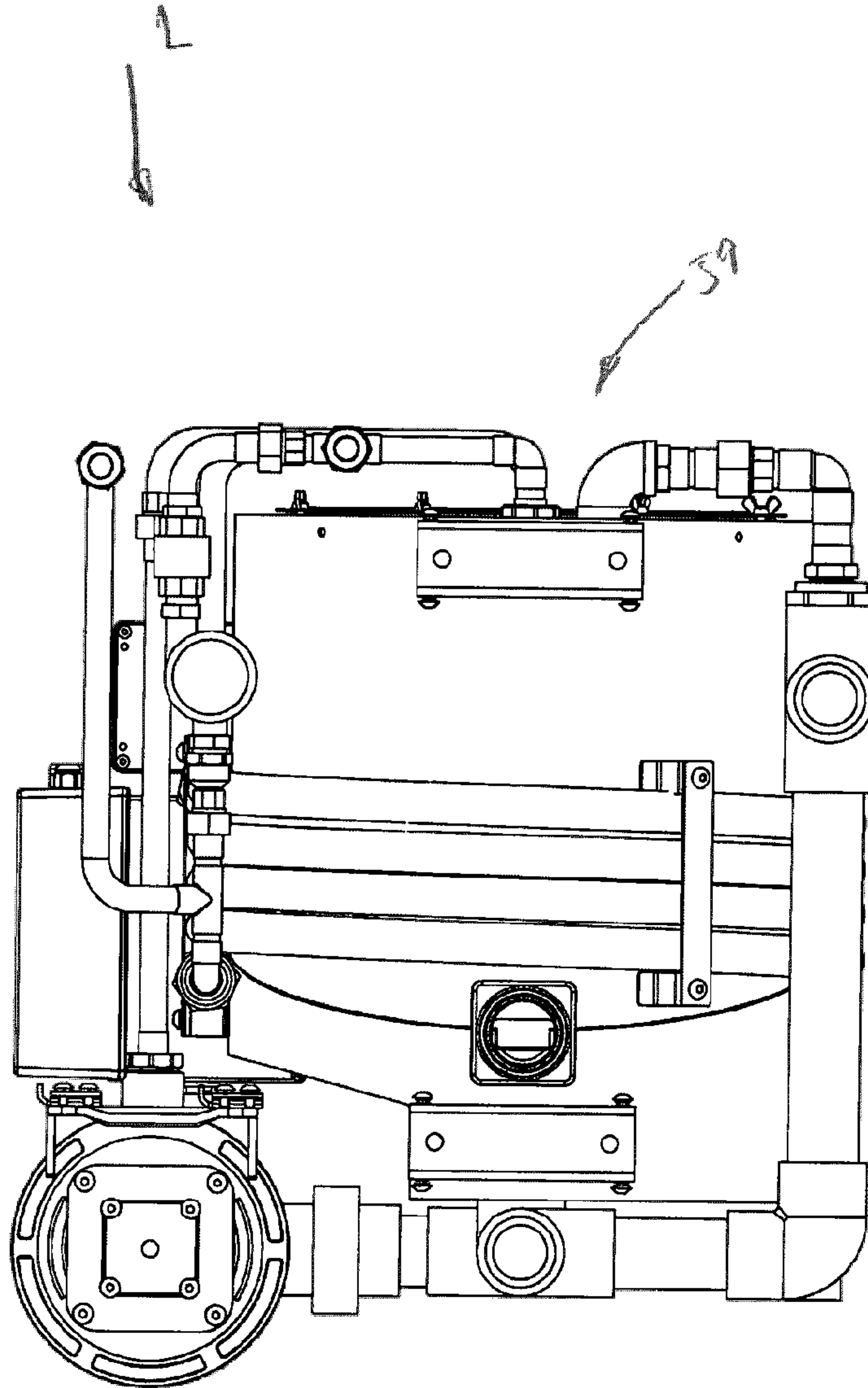


FIG. 6



Fig. 7



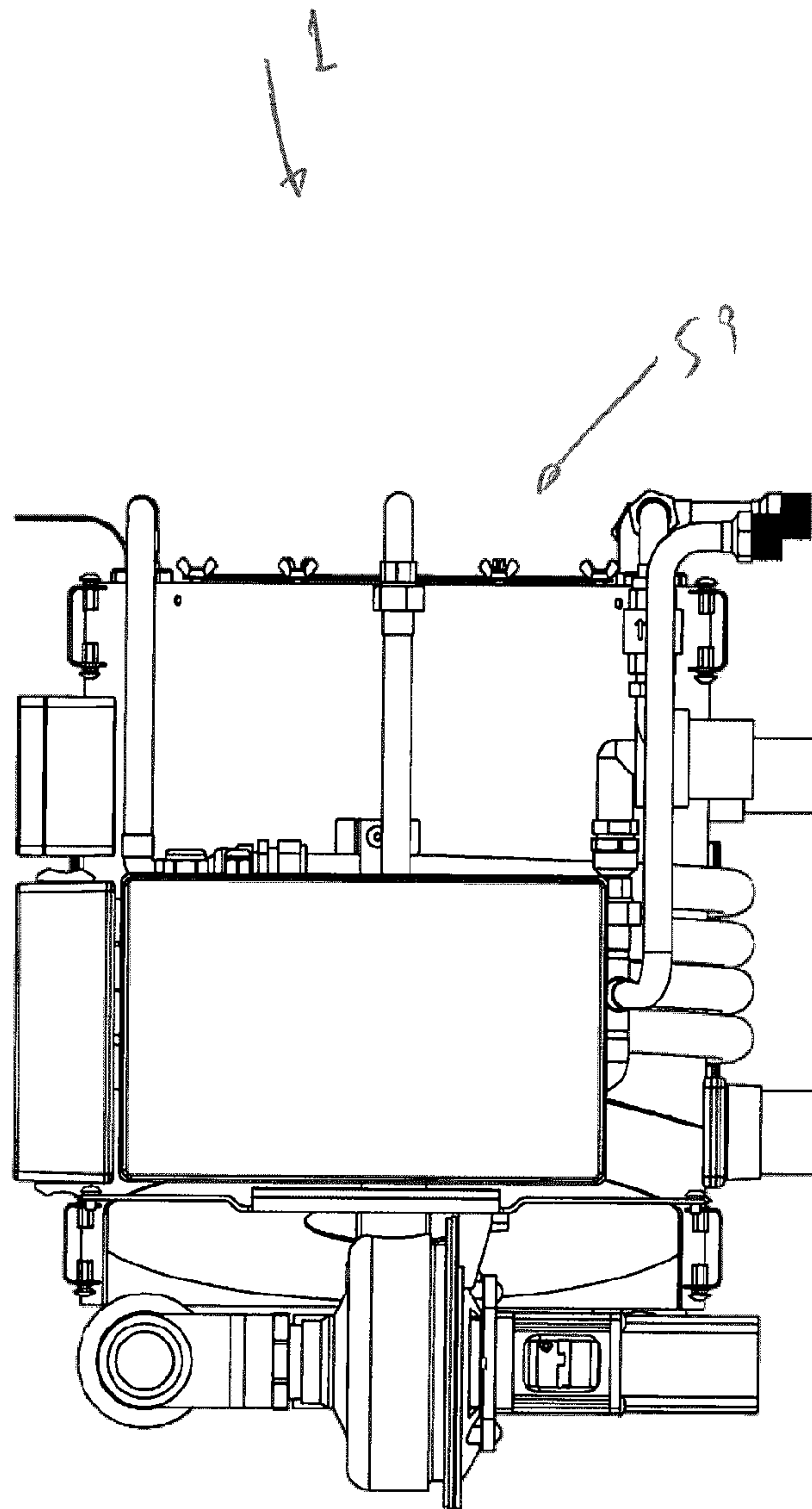
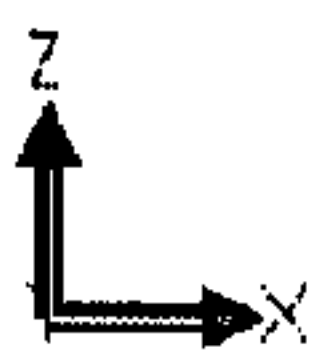
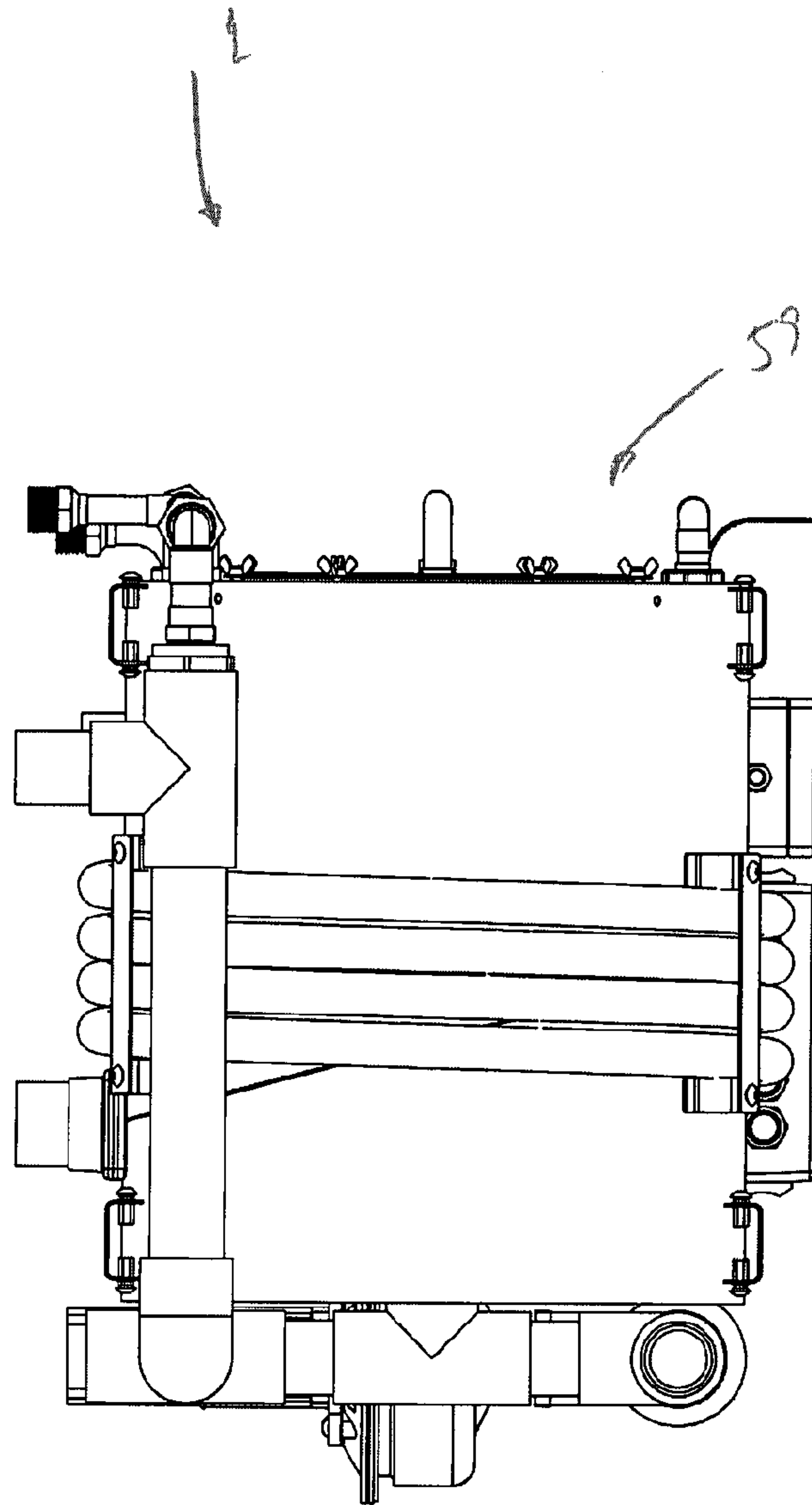
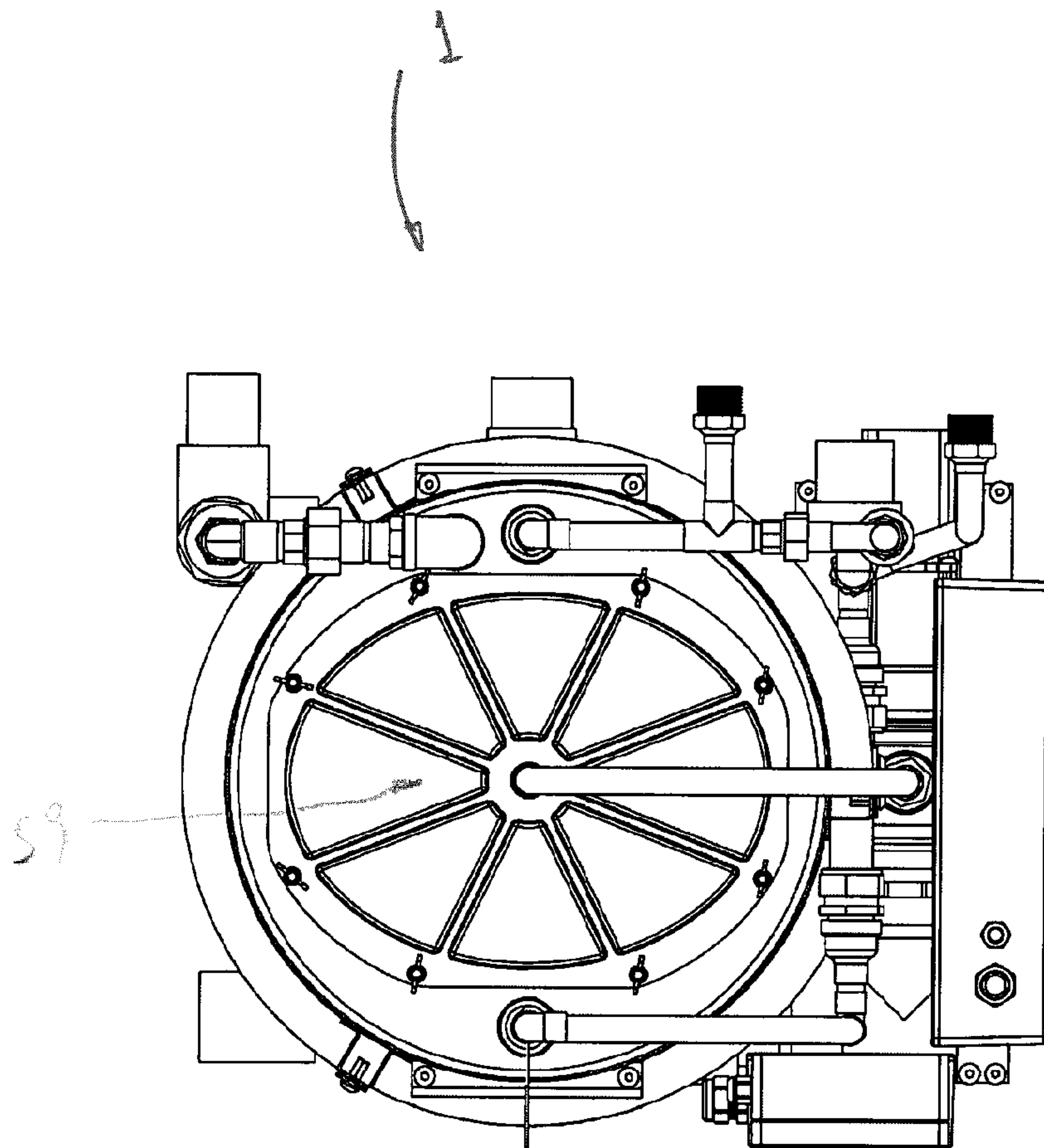
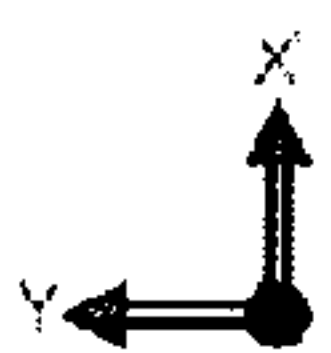


Fig. 9



FIG. 10

FIG. 11

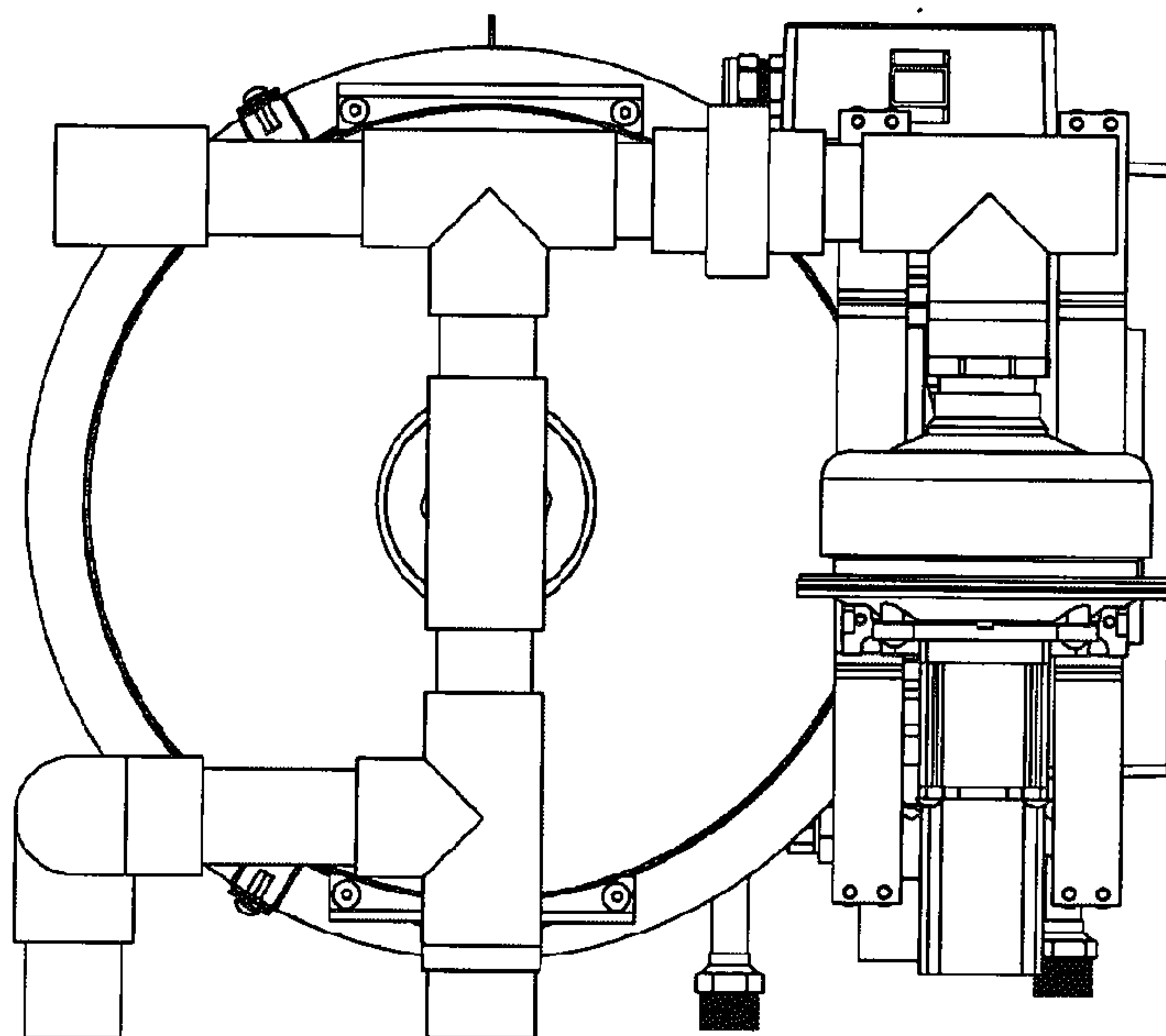
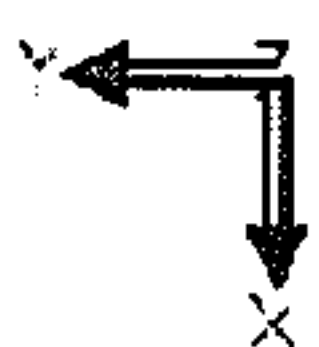


FIG. 12



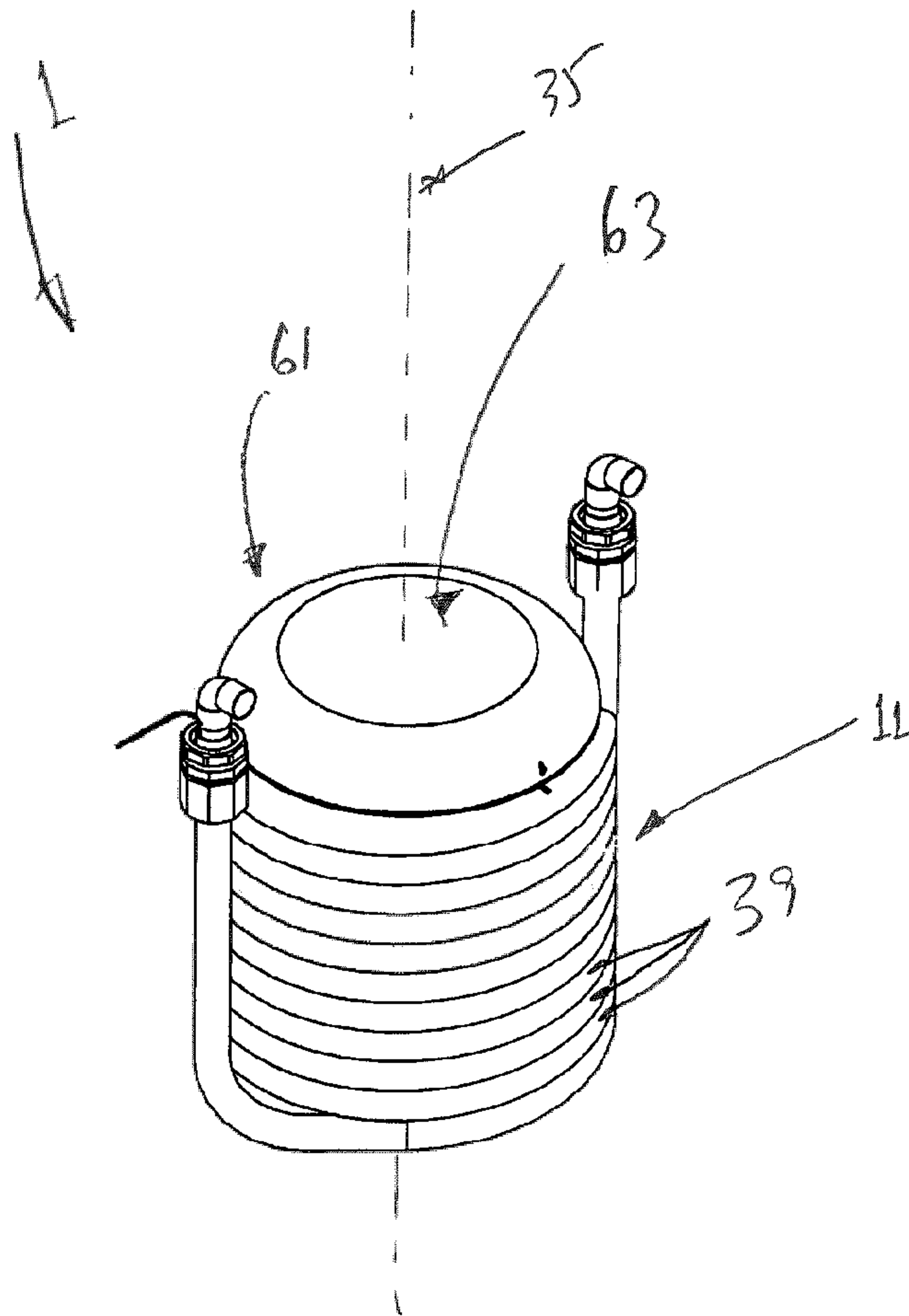
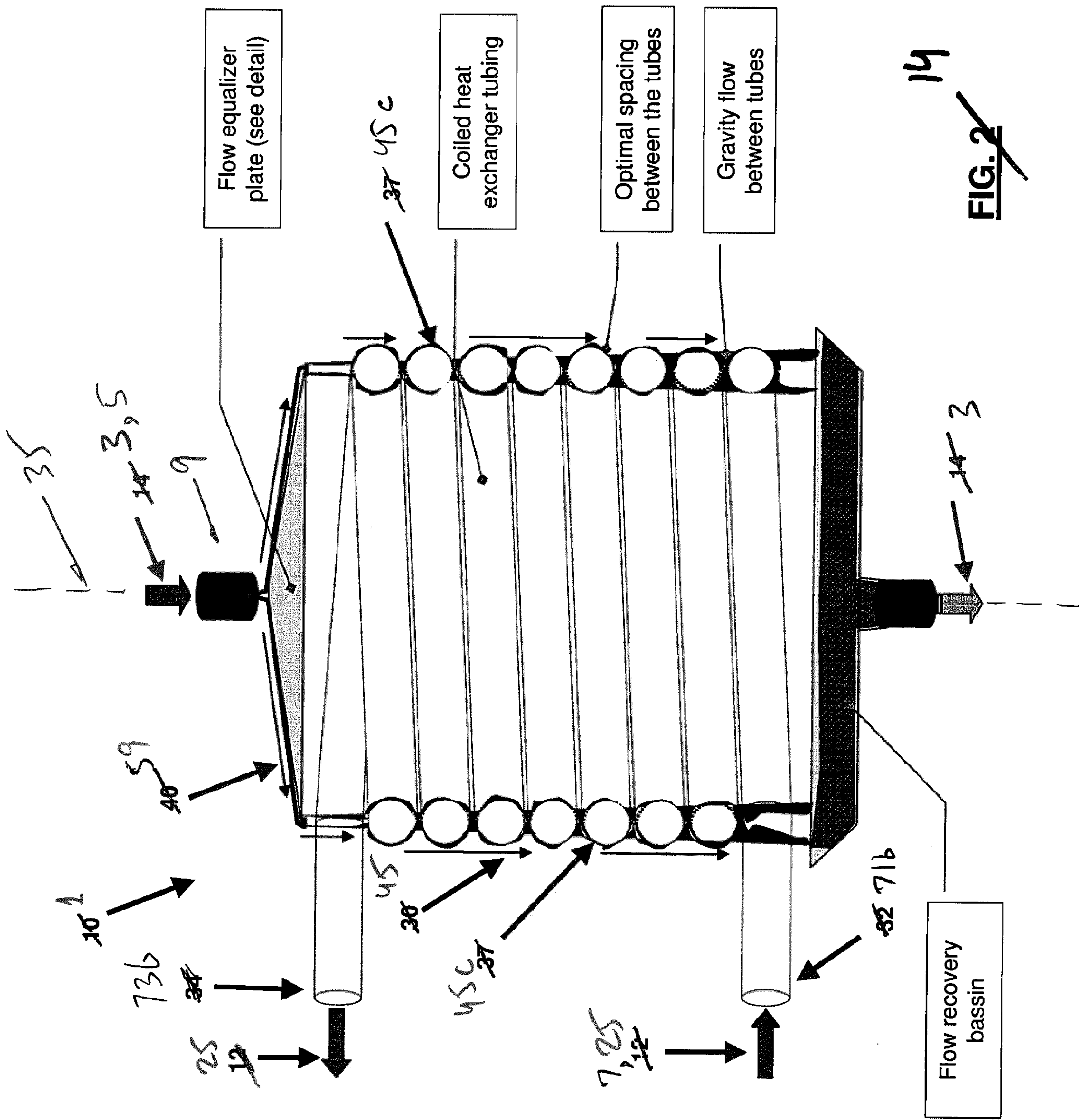


FIG. 13





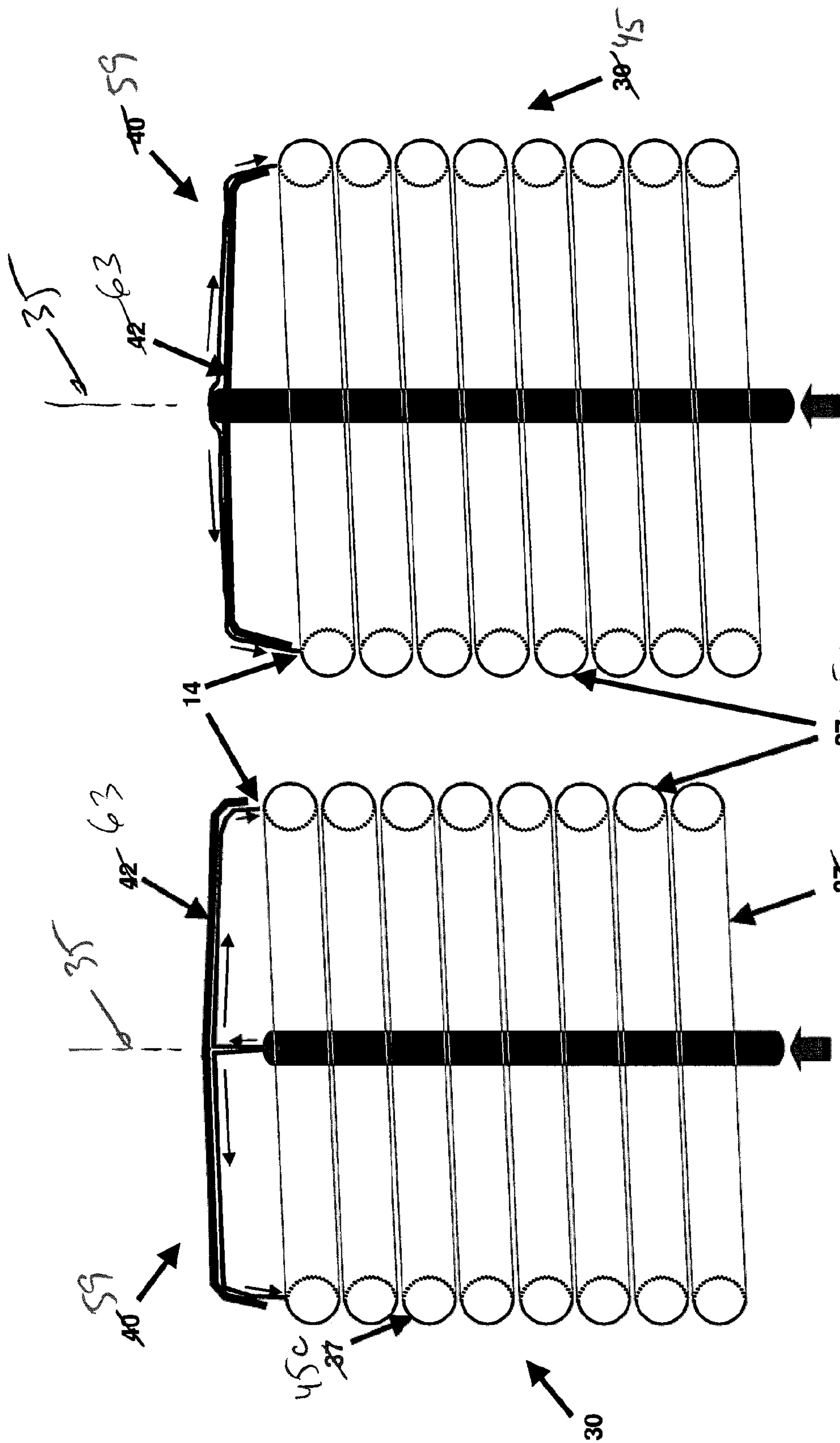


Figure C

Figure B

FIG. 16

FIG. 15

~~FIG. 3~~

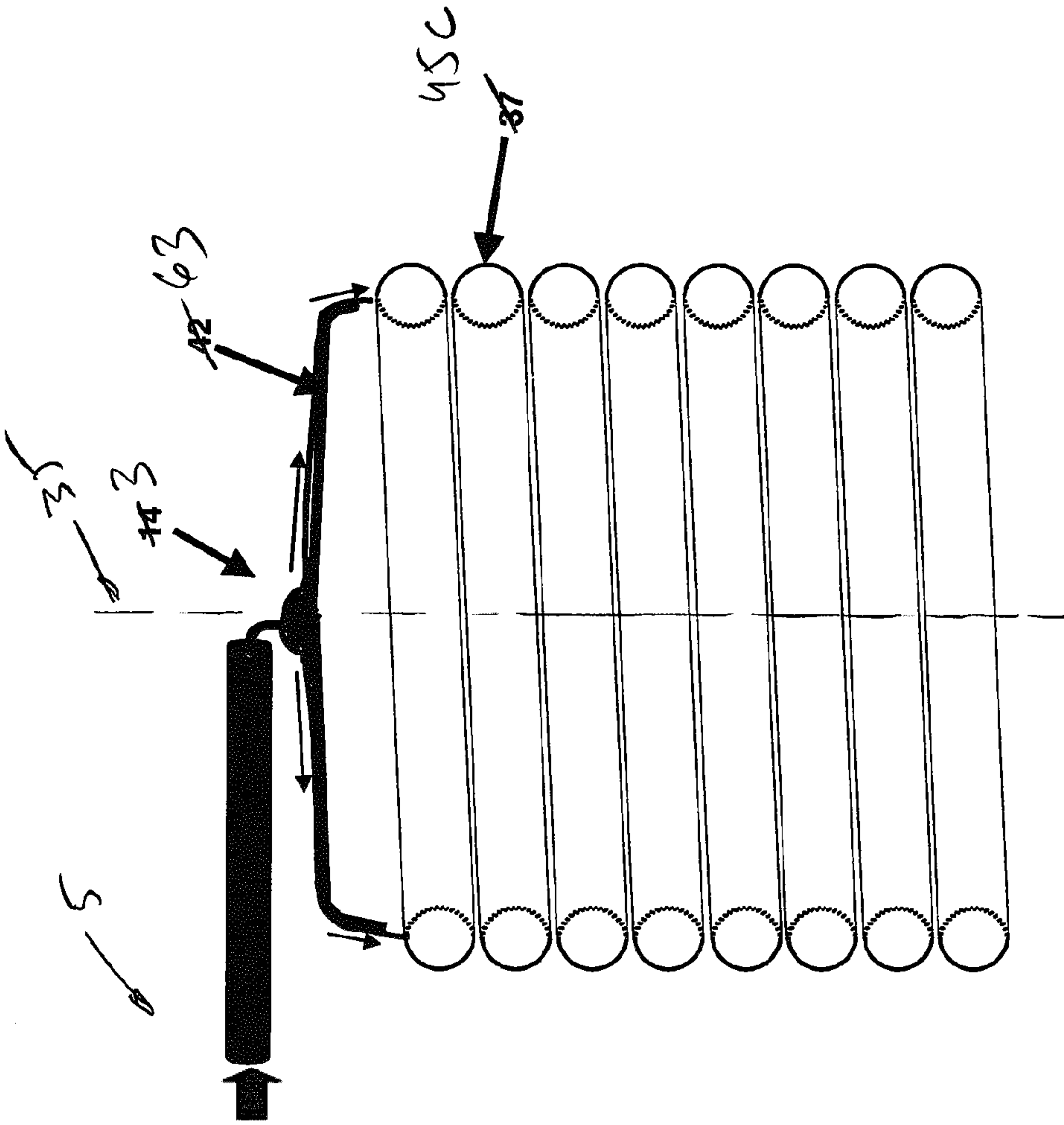
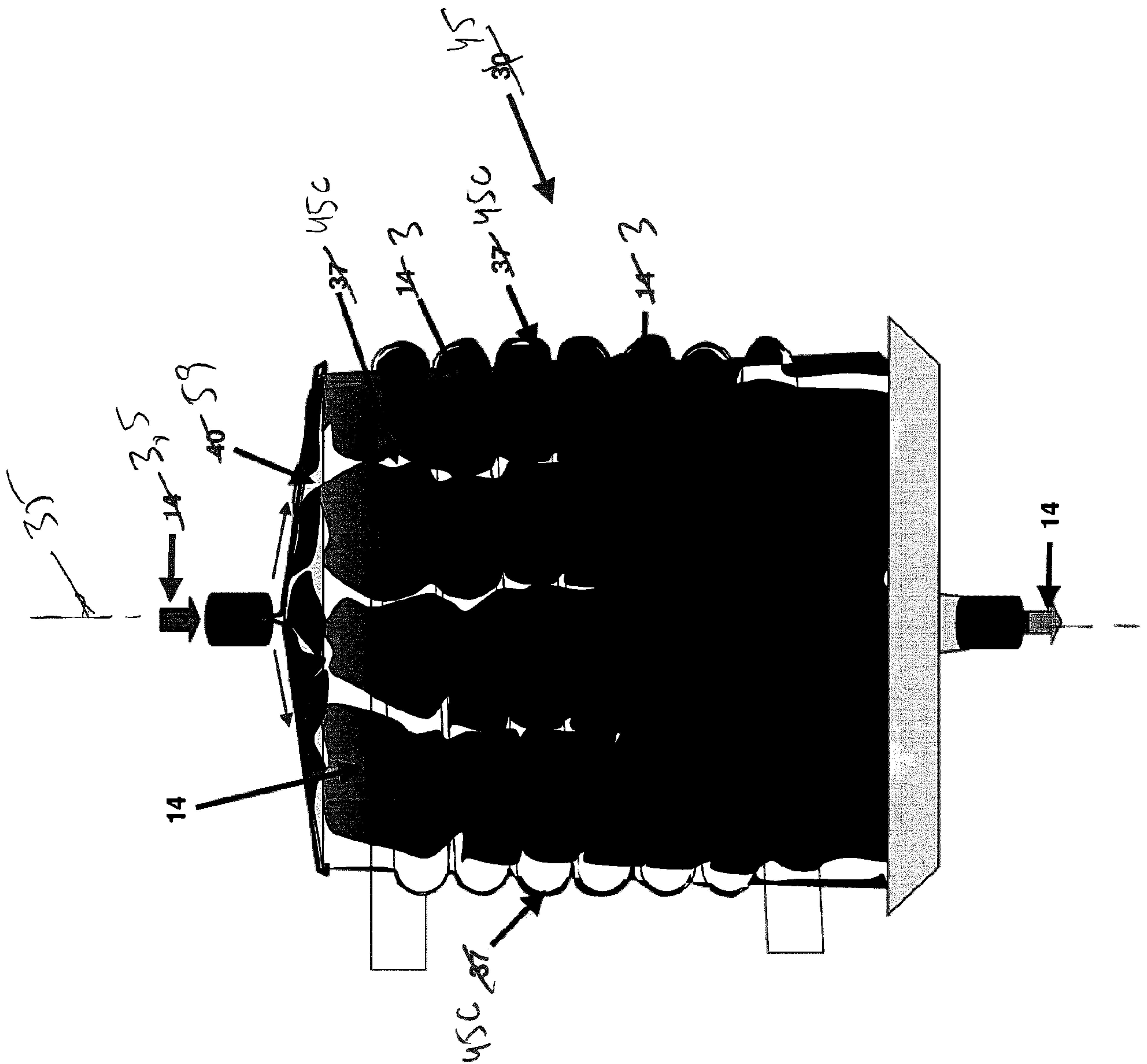


Figure D

17

~~FIG. 4~~



~~FIG. 6~~

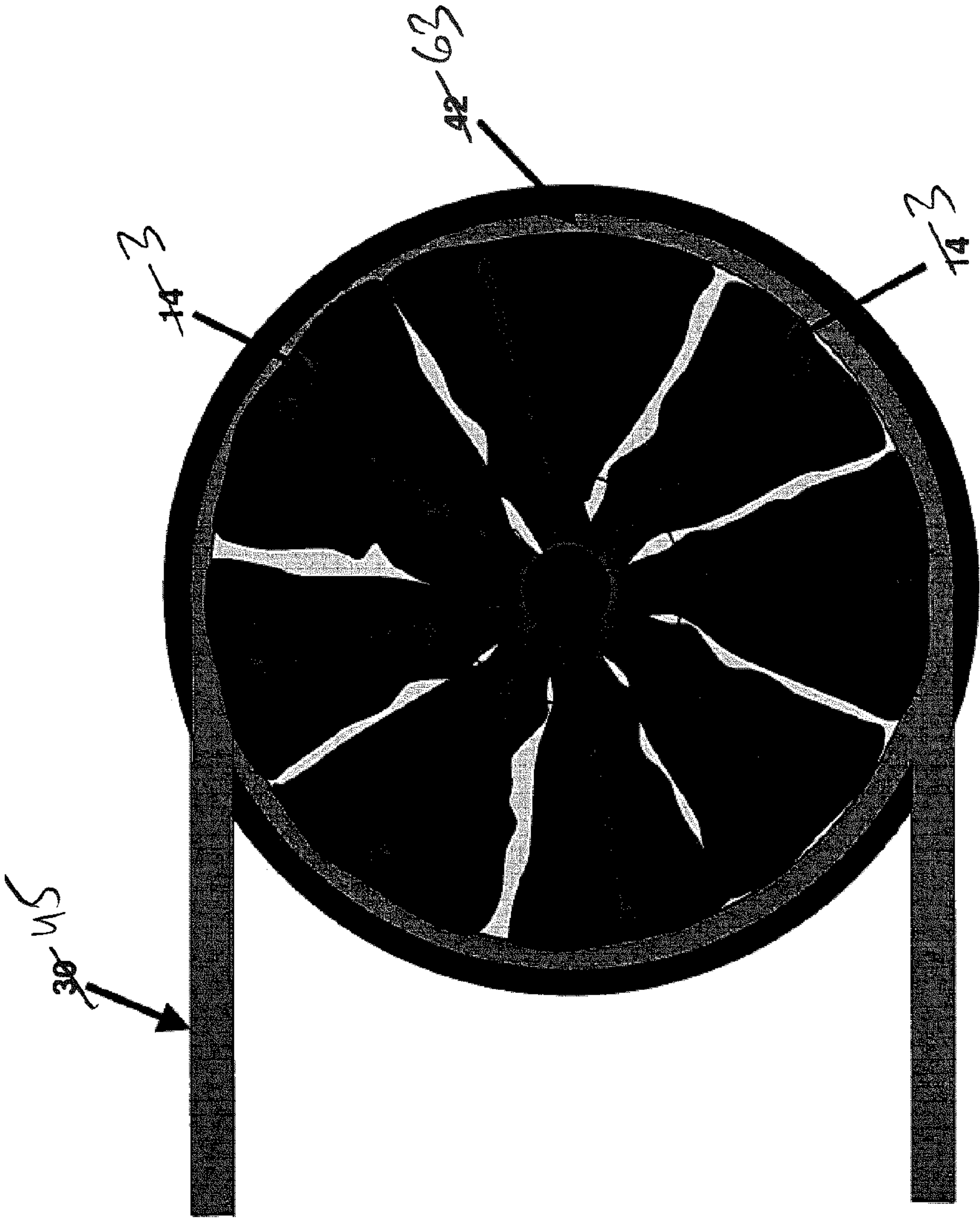
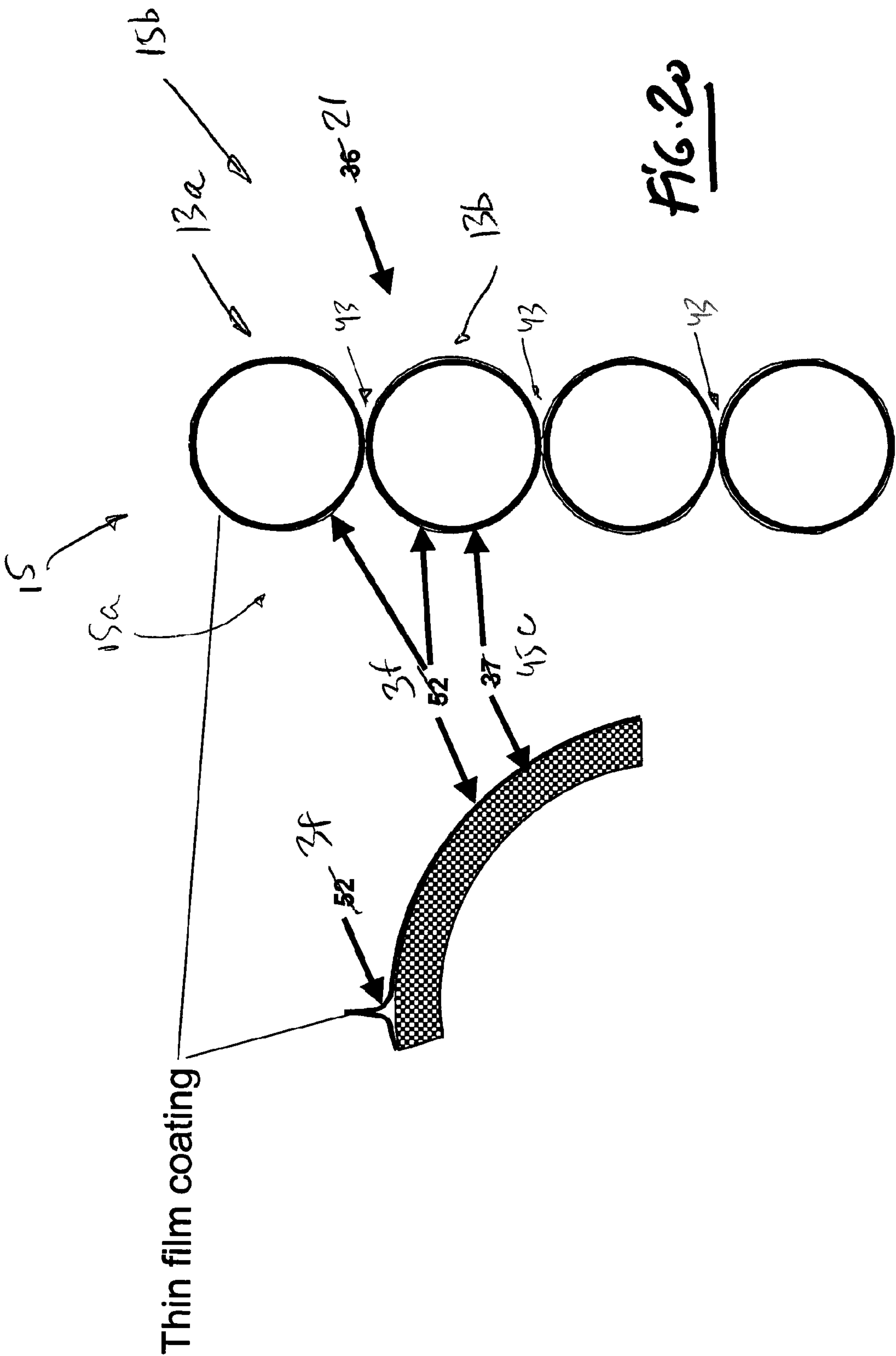
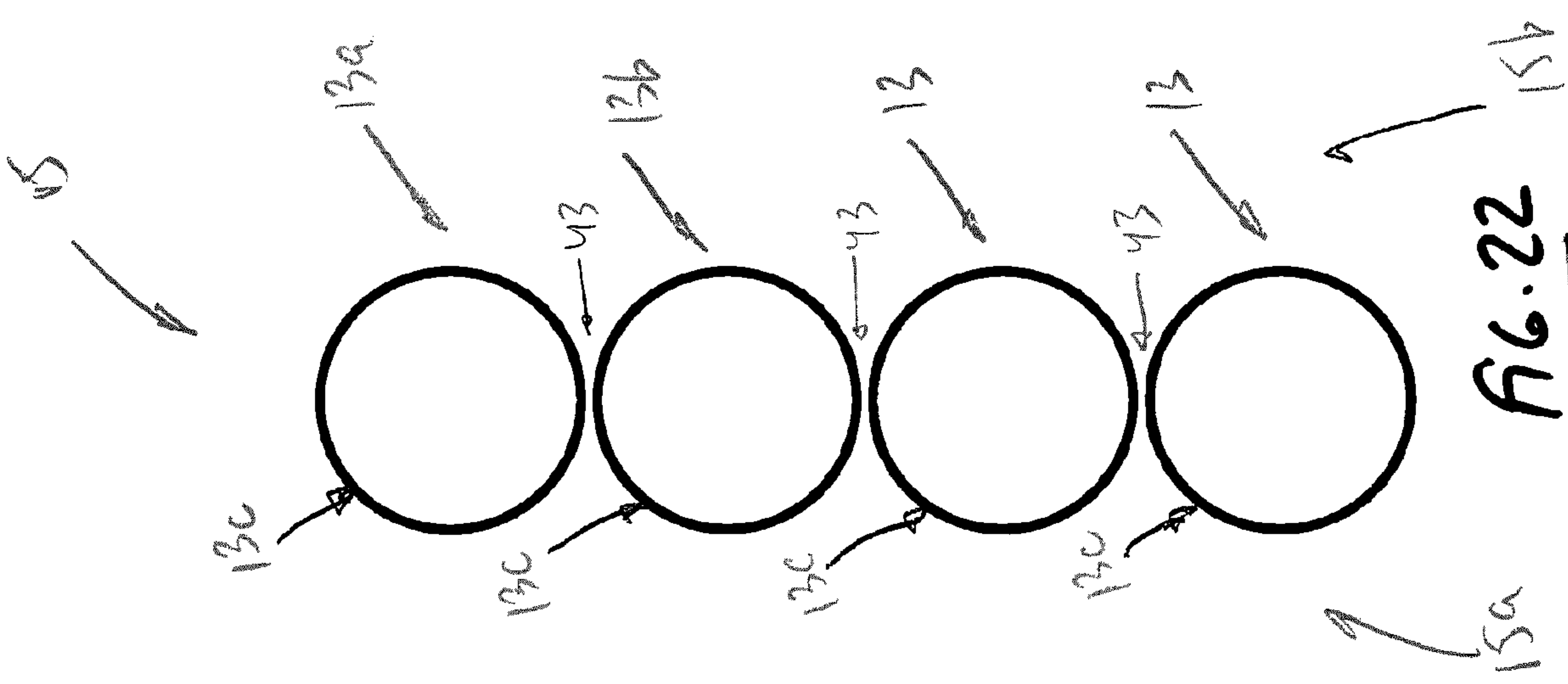
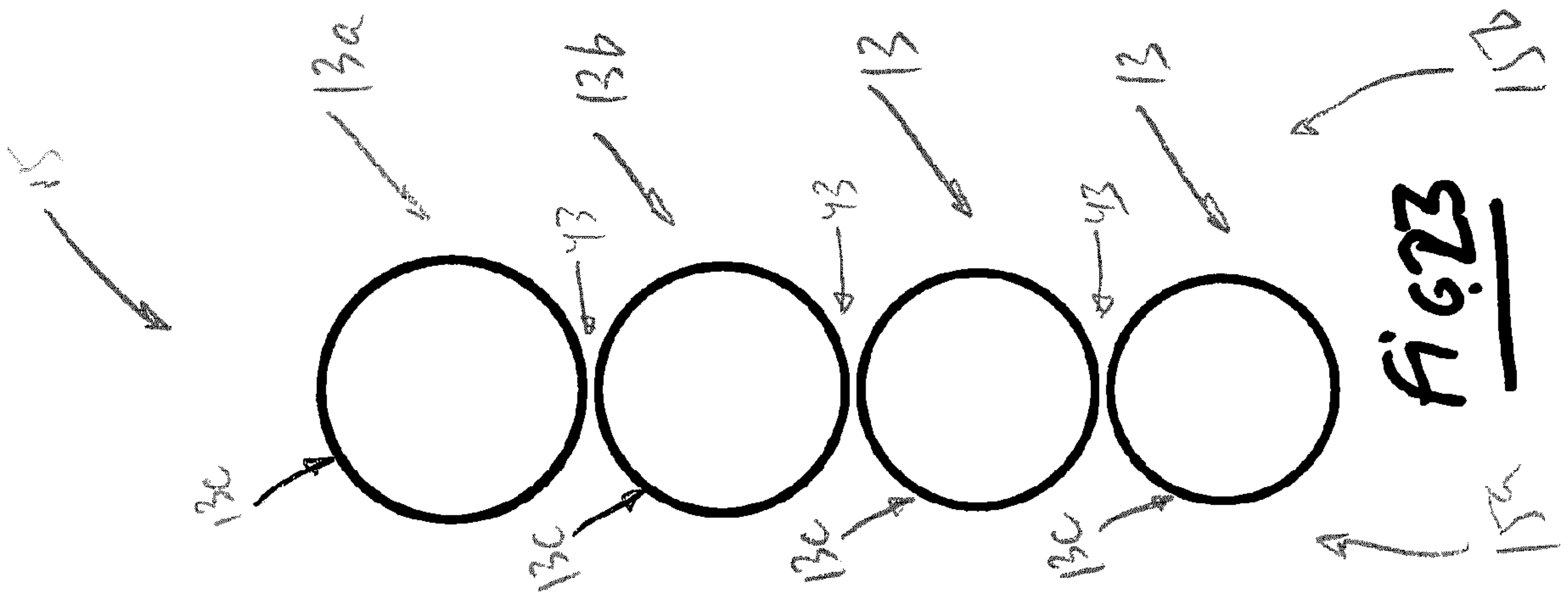
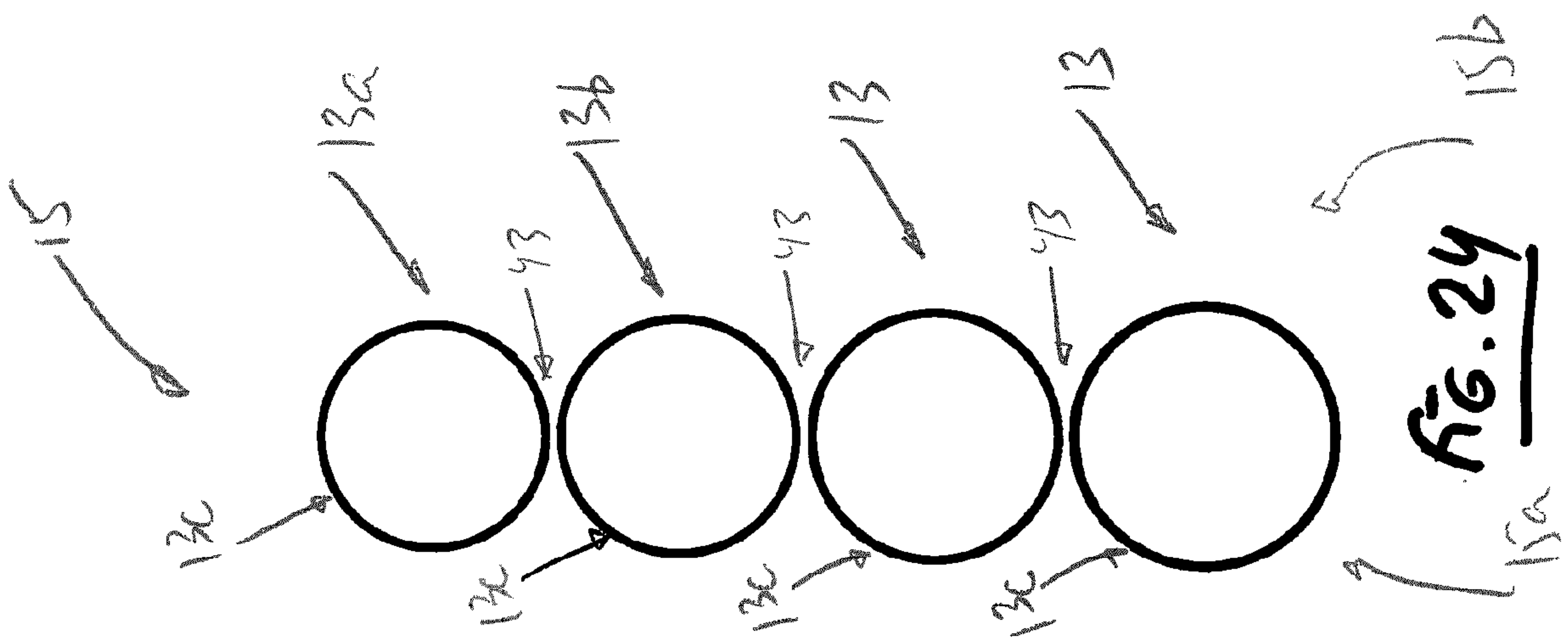


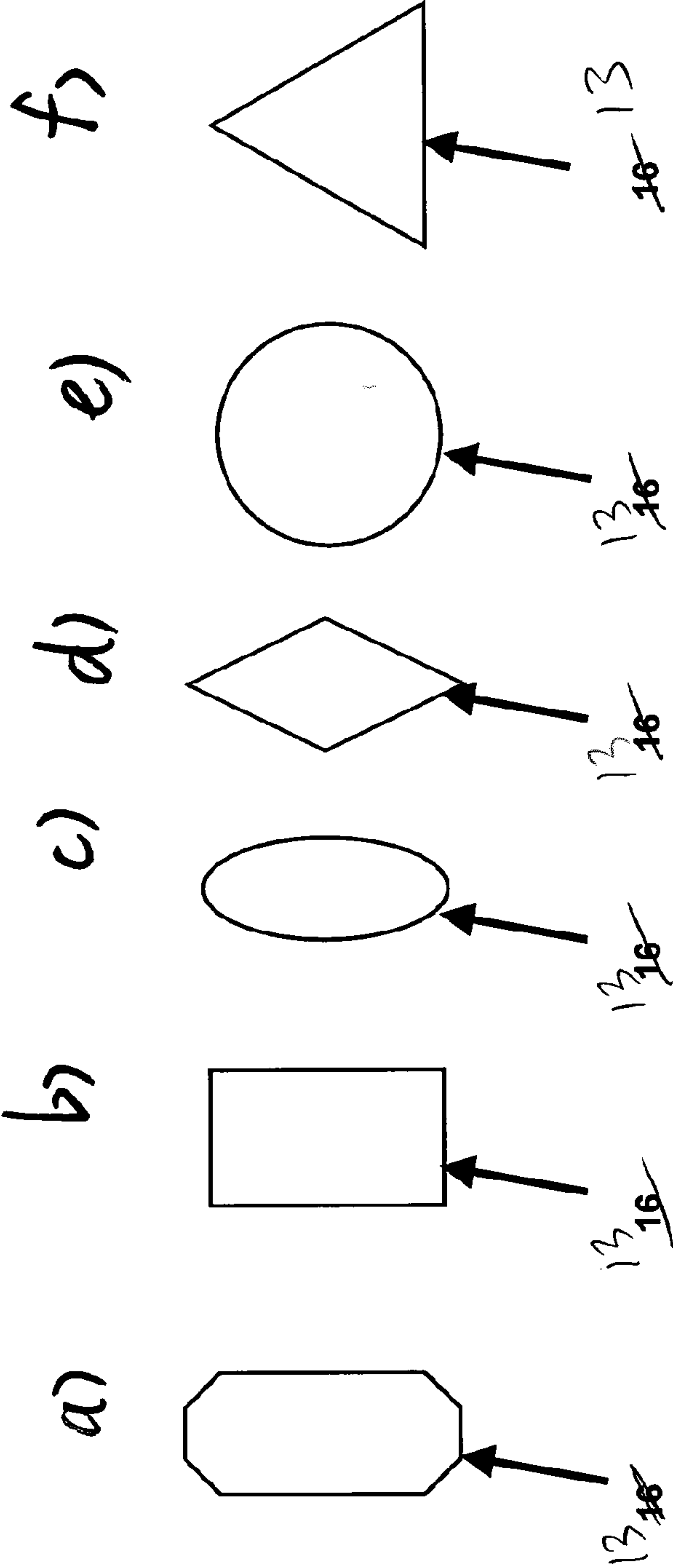
FIG. 5  
19



Coil tubing cross sections with thin film coating joining the external surface.

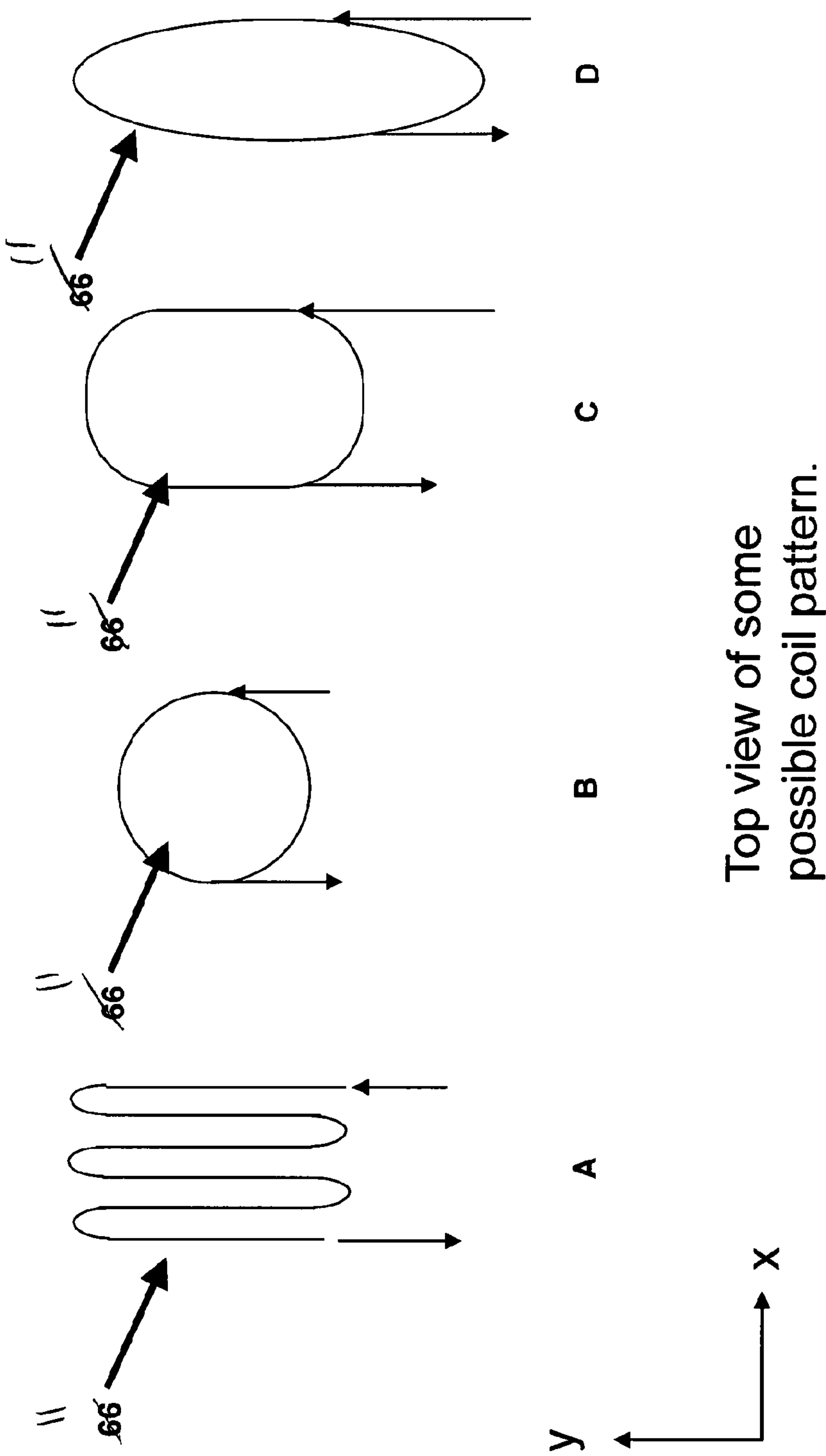
21  
~~Figure 31~~



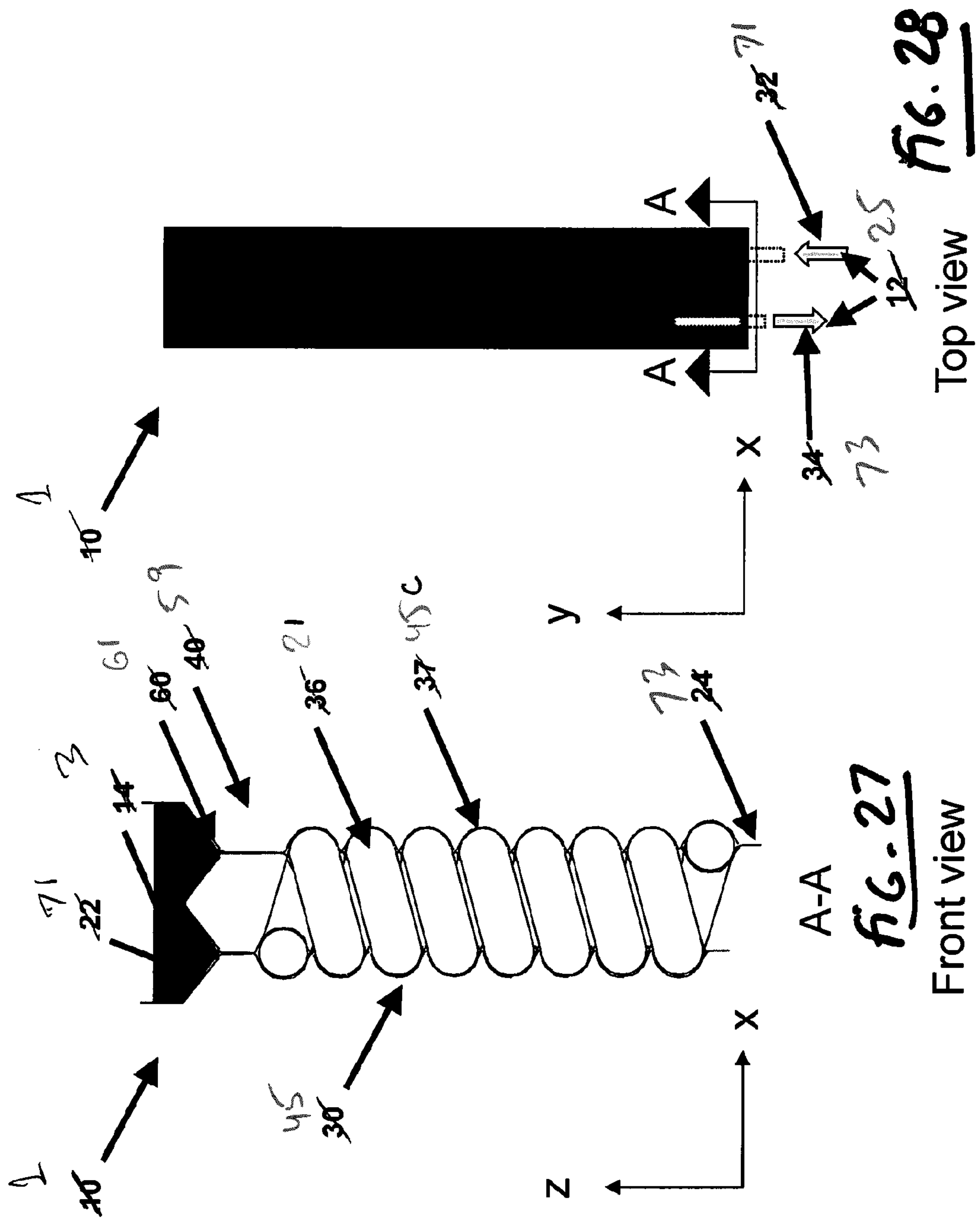


Example of coil tubing cross sections

25  
Figure 25

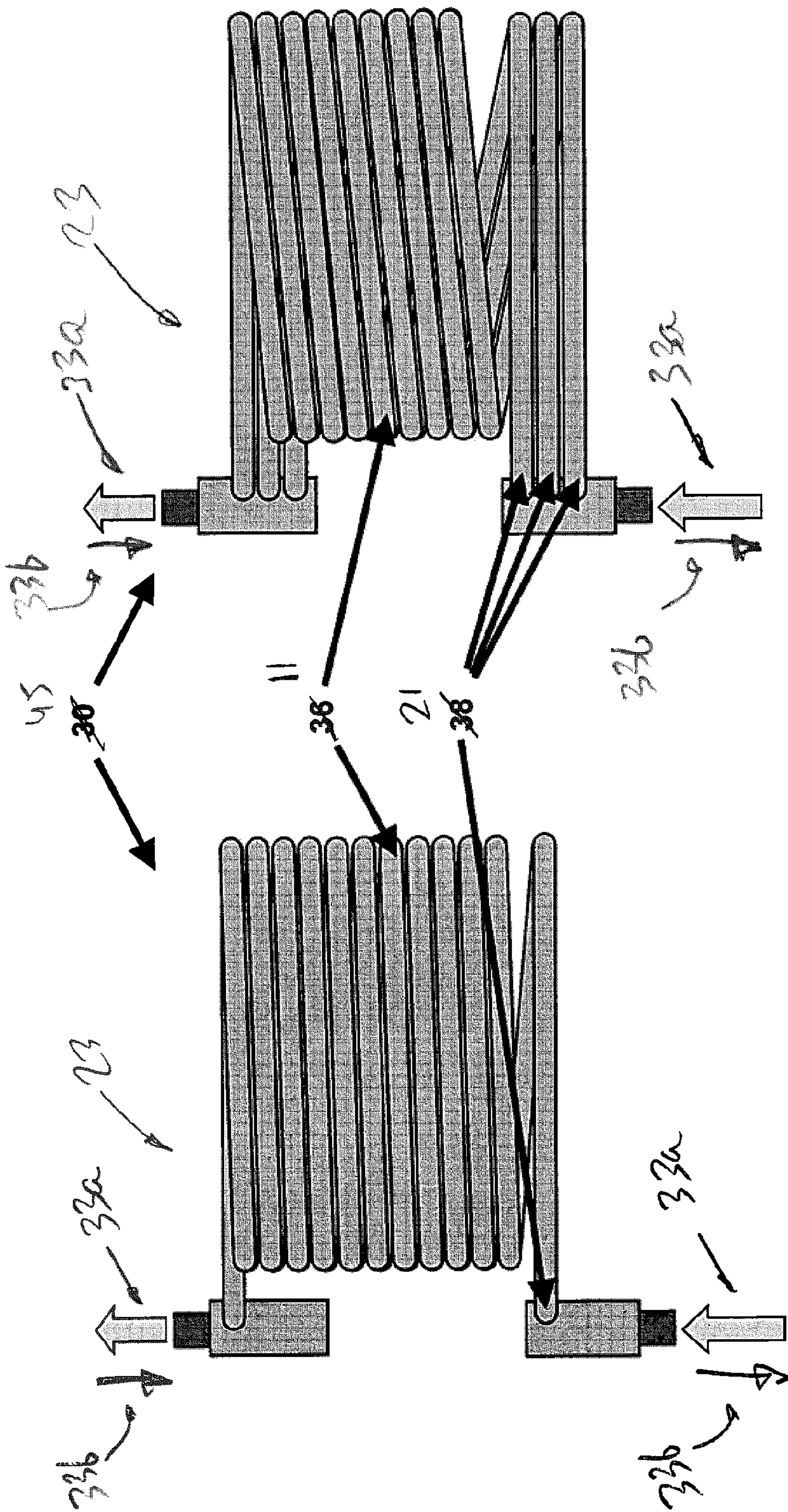


26  
Figure 27



## Example of possible coil pattern and distributor.

~~Figure 26~~



Example of single coil tubing circuit      Example of parallel coil tubing circuits  
Shown here 3 coils in parallel

fig. 29

fig. 30

~~Figure 30~~

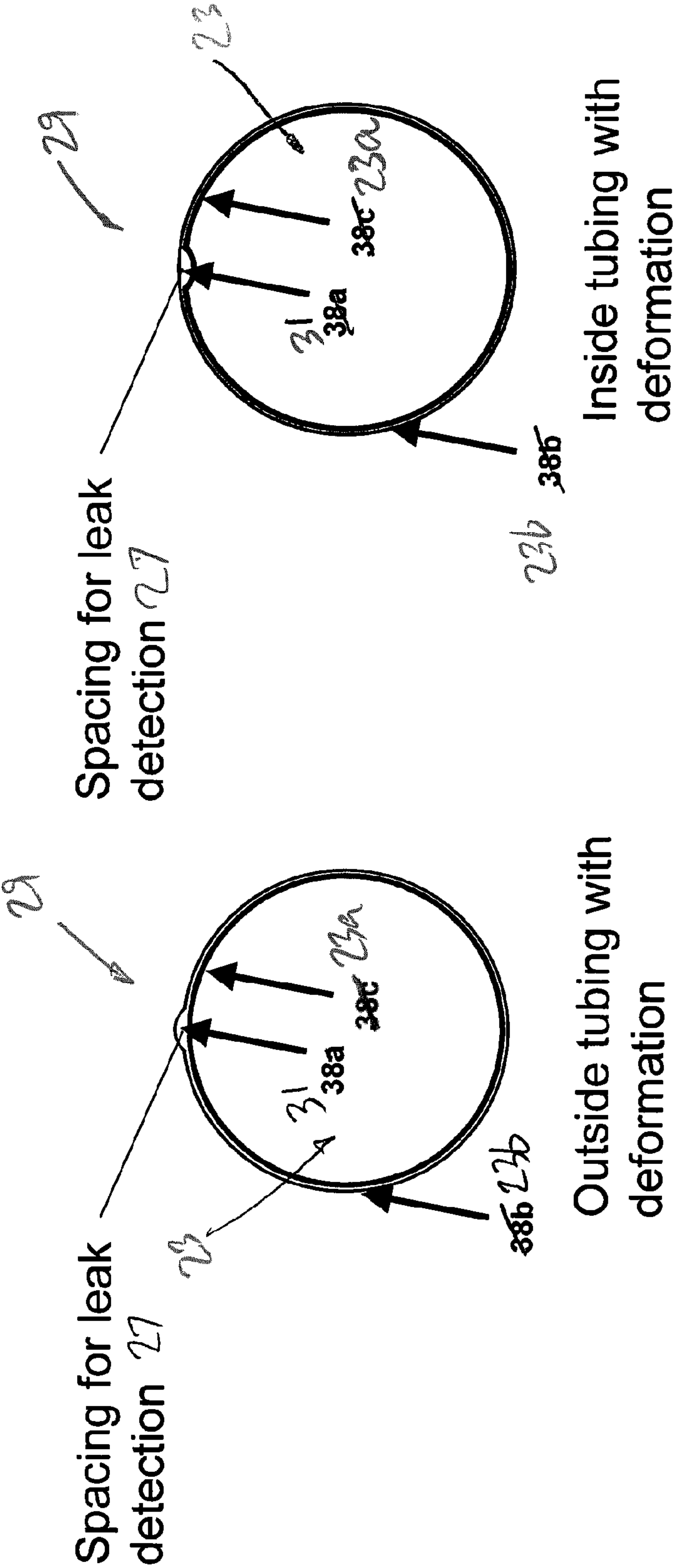
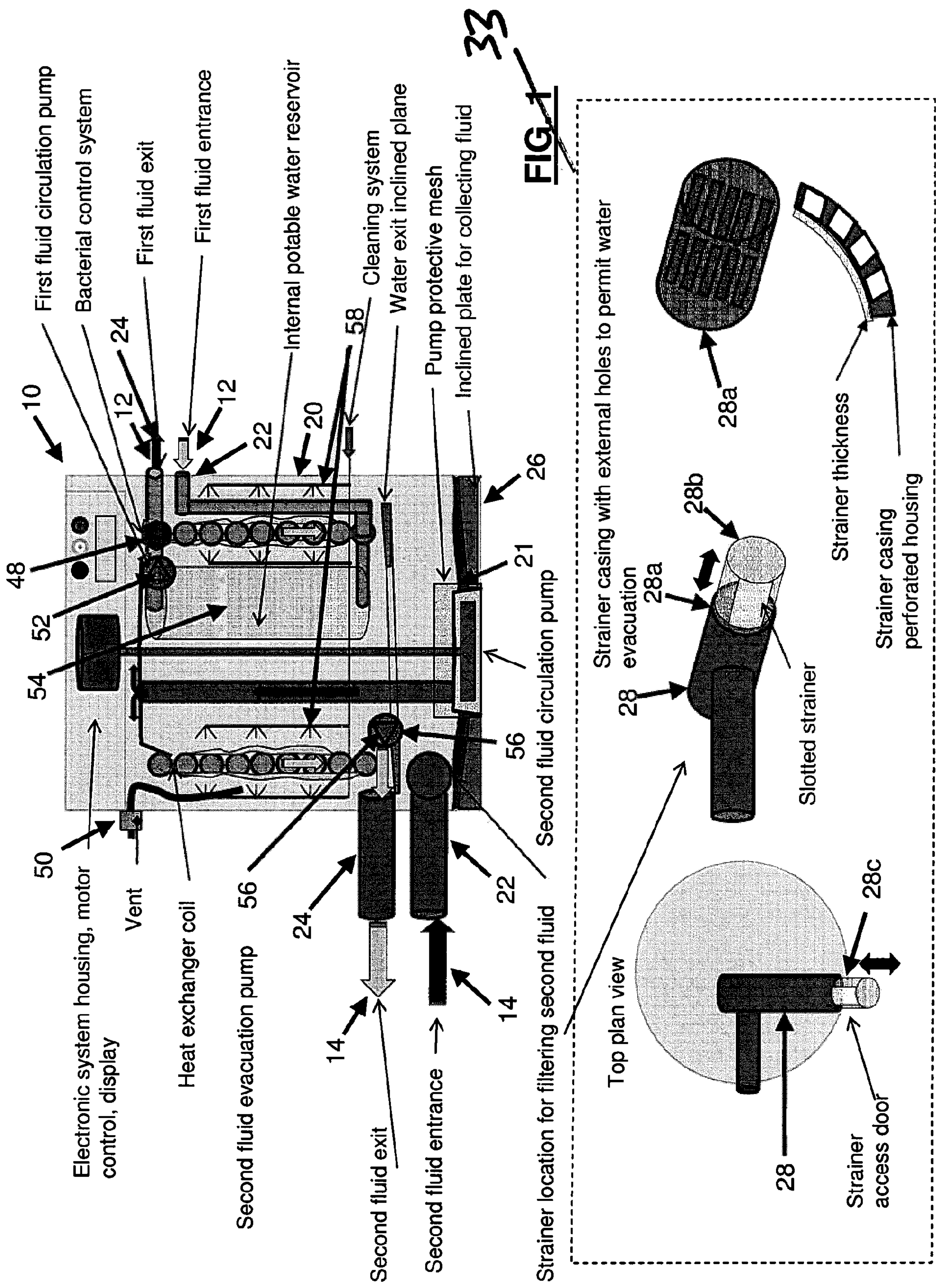
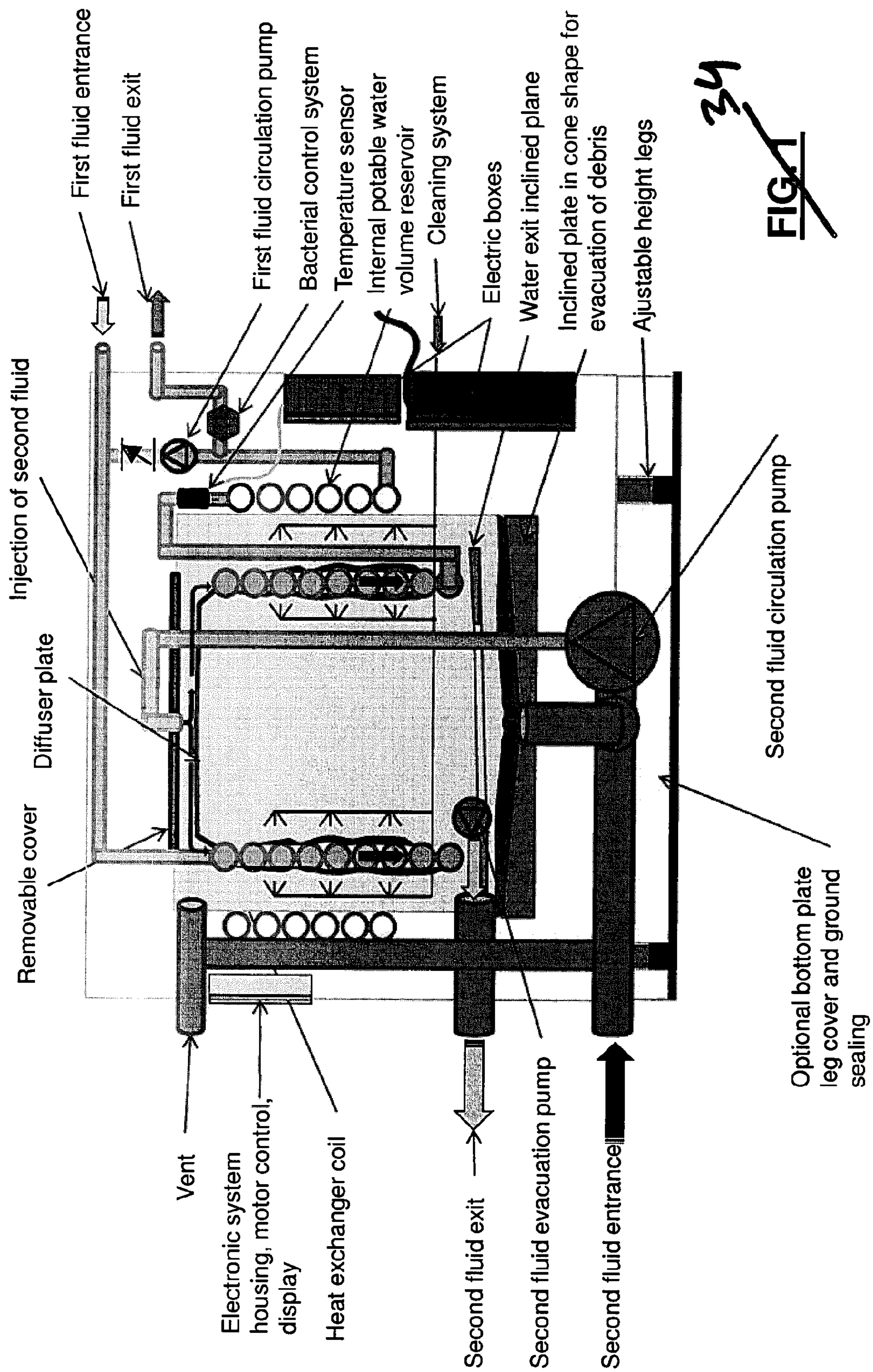


fig. 31

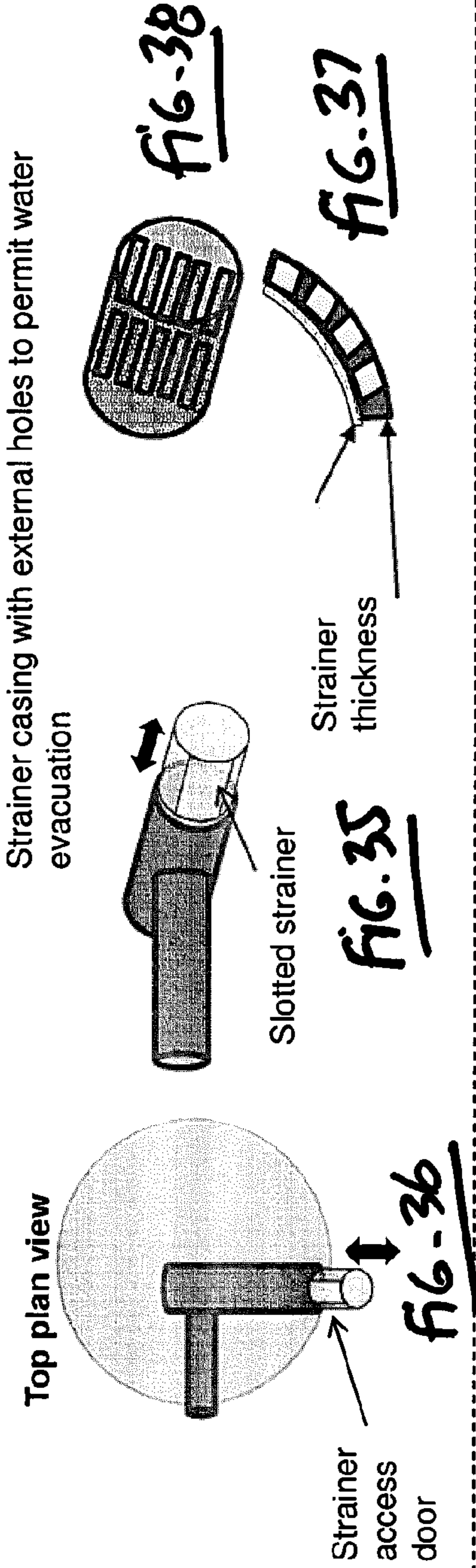
fig. 32

~~Figure 28~~

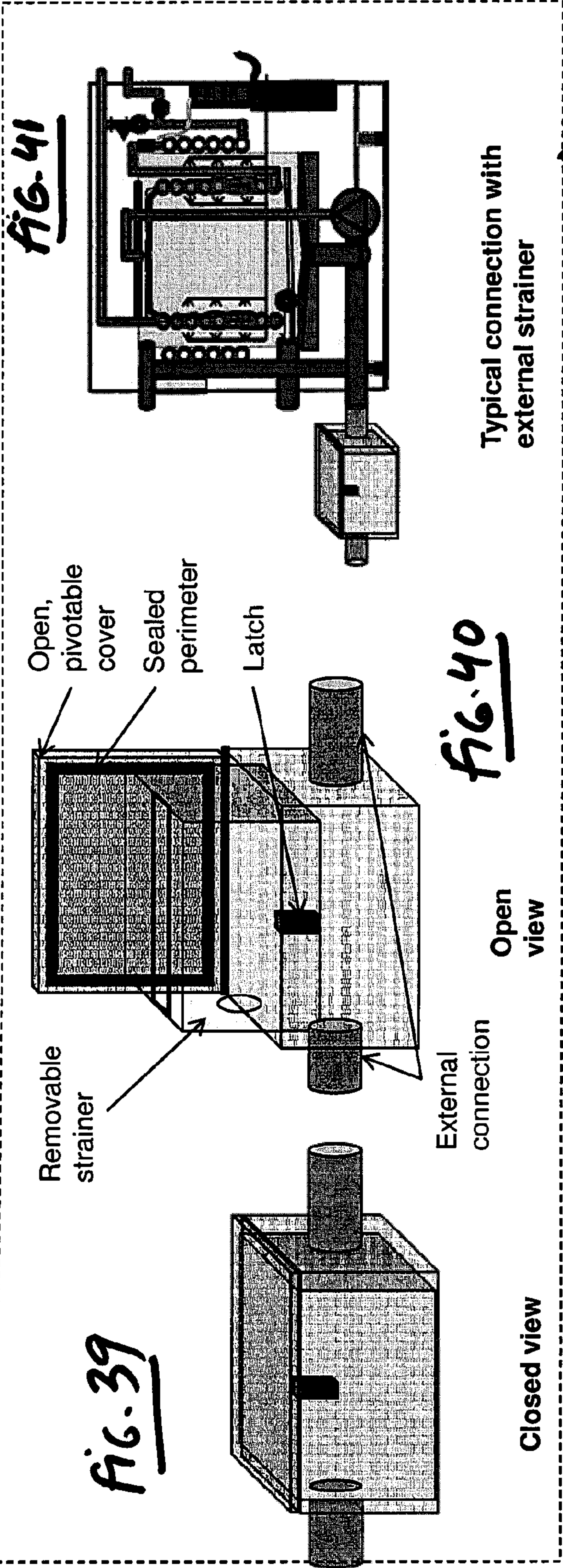




Inside strainer option for filtering discharge fluid

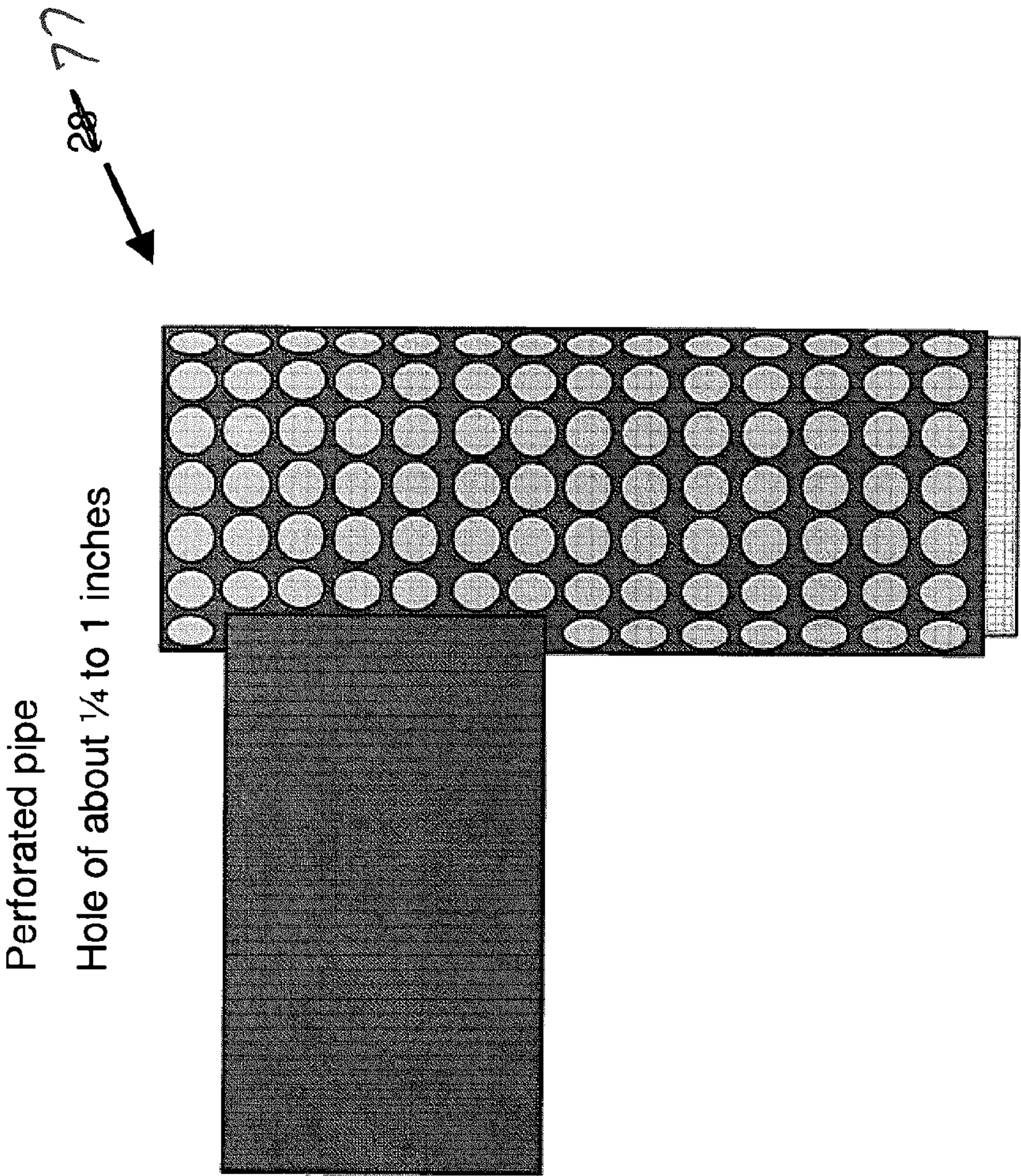


External strainer option for filtering discharge fluid



Filtration system

External view

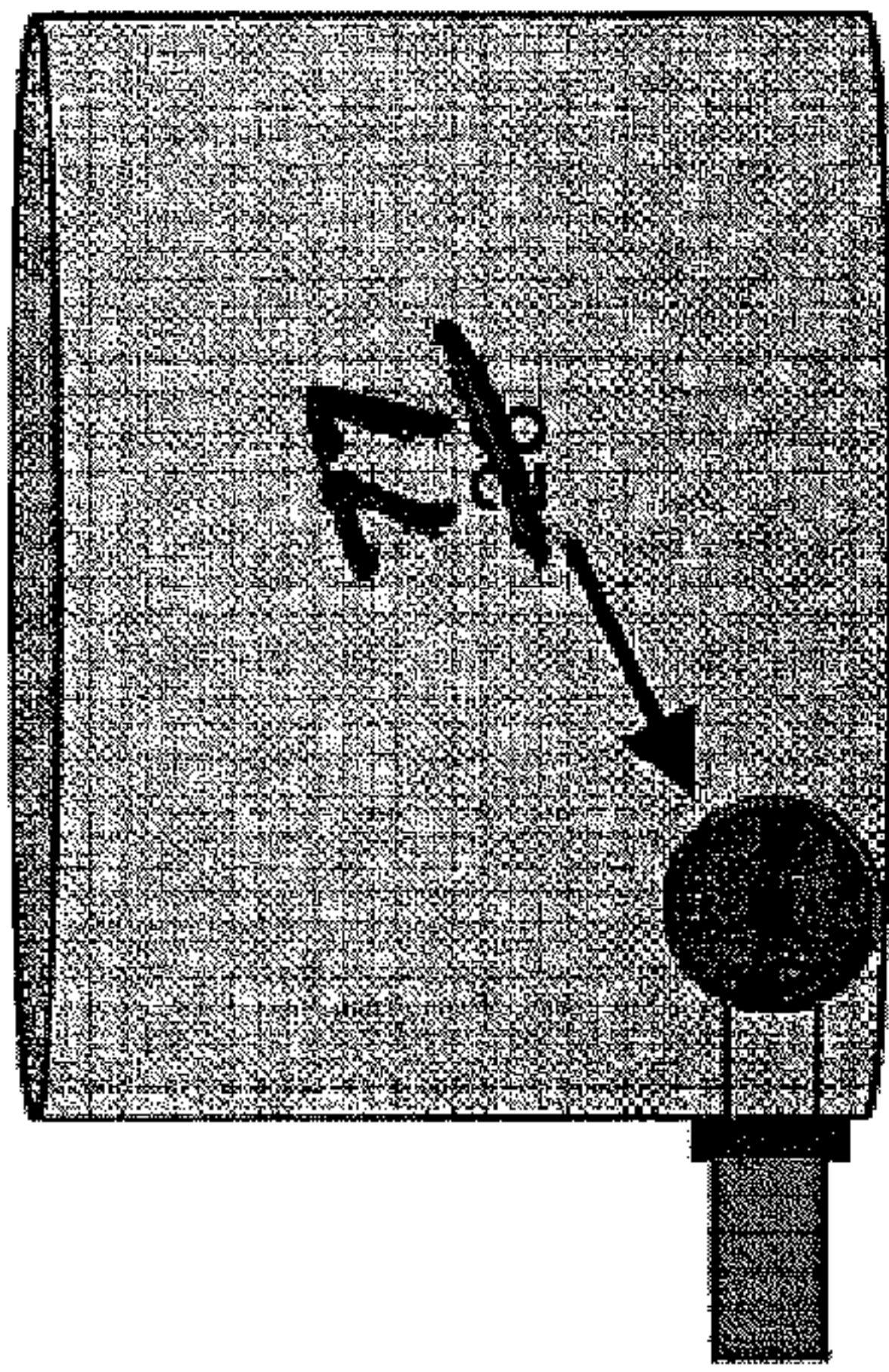


42

FIG. 15

Filtration system

External view



Cut away view A-A

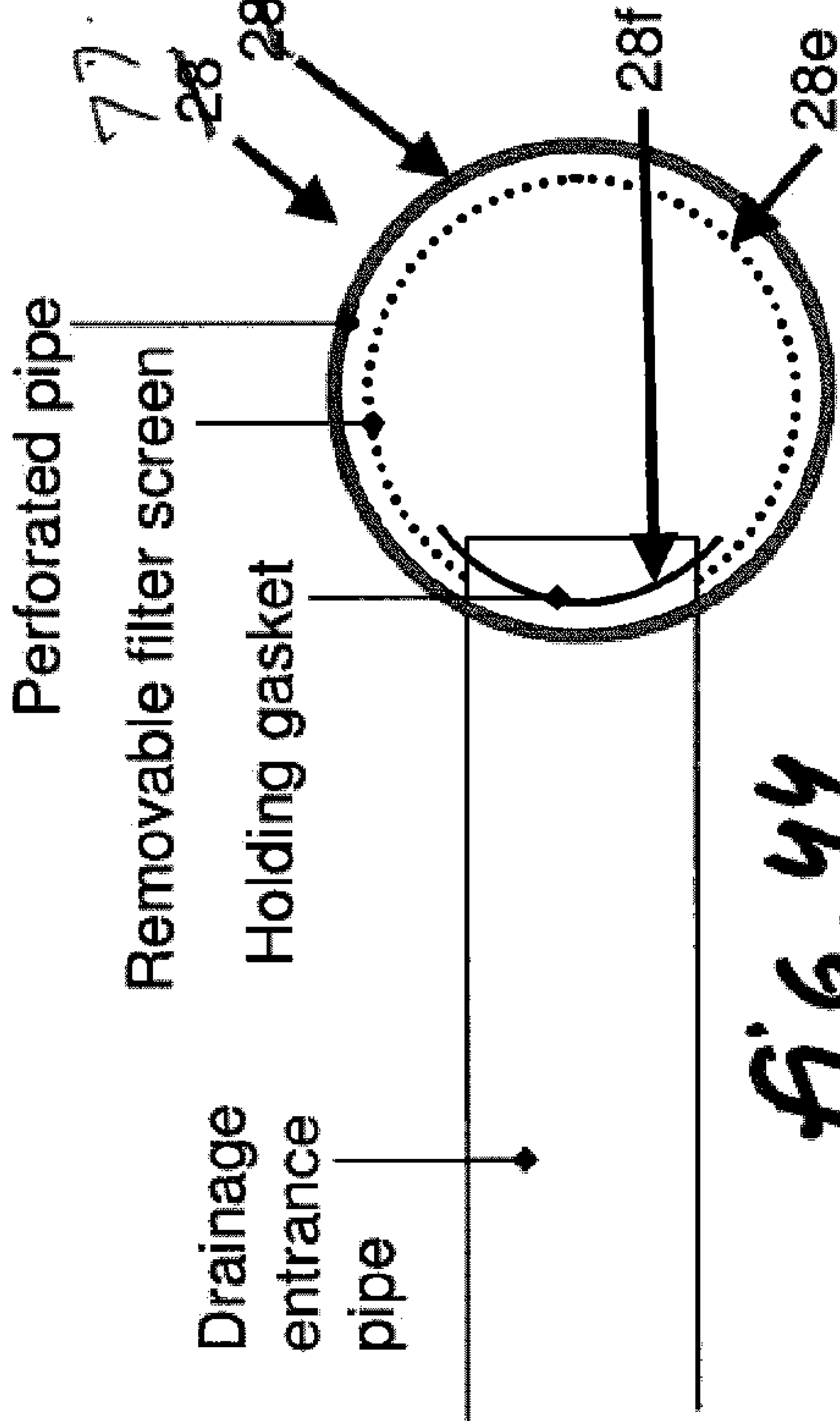


fig. 44

Filter screen: holes about 1/16 to 1/8 inches

Cut away top view

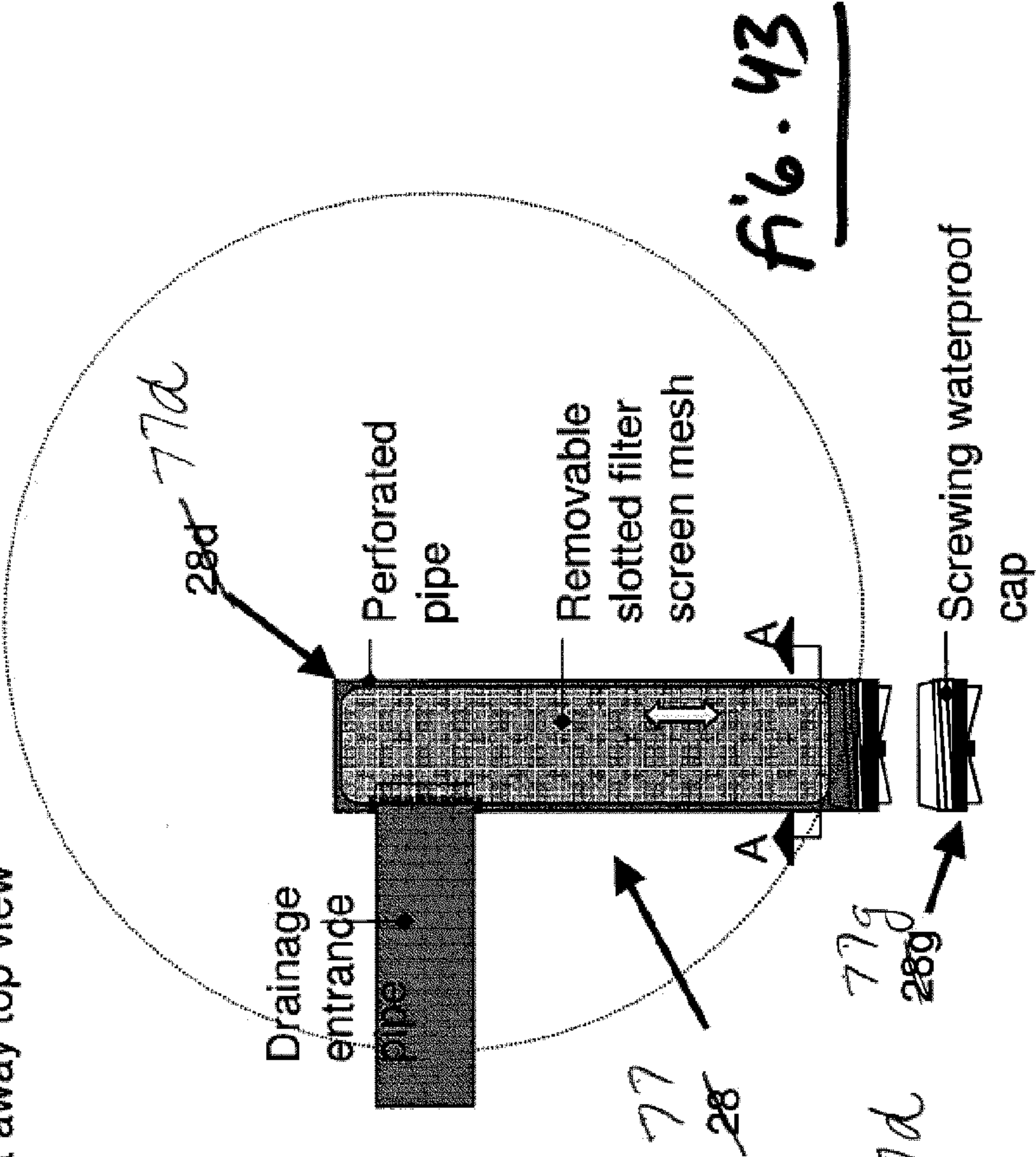


fig. 43

Alternate « rectangular » design - Cut away view A-A

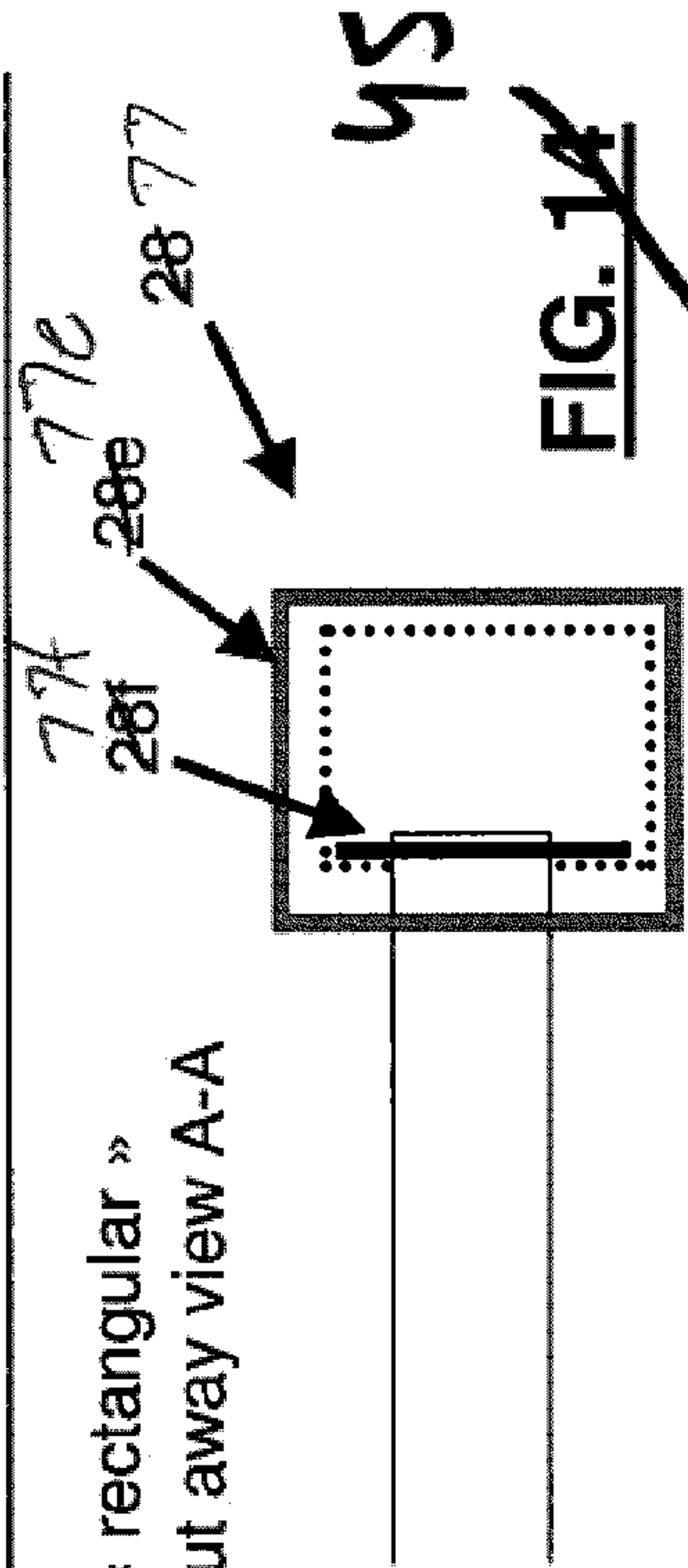
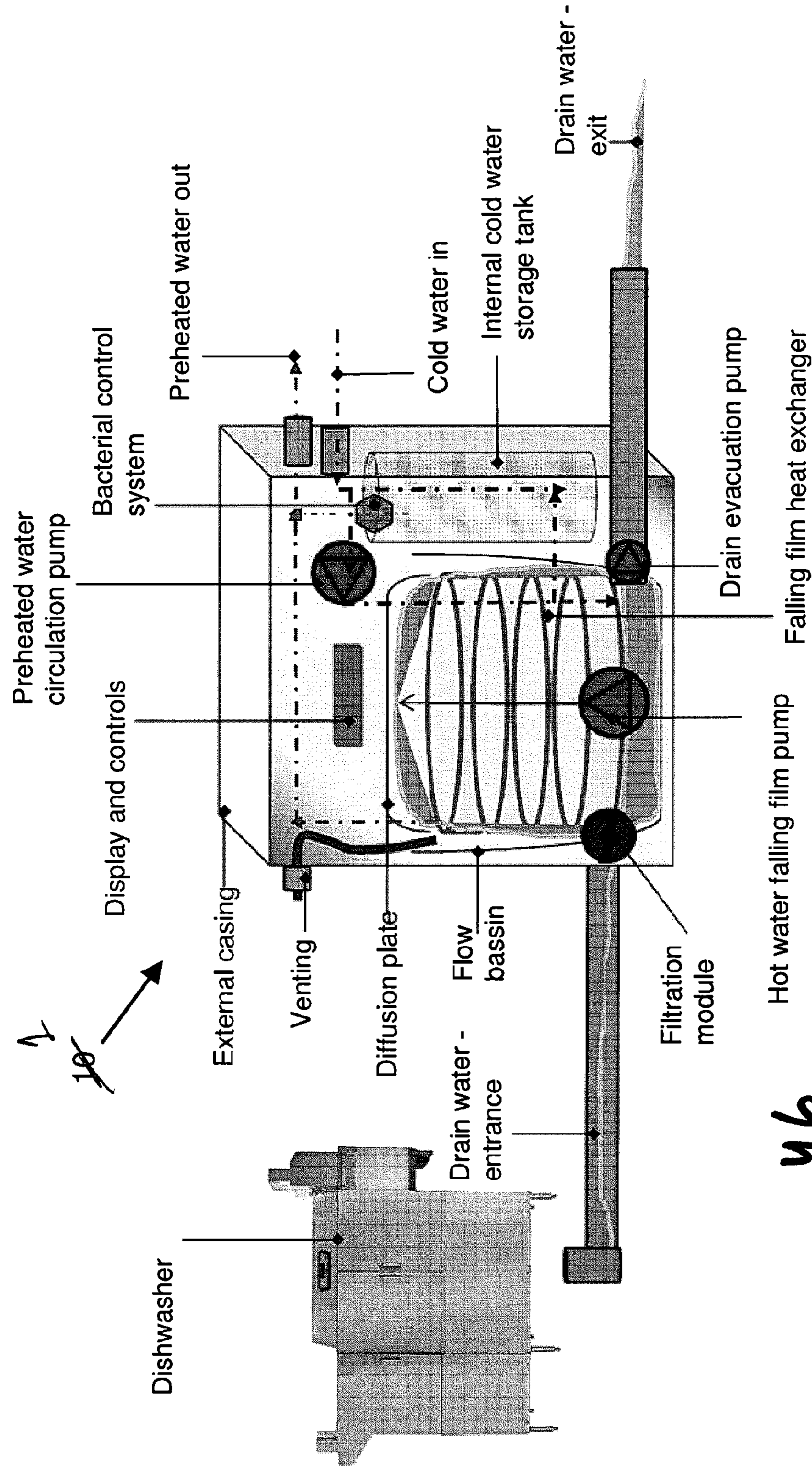


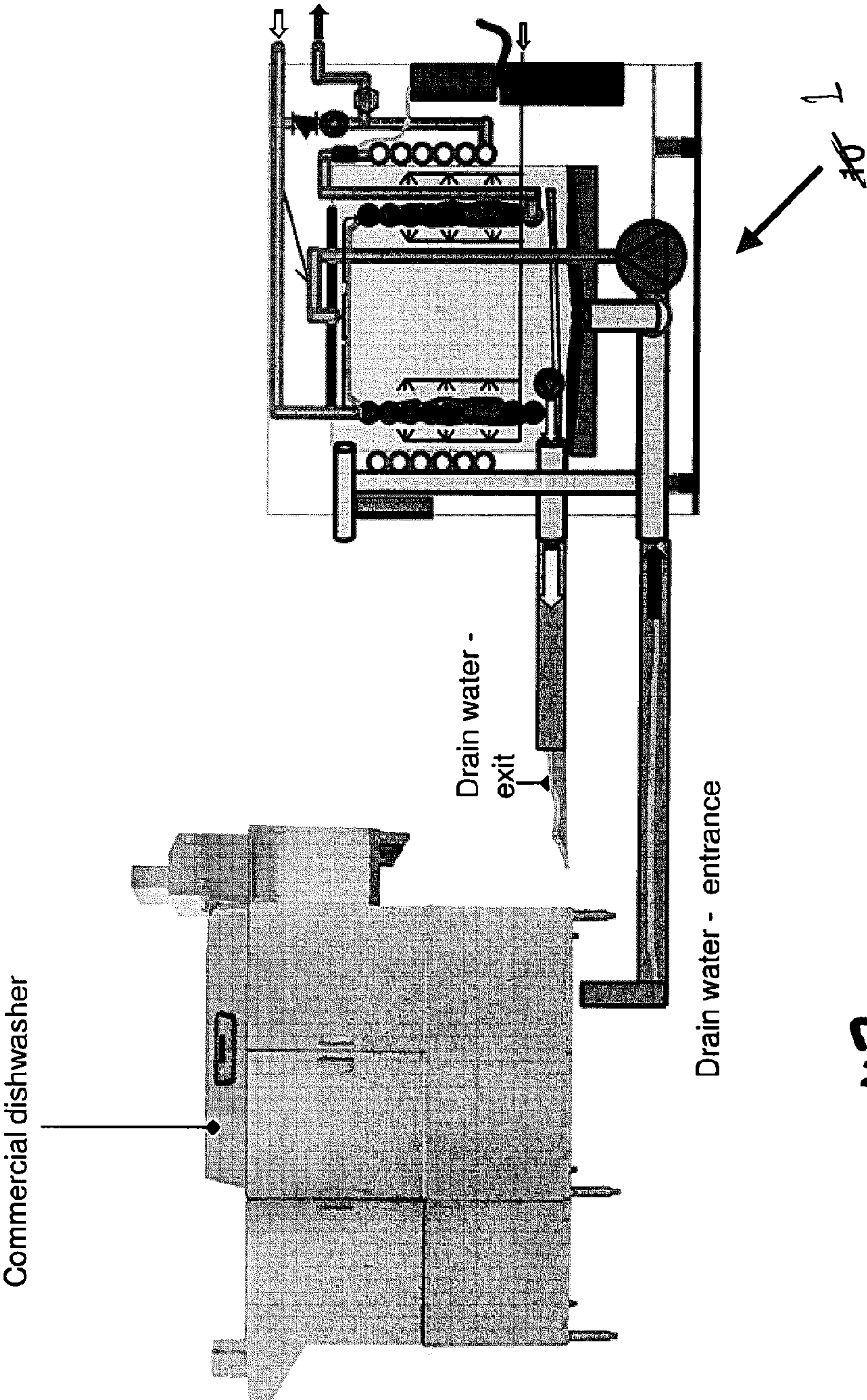
FIG. 14

45

Description of some inside components

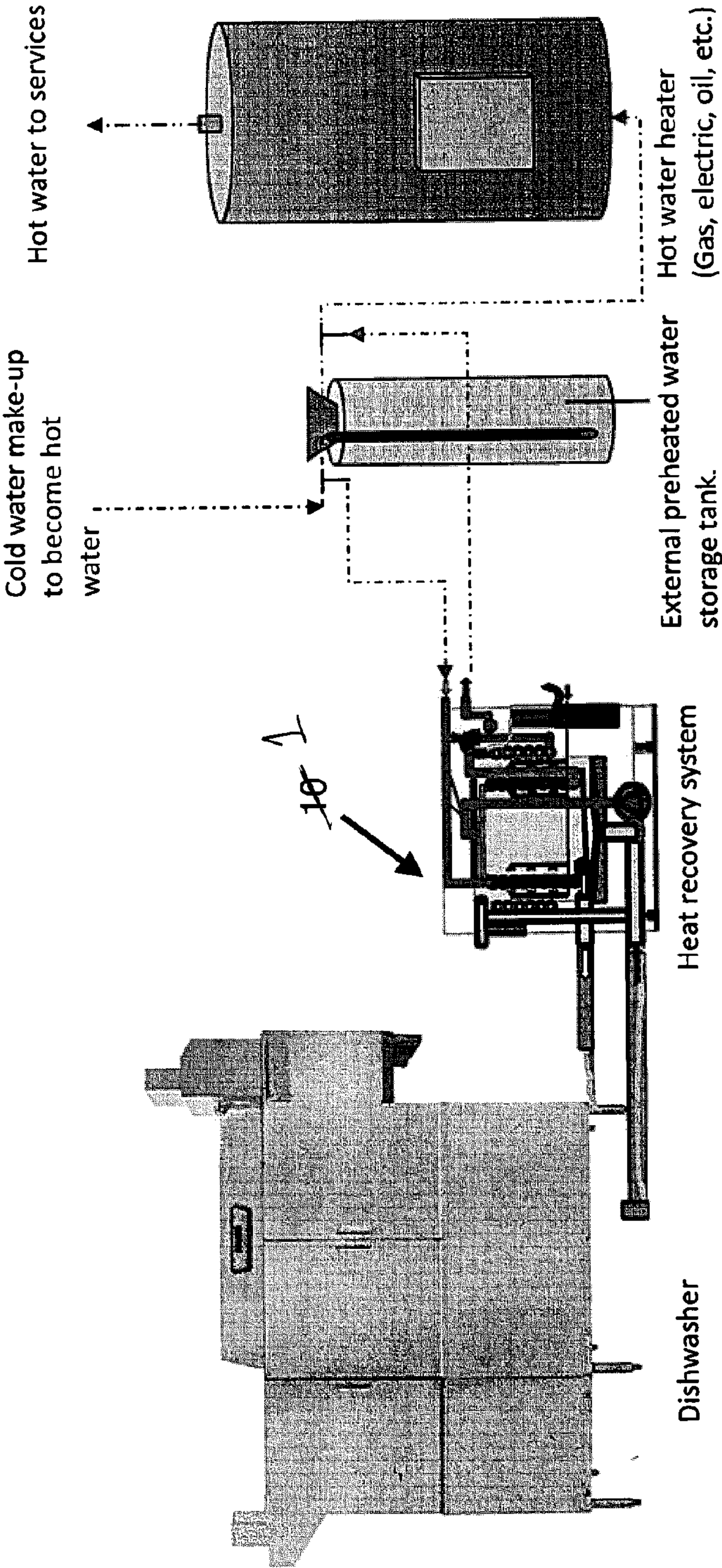


Description of some inside components



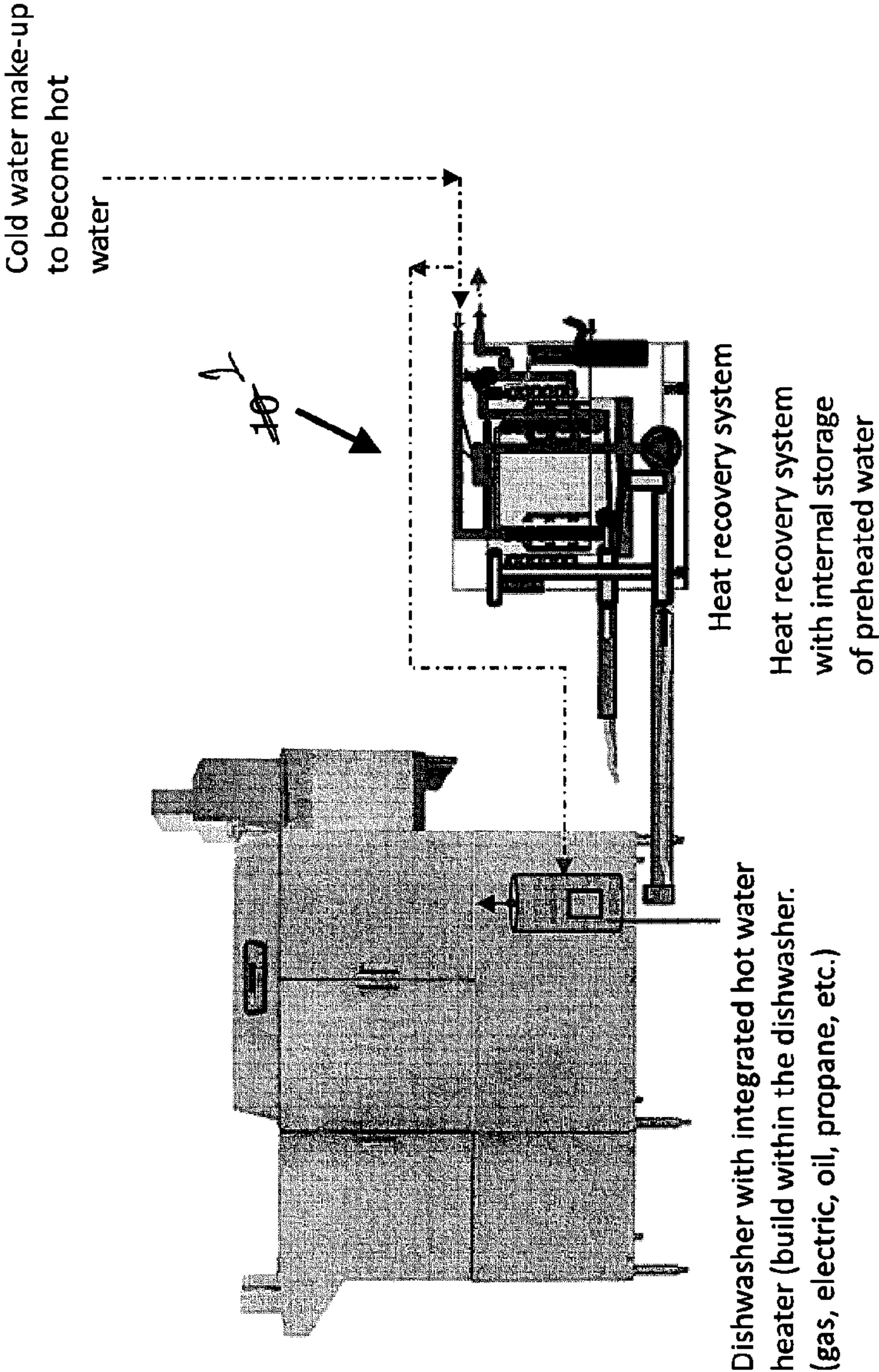
47  
**FIG. 18**

A) Type of water preheating  
1) Preheating hot water before the water heater



48  
FIG. 17

- A) Type of water preheating
- 2) Preheating cold water directly to dishwasher



B) Single or multiple system uses  
Using multiple systems with either option A)1) or A)2)  
Shown here is option A)2) in 3 unit multiple system.

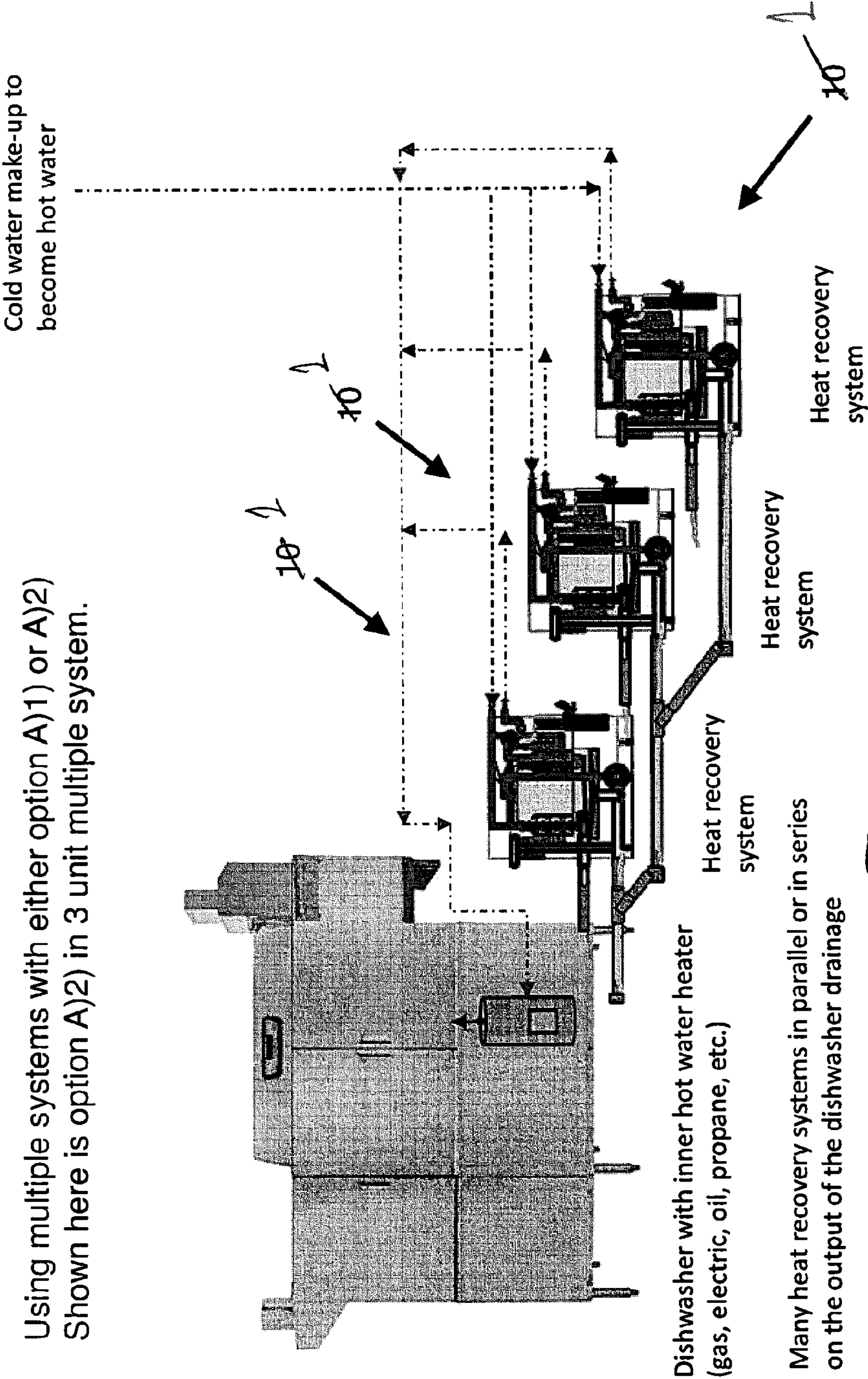


**FIG. 19** *SD*

C) Addition of a pumped storage system for high flow evacuation water load.

This alternative can be used with previous descriptions, A)1) or A)2), and B) multiple systems can be used. Shown here is option A)2), with single system with storage tank.

Cold water make-up to become hot water

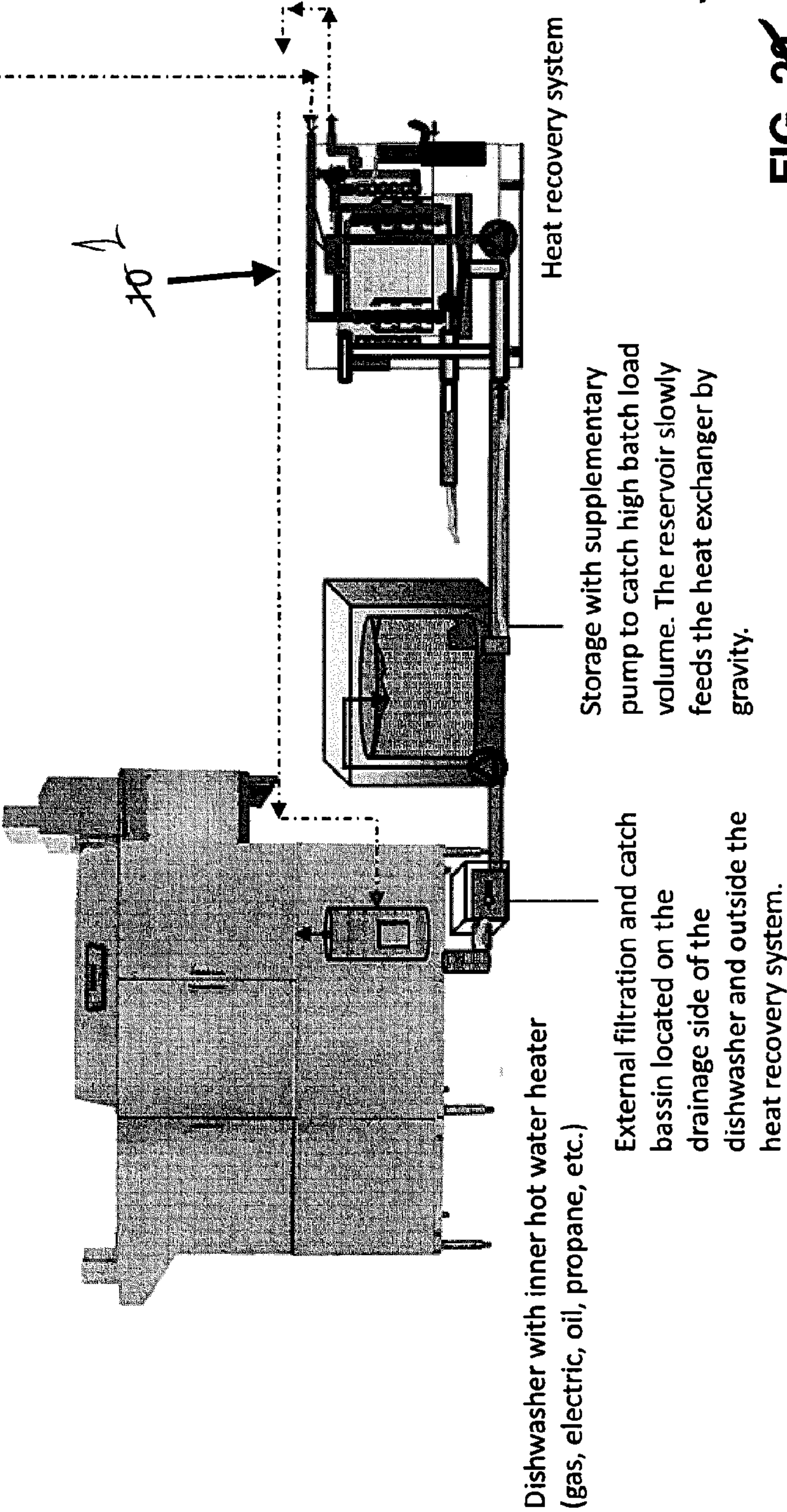
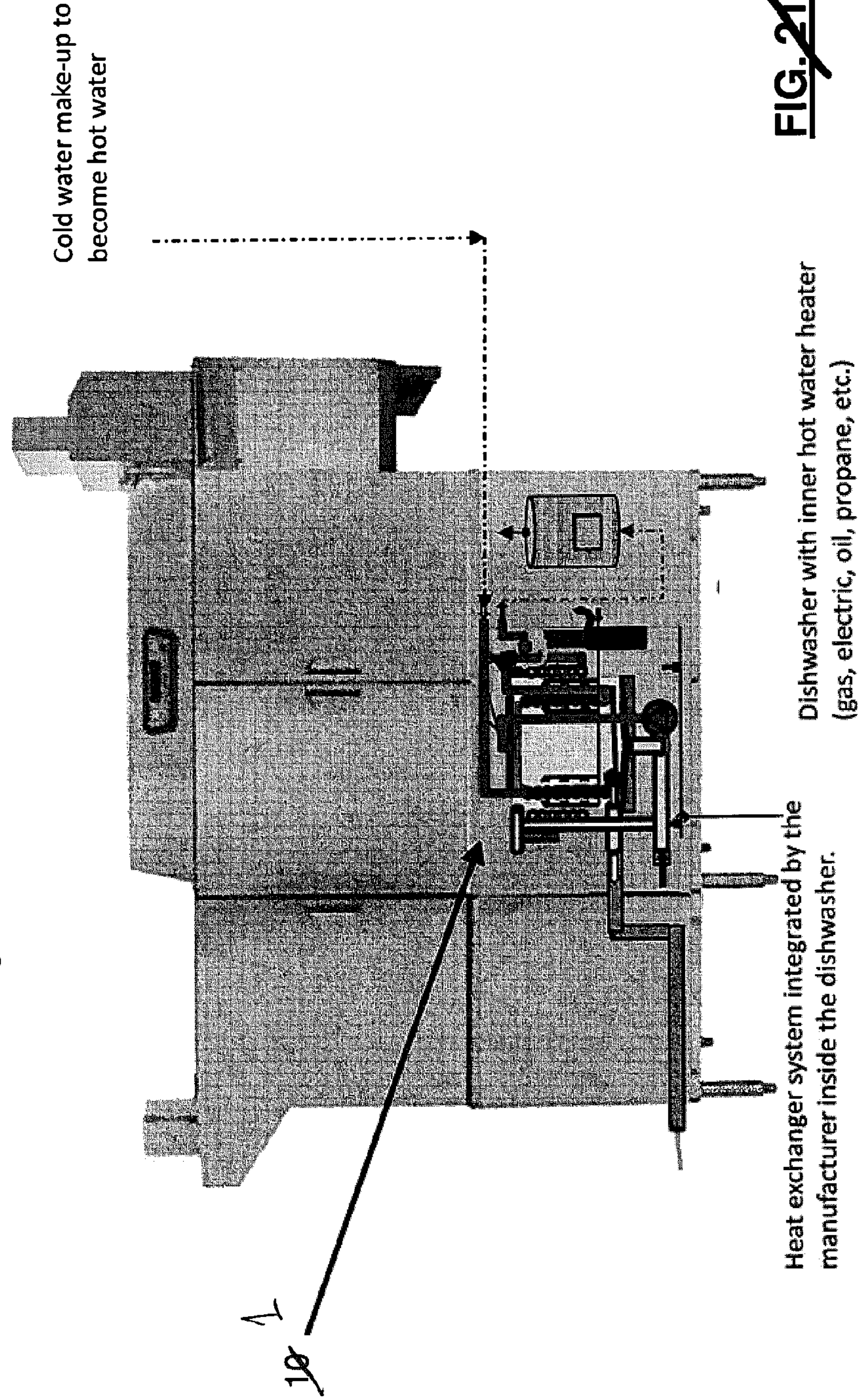


FIG. 20

51

D) Integration of the heat recovery system inside the dishwasher, as a dishwasher component.

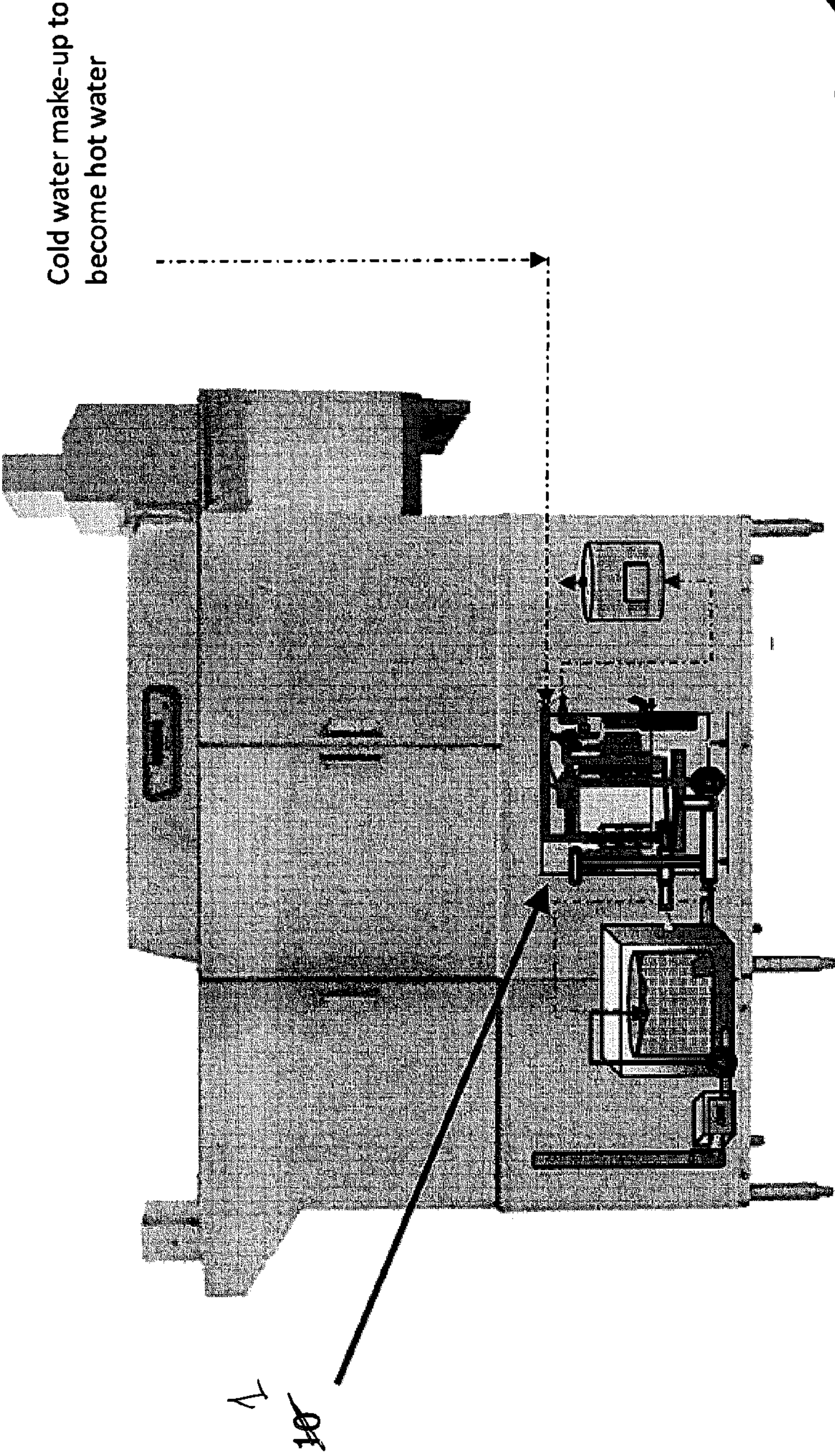
This alternative can be used with all previous descriptions. Shown here is option A)2), with heat recovery system for preheating cold water with inner storage tank.



52  
~~FIG. 21~~

E) Integration of the heat recovery system inside the dishwasher, as a dishwasher component.

This alternative can be used with all previous descriptions. Shown here is option A)2), with heat recovery system for preheating cold water with inner storage tank.



Heat exchanger system integrated by the manufacturer inside the dishwasher.

Dishwasher with inner hot water heater (gas, electric, oil, propane, etc.)

53

FIG. 22

F) Integration of the heat recovery system under the dishwasher, as a dishwasher component with drainage by gravity directly into the heat recovery component.

This alternative can be used with all previous descriptions. Shown here is option with heat recovery system for preheating cold water with inner storage tank.

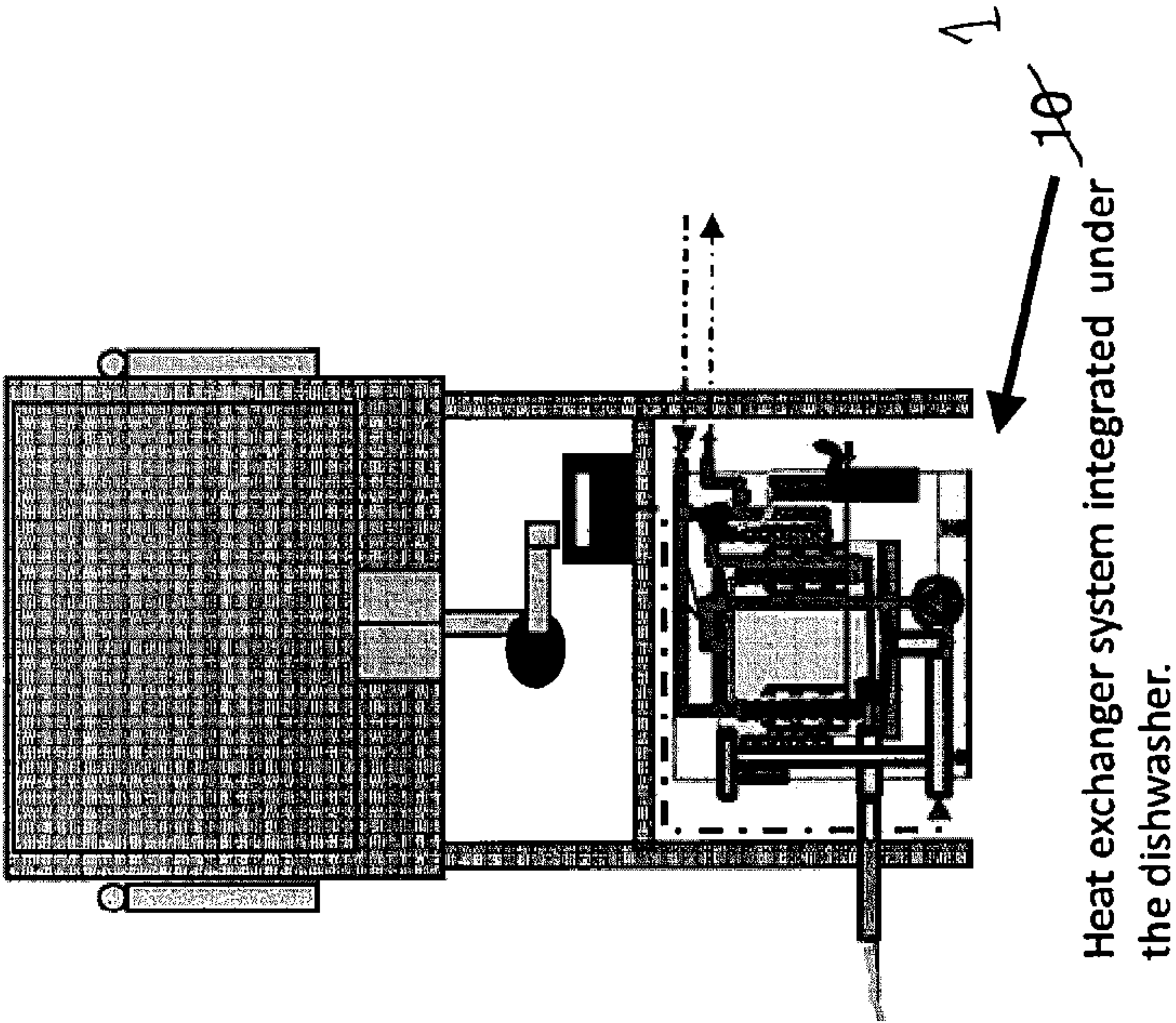
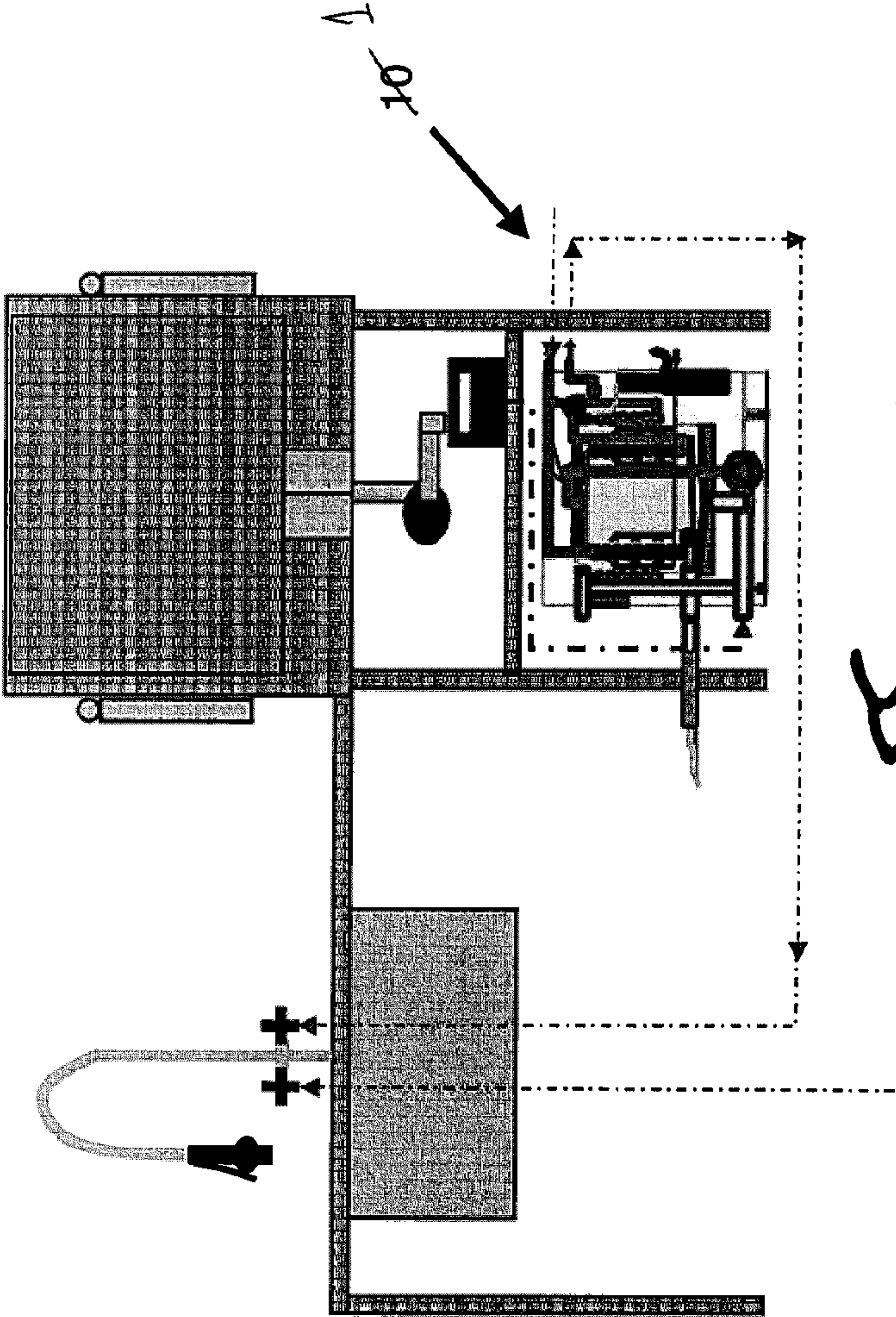


**FIG. 28**

F) Integration of the heat recovery system under the dishwasher, as a dishwasher component with drainage by gravity directly into the heat recovery component. The cold water used for the spray valve is preheated by the heat recovery system.

This alternative can be used with all previous descriptions. Shown here is option with heat recovery system for preheating cold water with inner storage tank.



Heat exchanger system integrated under the dishwasher and used for preheating spray valve water.

~~FIG. 24~~ SS

G) Integration of a heat pump module to realise a complete water heater system.

This alternative is a preheating system integrated with heat pump to make a complete water heater heating cold water from 40 F to 140 F or higher.

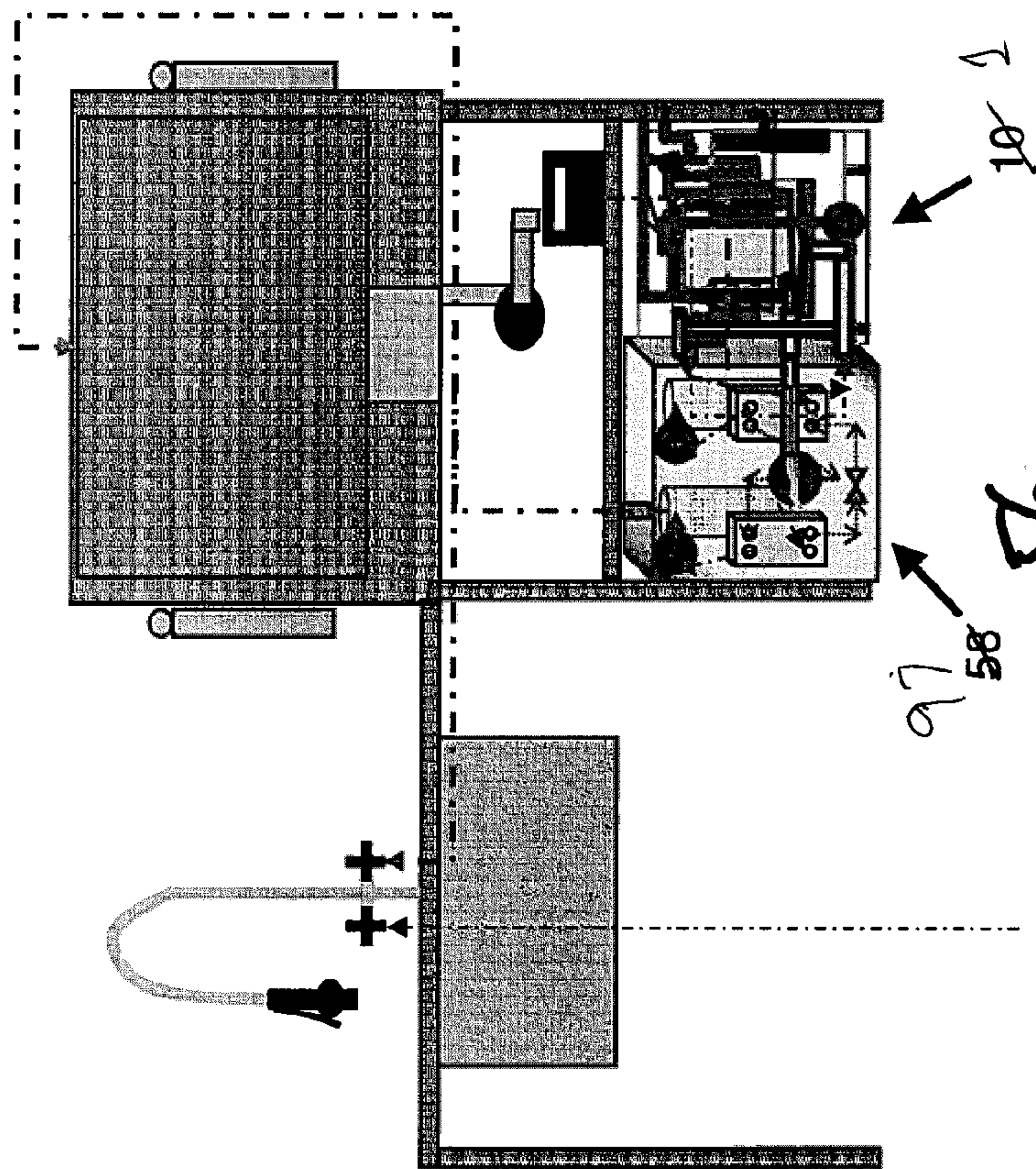
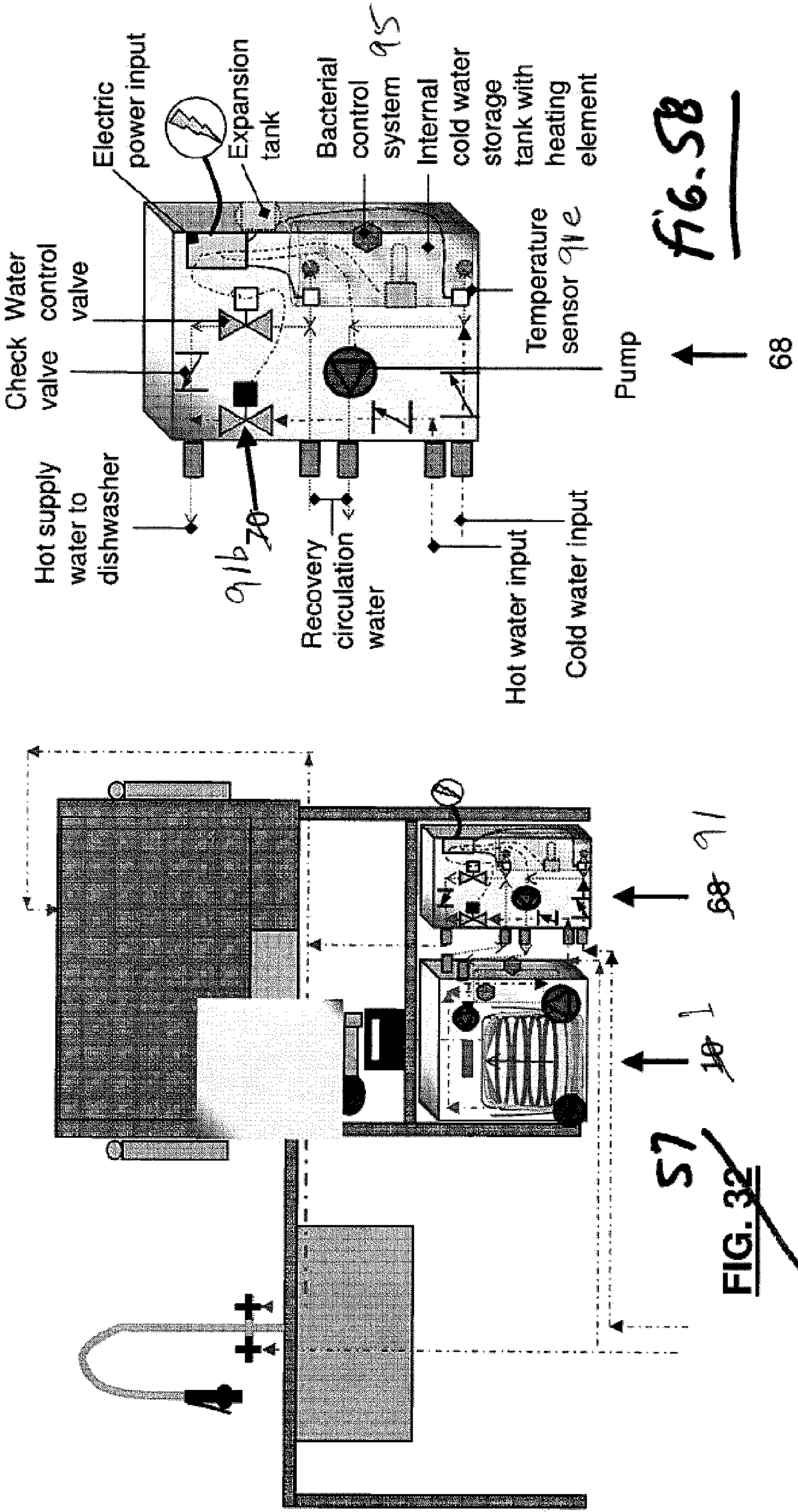


**FIG. 25**

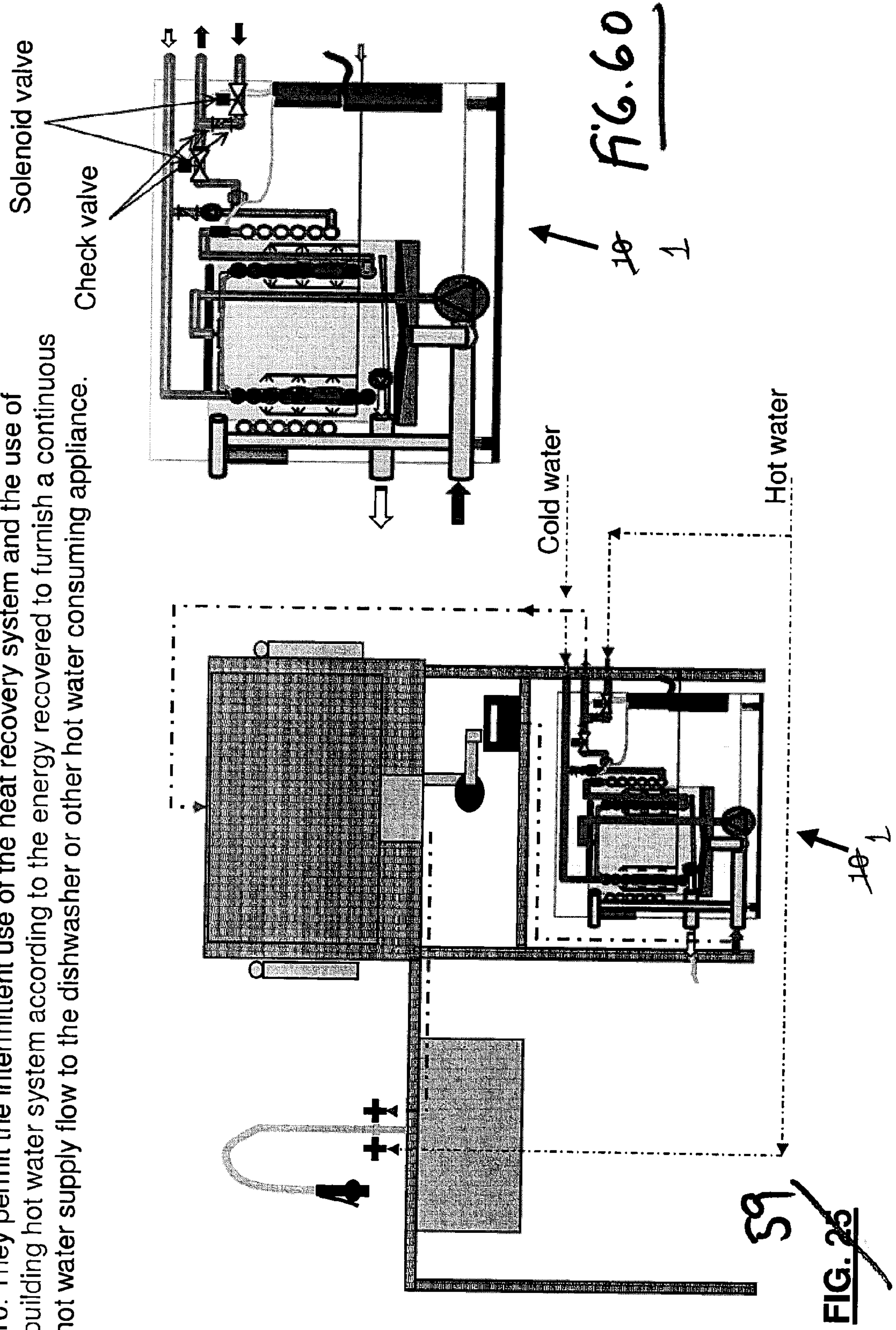
H) Integration of water selection module to facilitate installation.

This figure shows the water selection module as a stand alone module. Such device can also have all or part of its component integrated in device 10. They permit the intermittent use of the recovery system and the use of building hot water system according to the energy recovered.



G) Integration of a water selection module to realise a complete water heater system.

This figure shows the water selection module as part of a system integrated in device 10. They permit the intermittent use of the heat recovery system and the use of building hot water system according to the energy recovered to furnish a continuous hot water supply flow to the dishwasher or other hot water consuming appliance.



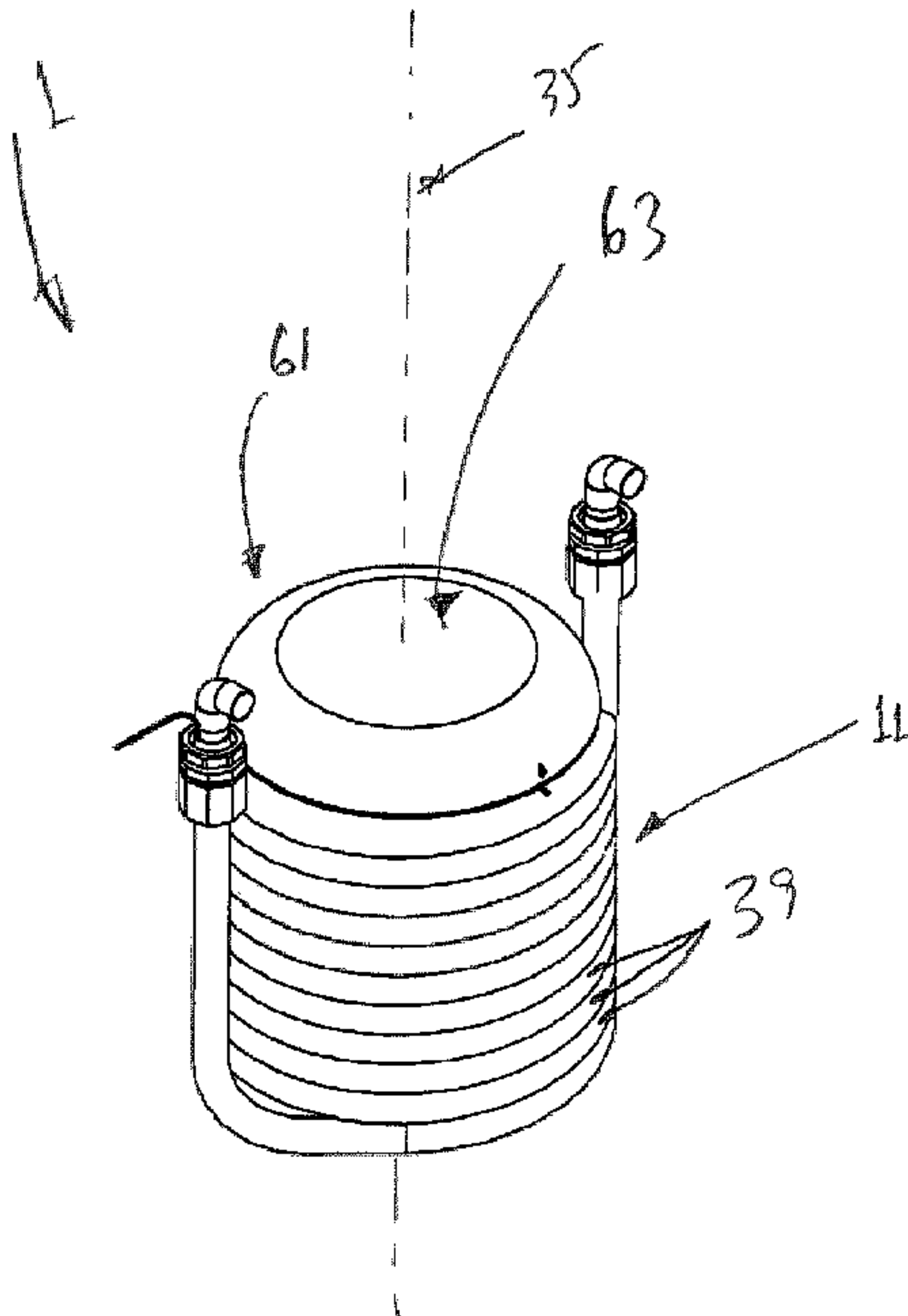


FIG. 13

