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(54) **PARALLEL FLOW CRYOGENIC LIQUEFIED GAS EXPANDERS**

KRYOGENE PARALLELFLUSS-FLÜSSIGGASEXPANDER  
DÉTENDEURS DE GAZ LIQUÉFIÉ CRYOGÉNIQUE À FLUX PARALLÈLE

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**US-A1- 2007 204 652**      **US-B1- 6 250 244**

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- "COMPRESSOR DESIGN YIELDS SAVINGS FOR KANSAS GAS PLANT", OIL AND GAS JOURNAL, PENNWELL, HOUSTON, TX, US, 24 October 1994 (1994-10-24), page 95, XP000770719, ISSN: 0030-1388
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URL:<http://www.ebaraintl.com/wp-content/uploads/2011/10/2009-Solving-New-Demands-in-LNG-Technology.pdf> [retrieved on 2015-05-20]

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**Description****BRIEF DESCRIPTION OF THE INVENTION**

**[0001]** The present invention is directed to cryogenic liquefied gas expanders configured within one or more containment vessels with parallel flow through the expanders, where cryogenic fluid enters through a common inlet and is split between a first expander and a second expander, while expanded cryogenic fluid is generated by both expanders and exits through a common outlet. Parallel flow between the liquefied gas expanders is further facilitated by a rotary control valve positioned either between the vessels or within a vessel and between the two liquefied gas expanders.

**BACKGROUND OF THE INVENTION**

**[0002]** Cryogenic liquids are liquefied gases that are maintained in their liquid state at very low temperatures, typically below -150 °C or -238 °F. Different cryogens become liquids under different conditions of temperature and pressure. Industrial facilities that produce, store, transport and utilize such gases make use of a variety of valves, pumps and expanders to move, control and process the liquids and gases. For example, Joule-Thomson (J-T) expansion valves are frequently used to reduce pressure within a system carrying liquefied natural gas (LNG). While J-T valves are important, they have limited value in comparison to certain types of liquefied gas expanders, which are able to reduce pressure while also reducing the enthalpy of the natural gas and generating work. For example, turbine expanders are able to reduce pressure and create rotational momentum that generates shaft torque (which reduces enthalpy). The shaft torque is then used by a generator to produce electrical power.

**[0003]** Hence, turbine expanders are frequently used to expand liquefied gas from a high pressure to a low pressure, while capturing energy generated by the expansion. In this manner, single-phase LNG expanders are used to enhance the performance of LNG liquefaction plants. Two-phase LNG expanders are further used to reduce liquefaction costs and increase production, which has the positive benefit of extending the lifetime of depleting gas fields by generating more usable liquid from the field.

**[0004]** When liquefied gas expanders are used in new plants, the new plant will require less power generation and smaller gas compressors, gas expanders and heat exchangers. When used in new or existing plants with pre-existing power generators, gas compressors, gas expanders and heat exchangers, the addition of liquefied gas expanders will increase LNG production. The value and importance of cryogenic liquefied gas expanders, and their various applications is disclosed in the presentation entitled "Comprehensive Applications for LNG Expanders," Joel V. Madison, Sixth World LNG Summit, November 30, 2005, Rome, Italy. International Publica-

tion Number WO/2007/148122 further discloses an LNG plant and the various manners in which expanders can be used therein.

**[0005]** The publication and corresponding presentation entitled "Transient Characteristics of Two-Phase LNG Expanders," Finley et al., American Institute of Chemical Engineers (AIChE) Spring National Meeting 2007, 7th Topical Conference on Natural Gas Utilization, April 22-26, 2007, Houston, Texas, provide an explanation of how different types of liquefied gas expanders are used in LNG production. In particular, this publication and presentation discuss how the loss of power in one expander and certain transient characteristics and no-load conditions of expanders can be addressed through the use of a single-phase expander in series with a two-phase expander within a single vessel. United States Publication Number 2008/0122226, also discloses the use of multiple expanders within a single vessel, but the expanders are used for distinctly different purposes and are neither in series nor in parallel.

**[0006]** The application of a single two-phase LNG expander in parallel with multiple Joule-Thomson (J-T) expansion valves within an overall LNG plant design is disclosed in the publication entitled "Two-Phase LNG Expanders," Kociemba et al., Gas Processors Association - GTL and LNG in Europe, February 24-25, 2005, Amsterdam, The Netherlands. The application demonstrated in this publication, however, is more reflective of the standard practice of placing a J-T valve in parallel with an expander to take the place of the expander should there be a need to shut the expander down temporarily.

**[0007]** When considering the modification of existing (in particular) LNG plant installations, the cost, size and construction impact of any modification, such as adding an expander, are major factors. Furthermore, while the addition of expanders may make it possible to increase flow capacity, increased flow capacity has historically required the size of the expanders to be increased and therefore the size of the vessels holding the expanders, as well as the passages and the diameter of the generators to be increased. In order to increase the diameter of current generators, the generator would have to be four pole, versus current two pole generators, which would significantly increase the size of the generators, while decreasing their efficiency, and significantly complicating the hydraulic component design, thereby further increasing costs. "COMPRESSOR DESIGN YIELDS SAVINGS FOR KANSAS GAS PLANT", OIL AND GAS JOURNAL, PENNWELL, HOUSTON, TX, US, 24 October 1994, page 95, ZP000770719, ISSN: 0030-1388 discloses a turboexpander compressor configuration resulting in lower initial capital costs and reduced energy costs during operation.

**SUMMARY OF THE INVENTION**

**[0008]** In accordance with the present invention, there is provided a parallel flow system according to claim 1.

Embodiments of the invention are set out in the dependent claims.

## BRIEF DESCRIPTION OF THE DRAWINGS

### [0009]

Figure 1 is a diagrammatic view of a single vessel containing two expanders configured to operate in parallel flow through operation of two external valves;

Figure 2 is a diagrammatic view of a single vessel containing two expanders configured to operate in parallel flow through operation of a rotary control valve;

Figure 3 is a partial cross-sectional view of a rotary control valve in accordance with the present invention;

Figure 4 further illustrates the rotary control valve of Figure 3 when the passages to both the lower expander and the upper expander are open;

Figure 5 further illustrates the rotary control valve of Figure 3 when the passages to the lower expander are open and the passages to the upper expander are closed;

Figure 6 further illustrates the rotary control valve of Figure 3 when the passages to both the lower expander and the upper expander are closed;

Figure 7 further illustrates the rotary control valve of Figure 3 when the passages to the lower expander are closed and the passages to the upper expander are open; and

Figure 8 is a cross-sectional view of the multiple expander vessel of Figure 2 further illustrating operation of the rotary control valve of Figure 3 and the interaction between the expanders within the vessel.

## DETAILED DESCRIPTION OF THE INVENTION

[0010] The present invention is directed to cryogenic liquefied gas expanders, and more particularly to two liquefied gas expanders (herein referred to as "expanders") operating in parallel within one or more containment vessels with parallel flow through the expanders. As noted above, it is known to use single-phase or two-phase expanders (both a type of liquefied gas expander), by themselves or within a single vessel, to enhance the performance of cryogenic plants and facilities. Expanders are also used in series and in parallel, where the physical arrangement is in parallel (meaning the expanders are physically located next to one another) and the flow through the expanders is in parallel. While the use of multiple expanders has its benefits, additional or different benefits are possible if expanders are used in parallel in a more compact physical arrangement, such as within a single vessel or in a serial physical arrangement, with parallel flow between the expanders. In particular, a serial arrangement, parallel flow design allows for a higher flow

capacity without increasing the size of the expanders, the size of the vessel(s), the size of the passages, or the diameter of the generators, thereby eliminating the need for a larger four pole generator. A serial arrangement, parallel flow design also reduces the cost of the expanders (overall), reduces space requirements and reduces disruption of the LNG plant for installation and maintenance.

[0011] In addition, the parallel flow design of the present invention increases operational flexibility. With two expanders operating in parallel within one or more vessels, and through utilization of the rotary control valve discussed below, the range of flow and head that the expanders can operate in is much larger than is possible with a single expander or multiple expanders, running in series or otherwise. For example, in a single or multi-expander design, to turn down flow by some percentage, the operating capacity of the expander(s) must be turned down by a corresponding percentage. Running such expanders at less than 100% or near full capacity, however, compromises the efficiency of the expanders and turning them down by as much as 50% renders the expander(s) inoperable. With the parallel flow design of the present invention, a fifty percent turndown is possible by simply not running one of the expanders and other percentage variations are possible through use of the control valves to selectively restrict flow through the expanders, as further described below.

[0012] As partially noted above, the serial arrangement, parallel flow design of the present invention is also much more compact than prior art designs with similar capacity. This is because the common inlet (for unexpanded cryogenic fluid) and outlet (for expanded cryogenic fluid) of the two expanders, as further illustrated below, reduces the amount of piping that is required and allows two expanders to operate within the space of approximately one expander. Since size, construction impact, and cost are all major factors in expander integration, this new design provides an attractive alternative to prior art designs that can be easily installed in both existing and new liquefaction plants. The novel rotary control valve of the present invention further enhances the compactness and operational flexibility of the design by eliminating the need for external control valves, as further explained below.

[0013] Figure 1 provides a simplistic diagrammatic illustration of a single vessel 10 containing an expander 12 in a first chamber 13 and an expander 14 in a second chamber 15, with the expanders 12 and 14 configured to operate in parallel flow through operation of two external valves 16 and 18 and passageways 17 and 19 between the first chamber 13 and the second chamber 15. Cryogenic fluid entering the vessel 10 at point 20 would be split within the vessel 10, with approximately half of the fluid being directed to expander 12 and half to expander 14. The passageways 17 and 19 are formed by positioning a plate or disk (not shown in Figure 1) between the two chambers 13 and 15.

**[0014]** The plate or disk of the divider 22 would create the passageways 17 and 19 and could be bolted between the two chambers 13 and 15, or welded, or both bolted and welded, so as to form a seal between the two chambers 13 and 15. Technically, the two chambers 13 and 15 could be separate vessels that are joined together by the divider 22 to form a single vessel, so references to a single vessel, herein, are understood to include two vessels operating as a single vessel, and references to chambers are understood to include separate vessels joined together to effectively form a single vessel. The plate or disk between the chambers or vessels would be formed of stainless steel or some other similarly suitable material. The divider 22 and passageways 17 and 19 could be structured in such a way as to look very much like the plate 44 and accompanying passages of the rotary valve illustrated in Figure 3 when positioned so as to enable flow between both chambers at the same time. Unlike the rotary valve, however, where plate 44 (shown in Figure 3) can be turned to create multiple different flow scenarios, as further described below, the divider 22 would be stationary at all times and only permit full flow between the two chambers 13 and 15. The expanders utilized in any of the various configuration described herein could be single-phase liquefied gas expanders or two-phase liquid-vapor expanders that expand liquid or liquid and vapor, respectively, from high pressure to lower pressure, as well as fixed speed expanders or variable speed expanders, as further explained below.

**[0015]** To regulate the parallel flow between the two expanders 12 and 14, external, independently operated valves 16 and 18 are utilized. When both valves 16 and 18 are open, fluid flows through expanders 12 and 14 along the illustrated paths. When valve 16 is open, but valve 18 is closed, fluid only flows through expander 12. When valve 16 is closed and valve 18 is open, fluid only flows through expander 14. The combination of valves and expander allows the careful control of the expanders 12 and 14 within the vessel 10. Further flexibility is possible by partially opening/closing the valves 16 and 18 to control the flow through each expander. This aspect of the present invention makes it possible to control the flow through both variable speed and fixed speed expanders, without having to adjust the speed at which the expanders operate (something which, of course, was not possible with a fixed speed expander).

**[0016]** Although Figure 1, and Figure 2 below, illustrate cryogenic fluid flowing through the vessels and expanders in a particular direction, known as upward flow, the direction of flow of the cryogenic fluid is not central to the present invention. Fluid could flow in the direction illustrated, or the opposite direction, referred to as downward flow, without departing from the intent of the present invention.

**[0017]** Further while the present invention is illustrated in the Figures of the drawing as a single vessel, multiple vessel configurations are possible as well. In such instances, one expander would be located within a first

vessel and a second expander would be located within a second vessel, with passageways formed between the two vessels so that expanded fluid created by the first expander is routed to the second vessel and around the outside of the second expander and unexpanded fluid in the first vessel is routed to the second expander in the second vessel. To route the fluid appropriately between the two vessels, pipes could be utilized to route the unexpanded fluid and the expanded fluid as necessary, a plate or disk as described above could be positioned between the two vessels, or a rotary valve of the type described below could be positioned between the two vessels. The key is that all of the unexpanded fluid enters through the same vessel inlet with some of the unexpanded fluid in the first vessel being routed to the second vessel at the same time that expanded fluid from the first vessel is routed to the second vessel and out through a common vessel outlet, so that fluid flow between the two vessels is in parallel, regardless of the physical arrangement between the vessels or expanders. This enables vessels to be positioned in a serial arrangement while operating in parallel, versus being positioned in parallel and operating in parallel, which requires significantly more space and is not practical in many installations.

**[0018]** One drawback to the embodiment illustrated in Figure 1 is the external nature of the valves 16 and 18. Because cryogenic fluid will be running through the valves as soon as they are turned on, the valves must be kept at cryogenic temperatures so they are always ready for use, which adds expense and requires more space. The motor used to run such valves are also expensive and must be explosion rated to prevent any form of industrial accident. Likewise, any external equipment cannot leak to the environment given the nature and temperature of the fluids flowing through them. These issues could be mitigated if it were possible to internalize (within the same vessel(s) as the expander) the valves and motors required to operate the valves.

**[0019]** Accordingly, Figure 2 discloses a structure similar to that of Figure 1, but in this preferred embodiment of the present invention, instead of two external valves being utilized, and additional passageways between the two chambers, a single rotary valve is used to direct fluid through one or both of the expanders, thereby further compacting the design, saving more space and cost, and reducing issues associated with externalized equipment. For example, utilization of a cryogenically submerged motor to operate a valve removes the requirement of making the motor explosion proof and makes motor or valve leakage inconsequential. As illustrated in Figure 2, the vessel 10 contains the two expanders 12 and 14 and a single rotary control valve 30 positioned in-between as a divider. As illustrated in Figure 2, two seals 32, positioned on either side of the valve 30, seal the valve 30 between the expanders 12 and 14 and create two sealed chambers 34 and 36 within the vessel 10, but seals are not required and two vessels could be used in place of a single vessel with two chambers. A cryogenic sub-

merged motor 33 is positioned within chamber 36 to operate the rotary control valve 30, as further illustrated with respect to Figure 3 below.

**[0020]** As noted above, in place of seals 32 between the valve 30 and the two chambers 34 and 36 (seals can pose issues at cryogenic temperatures anyway), it may be desirable to use the valve 30 as a form of divider and seal itself, especially since chamber 36 will be at a lower pressure than chamber 34. Making a portion of the plate 44 (discussed below with respect to Figure 3) out of TEFLON like material (that is not affected by the temperatures within the vessel 10) will also help to seal the two chambers 34 and 36. While this may allow some leakage between the two chambers 34 and 36, it would be small and therefore not a major issue, and the cryogenic fluid would still be retained within the vessel 10. This is also the case with respect to the embodiment of Figure 1, where seals between the two chambers containing the expanders within the vessel 10 are not significant.

**[0021]** Returning to the embodiment illustrated in Figure 2, fluid entering the first chamber 34 of the vessel 10 at single point 20 is split within the vessel 10, with approximately half of the fluid entering expander 12 and the other half going around the outside of expander 12. Fluid exiting expander 12 is then directed by valve 30 to the portion of the second chamber 36 of the vessel 10 outside of expander 14, while fluid flowing around the outside of expander 12 is directed by valve 30 to the input of the second expander 14. Fluid exiting expander 14 and flowing around expander 14 come together at the single output 38 of the vessel 10.

**[0022]** The rotary control valve 30 is further illustrated in Figure 3, which provides a partial cross-sectional view of the valve 30. Intake assembly 40 to the valve 30 is bolted to the output assembly (not shown in Figure 3) of expander 12. When a first set of passages 42 formed in a plate 44 of the valve 30 are aligned with the channels 45 of the intake assembly 40, the output fluid of expander 12 is directed to the outlet ports 46 so as to flow around the outside of expander 14. When a second set of passages 48 formed in the plate 44 are aligned with the inlet ports 50, vessel input fluid flowing around the outside of expander 12 is routed to the intake passages 52 of the intake assembly 54 of expander 14. To control the flow of fluid through the expanders 12 and 14, the motor 33 rotates a toothed gear 56 that engages the teeth of the plate 44 and rotates the plate 44 to the left or right. The plate 44 effectively operates like a sliding gate that opens or closes the flow passages or passageways at the crossing point between the seals of the two chambers 34 and 36.

**[0023]** The operation of the rotary valve 30 is further illustrated with reference now to Figures 4-7. In Figure 4, the plate 44 is positioned so that first set of passages 42 are aligned over the channels 45 of the intake assembly 40 so that fluid can flow out of the expander 12. Likewise, the second set of passages 48 are aligned over the intake passages 52 of the intake assembly 54 so fluid

can flow into expander 14. In Figure 5, the plate 44 has been rotated to the left so that the second set of passages 48 are now aligned over the channels 45 of the intake assembly 40, thereby leaving expander 12 open, and the first set of passages 42 are blocked, which also closes expander 14 by blocking the intake passages 52 (represented by the dotted circle). Figure 6 illustrates the plate 44 further rotated to the left, so that the first set of passages 42 and the second set of passages 48 are both closed, thereby blocking the channels 45 and the intake passages 52, and closing both expanders 12 and 14. Rotating the plate 44 once more to the left, as illustrated in Figure 7, causes the first set of passages 42 to be aligned with the intake passages 52, thereby opening expander 14, with the second set of passages 48 and the channels 45 being blocked, thereby closing expander 12. In addition, as previously noted, the plate 44 can also be partially rotated so as to only partially open/close the flow through the first set of passages 42, the second set of passages 48, or both sets of passages, thereby enabling significant operational flexibility.

**[0024]** The interaction between the expanders 12 and 14 and the rotary control valve 30 within the vessel 10 is further illustrated in Figure 8. Cryogenic fluid (either in the form of liquid or liquid/vapor) enters through the vessel intake point 20 and enters an interior of the first chamber 34, where some of the fluid designated by the arrow 60 enters expander 12 (if the expander 12 is on and the valve 30 is open to expander 12), while the remaining fluid flows around the outside of expander 12, which is positioned within the first chamber 34, as designated by the arrow 62 (if the valve 30 to expander 14 is open). The fluid entering the expander 12 is expanded and exits the expander 12, passes through the valve 30 and enters the interior of the second chamber 36, where it flows around the outside of expander 14. The fluid flowing through the interior of the first chamber 34 and around the outside of expander 12 follows the path 62 into the valve 30 and into expander 14, where it is expanded and exits expander 14 at outlet 30. The cryogenic fluid output from the expander 12 merges with the cryogenic fluid output from the expander 14 near the common vessel outlet 38.

**[0025]** While the present invention has been illustrated and described in terms of a preferred embodiment and several alternatives herein in association with the various drawing figures, it should not be limited to just the particular description contained in this specification. For example, the present invention could use a different type of gated valve positioned between the two chambers of the vessel 10. Many other alternative or equivalent components and steps could be used to practice and be within the scope of the present invention which is defined in the appended claims.

**Claims**

1. A parallel flow system for expanding a cryogenic fluid, comprising:

a cryogenic vessel (10) having a first chamber (13) into which the cryogenic fluid flows through a vessel inlet, a second chamber (15) from which an expanded cryogenic fluid flows through a vessel outlet;

a first expander (12) positioned within the first chamber (13) for receiving a first portion of the cryogenic fluid and producing a first portion of the expanded cryogenic fluid while a second portion of the cryogenic fluid flows through an interior of the first chamber (13) and around an outside of the first expander (12);

a second expander (14) positioned within the second chamber (15) for receiving the second portion of the cryogenic fluid and producing a second portion of the expanded cryogenic fluid while the first portion of the expanded cryogenic fluid flows through an interior of the second chamber (15) and around an outside of the second expander (14);

a first passageway (19) within the cryogenic vessel (10) for routing the second portion of the cryogenic fluid from the interior of the first chamber (13) to the second chamber (15); and

a second passageway (17) within the cryogenic vessel (10) for routing the first portion of the expanded cryogenic fluid from the first chamber (13) to the interior of the second chamber (15), wherein the first and second passageways (17, 19) are formed by a divider that comprises a plate or disk (22) positioned between the first and second chambers (13, 15).

2. The system as recited in claim 1, wherein the divider includes a rotary valve (30).

3. The system as recited in claim 2, wherein the rotary valve includes a rotating plate (44) forming one or more openings therein, one or more passages (42) for routing the first portion of the expanded cryogenic fluid from the first expander to the rotating plate, one or more passages (46) for routing the first portion of the expanded cryogenic fluid from the rotating plate to the interior of the second chamber, one or more passages (48) for routing the second portion of the cryogenic fluid from the first chamber to the rotating plate, one or more passages for routing the second portion of the cryogenic fluid from the rotating plate to the second expander, and a motor (33) for turning the rotating plate, wherein a partial or complete alignment between the one or more openings, the one or more passages for routing the first portion of the expanded cryogenic fluid from the first expander to the

rotating plate, and the one or more passages for routing the first portion of the expanded cryogenic fluid from the rotating plate to the interior of the second chamber creates the first passageway, and wherein a partial or complete alignment between the one or more openings, the one or more passages for routing the second portion of the cryogenic fluid from the first chamber to the rotating plate, and the one or more passages for routing the second portion of the cryogenic fluid from the rotating plate to the second expander creates the second passageway.

4. The system as recited in claim 1, further comprising one or more valves (16, 18) for regulating the cryogenic fluid flow and/or the expanded cryogenic fluid flow through the cryogenic vessel, wherein the one or more valves are located outside of the cryogenic vessel.

5. The system as recited in claim 1, wherein the first expander and the second expander are liquefied gas expanders.

6. The system as recited in claim 5, wherein the liquefied gas expanders include one phase expanders, two phase expanders, fixed speed expanders and variable speed expanders.

**Patentansprüche**

1. Parallelflosssystem zum Ausdehnen eines kryogenen Fluids, umfassend:

einen kryogenen Behälter (10), der eine erste Kammer (13), in die kryogenes Fluid durch einen Behältereinlass strömt, und eine zweite Kammer (15), aus der ein ausgedehntes kryogenes Fluid durch einen Behälterauslass strömt, aufweist;

einen ersten Expander (12), der zum Aufnehmen eines ersten Teils des kryogenen Fluids und zum Erzeugen eines ersten Teils des ausgedehnten kryogenen Fluids in der ersten Kammer (13) positioniert ist, während ein zweiter Teil des kryogenen Fluids durch einen Innenraum der ersten Kammer (13) und um eine Außenseite des ersten Expanders (12) strömt;

einen zweiten Expander (14), der zum Aufnehmen des zweiten Teils des kryogenen Fluids und zum Erzeugen eines zweiten Teils des ausgedehnten kryogenen Fluids in der zweiten Kammer (15) positioniert ist, während der erste Teil des ausgedehnten kryogenen Fluids durch einen Innenraum der zweiten Kammer (15) und um eine Außenseite des zweiten Expanders (14) strömt;

einen ersten Durchlass (19) im kryogenen Be-

- hälter (10) zum Leiten des zweiten Teils des kryogenen Fluids aus dem Innenraum der ersten Kammer (13) zur zweiten Kammer (15); und einen zweiten Durchlass (17) im kryogenen Behälter (10) zum Leiten des ersten Teils des ausgedehnten kryogenen Fluids aus der ersten Kammer (13) zum Innenraum der zweiten Kammer (15), wobei der erste und der zweite Durchlass (17, 19) mittels einer Trennung gebildet sind, die eine Platte oder Scheibe (22) umfasst, die zwischen der ersten und der zweiten Kammer (13, 15) positioniert ist.
2. System nach Anspruch 1, wobei die Trennung einen Drehschieber (30) beinhaltet.
3. System nach Anspruch 2, wobei der Drehschieber eine Drehplatte (44), die darin eine oder mehrere Öffnungen, einen oder mehrere Kanäle (42) zum Leiten des ersten Teil des ausgedehnten kryogenen Fluids vom ersten Expander zur Drehplatte, einen oder mehrere Kanäle (46) zum Leiten des ersten Teil des ausgedehnten kryogenen Fluids von der Drehplatte zum Innenraum der zweiten Kammer, eine oder mehrere Kanäle (48) zum Leiten des zweiten Teils des kryogenen Fluids von der ersten Kammer zur Drehplatte, einen oder mehrere Kanäle zum Leiten des zweiten Teils des kryogenen Fluids von der Drehplatte zum zweiten Expander bildet, und einen Motor (33) zum Drehen der Drehplatte beinhaltet, wobei eine teilweise oder komplette Fluchtung zwischen der einen oder den mehreren Öffnungen, dem einen oder den mehreren Kanälen zum Leiten des ersten Teils des ausgedehnten kryogenen Fluids vom ersten Expander zur Drehplatte und dem einen oder den mehreren Kanälen zum Leiten des ersten Teils des ausgedehnten kryogenen Fluids von der Drehplatte zum Innenraum der zweiten Kammer den ersten Durchlass schafft und wobei eine teilweise oder komplette Fluchtung zwischen der einen oder den mehreren Öffnungen, dem einen oder den mehreren Kanälen zum Leiten des zweiten Teils des kryogenen Fluids von der ersten Kammer zur Drehplatte und dem einen oder den mehreren Kanälen zum Leiten des zweiten Teils des kryogenen Fluids von der Drehplatte zum zweiten Expander den zweiten Durchlass schafft.
4. System nach Anspruch 1, ferner umfassend ein oder mehrere Ventile (16, 18) zum Regulieren des Stroms des kryogenen Fluids und/oder des Stroms des ausgedehnten kryogenen Fluids durch den kryogenen Behälter, wobei das eine oder die mehreren Ventile sich außerhalb des kryogenen Behälters befinden.
5. System nach Anspruch 1, wobei der erste Expander und der zweite Expander Flüssiggasexpander sind.

6. System nach Anspruch 5, wobei die Flüssiggasexpander Einphasenexpander, Zweiphasenexpander, Expander mit fester Geschwindigkeit und Expander mit variabler Geschwindigkeit beinhalten.

## Revendications

1. Système d'écoulement parallèle permettant de détendre un fluide cryogénique, comportant :

un récipient cryogénique (10) possédant une première chambre (13) dans laquelle le fluide cryogénique s'écoule à travers une admission de récipient, une seconde chambre (15) depuis laquelle un fluide cryogénique détendu s'écoule à travers une évacuation de récipient ;  
 un premier détendeur (12) positionné dans la première chambre (13) pour recevoir une première partie du fluide cryogénique et pour produire une première partie du fluide cryogénique détendu pendant qu'une seconde partie du fluide cryogénique s'écoule à travers un intérieur de la première chambre (13) et autour d'un extérieur du premier détendeur (12) ;  
 un second détendeur (14) positionné dans la seconde chambre (15) pour recevoir la seconde partie du fluide cryogénique et pour produire une seconde partie du fluide cryogénique détendu pendant que la première partie du fluide cryogénique détendu s'écoule à travers un intérieur de la seconde chambre (15) et autour d'un extérieur du second détendeur (14) ;  
 un premier passage (19) dans le récipient cryogénique (10) pour acheminer la seconde partie du fluide cryogénique depuis l'intérieur de la première chambre (13) vers la seconde chambre (15) ; et  
 un second passage (17) dans le récipient cryogénique (10) pour acheminer la première partie du fluide cryogénique détendu depuis la première chambre (13) vers l'intérieur de la seconde chambre (15),  
 les premier et second passages (17, 19) étant formés par un diviseur qui comprend une plaque ou un disque (22) positionné entre les première et seconde chambres (13, 15).

2. Système selon la revendication 1, dans lequel le diviseur comprend une valve rotative (30).

3. Système selon la revendication 2, dans lequel la valve rotative comprend une plaque tournante (44) formant une ou plusieurs ouvertures en son sein, un ou plusieurs passages (42) pour acheminer la première partie du fluide cryogénique détendu depuis le premier détendeur vers la plaque tournante, un ou plusieurs passages (46) pour acheminer la pre-

mière partie du fluide cryogénique détendu depuis la plaque rotative vers l'intérieur de la seconde chambre, un ou plusieurs passages (48) pour acheminer la seconde partie du fluide cryogénique depuis la première chambre vers la plaque tournante, un ou plusieurs passages pour acheminer la seconde partie du fluide cryogénique depuis la plaque tournante vers le second détendeur, et un moteur (33) pour faire tourner la plaque tournante, dans lequel un alignement partiel ou total entre la ou les ouvertures, le ou les passages pour acheminer la première partie du fluide cryogénique détendu depuis le premier détendeur vers la plaque tournante, et le ou les passages pour acheminer la première partie du fluide cryogénique détendu depuis la plaque tournante vers l'intérieur de la seconde chambre crée le premier passage, et dans lequel un alignement partiel ou total entre la ou les ouvertures, le ou les passages pour acheminer la seconde partie du fluide cryogénique depuis la première chambre vers la plaque tournante, et le ou les passages pour acheminer la seconde partie du fluide cryogénique depuis la plaque tournante vers le second détendeur crée le second passage.

4. Système selon la revendication 1, comprenant en outre une ou plusieurs valves (16, 18) permettant de réguler l'écoulement de fluide cryogénique et/ou l'écoulement de fluide cryogénique détendu à travers le récipient cryogénique, dans lequel la ou les valves sont situées à l'extérieur du récipient cryogénique.
5. Système selon la revendication 1, dans lequel le premier détendeur et le second détendeur sont des détendeurs de gaz liquéfié.
6. Système selon la revendication 5, dans lequel les détendeurs de gaz liquéfié comprennent des détendeurs à une phase, des détendeurs à deux phases, des détendeurs à vitesse fixe et des détendeurs à vitesse variable.

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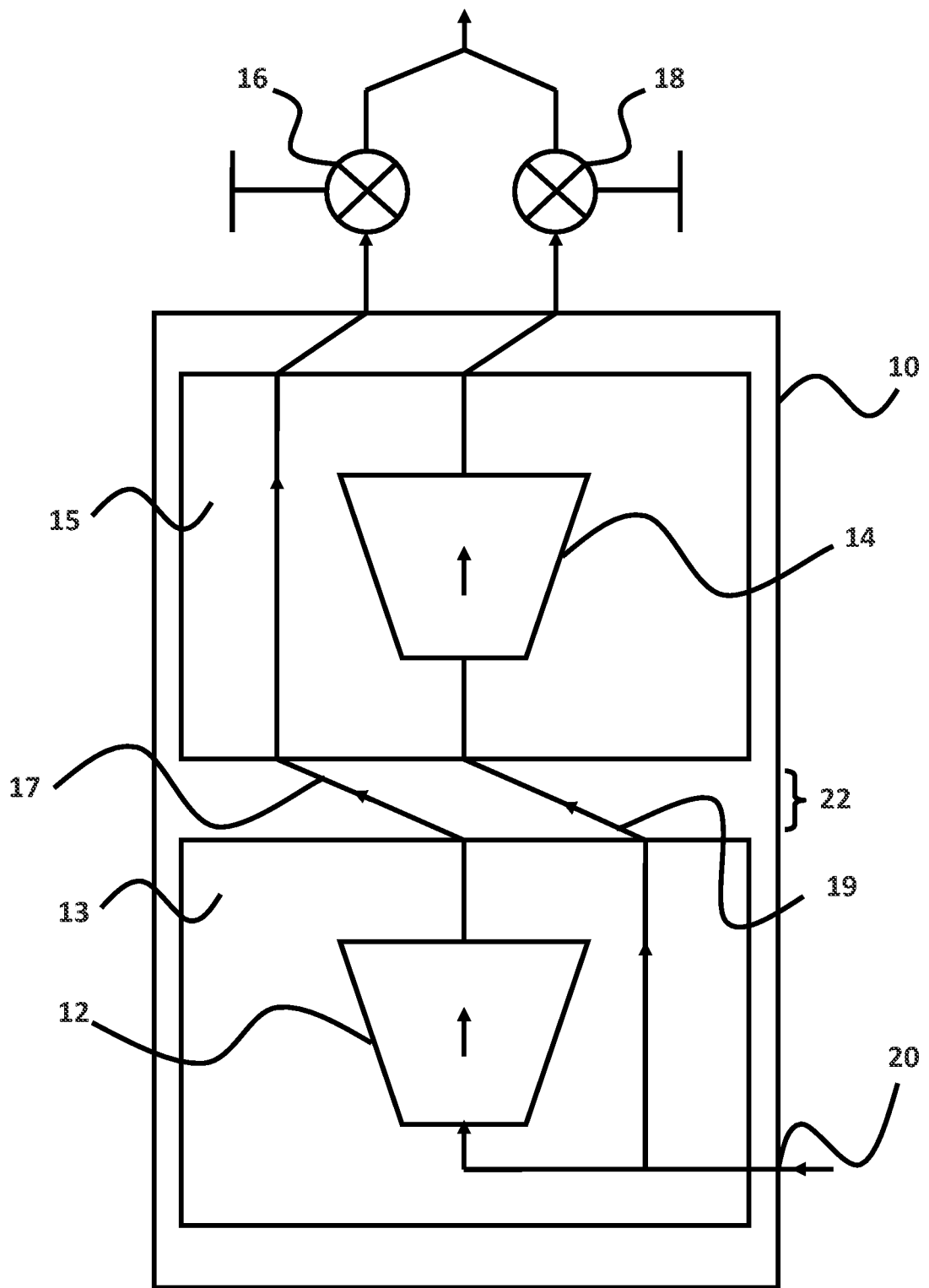


FIG. 1

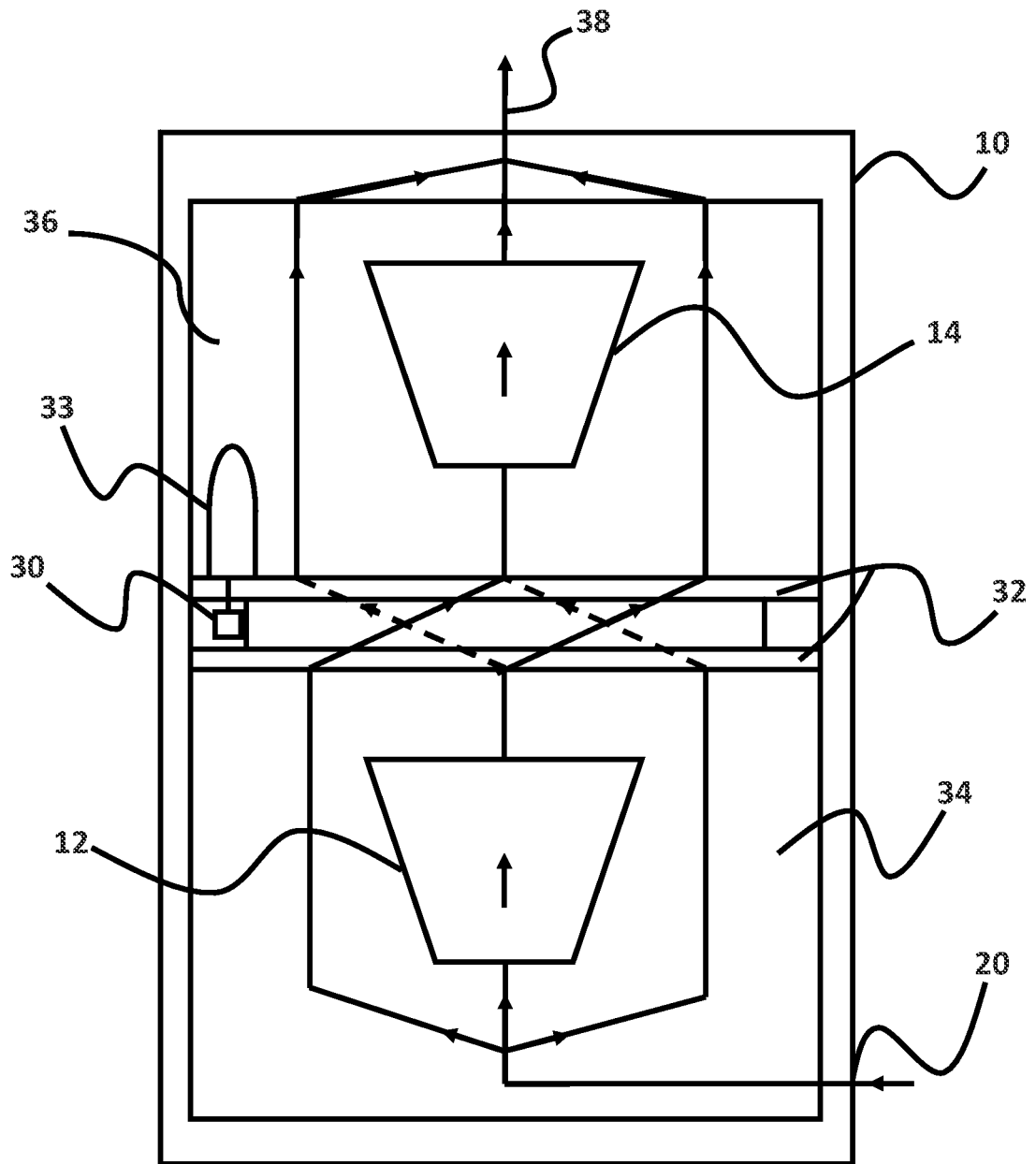


FIG. 2

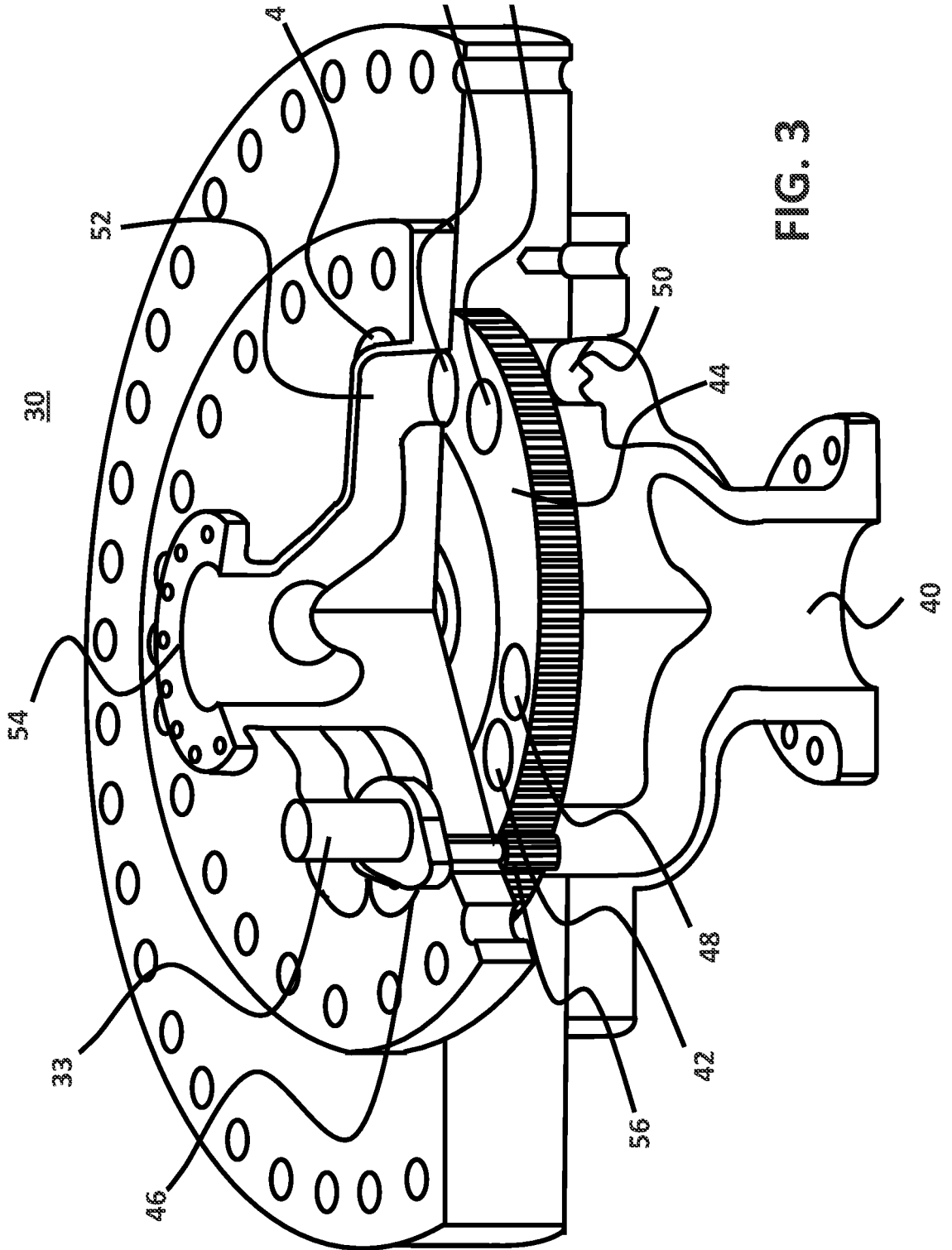


FIG. 3

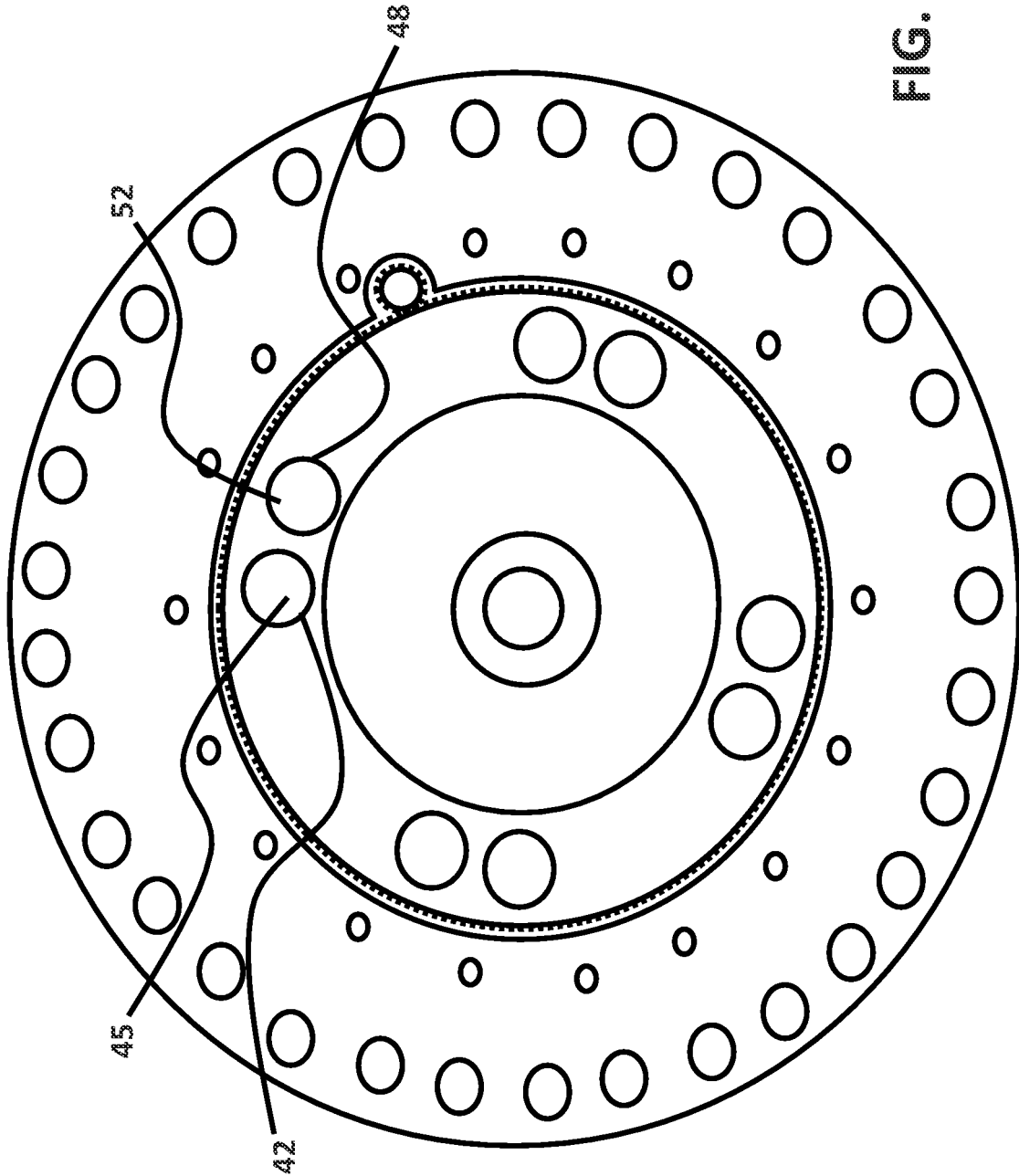


FIG. 4

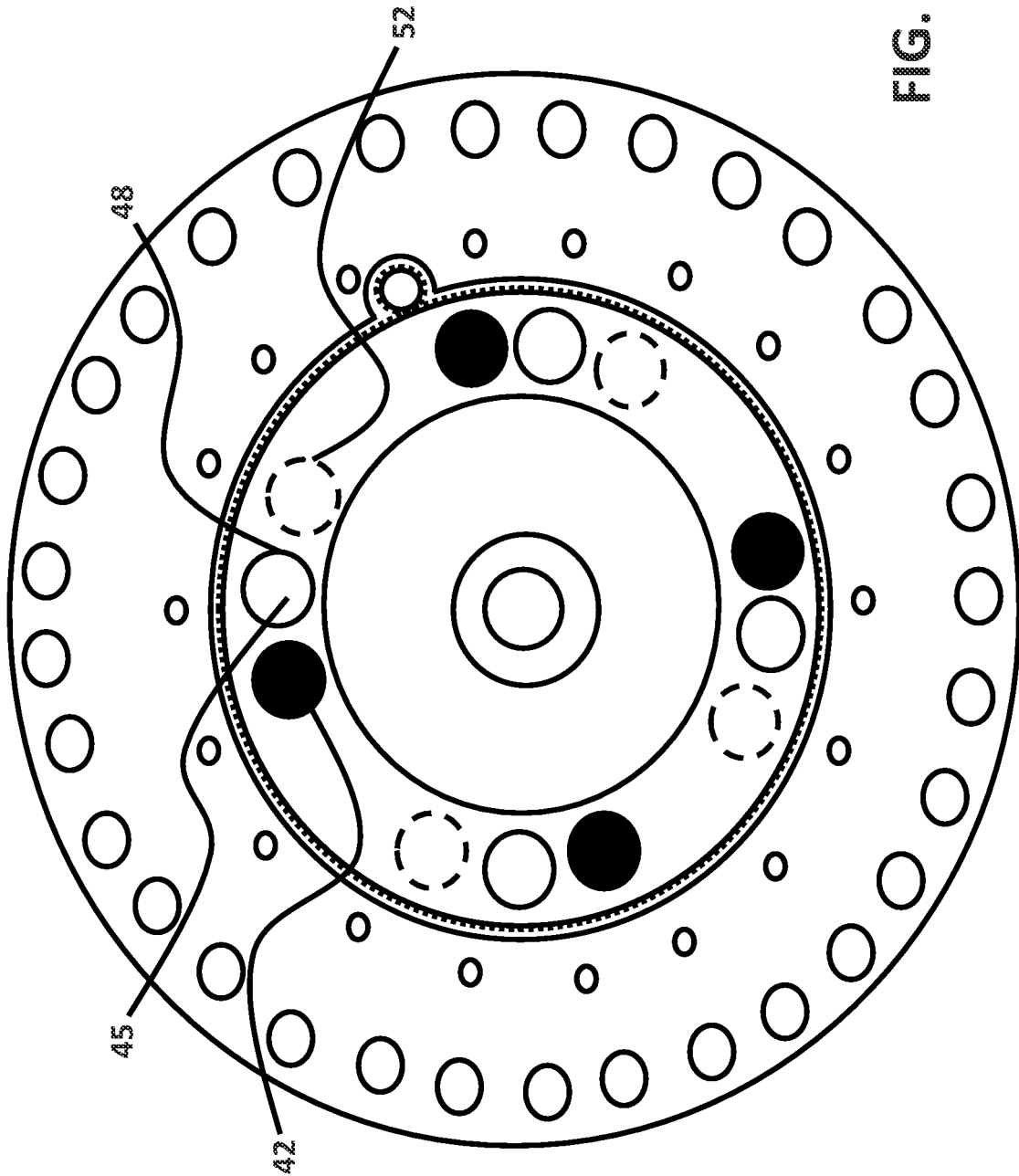


FIG. 5

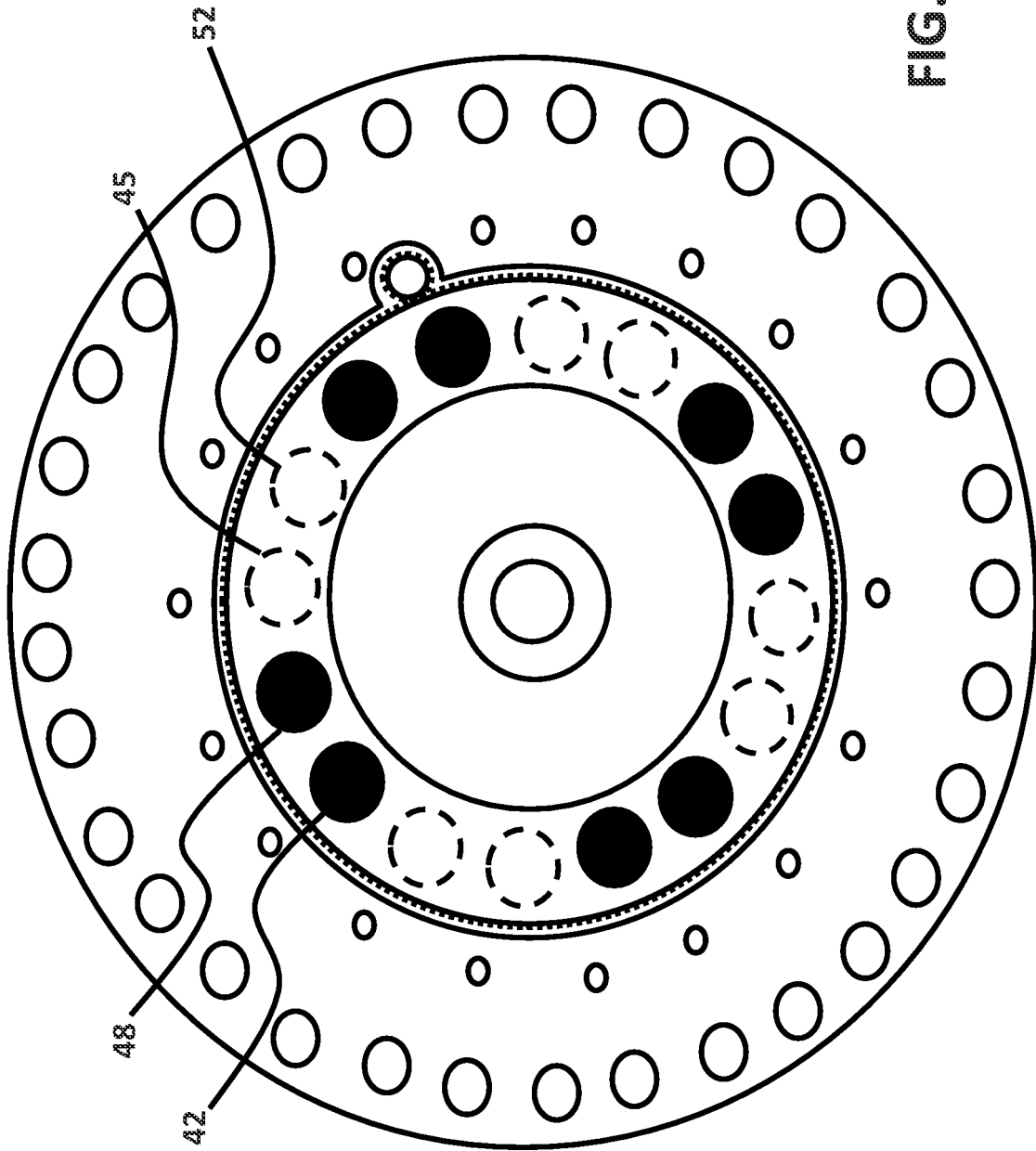


FIG. 6

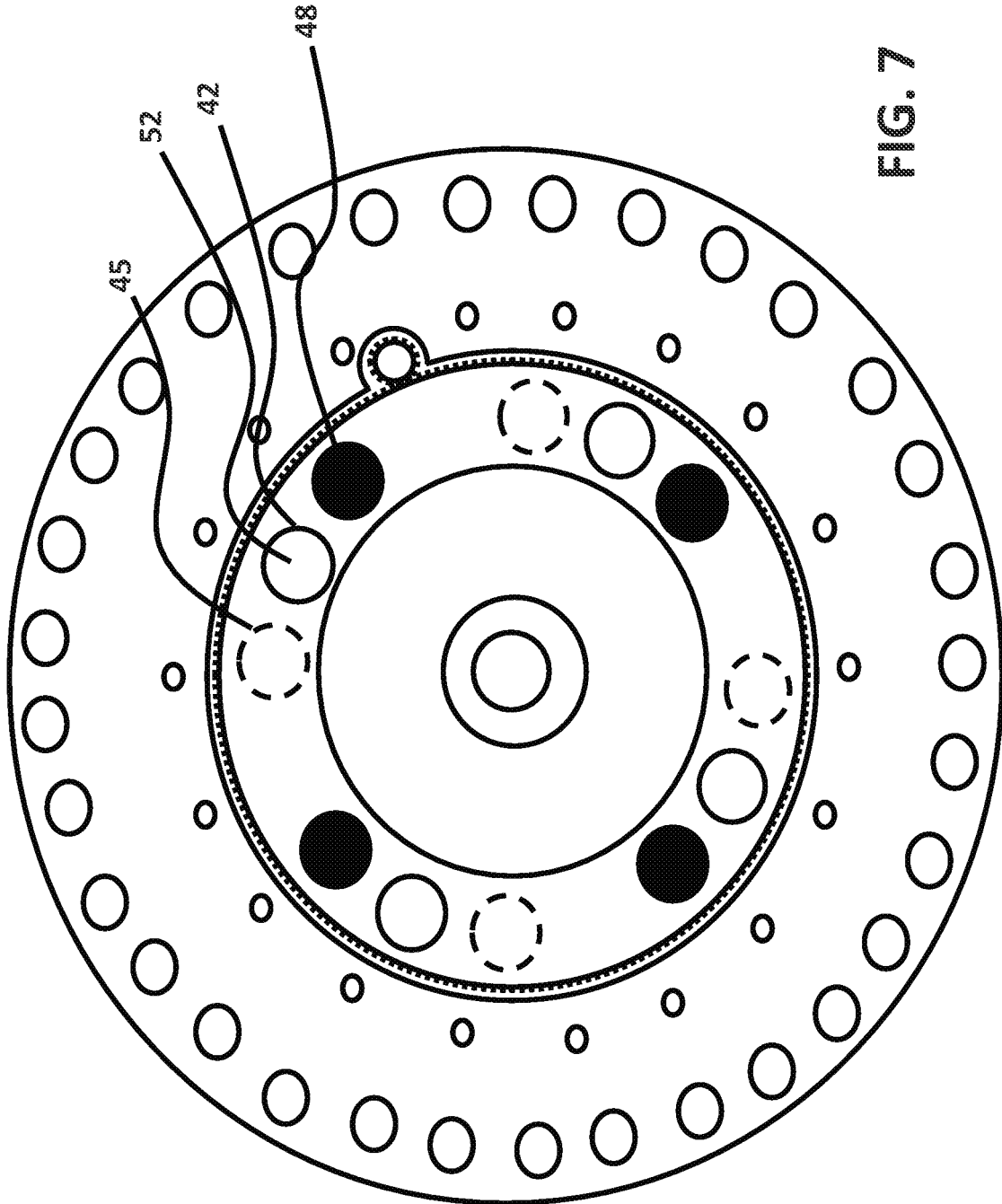


FIG. 7

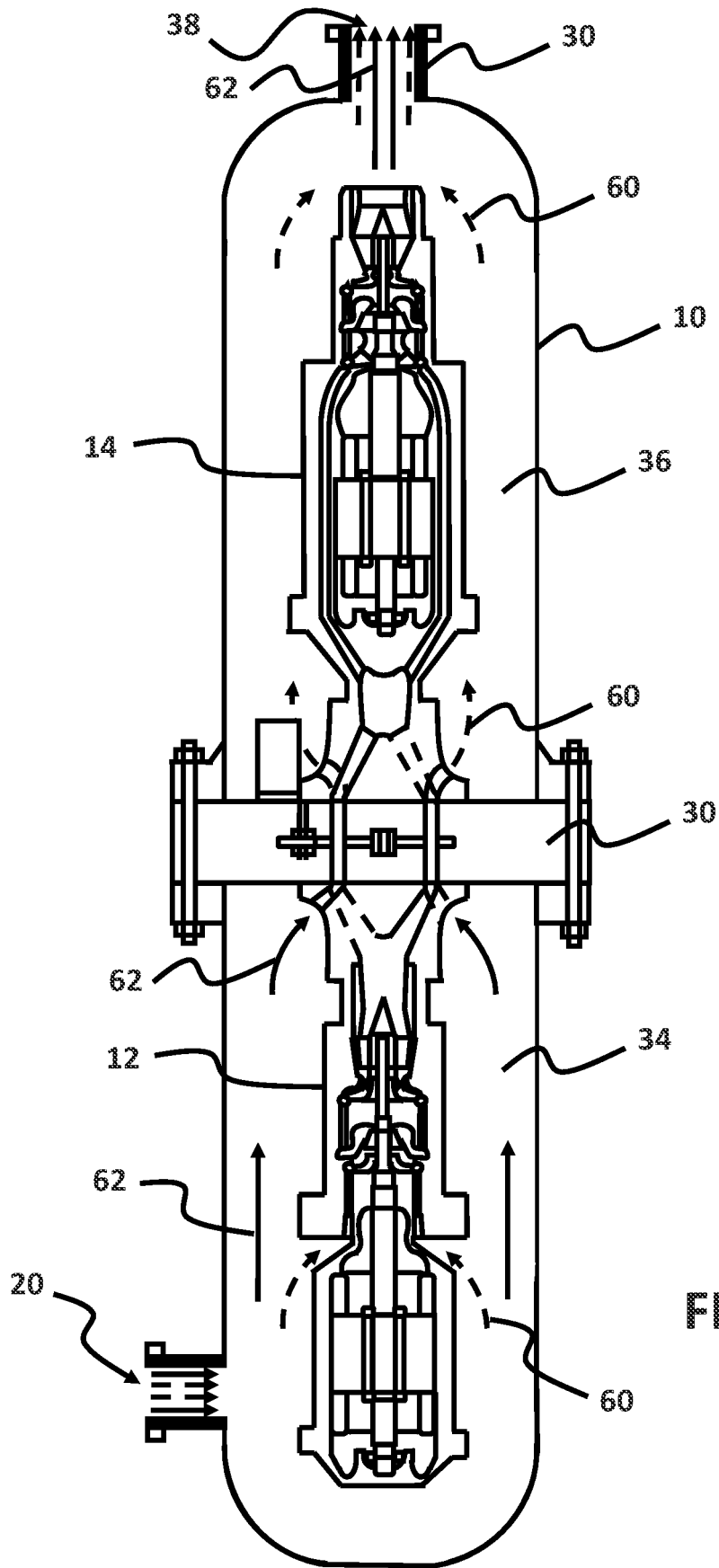


FIG. 8



**REFERENCES CITED IN THE DESCRIPTION**

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