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(54) **CENTRIFUGAL WET GAS COMPRESSION OR EXPANSION WITH A SLUG SUPPRESSOR AND/OR ATOMIZER**

ZENTRIFUGALE FLÜSSIGGASKOMPRESSION ODER -EXPANSION MIT EINEM BLASENUNTERDRÜCKER UND/ODER EINEM ZERSTÄUBER

COMPRESSION OU DÉTENTE DE GAZ HUMIDE CENTRIFUGE AVEC UN SUPPRESSEUR ET/OU UN PULVÉRISATEUR DE GRUMEAUX

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EP 2 504 497 B1

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Description

BACKGROUND OF INVENTION

Field of the Invention

[0001] The subject matter disclosed in this application relates to technology utilized in the compression or expansion of a multiphase fluid in a fluid handling system.

Description of Related Art

[0002] This section is intended to introduce various aspects of the art, which may be associated with exemplary embodiments of the present invention. This discussion is believed to assist in providing a framework to facilitate a better understanding of particular aspects of the present invention. Accordingly, it should be understood that this section should be read in this light, and not necessarily as admissions of prior art.

[0003] Traditionally it is understood that centrifugal compressors or gas expanders do not handle liquid slugs and thus it is assumed that they can only handle a fraction of one percent liquid by volume. Thus in many applications expensive liquid separators, dehydration processes and/or unit scrubbers are utilized to try and remove or separate the liquids prior to using centrifugal compressors or expanders. These devices are often designed for specific operating conditions and are then limited in the range of Gas Volume Fraction (GVF) that can be handled with a given process flow rate. Even with this expensive and complex processing equipment, if there is a sudden high level of liquids they can quickly saturate, fill and overflow the liquid separators once their capacity for liquid is exceeded resulting in slugging the compressor or expander equipment.

[0004] In general, multiphase pumps can be used if it is known that the fluid will generally be below 90% GVF. Centrifugal compressors are often restricted to applications with GVFs of 99.7 or higher and even this can cause problems within the machine for stability and affecting the reliability of the seals and bearings. Therefore, for processes outside this small range, the current practice is to separate the fluids prior to utilizing a centrifugal compressor even with the design limitation with the associated process and equipment. The same is true for gas expanders, which are functionally a centrifugal compressor running in reverse to extract energy in one form or another through a process pressure drop across the expander. The separators, scrubbers and dehydration units are not only expensive and limited in liquid capacity and volume flow range but they also tend to be very bulky, taking up expensive real estate in locations such as offshore platforms, subsea processing or onshore facilities. This coupled with complex control systems and additional auxiliary equipment like pumps, regulators, level controllers, transmitters and filters adds to the complexity and likelihood of failure of these systems. An example of a process where slugs may cause severe damage is shown in FIG. 1 which depicts a typical oil or gas well stream service where a separator 4 is used to separate liquids from the gas so that a centrifugal compressor 21 and pump 12 can then be used to boost the gas and liquid separately. The two are then combined again at 14 in order to transport both through a pipeline to a processing facility. If one machine could be used to transport the combined flow it has the potential to greatly reduce the overall cost and complexity of the total system.

[0005] Some additional issues with liquids are not only stability of the machine but also erosion of impellers and diffusers, fouling and resulting in imbalance if the liquids flash or vaporize while being compressed in the machine. However, testing has shown that erosion can be reduced or prevented by slowing down the liquid velocity at impact points and by reducing the droplet size. Fouling has also been reduced or even removed by increasing the liquid levels above the flash point in effect washing the internals of the machine.

[0006] The foregoing discussion of need in the art is intended to be representative rather than exhaustive. Technology that would improve the ability of compressors or expanders to handle the multiphase flow of fluid with a higher liquid content compared to the current state of the art would be of great value.

[0007] WO 86/0557 A1 relates to a pump or compressor unit suited particularly for mixed phase fluids, e.g. mixed gas and oil, has a multistage axial flow compressor device with contra-rotating vanes.

[0008] WO 2005/026497 A1 relates to a subsea compression system and method wherein a wellstream fluid is flowed through a flow line from a reservoir and into a separation vessel for subsequent compression in a compressor prior to export of gas.

BRIEF SUMMARY OF THE DISCLOSURE

[0009] The above noted problems in handling multiphase fluid flow have been addressed by utilizing a liquid slug suppressor and/or an atomizing device to enhance the upstream mixing of the liquid with the gas, thus enabling the centrifugal compressor or expander to better handle higher levels of liquid. The atomizing device may be any one of known fluid atomizers including one or more atomizing nozzles or a flow mixer device. This can be used in existing designs to help protect the compressor or expander from process upsets with additional liquid volume or as a stand alone design to help eliminate some of the required equipment such as the separator or liquid pump.

[0010] The slug suppressor slows down a slug of liquid and mixes it with gas already in the device to reduce the sudden change in density. This allows time for the compressor driver to slow down as the torque or load increases with the increase in liquid volume or reduction of GVF. The atomizing device further helps turn liquid slugs into droplets or mist mixed in with the gas to better help the

compressor in dealing with the change in density and load while reducing the impact, resulting in less erosion. Either product or both in series can be used in a compressor or expander application where there is a potential for some liquids or liquid upsets.

[0011] In context of this disclosure, the term "atomizing device" means any device or mechanism for breaking a liquid into a fog, mist, or spray of liquid. The term "atomized" as used herein is to be understood to mean small, discrete particles of liquid. Also the terms slug suppressor means any device that helps slow down the sudden change in fluid density of a high level of liquid within a gas stream by mixing the predominately liquid flow with gas that was flowing ahead of, with or behind the liquid.

[0012] The foregoing has outlined rather broadly the features and technical advantages of the present invention in order that the detailed description of the invention that follows may be better understood. Additional features and advantages of the invention will be described hereinafter which form the subject of the claims of the invention. It should be appreciated by those skilled in the art that the conception and specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present invention. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

[0013] The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages will be better understood from the following description when considered in connection with the accompanying figures. It is to be expressly understood, however, that each of the figures is provided for the purpose of illustration and description only and is not intended as a definition of the limits of the present invention, which is defined by the claims.

FIG. 1 is a schematic diagram of a known multiphase fluid handling system.

FIG. 2 is a schematic diagram of one embodiment of a multiphase fluid handling system according to the disclosure for compressing a multiphase fluid.

FIG. 3 is a schematic diagram of another embodiment of a multiphase fluid handling system according to the disclosure for expanding a multiphase fluid.

FIG. 4 is a schematic depiction of a slug suppressor and atomizing device combined.

FIG. 5 is a modified version of the multiphase fluid handling system shown in FIG. 2.

[0014] It should be noted that the figures are merely exemplary of several embodiments of the present invention and no limitations on the scope of the present invention are intended thereby. Further, the figures are generally not drawn to scale, but are drafted for purposes of convenience and clarity in illustrating various aspects of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0015] Reference will now be made to exemplary embodiments and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended. Alterations of further modifications of the inventive features described herein, and additional applications of the principles of the invention as described herein, which would occur to one skilled in the relevant art and having possession of this disclosure, are to be considered within the scope of the invention. Further, before particular embodiments of the present invention are disclosed and described, it is to be understood that this invention is not limited to the particular process and materials disclosed herein as such may vary to some degree. It is also to be understood that the terminology used herein is used for the purpose of describing particular embodiments only and is not intended to be limiting, as the scope of the present invention will be defined only by the appended claims and equivalents thereof.

[0016] FIG. 1 illustrates a known system for handling a multiphase fluid in a well head environment. Fluid, which may include water, oil, and gas for example, is directed into a cooler 1 and then into a separator tank 4 via a check valve 2 and conduit 3. Water is separated out and a pump 6 pumps the water to a remote location via conduit 7. Oil and condensate are collected and pump 12 delivers the oil and condensate to conduit 15 via conduits 11 and 13. Gas flows from separator 4 to compressor 21 via conduit 20, then it passes through check valve 23 and is combined with the oil/condensate flow at 14. A recycle line 30 is provided which includes valve 31, cooler 32 and check valve 33.

[0017] The principles of the invention are shown in one embodiment as schematically shown in FIG. 2. Multiphase fluid, for example fluid from a well head, is directed to the apparatus by a conduit 50, check valve 51, and conduit 52. The mixture of liquid and gas enters a fluid treatment device 55. The fluid treatment device may be a slug suppressor or a known atomizing device, such as one or more atomizing nozzles or a flow mixer. It may also be a combination of these elements. An example of a combined slug suppressor and atomizing device is shown in FIG. 4. Liquid accumulates in inner chamber 107 and gas flows in outer chamber 108. Baffles 104 are provided in the walls of inner chamber 107 to allow for sudden increases in liquid to spill over into the gas stream and mix with the gas. Thus a sudden increase in liquid flow is slowed down by using some of the gas still in the slug suppressor to reduce the liquid volume. Atomizing nozzles 105 at the lower end of the liquid chamber atom-

ize the liquid and spray it into the gas flow downstream of a tapered portion 109 of the gas flow path. The atomized liquid and gas streams continue to flow through conduit portion 106. A typical slug suppressor and atomizing device is available from Framo Engineering AS. A flow mixer may include counter swirling vanes or counter rotating vortices.

[0018] Referring again to FIG. 2, the mixture leaving the fluid treatment device 55 flows through conduit 56 to compressor 58. Compressed fluid leaves compressor 58 through conduit 60 and 61 to check valve 62 and to a distribution conduit 63 which delivers the compressed fluid to a desired location. A recycle line for the mixture from compressor 58 is provided at 66 that includes a valve 67, and check valve 69.

[0019] FIG. 3 illustrates the application of the principles of the invention in an expander system. A multiphase fluid passes through a multiphase flow meter 82, a control valve 84, and a conduit 85 into the fluid treatment device 55. From there the mixture flows through conduit 91, expander 93, conduit 94, check valve 95 and distribution conduit 96. The expander 93 may be connected to a generator or compressor 92 or any device that requires a source of power. A bypass line 99, 97 along with a valve 98 are provided for bypassing expander 93. A hydraulic torque converter 90 may be positioned between the expander 93 and generator or compressor 90.

[0020] Combining one or both of a slug suppressor and an atomizing device with torque control or speed reduction with increased load, liquid level or overall density of the fluid would further enable the wider operating range for a centrifugal compressor or expander. Speed control for the compressor for example can be achieved by utilizing a variable speed drive as shown in FIG. 2. A variable speed drive 57 (VSD), such as a motor or other mechanical or electrical drive, including but not limited to gas motor, steam or gas turbine, expander, hydraulic turbine, is connected to the compressor 58. The drive mechanism controlling the torque or speed between the driver and compressor may be electronic, hydraulic, or mechanical. Suitable means for controlling the variable speed drive may include sensors for sensing torque, load, fluid density, GVF or input power.

[0021] Speed or torque control helps make centrifugal compressors and expanders more robust, thus increasing reliability and reducing maintenance cost in wet services by designing the system to better manage a liquid slug and multiphase flow. This could be applied in all types of centrifugal compressor and expander applications where liquids are present or potentially present in the process, including well head services, subsea compressors or expanders, LNG expansion, wet gas compressors and other upstream and downstream processes.

[0022] An option for controlling the torque is through a hydraulic torque converter in place of using the VSD drive. Then conventional fixed speed motors, gas turbines and associated gears could be used for the compressor driver.

[0023] For an expander the flow control could use a two-or three-phase flow meter 82 to operate an inlet flow valve 84 or inlet guide vanes in order to reduce the flow as the GVF drops with increased liquid level, as shown in FIG 3. Other options are to use a hydraulic torque converter 90 between the gas expander 93 and what it is driving or any other method to measure the fluid density, multiphase flow mixture, mass flow, output power, or torque.

[0024] As shown in FIG. 5, the variable speed drive 57 of FIG. 2 may be replaced by a fixed speed driver 102. A hydraulic torque converter 101 may be positioned between the fixed speed driver and the compressor 58 to allow for varying the speed of compressor 58.

[0025] It should be understood that the preceding is merely a detailed description of specific embodiments of this invention and that numerous changes, modifications, and alternatives to the disclosed embodiments can be made in accordance with the disclosure herein without departing from the scope of the invention. Rather, the scope of the invention is to be determined only by the appended claims.

Claims

1. Apparatus for compressing a multiphase fluid comprising:

a first conduit (50) for conveying the multiphase fluid;
a slug suppressor connected to the first conduit (50);
a centrifugal compressor (58) connected to an output of the slug suppressor; and
a distribution conduit (63) connected to the compressor (58) for conveying the compressed multiphase fluid to a desired location,
characterized in that
the apparatus further comprises an atomizing device positioned in the first conduit (50);
wherein the slug suppressor and atomizing device are combined in a housing having an inlet and outlet, wherein the housing comprises

a first chamber (107) for accumulating liquid;
a second chamber (108) for accumulating gas;
a plurality of baffles (104) between the first and second chambers (107, 108) for allowing accumulated liquid in the first chamber (107) to spill over into the second chamber (108); and
a plurality of atomizing nozzles (105) located at the end portion of the first chamber (107).

2. The apparatus of claim 1 wherein the atomizing device is a flow mixer that includes at least two counter swirling vanes or counter rotating vortices.

3. The apparatus of claim 1 further comprising a variable speed drive (57) connected to a power input shaft of the compressor.

4. Apparatus according to claim 1 wherein the housing tapers from the inlet to the outlet.

5. Apparatus according to claim 1 further comprising a recycle conduit (66) connected at one end to the output of the compressor (58) and at its other end to the first conduit (50).

6. Apparatus according to claim 5 further comprising a recycle valve (67, 69) in the recycle conduit (66).

7. A method of compressing a multiphase fluid comprising:

providing a slug suppressor and an atomizing device,
wherein the slug suppressor and atomizing device are combined in a housing having an inlet and outlet, wherein the housing comprises

a first chamber (107) for accumulating liquid;
a second chamber (180) for accumulating gas;
a plurality of baffles (104) between the first and second chambers (107, 108) for allowing accumulated liquid in the first chamber (107) to spill over into the second chamber (108); and
a plurality of atomizing nozzles (105) located at the end portion of the first chamber (107);

directing a flow of multiphase fluid into the slug suppressor and atomizing device;
directing the output flow from the slug suppressor and atomizing device into an intake portion of a centrifugal compressor (58); and
compressing the multiphase fluid.

8. The method of claim 7 further comprising:
directing the multiphase fluid through a flow mixer prior to its being compressed.

9. The method of claim 7 further comprising:
using an electric or gas motor, gas or steam turbine, expander, hydraulic turbine or other driving device to provide power to the compressor (58).

10. The apparatus of claim 1 further comprising a means for controlling the compressor speed based on produced torque, load, fluid density, multiphase flow measurement or output power.

Patentansprüche

1. Vorrichtung zum Verdichten eines mehrphasigen Fluids umfassend:

eine erste Leitung (50) zum Zuführen des mehrphasigen Fluids,
einen Fluidschwall-Dämpfer, der mit der ersten Leitung (50) verbunden ist,
einen Radialverdichter (58), der mit einem Auslass des Fluidschwall-Dämpfers verbunden ist, und
eine Verteilungsleitung (63), die mit dem Verdichter (58) verbunden ist, um das verdichtete mehrphasige Fluid zu einem gewünschten Ort zu befördern,
dadurch gekennzeichnet, dass
die Vorrichtung weiter einen Zerstäuber aufweist, der in der ersten Leitung (50) angeordnet ist,
wobei der Fluidschwall-Dämpfer und der Zerstäuber in einem Gehäuse kombiniert sind, das ein Einlass und einen Auslass aufweist, wobei das Gehäuse umfasst:

eine erste Kammer (107) zum Ansammeln von Flüssigkeit,
eine zweite Kammer (108) zum Ansammeln von Gas,
eine Vielzahl von Ablenkblechen (104) zwischen der ersten und zweiten Kammer (107, 108), um zu ermöglichen, dass die in der ersten Kammer (107) angesammelte Flüssigkeit in die zweite Kammer (108) überläuft, und
eine Vielzahl von Zerstäuberdüsen (105), die an dem Endbereich der ersten Kammer (107) angeordnet sind.

2. Vorrichtung nach Anspruch 1, wobei der Zerstäuber ein Durchlaufmischer ist, der mindestens zwei gegenläufig wirbelnde Schaufeln oder gegenläufig rotierende Wirbel umfasst.

3. Vorrichtung nach Anspruch 1, die ferner eine variable Drehzahlregelung (57) umfasst, die mit einer Antriebswelle des Verdichters, verbunden ist.

4. Vorrichtung nach Anspruch 1, wobei sich das Gehäuse von dem Einlass zu dem Auslass hin verjüngt.

5. Vorrichtung nach Anspruch 1, die ferner eine Rückgewinnungsleitung (66) umfasst, die an einem Ende

mit dem Ausgang des Verdichters (58) und an seinem anderen Ende mit der ersten Leitung (50) verbunden ist.

6. Vorrichtung nach Anspruch 5, die ferner ein Rückgewinnungsventil (67, 69) in der Rückgewinnungsleitung (66) umfasst.

7. Verfahren zum Verdichten eines mehrphasigen Fluids, bei dem:

ein Fluidschwall-Dämpfer und ein Zerstäuber bereitgestellt werden,
wobei der Fluidschwall-Dämpfer und der Zerstäuber in einem Gehäuse kombiniert sind, das einen Einlass und einen Auslass aufweist, wobei das Gehäuse umfasst:

eine erste Kammer (107) zum Ansammeln von Flüssigkeit,
eine zweite Kammer (108) zum Ansammeln von Gas,
eine Vielzahl von Ablenkblechen (104) zwischen der ersten und zweiten Kammer (107, 108), um zu ermöglichen, dass die in der ersten Kammer (107) angesammelte Flüssigkeit in die zweite Kammer (108) überläuft, und
eine Vielzahl von Zerstäuberdüsen (105), die an dem Endbereich der ersten Kammer (107) angeordnet sind,
ein Strom des mehrphasigen Fluids in den Fluidschwall-Dämpfer und den Zerstäuber geleitet wird,
der Auslassstrom von dem Fluidschwall-Dämpfer und dem Zerstäuber in den Ansaugbereich des Radialverdichters (58) geleitet wird, und
das mehrphasige Fluid verdichtet wird.

8. Verfahren nach Anspruch 7, bei dem ferner
das mehrphasige Fluid durch einen Durchlaufmischer geleitet wird, bevor es verdichtet wird.

9. Verfahren nach Anspruch 7, bei dem ferner
ein elektrischer Motor oder Gasmotor, eine Gas- oder Dampfturbine, ein Expander, eine hydraulische Turbine oder andere Antriebe verwendet werden, um den Verdichter (58) mit Energie zu versorgen.

10. Vorrichtung nach Anspruch 1, die ferner
ein Mittel zum Steuern der Verdichterdrehzahl basierend auf dem produzierten Drehmoment, der Last, der Fluiddichte, der mehrphasigen Flussmessungen oder der Ausgangsleistung umfasst.

Revendications

1. Appareil de compression d'un fluide polyphasique comprenant :

un premier conduit (50) pour acheminer le fluide polyphasique ;
un suppresseur de bouchons relié au premier conduit (50) ;
un compresseur centrifuge (58) relié à une sortie du suppresseur de bouchons ; et
un conduit de distribution (63) relié au compresseur (58) pour acheminer le fluide polyphasique comprimé vers un emplacement souhaité,
l'appareil étant **caractérisé en ce qu'**il comprend en outre un dispositif de pulvérisation positionné dans le premier conduit (50) ;
dans lequel le suppresseur de bouchons et le dispositif de pulvérisation sont combinés dans un boîtier ayant une entrée et une sortie, où le boîtier comprend

une première chambre (107) pour accumuler un liquide ;
une deuxième chambre (108) pour accumuler un gaz ;
une pluralité de déflecteurs (104) entre les première et deuxième chambres (107, 108) pour permettre au liquide accumulé dans la première chambre (107) de déborder dans la deuxième chambre (108) ; et
une pluralité de buses de pulvérisation (105) situées au niveau de la partie d'extrémité de la première chambre (107).

2. Appareil de la revendication 1, dans lequel le dispositif de pulvérisation est un mélangeur continu à courant qui comporte au moins deux aubes à tourbillonnements inverses ou tourbillons contrarotatifs.

3. Appareil de la revendication 1, comprenant en outre un variateur de vitesse (57) relié à un arbre d'entrée de puissance du compresseur.

4. Appareil selon la revendication 1, dans lequel le boîtier s'effile depuis l'entrée vers la sortie.

5. Appareil selon la revendication 1, comprenant en outre un conduit de recyclage (66) relié au niveau d'une extrémité à la sortie du compresseur (58) et au niveau de son autre extrémité au premier conduit (50).

6. Appareil selon la revendication 5, comprenant en outre une soupape de recyclage (67, 69) dans le conduit de recyclage (66).

7. Procédé de compression d'un fluide polyphasique

comprenant les étapes consistant à :

fournir un suppresseur de bouchons et un dispositif de pulvérisation,
dans lequel le suppresseur de bouchons et le dispositif de pulvérisation sont combinés dans un boîtier ayant une entrée et une sortie, où le boîtier comprend

une première chambre (107) pour accumuler un liquide ;
une deuxième chambre (108) pour accumuler un gaz ;
une pluralité de déflecteurs (104) entre les première et deuxième chambres (107, 108) pour permettre au liquide accumulé dans la première chambre (107) de déborder dans la deuxième chambre (108) ; et
une pluralité de buses de pulvérisation (105) situées au niveau de la partie d'extrémité de la première chambre (107) ;

diriger un écoulement de fluide polyphasique dans le suppresseur de bouchons et le dispositif de pulvérisation ;
diriger l'écoulement de sortie depuis le suppresseur de bouchons et le dispositif de pulvérisation dans une partie d'admission d'un compresseur centrifuge (58) ; et
comprimer le fluide polyphasique.

8. Procédé de la revendication 7, comprenant en outre l'étape consistant à :
diriger le fluide polyphasique à travers un mélangeur continu à courant avant qu'il ne soit comprimé.

9. Procédé de la revendication 7, comprenant en outre l'étape consistant à :
utiliser un moteur électrique ou à gaz, une turbine à gaz ou à vapeur, un détenteur, une turbine hydraulique ou un autre dispositif d'entraînement pour fournir de la puissance au compresseur (58).

10. Appareil de la revendication 1, comprenant en outre un moyen pour réguler la vitesse du compresseur sur la base d'un couple produit, d'une charge, d'une densité de fluide, d'une mesure d'écoulement polyphasique ou d'une puissance de sortie.

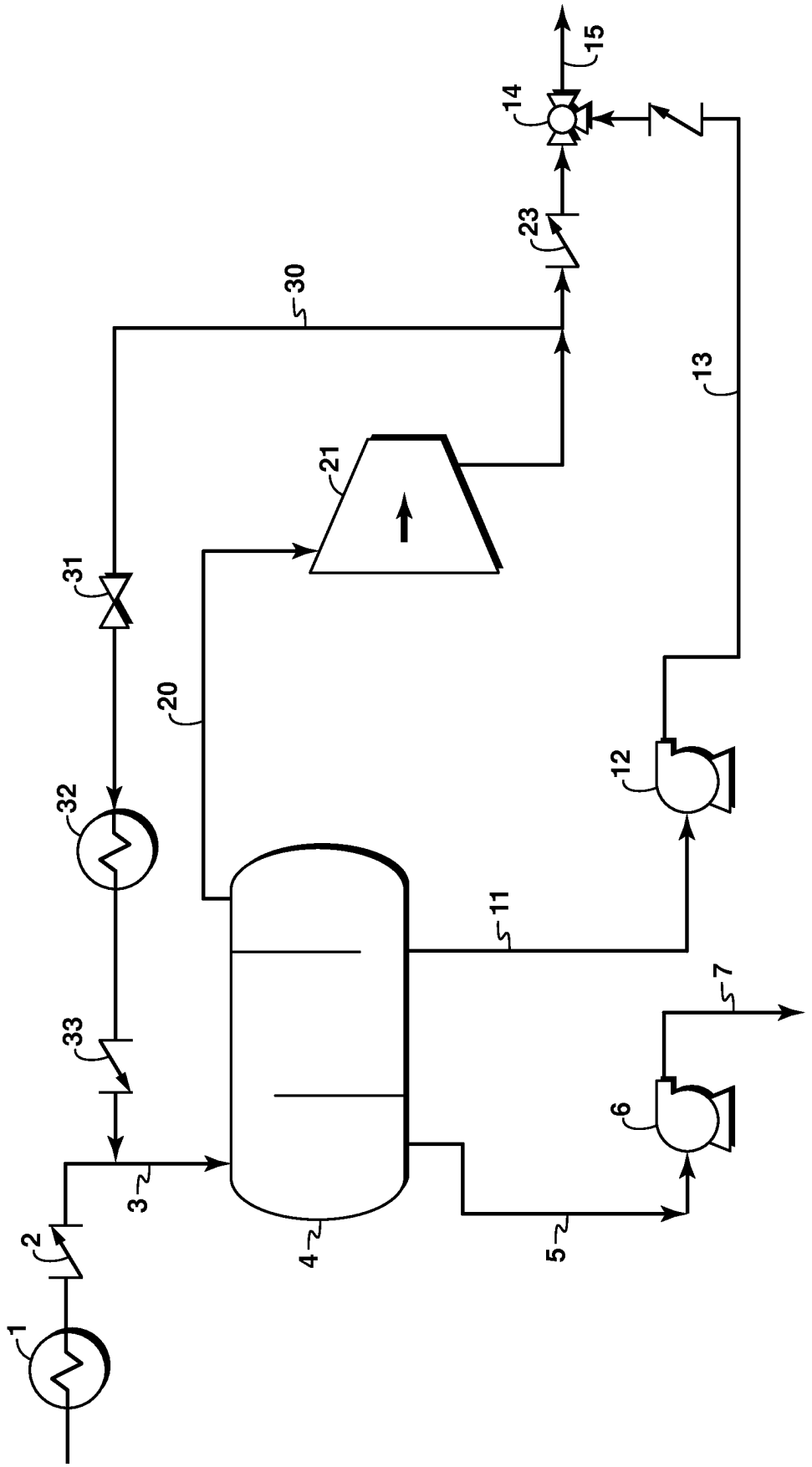

FIG. 1
Prior Art

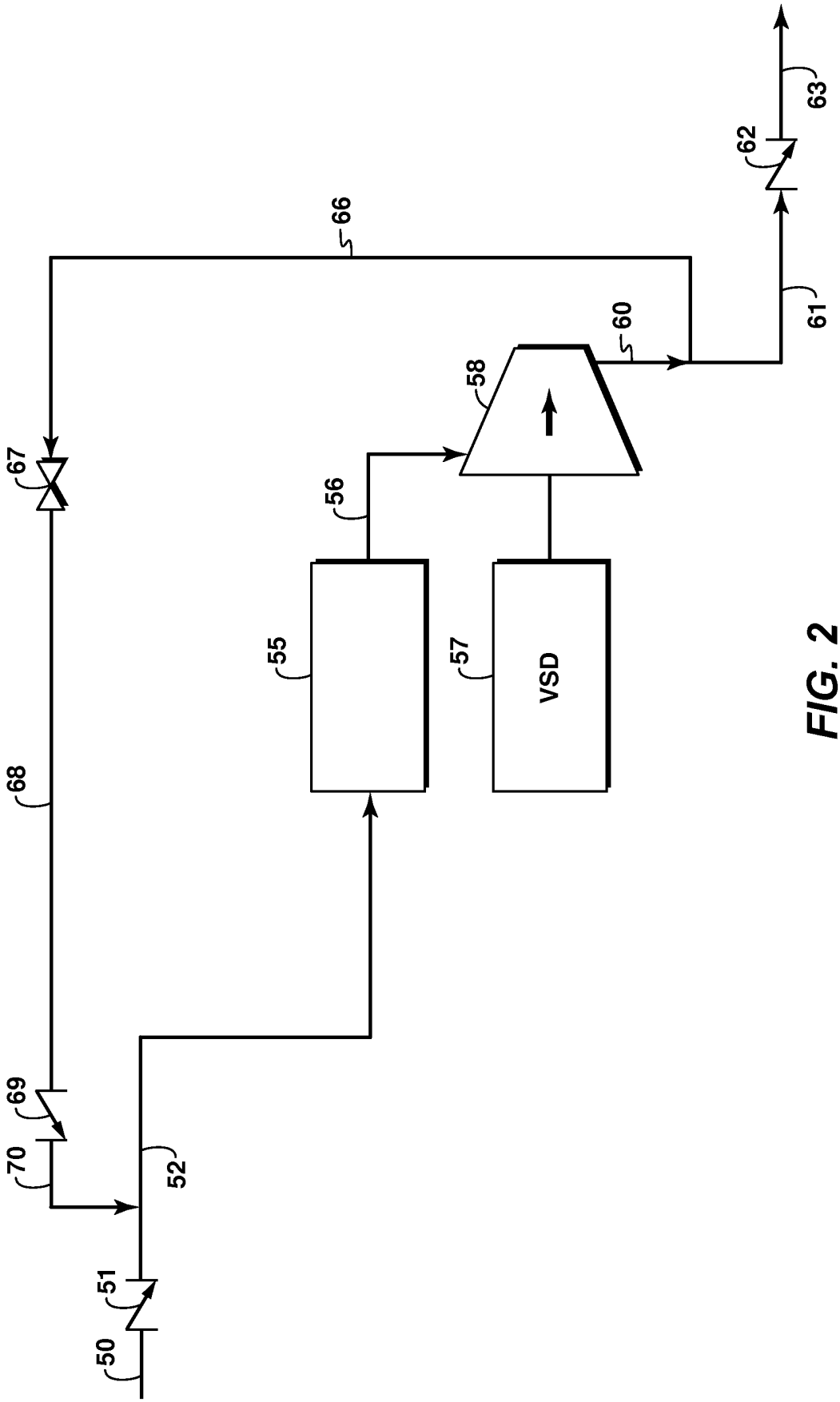

FIG. 2

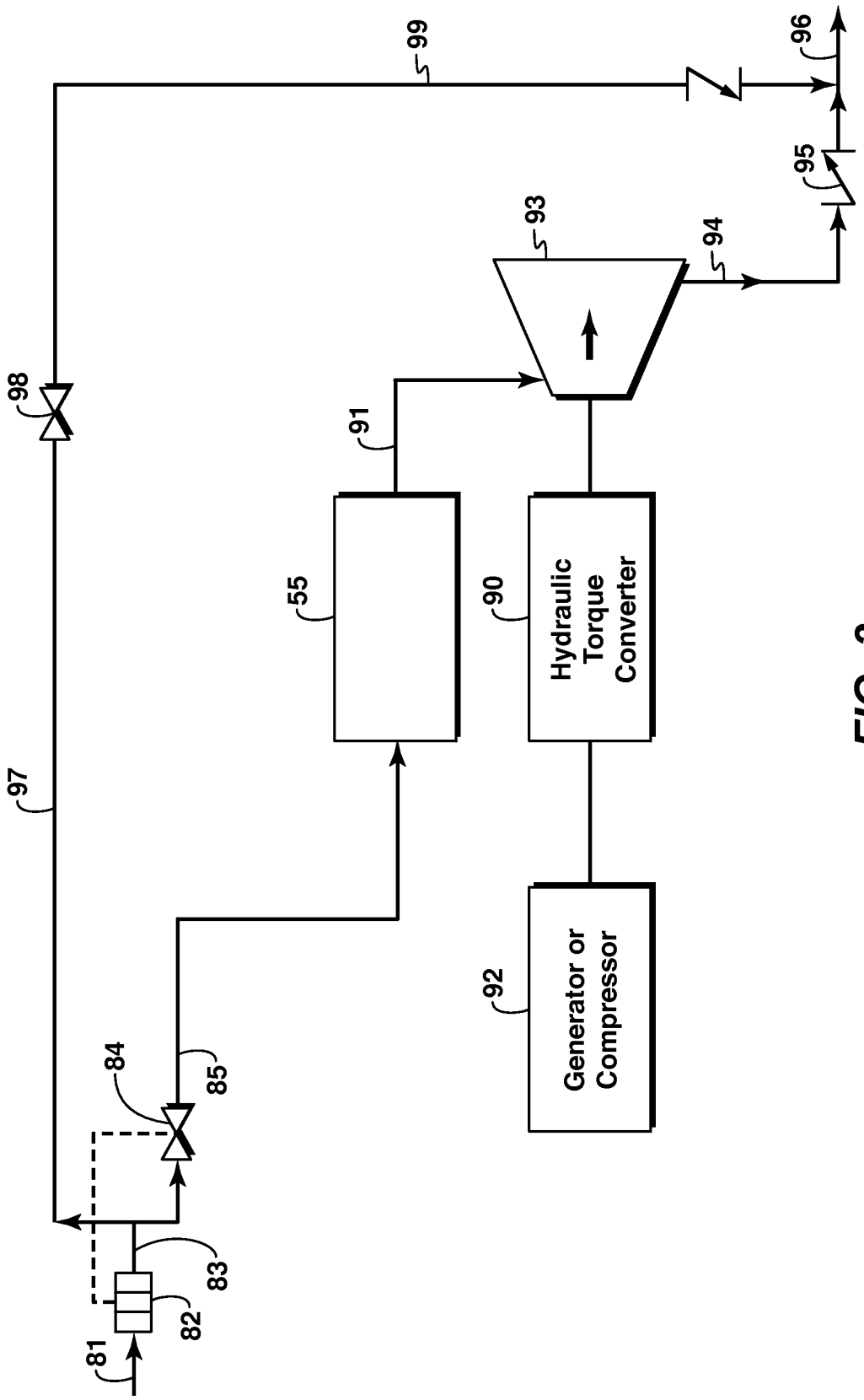
99
96
95
93
94
98
91
55
90
Hydraulic Torque Converter
97
92
Generator or Compressor
84
85
83
82
81

FIG. 3

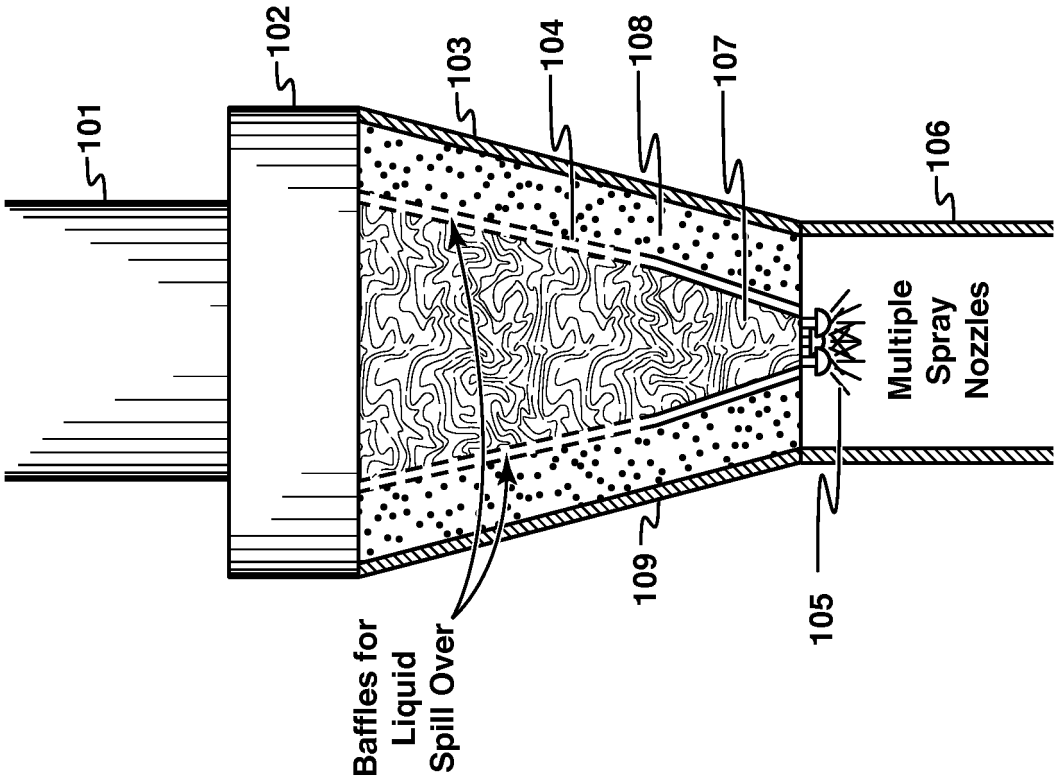
101
102
103
104
108
107
106
Multiple
Spray
Nozzles
109
105
Baffles for
Liquid
Spill Over

FIG. 4

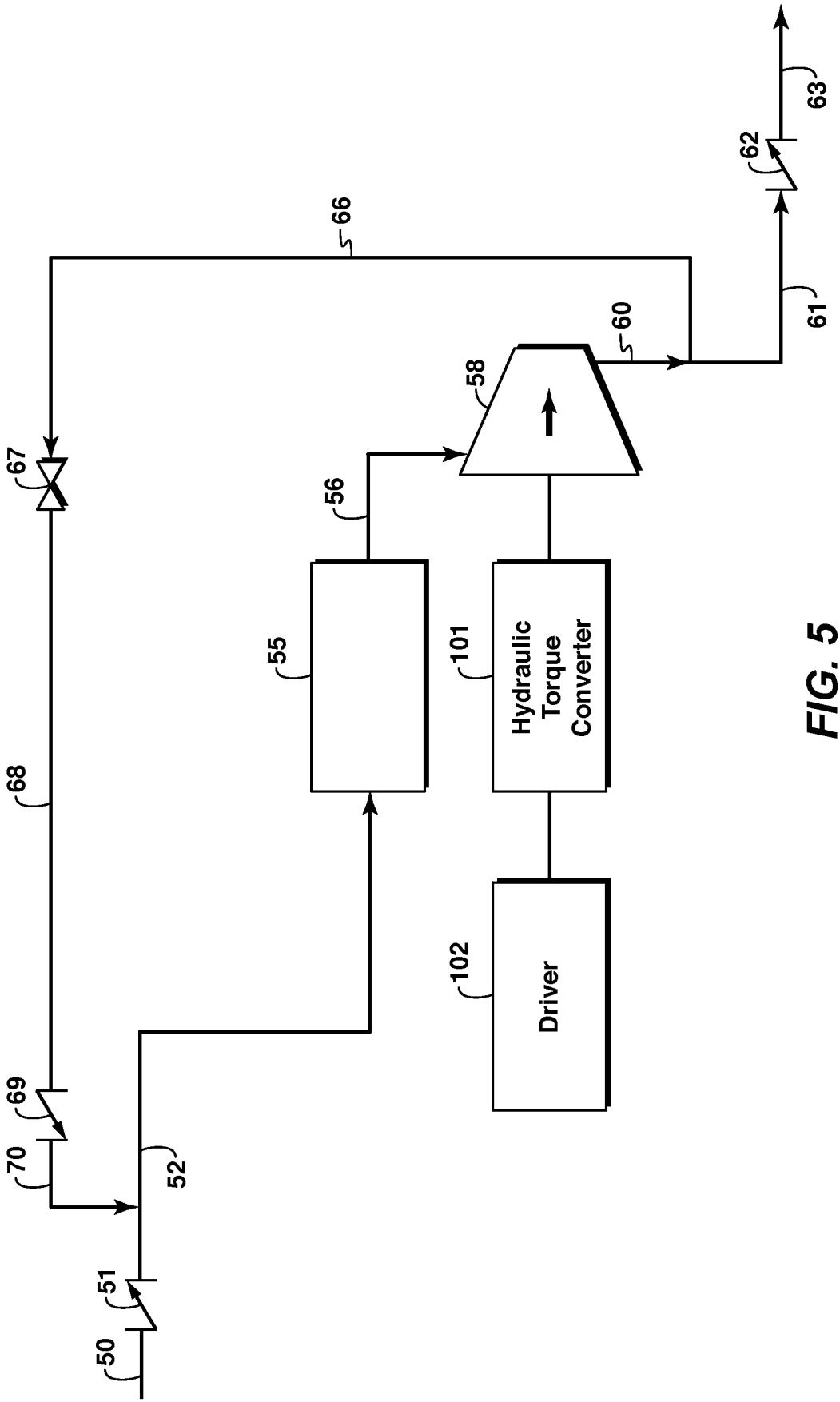
50
51
52
69
70
68
67
66
62
63
61
60
58
56
55
101
Hydraulic Torque Converter
102
Driver

FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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