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# (54) METHOD FOR OFFSHORE LIQUEFACTION

(71) Applicant: **FLNG, LLC**, Houston, TX (US)

(72) Inventors: **Robert Magee Shivers, III**, Houston, TX (US); **Richard Paul Michel**, Houston, TX (US); **Marcus LaRoy Morris**, Katy, TX (US); **Ned Phillip Baudat**, New Braunfels, TX (US); **Norman Paul Kolb**, Houston, TX (US)

(73) Assignee: **FLNG, LLC**, Houston, TX (US)

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(51) **Int. Cl.**

| | |
|---|---|
| ***F17C 3/08*** | (2006.01) |
| ***F17C 7/02*** | (2006.01) |
| ***F17C 13/08*** | (2006.01) |
| ***F25J 1/00*** | (2006.01) |
| ***B63B 22/02*** | (2006.01) |
| ***E02B 3/24*** | (2006.01) |

(52) **U.S. Cl.**
USPC ................ **62/611**; 62/45.1; 62/50.1; 62/53.2; 62/606; 114/230.14; 114/230.17

(58) **Field of Classification Search**
USPC ................ 62/52.3, 606, 611, 613, 45.1, 50.1, 62/50.2; 114/230.14, 230.17, 387
See application file for complete search history.

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*Primary Examiner* — Frantz F. Jules
*Assistant Examiner* — Keith Raymond
(74) *Attorney, Agent, or Firm* — Buskop Law Group, PC; Wendy Buskop

(57) **ABSTRACT**

A method for offshore liquefaction of natural gas and transport of produced liquefied natural gas using a floating production storage and offloading vessel, fluidly connected with a flexible conduit to a moored floating disconnectable turret which can be connected and reconnected to a liquefaction vessel with onboard liquefaction unit powered by a dual fuel diesel electric main power plant of the liquefied natural gas transport vessel.

**5 Claims, 8 Drawing Sheets**

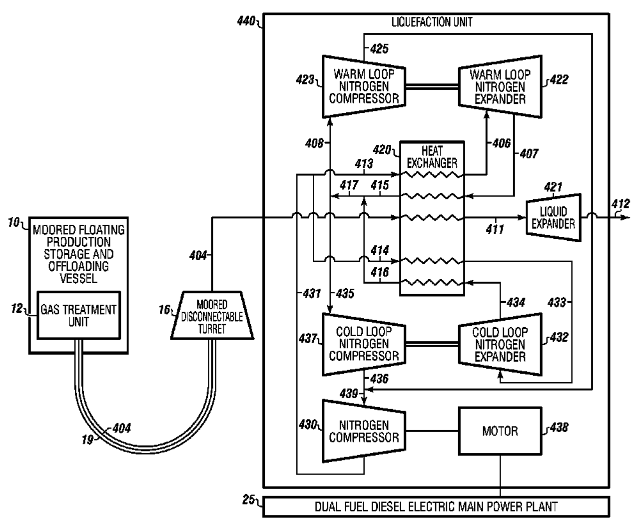

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FIGURE 1

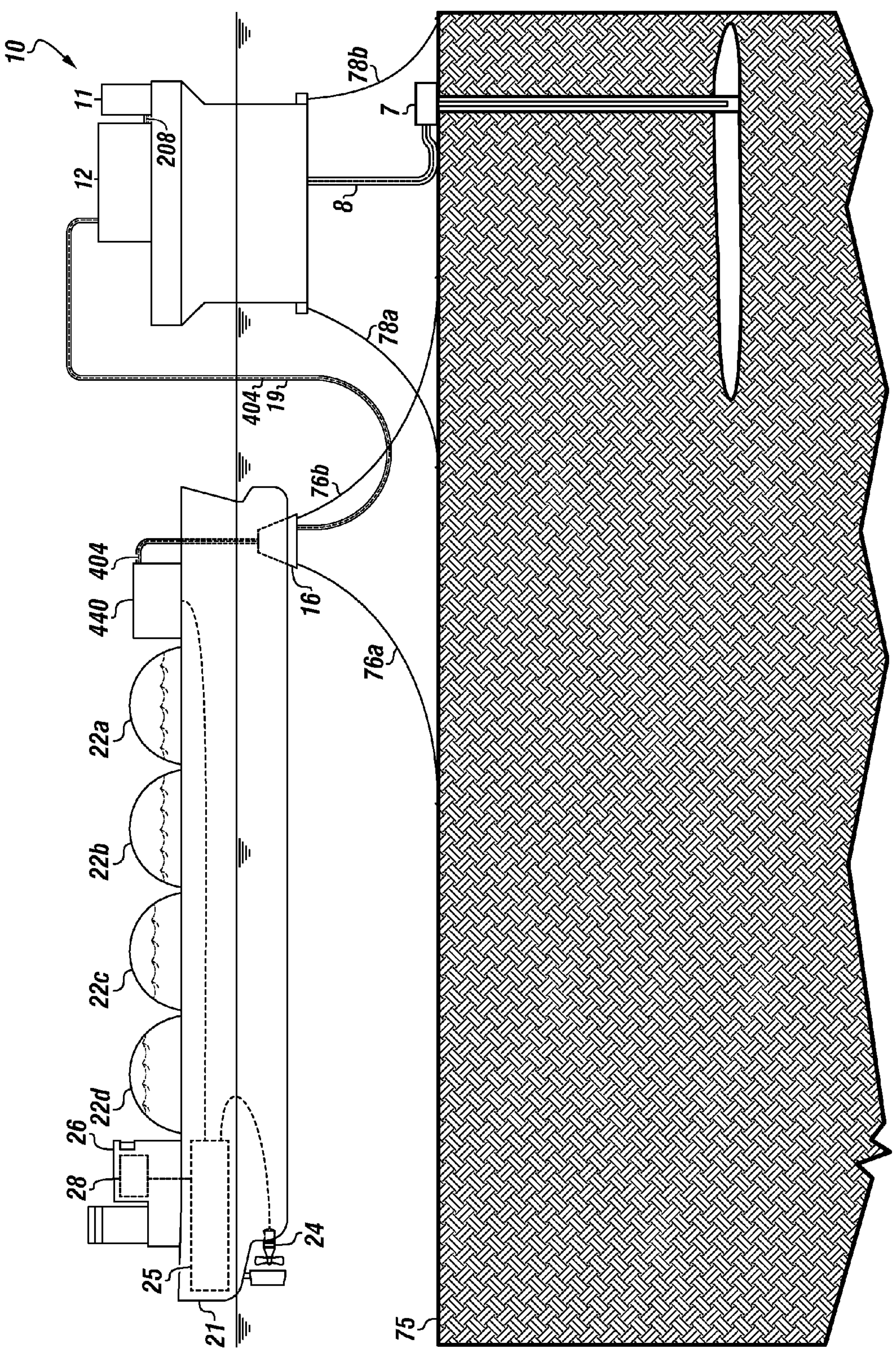

10
11
12
208
7
8
78b
78a
404
19
76b
404
440
16
76a
22a
22b
22c
22d
26
28
25
24
21
75

FIGURE 2

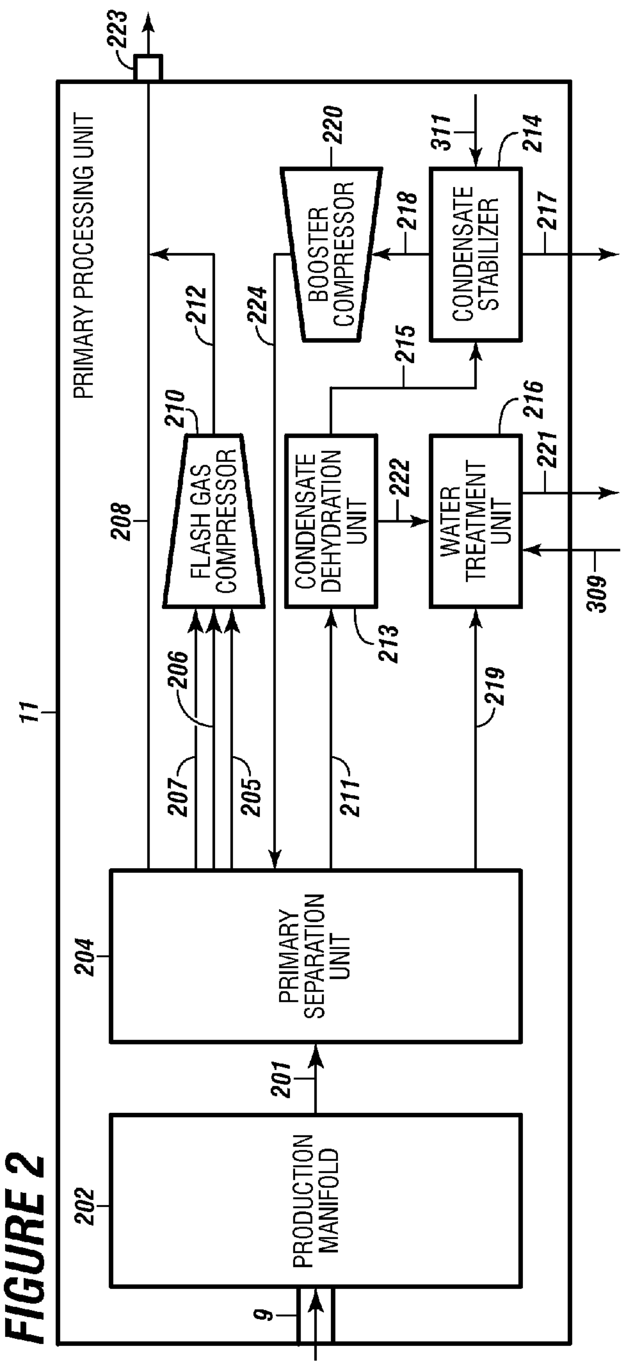
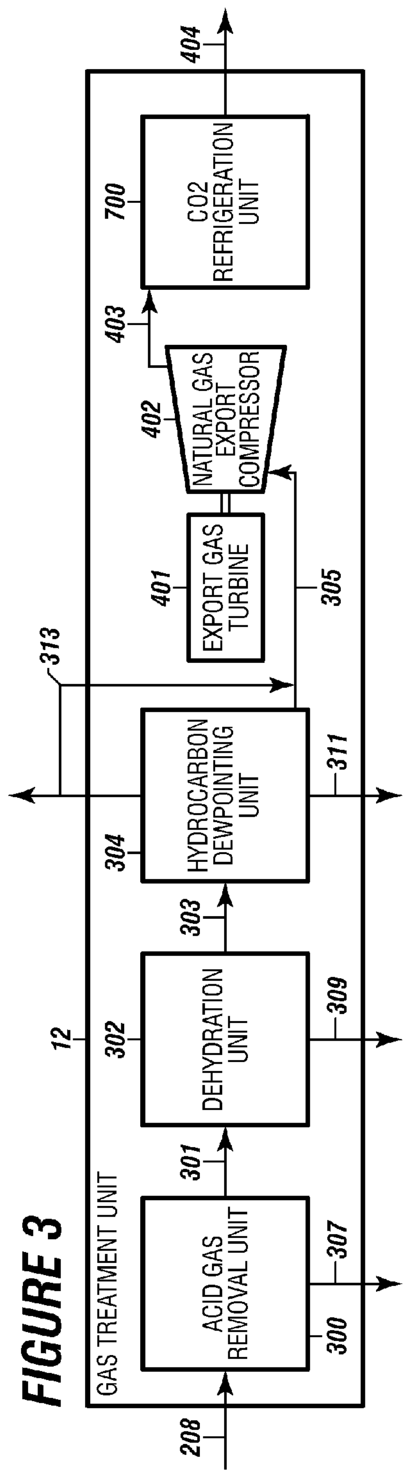



FIGURE 3



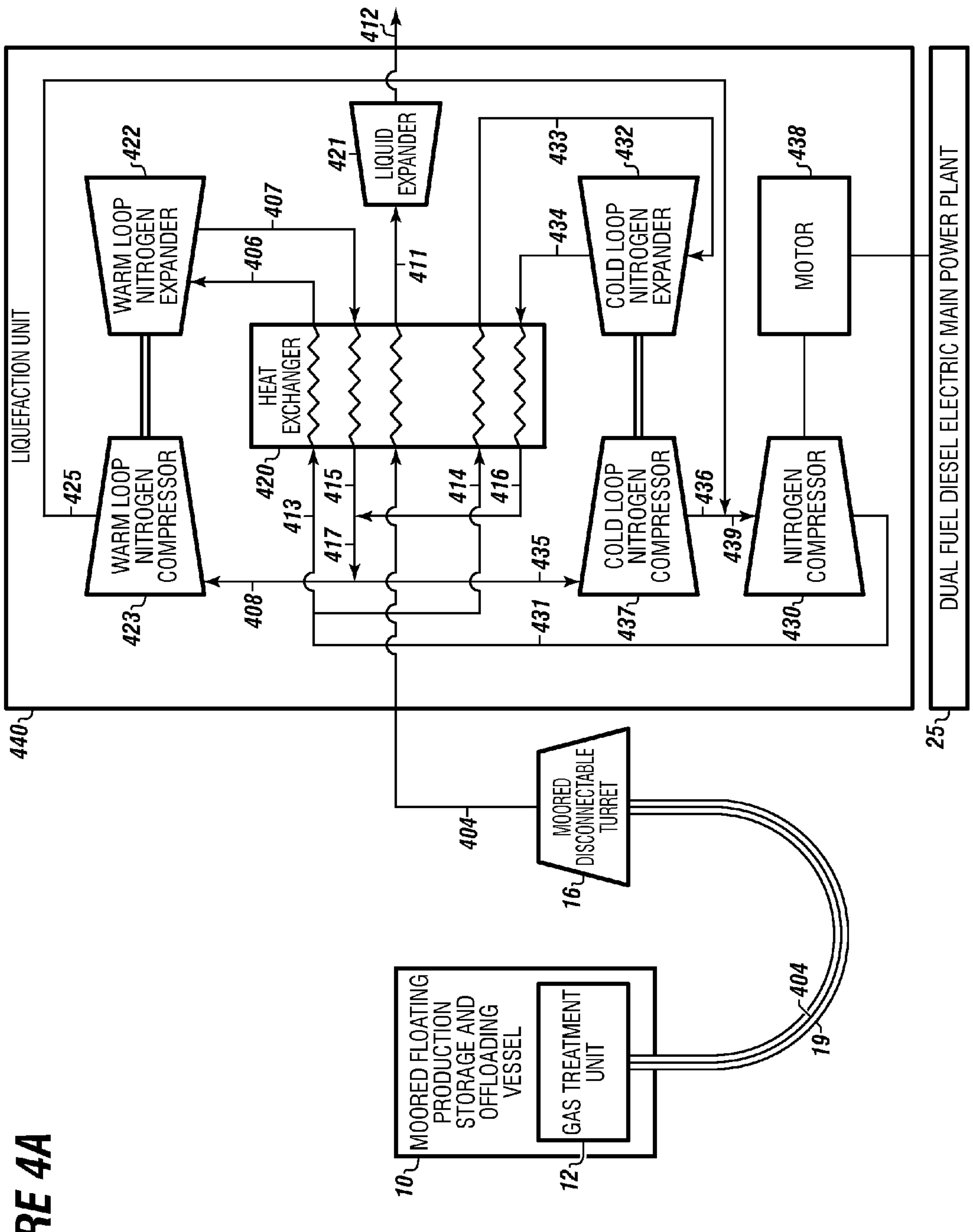

LIQUEFACTION UNIT
WARM LOOP NITROGEN EXPANDER
WARM LOOP NITROGEN COMPRESSOR
HEAT EXCHANGER
LIQUID EXPANDER
COLD LOOP NITROGEN EXPANDER
COLD LOOP NITROGEN COMPRESSOR
MOTOR
NITROGEN COMPRESSOR
DUAL FUEL DIESEL ELECTRIC MAIN POWER PLANT
MOORED DISCONNECTABLE TURRET
MOORED FLOATING PRODUCTION STORAGE AND OFFLOADING VESSEL
GAS TREATMENT UNIT
412
422
421
433
432
438
407
406
411
434
425
420
415
413
414
416
436
417
435
439
423
408
431
437
430
440
25
404
16
19
10
12

FIGURE 4A

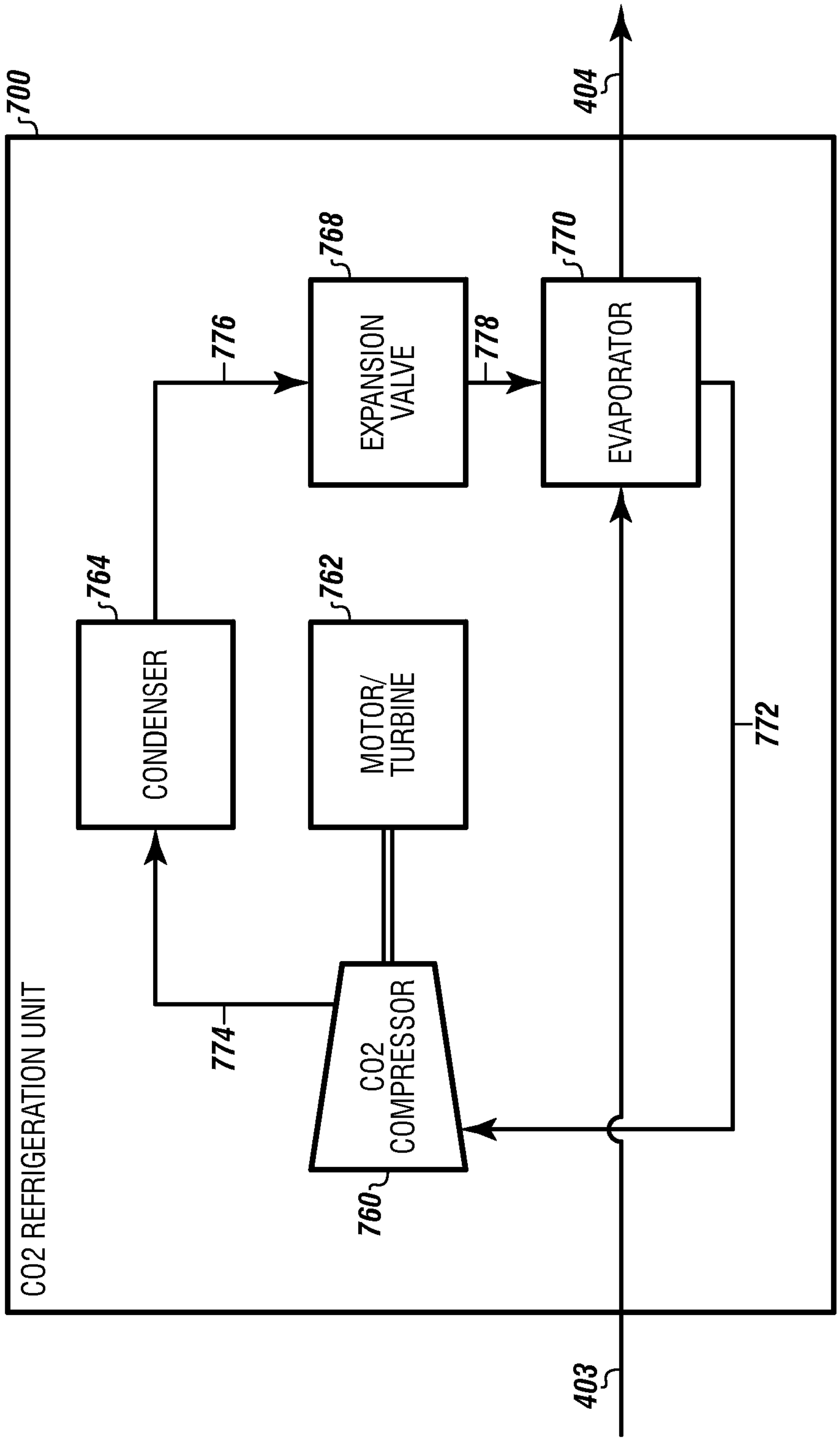

700
CO2 REFRIGERATION UNIT
CO2 COMPRESSOR
760
MOTOR/ TURBINE
762
CONDENSER
764
EXPANSION VALVE
768
EVAPORATOR
770
772
774
776
778
403
404

FIGURE 4B

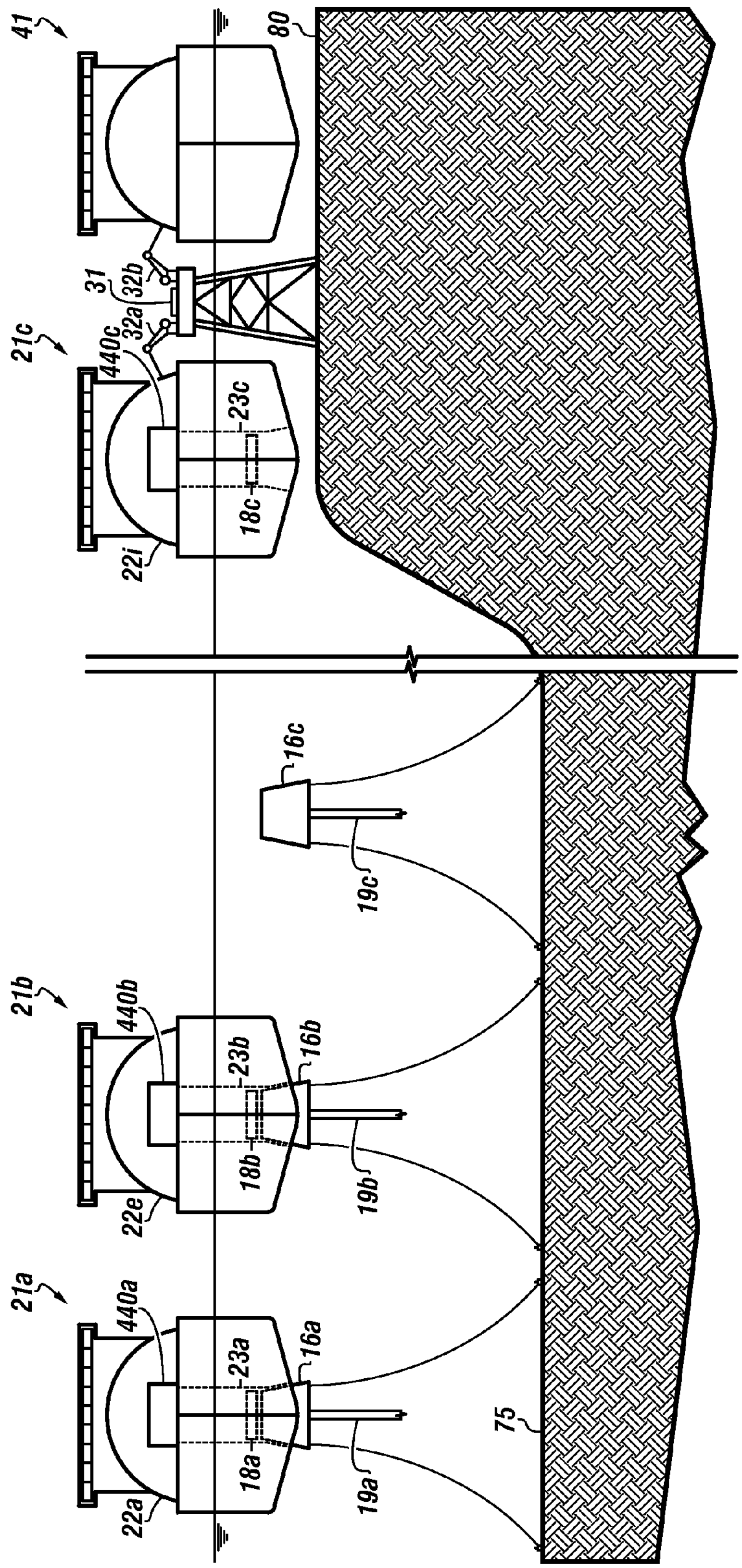

41
80
31
32a
32b
21c
440c
23c
18c
22i
16c
19c
21b
440b
23b
16b
18b
19b
22e
21a
440a
23a
16a
18a
19a
22a
75

FIGURE 5

# FIGURE 6A

CONNECTING A SUBSEA WELL TO A MOORED FLOATING PRODUCTION STORAGE AND OFFLOADING VESSEL USING A RISER 600

RECEIVING WELL GAS FROM ONE OR MORE SUBSEA WELLS AND COMBINING THE WELL GAS IN A PRIMARY PROCESSING UNIT MOUNTED ON THE MOORED FLOATING PRODUCTION STORAGE AND OFFLOADING VESSEL 602

SEPARATING CONDENSATE FROM THE COMBINED GAS TO PRODUCE A HIGH PRESSURE WET NATURAL GAS, THEN DEHYDRATING THE SEPARATED CONDENSATE AND TRANSFERRING REMOVED WATER FOR TREATMENT AND DISPOSAL, THEN FRACTIONATING AND STABILIZING THE DEHYDRATED CONDENSATE AND TRANSFERRING STABILIZED CONDENSATE TO STORAGE ON THE FLOATING PRODUCTION STORAGE AND OFFLOADING VESSEL 604

TRANSFERRING THE HIGH PRESSURE WET NATURAL GAS TO A GAS TREATMENT UNIT TO CREATE A TREATED GAS BY REMOVING ACID GASES (CO2 & H2S), WATER, AND HEAVY HYDROCARBON COMPONENTS (C5+) TO PRODUCE A TREATED GAS 606

COMPRESSING THE TREATED GAS WITH A NATURAL GAS EXPORT COMPRESSOR AND THEN TRANSFERRING THE COMPRESSED TREATED GAS TO A CARBON DIOXIDE REFRIGERATION UNIT TO REDUCE ITS TEMPERATURE, FORMING FEED GAS 608

TRANSFERRING THE FEED GAS TO A DISCONNECTABLE TURRET WHICH TRANSFERS THE FEED GAS TO A LIQUEFACTION UNIT ON A LIQUEFIED NATURAL GAS TRANSPORT VESSEL 610

USING A HEAT EXCHANGER TO LIQUEFY AND CONDENSE THE FEED GAS FORMING A HIGH PRESSURE LIQUEFIED GAS 612

EXPANDING THE HIGH PRESSURE LIQUEFIED GAS THROUGH A LIQUID EXPANDER FORMING A LOW PRESSURE LIQUEFIED NATURAL GAS STREAM 613

USING A WARM LOOP NITROGEN EXPANDER TO RECEIVE A WARM LOOP PRECOOLED NITROGEN GAS FROM THE HEAT EXCHANGER AND TRANSMITTING A WARM LOOP NITROGEN STREAM REFRIGERANT TO THE HEAT EXCHANGER WHICH IS THEN WARMED TO FORM WARM LOOP LOW PRESSURE NITROGEN GAS 614

USING A COLD LOOP NITROGEN EXPANDER TO RECEIVE COOLED COLD LOOP NITROGEN FROM THE HEAT EXCHANGER AND FORM COLD LOOP NITROGEN STREAM REFRIGERANT WHICH IS FLOWED TO THE HEAT EXCHANGER AND WARMED IN THE HEAT EXCHANGER FORMING COLD LOOP LOW PRESSURE NITROGEN GAS WHICH IS THEN COMBINED WITH WARM LOOP LOW PRESSURE NITROGEN GAS TO MAKE COMBINED LOW PRESSURE NITROGEN GAS 615

USING A WARM LOOP NITROGEN COMPRESSOR CONNECTED TO THE WARM LOOP NITROGEN EXPANDER TO RECEIVE MOST OF THE COMBINED LOW PRESSURE NITROGEN GAS AS FIRST STREAM WHICH FLOWS INTO THE WARM LOOP NITROGEN COMPRESSOR FORMING A WARM LOOP INTERMEDIATE PRESSURE NITROGEN GAS 616

USING A COLD LOOP NITROGEN COMPRESSOR CONNECTED TO THE COLD LOOP NITROGEN EXPANDER TO RECEIVE THE BALANCE OF THE COMBINED LOW PRESSURE NITROGEN GAS AS SECOND STREAM, AND FORM A COLD LOOP INTERMEDIATE PRESSURE NITROGEN GAS 618

6B

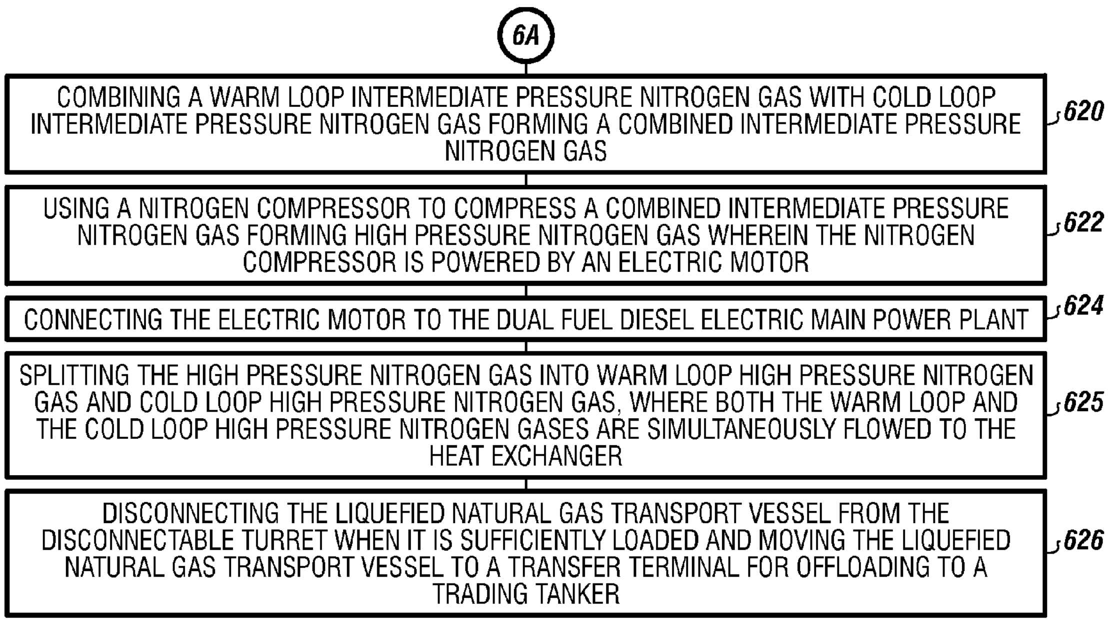

6A
COMBINING A WARM LOOP INTERMEDIATE PRESSURE NITROGEN GAS WITH COLD LOOP INTERMEDIATE PRESSURE NITROGEN GAS FORMING A COMBINED INTERMEDIATE PRESSURE NITROGEN GAS
620
USING A NITROGEN COMPRESSOR TO COMPRESS A COMBINED INTERMEDIATE PRESSURE NITROGEN GAS FORMING HIGH PRESSURE NITROGEN GAS WHEREIN THE NITROGEN COMPRESSOR IS POWERED BY AN ELECTRIC MOTOR
622
CONNECTING THE ELECTRIC MOTOR TO THE DUAL FUEL DIESEL ELECTRIC MAIN POWER PLANT
624
SPLITTING THE HIGH PRESSURE NITROGEN GAS INTO WARM LOOP HIGH PRESSURE NITROGEN GAS AND COLD LOOP HIGH PRESSURE NITROGEN GAS, WHERE BOTH THE WARM LOOP AND THE COLD LOOP HIGH PRESSURE NITROGEN GASES ARE SIMULTANEOUSLY FLOWED TO THE HEAT EXCHANGER
625
DISCONNECTING THE LIQUEFIED NATURAL GAS TRANSPORT VESSEL FROM THE DISCONNECTABLE TURRET WHEN IT IS SUFFICIENTLY LOADED AND MOVING THE LIQUEFIED NATURAL GAS TRANSPORT VESSEL TO A TRANSFER TERMINAL FOR OFFLOADING TO A TRADING TANKER
626

FIGURE 6B

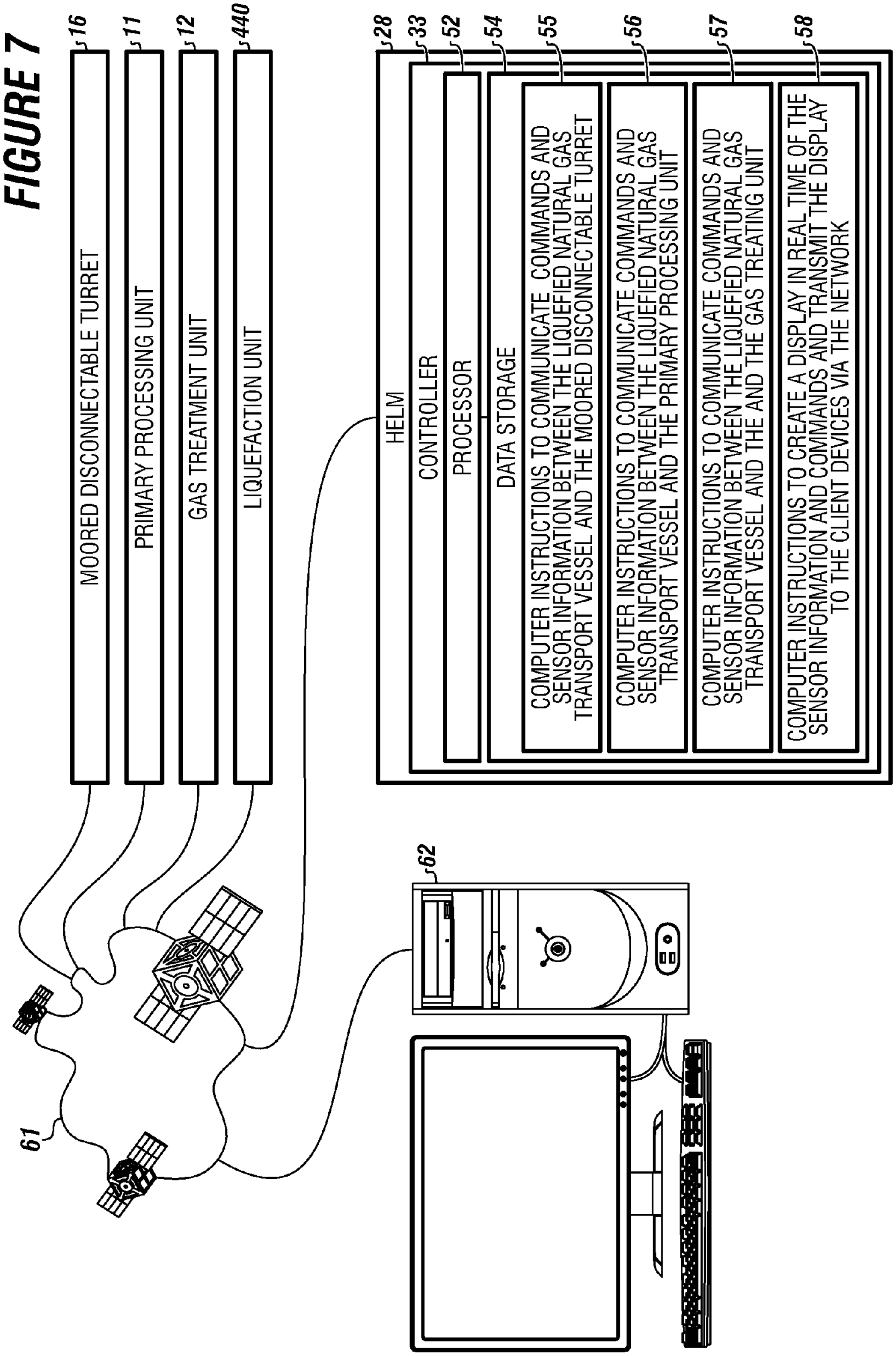

16
MOORED DISCONNECTABLE TURRET
11
PRIMARY PROCESSING UNIT
12
GAS TREATMENT UNIT
440
LIQUEFACTION UNIT
28
HELM
33
CONTROLLER
52
PROCESSOR
54
DATA STORAGE
55
COMPUTER INSTRUCTIONS TO COMMUNICATE COMMANDS AND SENSOR INFORMATION BETWEEN THE LIQUEFIED NATURAL GAS TRANSPORT VESSEL AND THE MOORED DISCONNECTABLE TURRET
56
COMPUTER INSTRUCTIONS TO COMMUNICATE COMMANDS AND SENSOR INFORMATION BETWEEN THE LIQUEFIED NATURAL GAS TRANSPORT VESSEL AND THE PRIMARY PROCESSING UNIT
57
COMPUTER INSTRUCTIONS TO COMMUNICATE COMMANDS AND SENSOR INFORMATION BETWEEN THE LIQUEFIED NATURAL GAS TRANSPORT VESSEL AND THE AND THE GAS TREATING UNIT
58
COMPUTER INSTRUCTIONS TO CREATE A DISPLAY IN REAL TIME OF THE SENSOR INFORMATION AND COMMANDS AND TRANSMIT THE DISPLAY TO THE CLIENT DEVICES VIA THE NETWORK
61
62

FIGURE 7

# METHOD FOR OFFSHORE LIQUEFACTION

## CROSS REFERENCE TO RELATED APPLICATIONS

The present application is a Continuation in Part of co-pending U.S. patent application Ser. No. 13/848,002 filed on Mar. 20, 2013, entitled "METHOD FOR LIQUEFACTION OF NATURAL GAS OFFSHORE." This reference is hereby incorporated in its entirety.

## FIELD

The present embodiments generally relate to a method for vessel power assisted liquefaction of natural gas offshore.

## BACKGROUND

A need exists for a cost effective method of liquefying natural gas system using a transport ship capable of reliable operation in moderate to severe metocean conditions enabling a the transport ship to quickly attach and detach from a moored turret to transit to sheltered water and discharge its cargo to a trading tanker.

A need exist for a method using a liquefaction vessel that utilizes vessel power to liquefy the natural gas.

A need exists for a method to improve the fuel efficiency of dual nitrogen expansion processes for liquefying natural gas offshore.

The present embodiments meet these needs.

## BRIEF DESCRIPTION OF THE DRAWINGS

The detailed description will be better understood in conjunction with the accompanying drawings as follows:

FIG. **1** is a diagram of a disconnectable turret fluidly connected between a floating production storage and offloading vessel and a floating liquefaction vessel usable in an embodiment of the method.

FIG. **2** is a diagram of a primary processing unit on a floating production storage and offloading vessel usable in an embodiment of the method.

FIG. **3** is a diagram of a gas treating unit on a floating production storage and offloading vessel usable in an embodiment of the method.

FIG. **4**A is a diagram of components of the liquefaction unit mounted to the transport vessel as the transport vessel fluidly connects to a disconnectable turret and the disconnectable turret connects to a floating production storage and offloading vessel usable in an embodiment of the method.

FIG. **4**B is a detail of a carbon dioxide refrigeration unit usable in the method.

FIG. **5** is a diagram depicting the offloading arrangements and transfer jetty using a plurality of transport vessels and a plurality of disconnectable turrets usable in an embodiment of the method.

FIGS. **6**A and **6**B are a diagram of a sequence of steps used in an embodiment of the method.

FIG. **7** is a diagram of the communication connections usable with the equipment usable to implement the method.

The present embodiments are detailed below with reference to the listed Figures.

## DETAILED DESCRIPTION OF THE EMBODIMENTS

Before explaining the present method in detail, it is to be understood that the method is not limited to the particular embodiments and that it can be practiced or carried out in various ways.



The invention relates to a method for offshore liquefaction of natural gas and transport of produced liquefied natural gas using a floating production storage and offloading vessel, and a liquefaction vessel attached to a disconnectable moored turret, wherein the method improves the fuel efficiency of a dual nitrogen expansion process for liquefying natural gas offshore

The invention uses a carbon dioxide refrigeration unit on a floating production storage and offloading vessel to pre-cool a high pressure feed gas prior to flowing to a floating liquefaction vessel.

Additionally the invention uses a dual fuel diesel electric power plant of a liquefaction vessel to drive the nitrogen compressors of the liquefaction unit on the liquefaction vessel.

The dual nitrogen processes used herein are compact, lightweight and safe for use offshore.

The combination of the carbon dioxide refrigeration unit with the use of a dual fuel diesel electric power plant on the liquefaction vessel that provides a improved fuel efficiency of the dual nitrogen expansion liquefaction process.

The onboard liquefaction unit is solely powered by a dual fuel diesel electric main power plant of the liquefaction vessel.

Alternatively, in areas with relatively benign metocean conditions, the liquefaction vessel can be offloaded directly in open water by a dynamically positioned liquefied natural gas shuttle tanker.

Significant natural gas reserves are discovered each year offshore in areas where there is little or no commercial market for the gas on nearby landmass due to the remote location of the natural gas reserves or due to a lack of industrial and commercial infrastructure.

Where the reserves are large enough, conventional onshore liquefied natural gas plants are used to liquefy, store and load the gas onto liquefied natural gas tankers for transport to markets in other countries.

The present method provides a cost effective means of developing small and mid-size offshore gas discoveries in remote regions.

The equipment used in this method can reliably operate not only in benign metocean conditions, but also in ocean conditions with a significant wave height of greater than 3 meters (10 feet).

The method can provide reliable operations in severe metocean conditions because no offshore transfer of liquefied natural gas cargo is required.

For gas liquefaction and liquefied natural gas storage, the method can use one or more modified Moss type liquefied natural gas carriers each moored on a disconnectable turret.

A Moss type liquefied natural gas carrier is proposed for use in this method due to the ability of the spherical tanks to tolerate liquefied natural gas sloshing effects in severe seas, but other liquefied natural gas containment methods such as membrane type methods can be used.

The Moss type liquefied natural gas carrier can utilize a dual fuel diesel electric main power plant for propulsion and, according to this novel method, to power liquefaction.

In one version, the floating production storage and offloading vessel, is a ship shaped vessel, a spread moored circular vessel, such as a SEVAN® type, a semisubmersible unit, a barge, or similar vessel, or in shallow water, a fixed platform.

Turning now to the Figures, FIG. **1** is a diagram of a liquefaction vessel connected to a disconnectable turret and floating production storage and offloading vessel.

The floating production storage and offloading vessel **10** can be connected to a disconnectable turret **16** via a flexible conduit **19** at a first pressure. The first pressure can range from 1000 psia to 1500 psia.

The disconnectable turret **16** can be held to the seafloor **75** using mooring cables **76***a* and **76***b*.

The floating production storage and offloading vessel **10** can be moored to the seafloor **75** with mooring cables **78***a* and **78***b*.

The floating production storage and offloading vessel **10** can be connected to a well **7** with a subsea flow line **8**.

The floating production storage and offloading vessel **10** receives natural gas, produced water, and condensate as a mixed stream from the well **7**.

The disconnectable turret **16** can receive pre-cooled high pressure feed gas **404** via the flexible conduit **19** from a carbon dioxide refrigeration unit on the floating production storage and offloading vessel **10** at a pressure from 1000 psia to 1500 psia and at a temperature from −40 degrees Fahrenheit to 60 degrees Fahrenheit.

A liquefaction vessel **21** can be connected in a removable latching manner to the disconnectable turret **16**.

The subsea flow line **8** conveys well gas from the well **7** to a primary processing unit **11** on the floating production storage and offloading vessel **10**.

The primary processing unit **11** produces high pressure flash gas stream **208**, and treated water **221** and stabilized condensate **217**, which are shown in FIG. **2**.

A gas treatment unit **12** shown in detail in FIG. **3**, can be mounted on the floating production storage and offloading vessel **10** for treating the high pressure flash gas stream **208** to produce pre-cooled high pressure feed gas **404** which is conveyed through flexible conduit **19** to the disconnectable turret **16**.

The liquefaction vessel **21** has a liquefaction unit **440** for receiving pre-cooled high pressure feed gas **404** from the moored disconnectable turret **16**.

The pre-cooled high pressure feed gas **404** is transferred to a heat exchanger **420** on the liquefaction vessel **21**, which is shown in FIG. **4**A.

The liquefaction vessel **21** has liquefied natural gas storage **22***a*-**22***d*, as well as a propulsion means **24**, a dual fuel diesel electric main power plant **25** in communication with the propulsion means **24** and a navigation station **26** with a helm **28**.

FIG. **2** shows the details of the primary processing unit **11**.

The primary processing unit **11** can have a production manifold **202** connected to a subsea flow line **9** for receiving natural gas from a well, such as a subsea well, a platform well, or a similar well.

A primary separation unit **204** is connected to the production manifold **202** by a wet gas stream **201**.

A flash gas compressor **210** receives a plurality of wet natural gas streams **205**, **206**, and **207** from the primary separation unit **204**.

One of the wet natural gas streams can be a first low pressure wet natural gas at a pressure from 150 psia to 250 psia.

Another of the streams is at second intermediate pressure from 400 psia to 600 psia.

Still another of the streams is a third intermediate pressure wet natural gas having a pressure from 900 psia to 1200 psia.

The flash gas compressor **210** can compress the wet natural gases from the wet natural gas streams **205**, **206**, and **207** and form compressed wet natural gas **212**.

A high pressure flash gas stream **208** can flow directly from the primary separation unit **204** to an outlet **223**. The high pressure flash gas can be flowed at a pressure from 1500 psia to 2000 psia.

The wet condensate **211** is transferred from the primary separation unit **204** to a condensate dehydration unit **213** forming an unstabilized dry condensate **215**.

Water **222** is transferred from the condensate dehydration unit **213** to a water treatment unit **216**. The water treatment unit **216** forms treated water **221**.

Water vapor **309** flows from a dehydration unit **302** in the gas treatment unit **12** which is detailed in FIG. **3**.

A condensate stabilizer **214** is used for receiving pentanes and heavier hydrocarbon compounds, which group is referred to as "C5+", such as condensate **311**, and the unstabilized dry condensate **215**. The condensate **311** is formed by a hydrocarbon dewpointing unit in the gas treatment unit **12** shown in FIG. **3**.

The stabilized condensate **217** is flowed to storage in the hull of the floating production storage and offloading vessel and/or to storage in the liquefaction vessel while sending removed flash gas **218** to a booster compressor **220** and then to the primary separation unit **204** as compressed flash gas **224**.

The water treatment unit **216** is fluidly connected to the primary separation unit **204**. The water treatment unit **216** can receive untreated produced water **219** from the primary separation unit **204** and forms treated water **221**, which in embodiment can be discharged to the sea.

FIG. **3** is a diagram of the gas treatment unit **12** on the floating production storage and offloading vessel.

The gas treatment unit **12** can have an acid gas removal unit **300** can be mounted on the first floating production storage and offloading vessel **10**.

The acid gas removal unit **300** can receive the high pressure flash gas stream **208** from the primary processing unit.

The acid gas removal unit **300** removes acid gas **307**, such as $CO_2$ and/or $H_2S$ for venting, flaring or disposal.

A dehydration unit **302** receives sweetened gas **301** from the acid gas removal unit **300** and removes water vapor **309** to produce dry gas **303**.

The water vapor **309** from the dehydration unit **302** is sent to the water treatment unit **216** shown in FIG. **2**.

A hydrocarbon dewpointing unit **304** receives the dry gas **303** and removes heavy hydrocarbon compounds, such as but not limited, to propane ($C_3$), butane ($C_4$), and pentanes plus ($C_5$+), forming the feed gas **305**.

The propane and butane can be blended into a liquefied natural gas feed **313**, or sent to storage to be sold as a separate product stream. The terms "propane" and "butane" are abbreviated herein as "$C_3$" and "$C_4$" respectively and are often referred to collectively as "liquefied petroleum gas".

Condensate **311** from the hydrocarbon dewpointing unit **304** can be removed. The condensate **311** typically contains $C_5$ and heavy hydrocarbons, usually referred to as "pentanes plus" and abbreviated as "$C_5$+".

The condensate **311** can be sent to the condensate stabilizer **214** as shown in FIG. **2**.

An export gas turbine **401** drives a natural gas export compressor **402** that receives feed gas **305** and forms a high pressure feed gas **403**.

High pressure feed gas **403** is sent to a carbon dioxide refrigeration unit **700** to form a pre-cooled high pressure feed gas **404**.

FIG. **4**A is a diagram of components of a liquefaction unit **440** located on the transport vessel fluidly connected to the moored disconnectable turret **16**.

The disconnectable turret is fluidly connected through flexible conduit **19** to the floating production storage and offloading vessel **10** with the gas treatment unit **12**.

The gas treatment unit **12** produces a pre-cooled high pressure feed gas **404**. This high pressure feed gas is conveyed through the flexible conduit **19** to the disconnectable turret **16**.

The disconnectable turret conveys the pre-cooled high pressure feed gas **404** to a heat exchanger **420** in the liquefaction unit **440**.

The heat exchanger **420** cools the pre-cooled high pressure feed gas **404** producing a liquefied high pressure gas stream **411**.

The liquefied high pressure gas stream **411** is flowed through a liquid expander **421** forming a low pressure liquefied natural gas stream **412** which can be sent to liquefied natural gas storage.

High pressure nitrogen gas **431** from the nitrogen compressor **430** is divided into a warm loop high pressure nitrogen gas **413** and a cold loop high pressure nitrogen gas **414**, wherein both gases flow to the heat exchanger **420**.

A warm loop nitrogen expander **422** receives a cooled warm loop gas **406** from the heat exchanger **420** and transmitting a warm loop nitrogen refrigerant **407** to the heat exchanger **420** which is then warmed to form warm loop low pressure nitrogen gas **415**.

A warm loop nitrogen compressor **423** can be connected to the warm loop nitrogen expander **422**

A cold loop nitrogen expander **432** receives a cooled cold loop nitrogen **433** from the heat exchanger **420** and transmitting a cold loop nitrogen stream refrigerant **434** to the heat exchanger **420** which is then warmed to form cold loop low pressure nitrogen gas **416**.

A cold loop nitrogen compressor **437** is connected to the cold loop nitrogen expander **432**

The cold loop low pressure nitrogen gas **416** is then combined with the warm loop low pressure nitrogen gas **415** to make combined low pressure nitrogen gas **417**.

A warm loop compressor **423** receives a portion of the combined low pressure nitrogen gas **417** and the cold loop nitrogen compressor **437** receives the balance of the combined low pressure nitrogen gas **417**.

The portion going to the warm loop compressor is typically 70 to 80% of the stream of gas.

The warm loop nitrogen expander **422** powers the warm loop nitrogen compressor **423**.

The warm loop nitrogen compressor forms a warm loop intermediate pressure nitrogen gas **425**.

A cold loop compressor **437** receives the balance of the combined low pressure nitrogen gas **417**.

The cold loop nitrogen expander **432** powers the cold loop nitrogen compressor **437**.

The cold loop nitrogen compressor **437** forms a cold loop intermediate pressure nitrogen gas **436**.

The cold loop intermediate pressure nitrogen gas **436** is blended with the warm loop intermediate pressure nitrogen gas **425** forming a combined intermediate pressure nitrogen gas **439** that is transferred to a nitrogen compressor **430** forming high pressure nitrogen gas **431**.

The nitrogen compressor **430** is powered by a motor **438** which is connected to a dual fuel diesel electric main power plant **25** of the transport vessel.

In embodiments, the liquefaction vessel has a propulsion means connected to a dual fuel power supply which can be a diesel electric main power plant or a steam turbo-electric plant. The dual fuel diesel electric main power plant or steam turbo-electric plant is electrically connected to the liquefaction unit **440**.

FIG. 4B shows details of a carbon dioxide refrigeration unit **700** that produces pre-cooled high pressure feed gas **404** from high pressure feed gas **403** of the gas treatment unit.

The high pressure feed gas **403** is transferred to an evaporator **770**.

The evaporator **770** sends low pressure carbon dioxide gas **772** to a carbon dioxide compressor **760**. The carbon dioxide compressor is driven by a motor or turbine **762**.

High pressure carbon dioxide gas **774** is flowed from the carbon dioxide compressor **760** to a condenser **764** forming high pressure carbon dioxide refrigerant **776**.

The high pressure carbon dioxide refrigerant **776** is flowed through an expansion valve **768** to form cold carbon dioxide refrigerant **778**.

The cold carbon dioxide refrigerant **778** flows to the evaporator **770** to cool the high pressure feed gas **403** forming the pre-cooled high pressure feed gas **404**.

FIG. **5** is a diagram depicting off-loading arrangements and a transfer jetty using a plurality of liquefied natural gas transport vessels **21** and a plurality of disconnectable turrets **16**.

A plurality of liquefied natural gas transport vessels **21***a*, **21***b*, and **21***c* are shown.

Liquefied natural gas transport vessels **21***a* and **21***b* are connected to disconnectable turrets **16***a* and **16***b* respectively.

Disconnectable turret **16***b* can connect to a flexible conduit **19***b* that can also engage the floating production storage and offloading vessel **10** of FIG. **1**.

A third disconnectable turret **16***c* is depicted with the liquefaction vessel disconnected.

The disconnectable turret **16***c* has a flexible conduit **19***c* in fluid communication with the floating production storage and offloading vessel **10** of FIG. **1**.

Each liquefaction vessel **21***a*-**21***c* has a liquefaction unit **440***a*-**440***c*.

Each liquefaction unit **440***a*-**440***c* is electrically connected to the dual fuel diesel electric main power plant of the transport vessel.

The liquefaction vessel **21***a* has liquefaction unit **440***a* as well as a plurality of liquefied natural gas storage, one of which, storage unit **22***a* is shown. The vessel also has a turret receptacle **23***a* and a means to recover (pick up out of the sea) and latch onto the disconnectable turret (which is not shown).

The turret can be buoyant.

The turret receptacle has fluid swivels **18***a*, **18***b* and **18***c* that can be gas swivels, and piping that can be connected and disconnected to the disconnectable turret to provide a fluid connection with the disconnectable turret.

Each of the fluid swivels can be conveniently and quickly connectable and disconnectable with the fluid conduits in the disconnectable turret.

The liquefaction vessel **21***b* has a liquefaction unit **440***b*, which is electrically connected to the dual fuel diesel electric main power plant.

The liquefaction vessel **21***b* has a liquefied natural gas storage **22***e* shown as well as, a turret receptacle **23***b*, and a means to recover and latch onto the disconnectable turret (which is not shown). The turret receptacle **23***b* can be identical to the turret receptacle **23***a*. The turret receptacle **23***b* has a fluid swivel **18***b*.

A liquefaction vessel **21***c* has a liquefaction unit **440***c*, which is electrically connected to the dual fuel diesel electric main power plant of the vessel.

The vessels **21***a* and **21***b* are depicted connected to the turrets which are moored in deep water above a sea floor **75**.

The liquefaction vessel **21***c* has a liquefied natural gas storage **22***i* depicted, a turret receptacle **23***c*, and a fluid swivel **18***c* in the turret receptacle. The vessel has a means to recover and latch onto the disconnectable turret which is not shown.

In the Figure, transport vessel **21***c* is connected to a transfer terminal **31**.

A transfer terminal **31** is shown secured to the shallow seafloor **80** in sheltered or calm, water such as from 50 feet to 200 feet.

Transfer terminal **31** has articulated liquefied natural gas loading arms **32***a* and **32***b* depicted. Articulated liquefied natural gas loading arm **32***a* is shown connected to the liquefied natural gas transfer vessel **21***c*.

Articulated liquefied natural gas loading arm **32***b* is shown connected to a liquefied natural gas trading tanker **41** for receiving the cargo from the liquefaction vessel **21***c*.

In one or more embodiments, the articulated liquefied natural gas loading arms can be replaced with hoses.

In other embodiments, in benign water with predominant wave height less than 2 meters, a dynamically positioned shuttle tanker can be used to directly connect to the liquefied natural gas transport vessels and offload in a side by side or tandem configuration.

FIGS. **6**A and **6**B are a diagram of the sequence of steps that can be usable with the equipment already discussed.

The method can include connecting a subsea well to a moored floating production storage and offloading vessel using a riser, as shown in step **600**.

The method can include receiving well gas from one or more subsea wells and combining the well gas in a primary processing unit mounted on the moored floating production storage and offloading vessel, as shown in step **602**.

The method can include separating condensate from the combined gas to produce a high pressure wet natural gas, then dehydrating the separated condensate and transferring removed water for treatment and disposal, then fractionating and stabilizing the dehydrated condensate and transferring stabilized condensate to storage on the floating production storage and offloading vessel, as shown in step **604**.

The method can include transferring the high pressure wet natural gas to a gas treatment unit to create a treated gas by removing acid gases (co2 & h2s), water, and heavy hydrocarbon components (c5+) to produce a treated gas, as shown in step **606**.

The method can include compressing the treated gas with a natural gas export compressor and then transferring the compressed treated gas to a carbon dioxide refrigeration unit to reduce its temperature, forming feed gas, as shown in step **608**.

The method can include transferring the feed gas to a disconnectable turret which transfers the feed gas to a liquefaction unit on a liquefied natural gas transport vessel, as shown in step **610**.

The method can include using a heat exchanger to liquefy and condense the feed gas forming a high pressure liquefied gas, as shown in step **612**.

The method can include expanding the high pressure liquefied gas through a liquid expander forming a low pressure liquefied natural gas stream, as shown in step **613**.

The method can include using a warm loop nitrogen expander to receive a warm loop precooled nitrogen gas from the heat exchanger and transmitting a warm loop nitrogen stream refrigerant to the heat exchanger which is then warmed to form warm loop low pressure nitrogen gas, as shown in step **614**.

The method can include using a cold loop nitrogen expander to receive a cold loop precooled nitrogen gas from the heat exchanger and form cold loop nitrogen refrigerant which is flowed to the heat exchanger and warmed forming cold loop low pressure nitrogen gas which is then combined with warm loop low pressure nitrogen gas to make combined low pressure nitrogen gas, as shown in step **615**.

The method can include using a warm loop nitrogen compressor connected to the warm loop nitrogen expander to receive most of the combined low pressure nitrogen gas from the heat exchanger and form an intermediate pressure nitrogen gas, as shown in step **616**.

The method can include using a cold loop nitrogen compressor connected to the cold loop nitrogen expander to receive the balance of the combined low pressure nitrogen gas from the heat exchanger and form an intermediate pressure nitrogen gas, as shown in step **618**.

The method can include combing the two intermediate pressure nitrogen streams from the warm loop compressor and cold loop compressor forming combined intermediate pressure nitrogen gas, as shown in step **620**.

The method can include using a nitrogen compressor for compressing the combined intermediate pressure nitrogen gas forming a high pressure nitrogen gas wherein the nitrogen compressor is powered by an electric motor, as shown in step **622**.

The method can include connecting the electric motor to the dual fuel diesel electric main power plant, as shown in step **624**.

The method can include splitting the high pressure nitrogen gas into a warm loop high pressure nitrogen gas and a cold loop high pressure nitrogen gas, where both gases are simultaneously flowed to the heat exchanger, as shown in step **625**.

The method can include disconnecting the liquefied natural gas transport vessel from the disconnectable turret when it is sufficiently loaded and moving the liquefied natural gas transport vessel to a transfer terminal for offloading to a trading tanker, as shown in step **626**.

In one or more embodiments, a fixed production storage and offloading platform can be used instead of the floating production storage and offloading vessel.

The fixed production storage and offloading platform can have a primary processing unit mounted on the fixed production storage and offloading platform for receiving gas from a well; a gas treatment unit mounted on the fixed production storage and offloading platform for treating a process stream from the primary processing unit to produce treated inlet gas streams; and a first liquefaction portion that includes a natural gas compressor for receiving liquefied natural gas inlet quality gas, forming a high pressure liquefied natural gas inlet quality gas at a pressure from 1200 psia to 2000 psia. The platform can connect in a manner identical to the floating production storage and offloading vessel to the disconnectable turrets as shown in prior Figures.

FIG. **7** depicts the electronic communications usable to perform the invention.

The transport vessel has a processor **52** which connects to a controller **33** for operating the liquefaction unit **440** and to communicate with the helm **28**. The helm connects to a network **61** which communicates to a remote server **62**. The remote server has a processor **52** and data storage **54** for monitoring the liquefaction process and the loading of the tanker.

The processor **52** communicates with an onboard data storage **54** in order to use computer instructions to communicate with the moored disconnectable turret **16**, the primary processing unit **11**, and the gas treatment unit **12**.

The onboard data storage has computer instructions **55** to communicate commands and sensor information between the liquefaction vessel and the moored disconnectable turret.

The onboard data storage **54** also has computer instructions **56** to communicate commands and sensor information between the liquefaction vessel and the primary processing unit.

The onboard data storage **54** also has computer instructions **57** to communicate commands and sensor information between the liquefaction vessel and the gas treatment unit.

The onboard data storage **54** also has computer instructions **58** to create a display in real time of the sensor information and commands and transmit the display to client devices, such as the remote server via the network.

Like the remote server, client devices have processors and a data storage. Client devices can be computers. The remote server can be a computer. The onboard processor with data storage can be a computer. Other usable client devices include Ipads, cellular phones, and personal computing devices.

The network can be a satellite network, a cellular network, the internet or combinations of these networks.

While these embodiments have been described with emphasis on the embodiments, it should be understood that within the scope of the appended claims, the embodiments might be practiced other than as specifically described herein.

What is claimed is:

**1**. A method for processing natural gas from an offshore well that improves fuel efficiency of a dual nitrogen expansion process for liquefying natural gas offshore, the method comprising:

a. connecting a subsea well to a moored floating production storage and offloading vessel using a riser;

b. receiving well gas from one or more subsea wells and combining the well gas in a primary processing unit mounted on the moored floating production storage and offloading vessel;

c. separating condensate from the combined gas to produce a high pressure flash gas stream, a wet low pressure natural gas stream, and a wet intermediate pressure natural gas stream, then dehydrating the separated wet condensate and transferring removed water for treatment and disposal;

d. fractionating and stabilizing the dry condensate and transferring stabilized condensate to storage on the floating production storage and offloading vessel;

e. compressing the wet low pressure and wet intermediate pressure natural gas streams which are then combined with the high pressure flash gas;

f. transferring the high pressure flash gas to a gas treatment unit to create a feed gas by removing acid gases ($CO_2$ & $H_2S$), water, and heavy hydrocarbon components (C5+);

g. compressing the feed gas with a natural gas export compressor and transfer a high pressure feed gas to a carbon dioxide refrigeration unit to reduce its temperature, forming pre-cooled high pressure feed gas;

h. transferring the pre-cooled high pressure feed gas to a disconnectable turret which transfers the pre-cooled high pressure feed gas to a liquefaction unit on a liquefied natural gas transport vessel;

i. using a heat exchanger to liquefy and condense the pre-cooled high pressure feed gas forming a liquefied high pressure gas stream;

j. expanding the liquefied high pressure gas stream through a liquid expander forming a low pressure liquefied natural gas stream;

k. using a warm loop nitrogen expander to receive cooled warm loop gas from the heat exchanger and form warm loop nitrogen refrigerant which is flowed to the heat exchanger and warmed in the heat exchanger forming warm loop nitrogen gas;

l. using a cold loop nitrogen expander to receive cooled cold loop nitrogen from the heat exchanger and form cold loop nitrogen stream refrigerant which is flowed to the heat exchanger and warmed in the heat exchanger forming cold loop low pressure nitrogen gas which is then combined with warm loop low pressure nitrogen gas to make combined low pressure nitrogen gas;

m. using a warm loop nitrogen compressor connected to the warm loop nitrogen expander to receive most of the combined low pressure nitrogen gas as a first stream which flows into the warm loop nitrogen compressor forming a warm loop intermediate pressure nitrogen gas;

n. using a cold loop nitrogen compressor connected to the cold loop nitrogen expander to receive the balance of the combined low pressure nitrogen gas as a second stream, and form a cold loop intermediate pressure nitrogen gas;

o. combining a warm loop intermediate pressure nitrogen gas with cold loop intermediate pressure nitrogen gas forming a combined intermediate pressure nitrogen gas;

p. using a nitrogen compressor to compress a combined intermediate pressure nitrogen gas forming high pressure nitrogen gas wherein the nitrogen compressor is powered by an electric motor;

q. connecting the electric motor to the dual fuel diesel electric main power plant;

r. splitting the high pressure nitrogen gas into warm loop high pressure nitrogen gas and cold loop high pressure nitrogen gas, where both the warm loop high pressure nitrogen gas and the cold loop high pressure nitrogen gas are simultaneously flowed to the heat exchanger; and

s. disconnecting the liquefaction vessel from the disconnectable turret when it is sufficiently loaded and moving the liquefaction vessel to a transfer terminal for offloading.

**2**. The method of claim **1**, further comprising using a processor in communication with a helm to communicate to a network to communicate with a remote processor to enable remote monitoring of the processing of the natural gas.

**3**. The method of claim **1**, further comprising using a turret receptacle and a means to recover and latch onto the disconnectable turret incorporated into the liquefied natural gas transport vessel.

**4**. The method of claim **1** wherein the carbon dioxide refrigeration unit that produces pre-cooled high pressure feed gas from high pressure feed gas of the gas treatment unit comprises: an evaporator; a carbon dioxide compressor; a condenser and an expansion valve connected in series.

**5**. The method of claim **1**, further comprising using at least two articulated arms connected to a transfer terminal for offloading from one of the transport vessels to a trading tanker for moving the liquefied natural gas to market.

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