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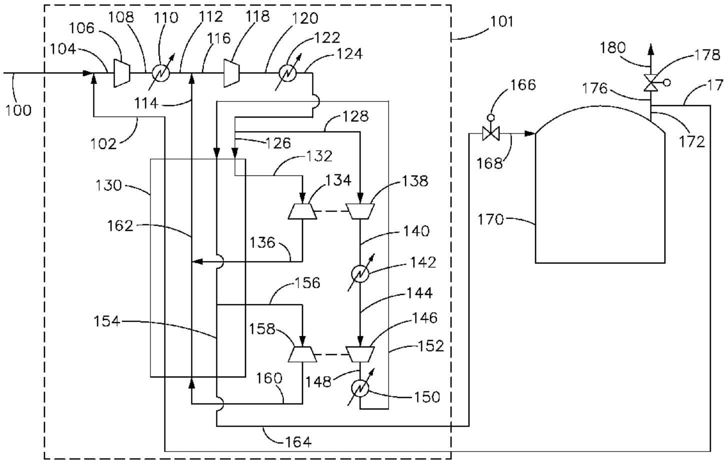

FIG. 1

(57) **Abstract**: A system and process for liquefying a gas, comprising introducing a feed stream into a liquefier comprising at least a warm expander and a cold expander; compressing the feed stream in the liquefier to a pressure greater than its critical pressure and cooling the compressed feed stream to a temperature below its critical temperature to form a high pressure dense-phase stream; removing the high pressure dense-phase stream from the liquefier, reducing the pressure of the high pressure dense-phase stream in an expansion device to form a resultant two-phase stream and then directly introducing the resultant two-phase stream into a storage tank; and combining a flash portion of the resultant two-phase stream with a boil-off vapor from a liquid in the storage tank to form a combined vapor stream, wherein the temperature of the high pressure dense-phase stream is lower than the temperature of a discharge stream of the cold expander.

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TITLE: Integrated Liquid Storage

BACKGROUND

Nitrogen liquefiers are well known in the art and are generally linked to a nitrogen generator, for example, or an Air Separation Unit (ASU). Liquefiers may be used to liquefy low pressure gaseous nitrogen from an ASU, for example. Liquefiers may also take at least a part of their feed from the ASU at higher pressure and/or at cryogenic temperatures for liquefying purposes.

In traditional liquefaction processes, high pressure nitrogen is cooled to cryogenic temperatures to form a dense-phase fluid (i.e., a fluid below its critical temperature and above its critical pressure) and then reduced in pressure, normally through the use of a valve or dense fluid expander, so that it forms mostly liquid with some flash vapor. This two-phase mixture is then fed to a separator. A cold expander also typically discharges a vapor or slightly liquefied stream into the separator. Vapor from the separator is re-warmed to ambient temperature and then recycled in the process, whilst the liquid is subcooled before being fed to an insulated liquid storage tank, for example. This subcooling may take place by pressure reduction in a second separator at a lower pressure or indirectly in a subcooler by heat exchange against a boiling liquid at low pressure. The use of a subcooler allows enough pressure to be maintained in the liquid to transfer it to storage without using pumps, for example.

Portions of the liquid produced in the liquefier may be stored, for example, in an insulated liquid storage tank for future use or be exported by road tanker while other portions of the liquid may be returned to the ASU to provide refrigeration, for example.

If a second separator is used, the second separator must be elevated above the level of the storage tank if the use of additional pumps is to be avoided.

Storage of the liquid in insulated liquid storage tanks is, however, not a simple solution. Heat ultimately leaks into the insulated liquid storage tank from the surroundings due to imperfect insulation, for example. Also, part of the liquid stored in the insulated liquid storage tanks evaporates and requires the production of additional liquid to compensate for such loss. Traditionally, the cold vapor that is formed as a result of the liquid evaporating in the insulated liquid storage tank is vented to atmosphere to avoid the pressure of the insulated liquid storage tank from rising, however, refrigeration is then lost in the process.

Previously disclosed nitrogen liquefiers linked to ASU plants were, therefore, problematic for several reasons. First, recovery of flash or cold boil-off vapor from the insulated liquid nitrogen tank required use of a cold blower. Cold blowers were used to pressurize the flash or cold boil-off vapor from the tank so that it was at sufficient pressure to be sent back to the liquefier or ASU to allow for its refrigeration to be recovered. Only part of the refrigeration can be recovered, however, when a blower is used because the blower's power is ultimately added to the cold stream of boil-off vapor as heat. Moreover, blowers are inconvenient and expensive to install and maintain, and add further complexity to these systems and processes, thus, making use of blowers uneconomical

Second, use of cold end liquid nitrogen separators add complexity to the process, and make it more costly to implement as they must all be enclosed within an insulated cold box. Large and complex cold boxes are difficult to deal with when scheduling shipping routes because certain destination locations may be hard or even impossible to reach with such large pre-insulated loads (i.e., cold box loads).

Third, liquefaction processes have typically included subcoolers to reduce the flash gas formed in the tank. Such subcoolers also add undesirable cost and complexity to the process.

Moreover, while early liquefiers (i.e., liquefiers used prior to the liquefiers traditionally used today) employed a single expander and utilized only a single separator device, these early liquefiers were relatively inefficient. To increase the efficiency of the liquefiers, later liquefier designs used multiple expanders and multiple separators to recover flash vapors at intermediate pressures. Recovery of the flash vapors at intermediate pressures was thought, for many years and to this very day, to be necessary because flash vapor formed as a result of a liquid product entering a liquid storage tank was not desirable and, thus, would have been vented to the atmosphere to control the pressure of the storage tank. Such venting would, of course, result in loss of the valuable refrigeration from the flash vapor.

Thus, there was a need in the industrial gases industry for a simple and low cost liquefaction process with the efficiency benefit of tank flash and boil-off vapor recovery without the complexity of cold blowers, cold end separators, or subcoolers.

SUMMARY

The described embodiments satisfy the need in the art by providing a simplified and efficient liquefier using a liquid storage tank as a flash separator and recovering the flash and boil-off vapor from storage through the liquefier. Separators and subcoolers may be eliminated from the liquefier design and process. As the cold portion of the liquefier is essentially only a heat exchanger and piping, it may be insulated directly and the separate cold box structure eliminated. The described embodiments utilize a design and process that is opposed to conventional wisdom for the construction of efficient liquefier designs and processes.

Production of liquid in a separate liquefier rather than in an ASU plant has operational advantages such as being easy to turn on and off according to demand, but has the significant disadvantages of the high capital cost and lower efficiency associated with a separate process unit. In general, increasing process efficiency will increase capital cost, and capital cost has to be increased to improve efficiency. The process and system described allows this capital cost to be reduced at the same time as improving the efficiency.

In one embodiment, a process for liquefying a gas is disclosed, comprising introducing a feed stream into a liquefier comprising at least a warm expander and a cold expander; compressing the feed stream in the liquefier to a pressure greater than its critical pressure and cooling the compressed feed stream to a temperature below its critical temperature to form a high pressure dense-phase stream; removing the high pressure dense-phase stream from the liquefier and reducing the pressure of the high pressure dense-phase stream in an expansion device to form a resultant two-phase stream and then directly introducing the resultant two-phase stream into a storage tank; and combining a flash portion of the resultant two-phase stream with a boil-off vapor from a liquid in the storage tank to form a combined vapor stream, wherein the temperature of the high pressure dense-phase stream is lower than the temperature of a discharge stream of the cold expander.

In another embodiment, a system for liquefying an atmospheric gas is disclosed, comprising: a first conduit for accepting a feed stream; a liquefier fluidly connected to the first conduit for compressing and cooling the feed stream to form a high pressure dense phase fluid, wherein the liquefier comprises at least a warm expander, a cold expander, a compressor for compressing the feed stream to a pressure greater than its critical pressure, and a heat exchanger, for cooling the compressed feed stream to a temperature below its critical temperature; a second conduit fluidly connected to the liquefier for accepting the high pressure dense-phase stream from the liquefier; a first expansion device fluidly connected to the second conduit to reduce the pressure of the high pressure dense-phase stream to form a resultant two-phase stream; a third conduit fluidly connected to the first expansion device for accepting the two-phase expanded stream; and a storage tank fluidly connected to the third conduit for accepting and storing the two-phase expanded stream, wherein the storage tank is designed to operate at a pressure at or below 1.5 bara, and wherein the heat exchanger is designed such that the temperature of the high pressure dense-phase stream is lower than the temperature of a discharge stream of the cold expander.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

The foregoing summary, as well as the following detailed description of exemplary embodiments, is better understood when read in conjunction with the appended drawings. For the purpose of illustrating embodiments, there is shown in the drawings exemplary constructions; however, the invention is not limited to the specific methods and instrumentalities disclosed. In the drawings:

Figure 1 is a flow diagram of an exemplary process for using a liquid storage tank as a flash separator and recovering the flash and boil-off vapor from storage through the liquefier, in accordance with the present invention;

Figure 2 is a flow diagram of an alternative exemplary process incorporating a different liquefier configuration;

Figure 3 is a flow diagram of a previously disclosed process with the same expander configuration as shown in Figure 1, wherein the process includes a cold end separator and subcooler, but comprises no flash vapor or boil-off recovery from the tank; and

Figure 4 is a flow diagram illustrating various ways to integrate the exemplary process of Figure 1 with an Air Separation Unit where any other process according to the invention may be integrated with the Air Separation Unit in a similar fashion.

DETAILED DESCRIPTION

Figure 1 illustrates an exemplary system and process for using a liquid storage tank 170 as a flash separator and recovering the flash and boil-off vapor from the liquid storage tank 170 through the liquefier 101. Figure 1 discloses low pressure nitrogen feed stream 100 being combined with warmed tank flash and boil-off vapor stream 102 to form combined stream 104. The low pressure feed stream 100 may be nitrogen, or it may be another gas or gas mixture such as air, oxygen, argon, carbon monoxide, neon, ethylene, helium, or hydrogen, for example. The combined stream 104 is then compressed in the feed compressor 106 to about 6 bara to form compressed stream 108. Compressed stream 108 is then cooled in an aftercooler 110 to form cooled stream 112. Cooled stream 112 is then combined with recycle stream 114 to form stream 116. Stream 116 is then compressed in recycle compressor 118 to about 32 bara resulting in compressed stream 120. Stream 120 is then cooled in an aftercooler 122 to form stream 124. Stream 124 is then split into streams 126 and 128.

Stream 126 is (optionally) cooled in the heat exchanger 130 to form stream 132. Stream 132 is then expanded in warm expander 134 to around 6 bara to form warm expanded stream 136.

Stream 128 is further compressed in the warm compander compressor 138 to form stream 140. Stream 140 is then cooled in the warm compander aftercooler 142 to form cooled stream 144. Cooled stream 144 is then compressed again in cold compander compressor 146 to about 65 bara to form compressed stream 148. Compressed stream 148 is then cooled again in the cold compander compressor aftercooler 150 to form high pressure stream 152. This high pressure stream 152 is cooled in the heat exchanger 130 to an intermediate temperature of about 182 K, producing streams 154 and 156.

Stream 156 is expanded in a cold expander 158 to form discharge stream 160. Discharge stream 160 is returned to the cold end of the heat exchanger 130 where it is warmed and mixed with the exhaust stream 136 from the warm expander 134 to form stream 162. Stream 162 is warmed in heat exchanger 130 to form recycle stream 114. Recycle stream 114 is then mixed with compressed feed stream 112 and fed to the suction of the recycle compressor 118.

Stream 154 is further cooled in the heat exchanger 130 to form a high pressure dense-phase stream 164. High pressure dense-phase stream 164 is withdrawn from the cold end of the heat exchanger 130 at a temperature of about 96 K, reduced in pressure across one or more expansion devices 166 to form stream 168, where stream 168 is fed directly into a liquid storage tank 170. As used herein, the term “fed directly” shall mean that the designated stream, after exiting the one or more expansion devices 166 is provided to the liquid storage tank 170 via a conduit without encountering any further apparatus that would alter the composition, temperature, or pressure of the designated stream. Moreover, as used herein “directly connected” shall mean that a first device or piece of an apparatus is connected to a second device or piece of an apparatus without any intermediate devices or pieces of apparatus that would alter the composition, temperature, or pressure of a stream passing through, for example, the first device to the second device.

Stream 168 is flashed into the liquid storage tank 170 to produce mostly liquid with some vapor. The liquid from stream 168 will add to the liquid already present in the liquid storage tank 170, whilst the flash vapor will combine with boil-off vapor already present in the liquid storage tank 170. A combined vapor stream 172 composed of flash vapor and boil-off vapor is withdrawn from the liquid storage tank 170, and, during normal operation, is fed to the heat exchanger 130 of the liquefier 101 as stream 174. Stream 174 is warmed in the heat exchanger 130 to form warmed tank flash and boil-off vapor stream 102 and mixed with the low pressure feed 100 to form combined stream 104 entering the make-up compressor 106 of the liquefier 101.

If the liquefier 101 is not operating, the liquid storage tank 170 boil-off vapors can be removed from the liquid storage tank 170 as combined vapor stream 172, 176, reduced in pressure across one or more expansion devices 178 to form stream 180, and vented to the atmosphere to control the pressure of the liquid storage tank 170.

One of the significant benefits of this system arrangement is the simplified design. Heat exchanger 130, expanders 134, 158 and the associated piping may be insulated separately, for example, with an insulating material such as mineral wool, polyurethane foam, foamglass, “cryogel,” or a suitable alternative, or installed in small local cold boxes connected by insulated piping. Reducing the size requirements of the cold box is especially important when dealing with and scheduling shipping routes because certain destination locations may be hard or impossible to reach with larger pre-insulated loads (i.e., cold box loads).

Further, contrary to traditional belief, recovery of the boil-off vapor from the liquid storage tank 170 surprisingly improves the overall efficiency of the liquefier 101 and storage system by around 0.5-1.0% (depending on the relative sizes of the liquid storage tank 170 and liquefier 101 and the quality of tank insulation) compared to previous designs where the boil-off gas was not recovered, as its cold is used to partially cool the product and reduce the power required by the liquefier 101 rather than being wasted by venting it directly to atmosphere. In addition, the required nitrogen feed flow is reduced (as the previously vented nitrogen is recovered) which could lead to use of smaller ASUs.

If the low pressure nitrogen feed stream 100 to the liquefier 101 is at a pressure high enough to provide the low pressure nitrogen feed stream 100 directly into the suction of the recycle compressor 118, the feed compressor 106 may also be eliminated, and in that case, the warmed tank flash and boil-off vapor stream 102 may be vented to the atmosphere through a valve to simply control the pressure of the liquid storage tank 170.

With surprising and unexpected result, Applicants found that if high pressure dense-phase stream 164 is cooled below the temperature of discharge stream 160 through indirect heat exchange against the recovered combined vapor stream 174 in heat exchanger 130, then reduction of the pressure of high pressure dense-phase stream 164 to the pressure of discharge stream 160 would not result in the generation of significant amounts of flash vapor, thus, the efficiency of the liquefier 101 is not reduced by eliminating the additional separator and its related components. In fact, one skilled in the art will appreciate that this exemplary embodiment eliminates the need for separators and subcoolers (for example separator 304 and subcooler 310 of Figure 3) while maintaining a high level of efficiency. For example, while traditional systems and processes may have used two or more separators to recover the flash vapors at high and reduced pressures, the disclosed system and process achieves the same result minus substantial capital cost and substantial transport planning while achieving equal or better efficiencies.

In another embodiment, and as illustrated in Figure 2, a similar system and process to Figure 1 is disclosed; however this embodiment comprises a different expander arrangement. In this system/process, stream 124 from the recycle compressor aftercooler 122 is split into two streams 226 and 228 that feed the compressor ends of the warm and cold companders 238 and 246 arranged in parallel. The respective outlet streams 240 and 248 of the warm and cold companders 238 and 246 are combined into stream 249 and cooled in aftercooler 250 before being fed to heat exchanger 130 as stream 252. Stream 252 is cooled to a first intermediate temperature in heat exchanger 130 before being split into streams 232 and 253.

Stream 232 is expanded in warm expander 234 to form stream 236 and combined with warming discharge stream 160 forming stream 162 at an intermediate location of the heat exchanger 130. Stream 253 is further cooled to a second intermediate temperature and split again into streams 256, 254. Stream 256 is expanded in cold expander 258 to form discharge stream 160. Discharge stream 160 is then warmed in the heat exchanger 130. Stream 254 is further cooled in heat exchanger 130 to form the high pressure dense-phase stream 164 that is fed to the liquid storage tank 170 via expansion device 166.

Figure 3 is a flow diagram of a previously disclosed prior art process with the same expander configuration as shown in Figure 1 but where the process comprises no flash vapor or boil-off recovery from the tank. Figure 3 is provided for exemplary purposes and to be used to compare with the system and process of Figure 1.

As illustrated in Figure 3, a cold end separator 304 and subcooler 310 are incorporated in the liquefier 301 and there is no recovery of the flash or boil-off vapor from the liquid storage tank 170. The high pressure dense-phase stream 164 from the cold end of the heat exchanger 130 is reduced in pressure in one or more expansion devices 300 and the resulting two-phase stream 302 is then fed to a separator 304 along with the cold expander discharge stream 160 that may contain some liquid. Vapor stream 306 from separator 304 is warmed in heat exchanger 130 to an intermediate temperature where it is combined with the warm expander exhaust stream 136 to form stream 162. Liquid stream 308 from separator 304 is subcooled in subcooler 310 to about 78 K to form stream 312. A portion 316 of subcooled liquid stream 312 is reduced in pressure in one or more expansion devices 318 and then evaporated in subcooler 310 to form vapor stream 320 and reheated in heat exchanger 130 to form stream 102. The remaining portion 314 of subcooled liquid stream 312 is fed to the liquid storage tank 170 via one or more expansion devices 166 to form stream 168 where stream 168 is fed into the liquid storage tank 170. Flash and boil-off vapor from the liquid storage tank 170 is vented via stream 176 through expansion device 178 to form stream 180 (to be vented to the atmosphere) to control the tank pressure.

Figure 4 is a flow diagram illustrating several exemplary options for integrating the liquefier system and process of Figure 1 with an ASU or nitrogen generator. For example, the low pressure nitrogen feed stream 100 from the warm end of the ASU may be completely or partly replaced by one or more of alternative feed streams 400, 404, or 408.

A high pressure nitrogen stream 400 from the warm end of the ASU or nitrogen generator may also be mixed with stream 112 from the feed compressor aftercooler 110 to form stream 402 that may then be mixed with stream 114 to form stream 116 that is fed to the recycle compressor 118. Alternatively, stream 400 may be mixed downstream of where stream 114 combined with stream 112, or into an interstage location of the feed compressor 106 or recycle compressor 118.

A low pressure nitrogen stream 404 from a low pressure column or subcooler at the cold end of the ASU may be mixed with the returning low pressure stream 174 from the liquid storage tank 170 to form stream 406 that is then heated in the heat exchanger 130.

A cold high pressure nitrogen stream 408 from a high pressure column of the ASU or nitrogen generator or the single column of a single column nitrogen generator may be mixed with the discharge stream 160 from the cold expander 158 to form stream 410 that is then heated in heat exchanger 130.

Additionally, a divided portion stream 412 of the high pressure dense-phase stream 164 from the cold end of the liquefier may be fed directly to the ASU or nitrogen generator to provide refrigeration whilst the remaining portion 414 may be fed to the liquid storage tank 170. As used herein a “divided portion” of a stream shall mean a portion having the same chemical composition as the stream from which it was taken. Divided portion stream 412 may be fed, for example, to the High Pressure (HP) column, the Low Pressure (LP) column, the subcooler, or the heat exchanger of an ASU.

EXAMPLE

Tables 1 and 2 provide exemplary flow rates, temperatures, and pressures for the configurations/processes of Figure 1 and Figure 3. The configuration/process disclosed in Figure 1 resulted in the data of Table 1, where 300 tonnes per day of liquid nitrogen was produced in liquid storage tank 170. The configuration/process consumed approximately 5950 kW of electricity.

Table 1

Stream	100	102	114	132	152	156	160	164	174	in tank
Flow (kmol/hr)	446	122	2386	978	1977	1409	1409	569	122	446
Temperature (K)	299	299	299	267	303	182	97	96	78	78
Pressure (bar (abs))	1.03	1.03	6.00	31.84	64.80	64.60	6.20	64.60	1.10	1.10

The configuration/process disclosed in Figure 3 resulted in the data of Table 2, where 300 tonnes per day of liquid nitrogen was also produced in liquid storage tank 170. This configuration/process consumed approximately 6000 kW of electricity.

Table 2

Stream	100	102	114	132	152	156	160	164	176	312	314	in tank
Flow (kmol/hr)	460	97	2552	1238	1871	1369	1369	502	13	557	460	446
Temperature (K)	299	299	299	254	303	174	97	99	78	79	79	78
Pressure (bar(abs))	1.03	1.03	6.00	30.05	64.80	64.60	6.20	64.60	1.10	6.00	6.00	1.10

Importantly, the exemplary process of Figure 1/Table 1 produces the same net quantity (446 kmol/hr) of liquid nitrogen in the liquid storage tank, but uses 0.8% less power than the previously disclosed process of Figure 3/Table 2, has a 3% lower feed rate (stream 100) due to the recovery of flash and boiloff vapor from the liquid storage tank (stream 174) and elimination of tank boil-off losses to atmosphere (stream 176), and provides significant capital cost savings from the elimination of a first separator, a second separator or subcooler, and their associated valves, controls and insulating enclosure. As the cold portion of the liquefier comprises essentially only a heat exchanger and the associated piping, the liquefier equipment may be insulated directly and the separate cold box structure required to contain and insulate the first separator, the second separator or subcooler, and their associated valves, and controls may be eliminated, thus, significantly reducing the size of the cold box. Reducing the size requirements of the cold box is especially important when dealing with and scheduling shipping routes because certain destination locations may be hard or even impossible to reach with larger pre-insulated loads (i.e., cold box loads).

While aspects of the present invention has been described in connection with the preferred embodiments of the various figures, it is to be understood that other similar embodiments may be used or modifications and additions may be made to the described embodiment for performing the same function of the present invention without deviating therefrom. Therefore, the claimed invention should not be limited to any single embodiment, but rather should be construed in breadth and scope in accordance with the appended claims.

CLAIMS

1. A process for liquefying a gas, comprising:

introducing a feed stream into a liquefier comprising at least a warm expander and a cold expander;

compressing the feed stream in the liquefier to a pressure greater than its critical pressure and cooling the compressed feed stream to a temperature below its critical temperature to form a high pressure dense-phase stream;

removing the high pressure dense-phase stream from the liquefier and reducing the pressure of the high pressure dense-phase stream in an expansion device to form a resultant two-phase stream and then directly introducing the resultant two-phase stream into a storage tank; and

combining a flash portion of the resultant two-phase stream with a boil-off vapor from a liquid in the storage tank to form a combined vapor stream, wherein the temperature of the high pressure dense-phase stream is lower than the temperature of a discharge stream of the cold expander.

2. The process of claim 1, further comprising heating at least part of the combined vapor stream to ambient temperature.

3. The process of claim 2, further comprising mixing the warmed combined vapor stream with the feed stream for recycle.

4. The process of claim 2, further comprising venting the warmed combined vapor stream to the atmosphere to control the pressure of the storage tank.

5. The process of claim 2, wherein the pressure of the storage tank is less than 1.5 bara.

6. The process of claim 1, further comprising removing at least part of the combined vapor stream from the storage tank, reducing the pressure of the combined vapor stream in one or more expansion devices to form a low pressure combined vapor stream, and venting the low pressure combined vapor stream to the atmosphere to control the pressure of the storage tank.

7. The process of claim 1, wherein the feed stream is a low pressure nitrogen feed stream from a warm end of an Air Separation Unit.

8. The process of claim 1, further comprising mixing a low pressure nitrogen stream from a low pressure column or subcooler of an Air Separation Unit with the combined vapor stream from the storage tank prior to heating.

9. The process of claim 1, further comprising taking a divided portion of the high pressure dense phase fluid from the liquefier, feeding the divided portion of the high pressure dense phase fluid directly to an Air Separation Unit or nitrogen generator to provide refrigeration.

10. The process of claim 9, wherein the divided portion of the high pressure dense phase fluid is reduced in pressure and fed to a High Pressure (HP) column, a Low Pressure (LP) column, a subcooler, or a main heat exchanger of the Air Separation Unit.

11. A system for liquefying an atmospheric gas, comprising:

a first conduit for accepting a feed stream;

a liquefier fluidly connected to the first conduit for compressing and cooling the feed stream to form a high pressure dense phase fluid, wherein the liquefier comprises at least a warm expander, a cold expander, a compressor for compressing the feed stream to a pressure greater than its critical pressure, and a heat exchanger, for cooling the compressed feed stream to a temperature below its critical temperature;

a second conduit fluidly connected to the liquefier for accepting the high pressure dense-phase stream from the liquefier;

a first expansion device fluidly connected to the second conduit to reduce the pressure of the high pressure dense-phase stream to form a resultant two-phase stream;

a third conduit fluidly connected to the first expansion device for accepting the two-phase expanded stream; and

a storage tank fluidly connected to the third conduit for accepting and storing the two-phase expanded stream,

wherein the storage tank is designed to operate at a pressure at or below 1.5 bara, and wherein the heat exchanger is designed such that the temperature of the high pressure dense-phase stream is lower than the temperature of a discharge stream of the cold expander.

12. The system of claim 11, wherein the storage tank is directly connected to the third conduit and wherein the first expansion device is directly connected to the second conduit.

13. The system of claim 11, further comprising a fourth conduit fluidly connected to the storage tank for accepting a combined vapor stream comprising a flash vapor portion of the resultant two-phase stream and a boil-off vapor portion from a liquid in the storage tank.

14. The system of claim 13, wherein the fourth conduit is fluidly connected to the heat exchanger and the first conduit.

15. The system of claim 13, further comprising a second expansion device fluidly connected to the fourth conduit to reduce the pressure of the combined vapor stream to control the pressure of the storage tank.

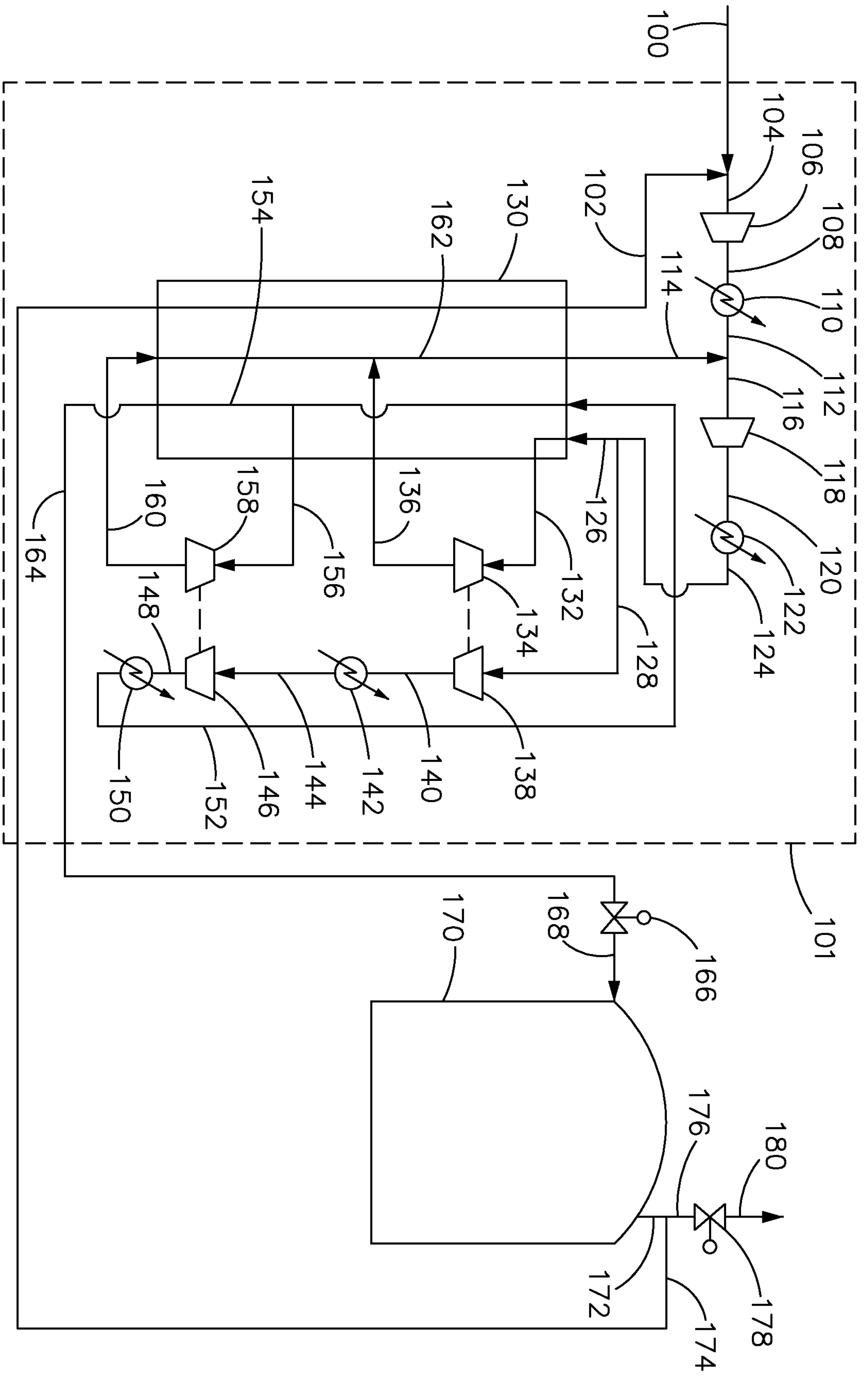
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FIG. 1

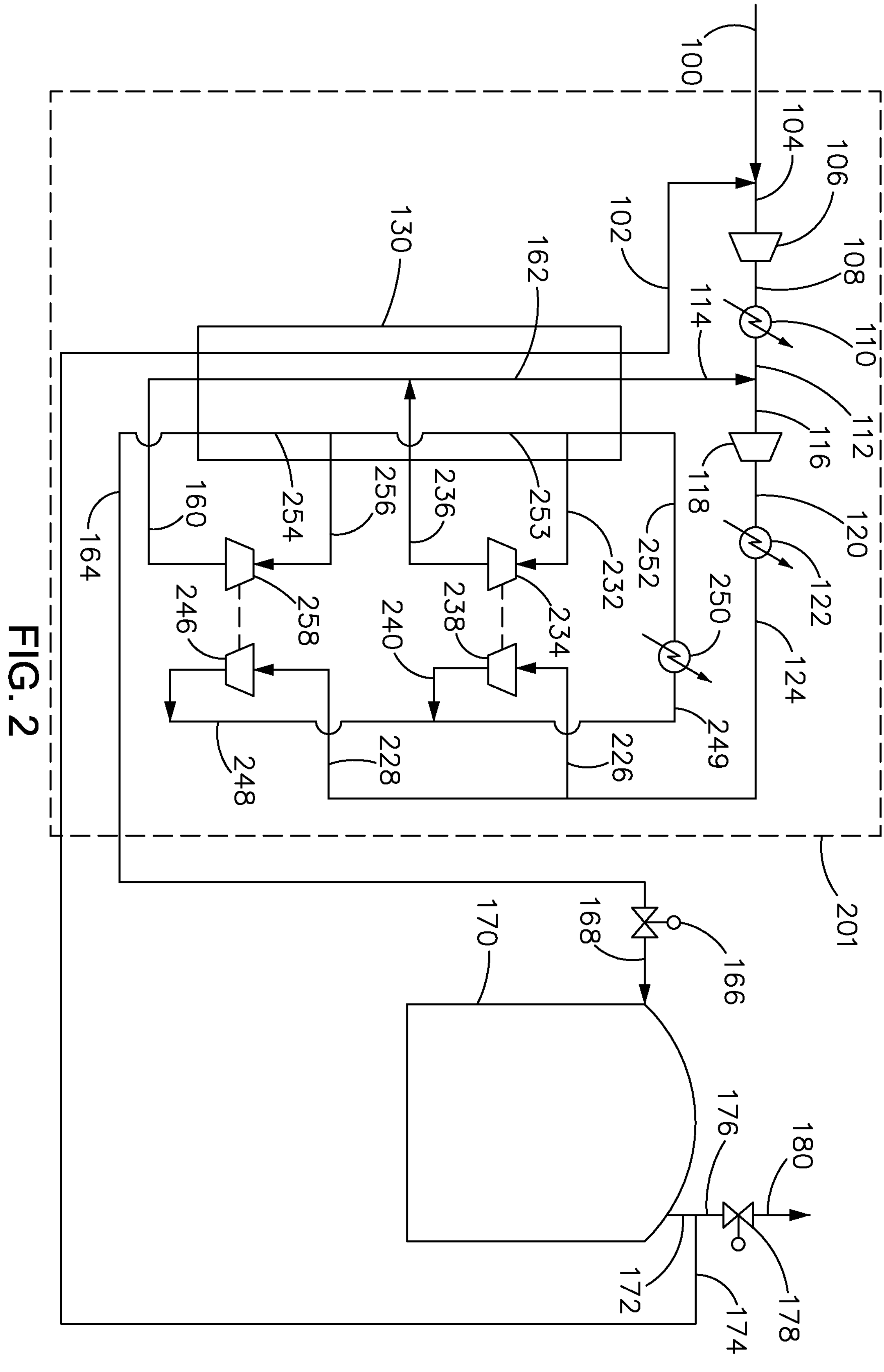
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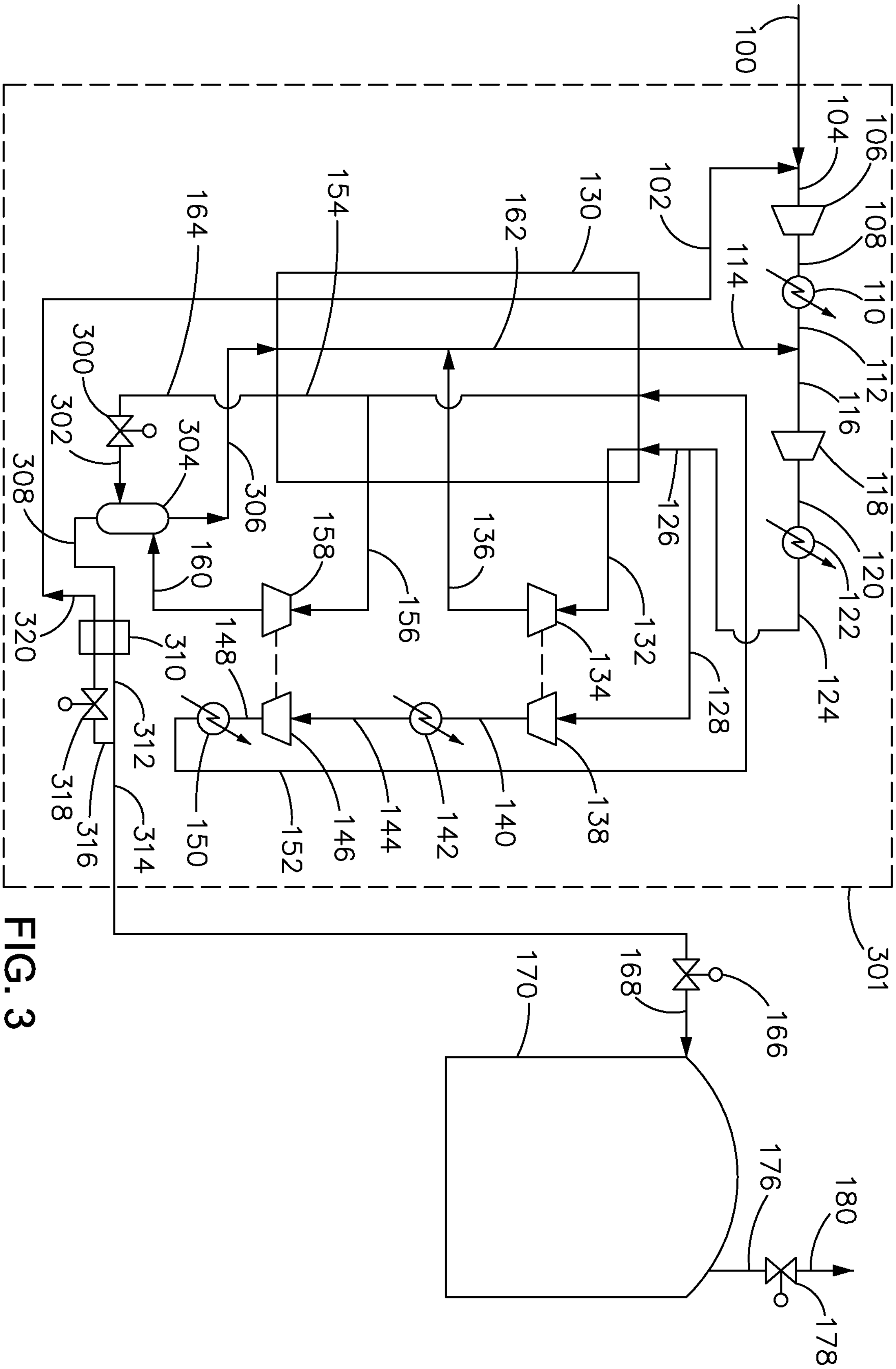
FIG. 2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314
316
318
320
301
166
168
170
176
178
180

FIG. 3

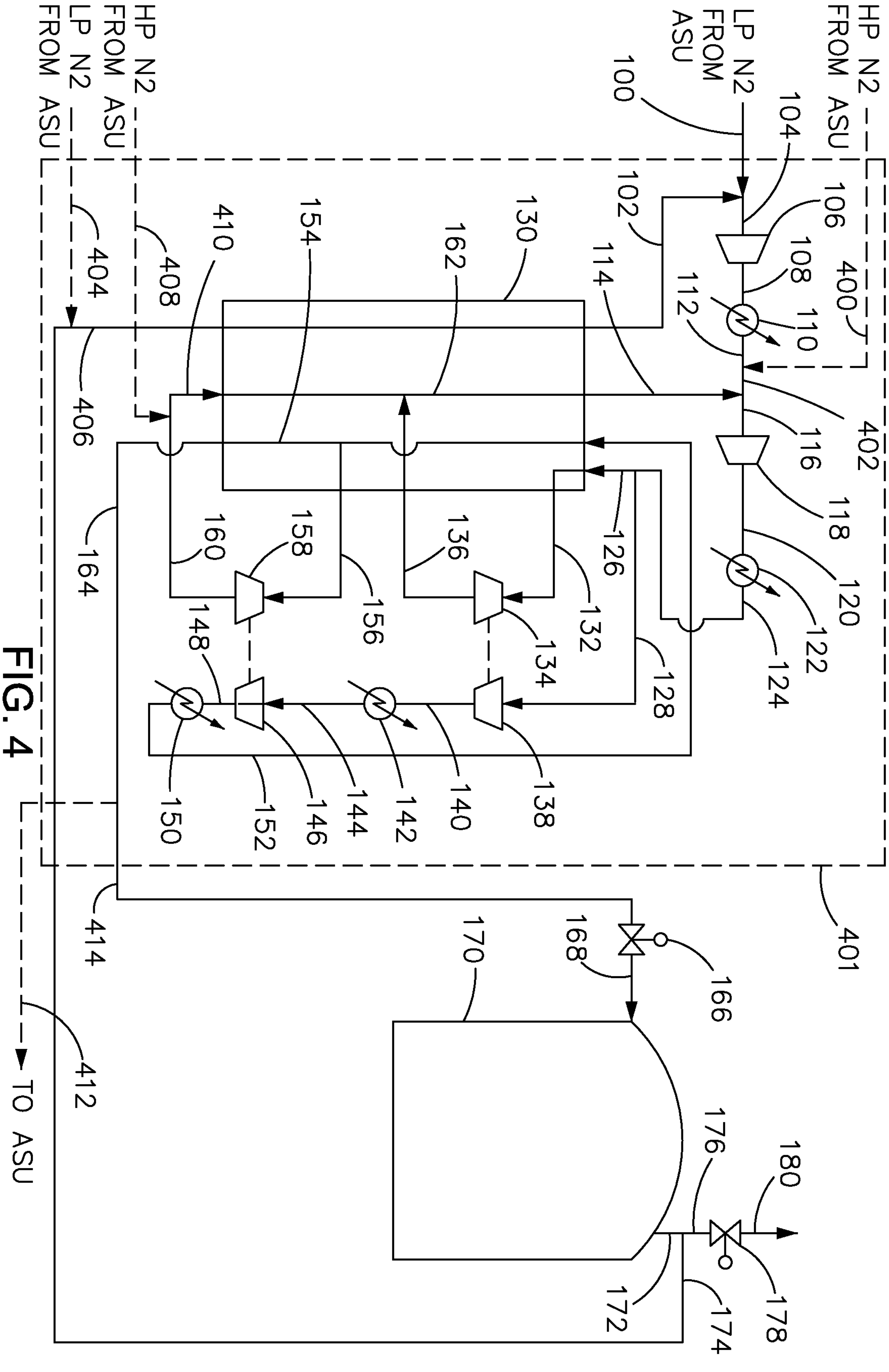
HP N2 FROM ASU
LP N2 FROM ASU
100
104
106
108
110
112
400
402
102
114
116
118
120
122
124
130
162
154
410
126
128
132
134
136
138
140
142
144
146
148
150
152
156
158
160
164
401
404
406
408
412
414
TO ASU
166
168
170
172
174
176
178
180
HP N2 FROM ASU
LP N2 FROM ASU

FIG. 4