# United States Patent

[11] 3,578,073

[72] Inventor Maurice Bosquain, Paris, France
[21] Appl. No. 716,486
[22] Filed Mar. 27, 1968
[45] Patented May 11, 1971
[73] Assignee L'Air Liquide Societe Anonyme Pour L'Etude Et L'Exploitation Des Procedes Georges Claude
[32] Priority Mar. 31, 1967
[33] France
[31] 100919


## [54] HEAT EXCHANGE APPARATUS WITH INTEGRAL FORMATION OF HEAT EXCHANGERS AND SEPARATORS

2 Claims, 7 Drawing Figs.


[52] U.S. Cl. .......... 165/111, 62/9, 62/23, 62/40, 165/145
[51] Int. Cl. .......... F25j 1/00, F25j 5/00, F25j 3/00
[50] Field of Search .......... 62/42, 43, 44; 165/111, 132, 145



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,127,732 | 8/1938 | Heitman | 165/132 |
| 2,508,247 | 5/1950 | Giauque | 165/145 |
| 2,952,985 | 9/1960 | Brandon | 62/42 |
| 3,181,307 | 5/1965 | Kuerston | 62/40 |
| 3,240,023 | 3/1966 | DeLano | 62/23 |
| 3,274,787 | 9/1966 | Grenier | 62/23 |
| 3,364,685 | 1/1968 | Perret | 62/40 |

OTHER REFERENCES

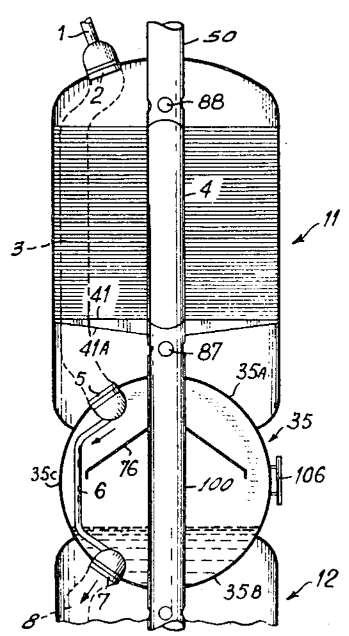
Kleemenko, One Flow Cascade Cycle, Progress in Refrigeration Science and Technology; Pergamon Press 1960 Pages 34— 39



*Primary Examiner*—Wilbur L. Bascomb, Jr.
*Assistant Examiner*—Arthur F. Purcell
*Attorney*—Young and Thompson



**ABSTRACT:** An indirect heat exchange assembly comprises superimposed heat exchangers with nests of tubes and liquid separators disposed between the exchangers. The nests of tubes open onto the walls of the separators, which thus serve the purpose of headers or collectors. Further features are that the separators can have their bases common to those of adjacent exchangers but their lateral walls exposed for easy access; the different exchangers can be disposed in a common shell with the two successive exchangers of which the exchange surfaces are the smallest disposed concentrically inside the shell, these latter two exchangers having coiled tubes with the shell of the smaller of the two exchangers forming the core of the larger coiled nest of tubes.

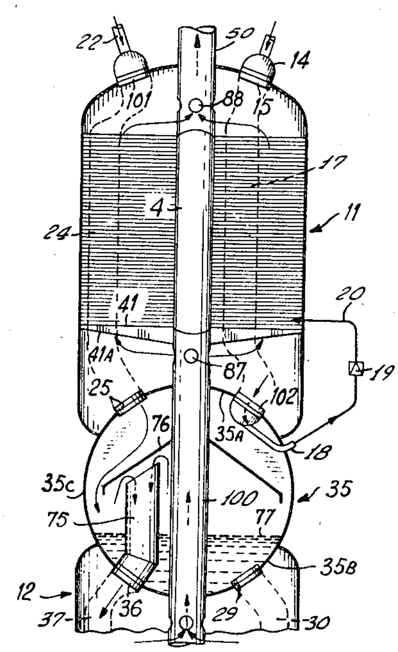
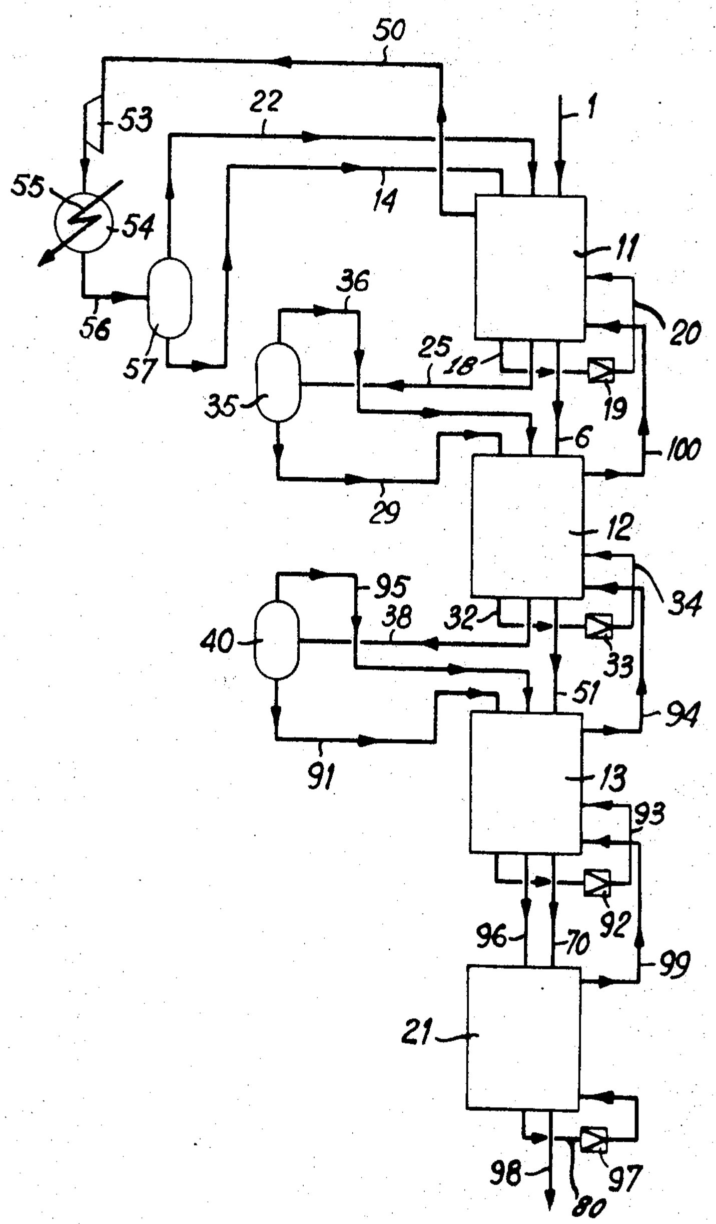
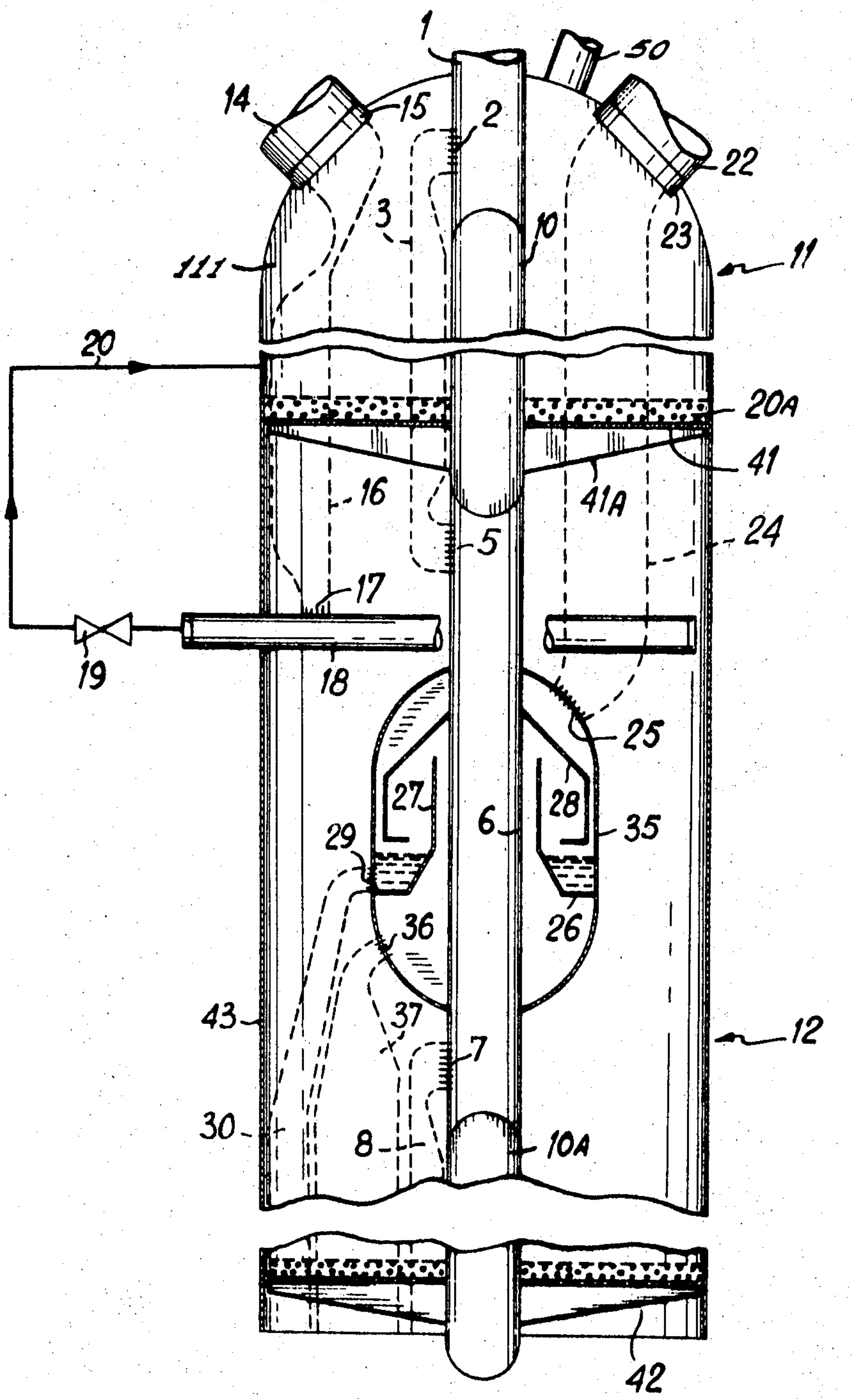


Fig.1




INVENTOR
MAURICE BOSQUAIN
By Young + Thompson
ATTYS.

Fig. 2




INVENTOR

MAURICE BOSQUAIN

By Young + Thompson

ATTYS.

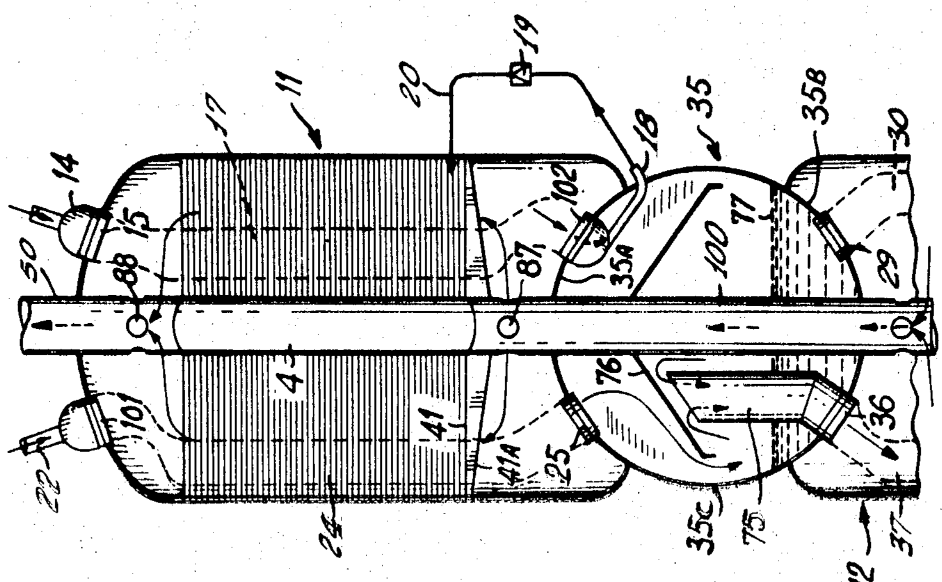



Fig. 3B

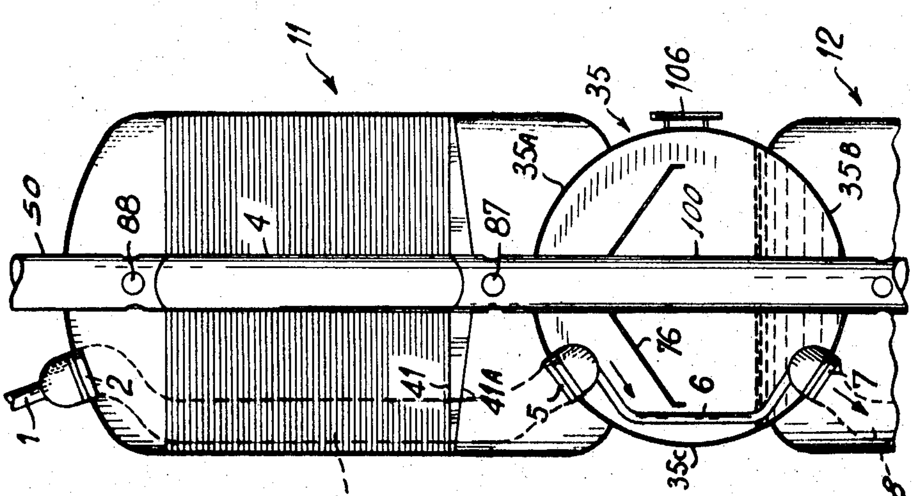



Fig. 3A

INVENTOR

MAURICE BOSQUAIN

By Young + Thompson

ATTYS.

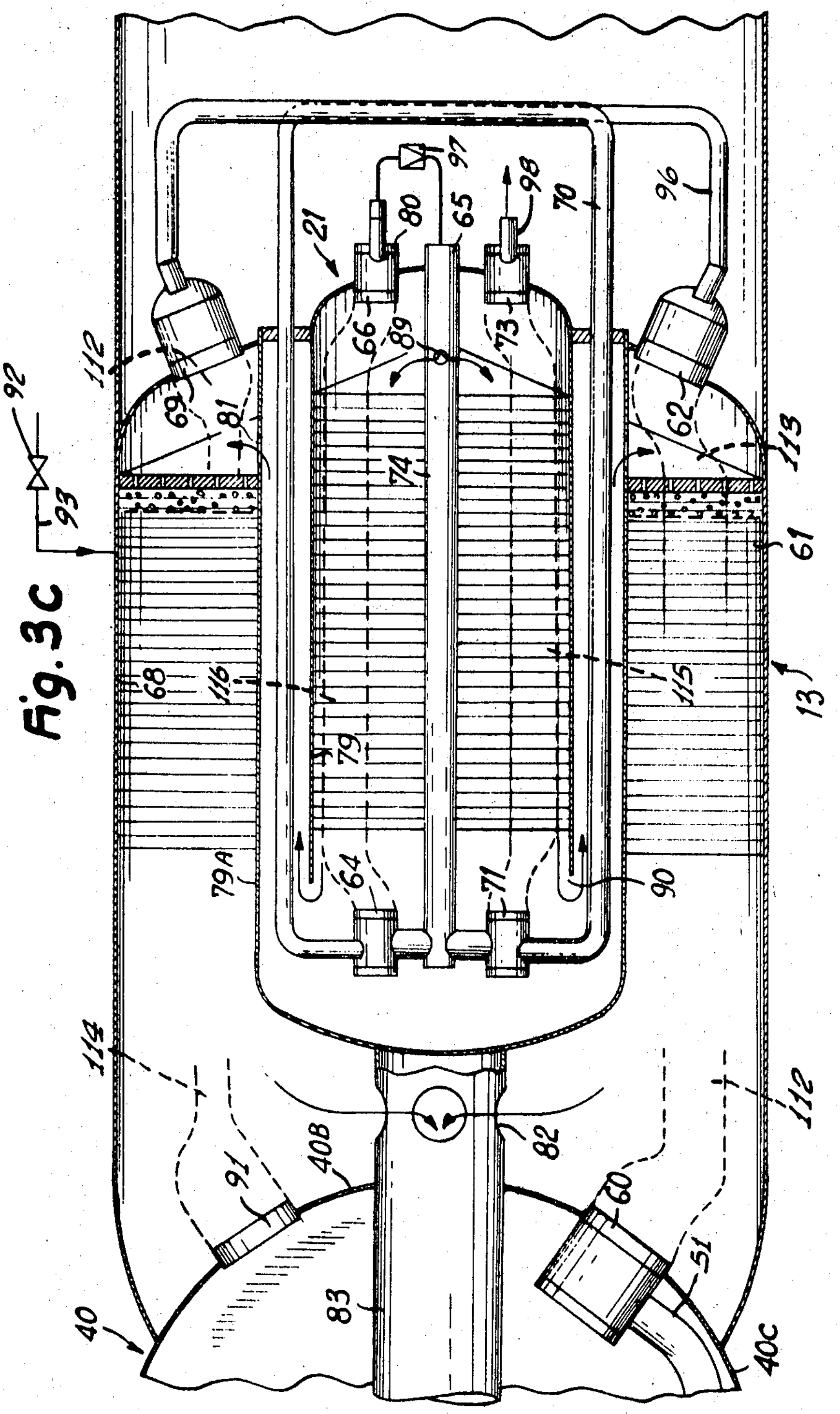



Fig. 3c

INVENTOR

MAURICE BOSQUAIN

BY Young + Thompson

ATTYS.

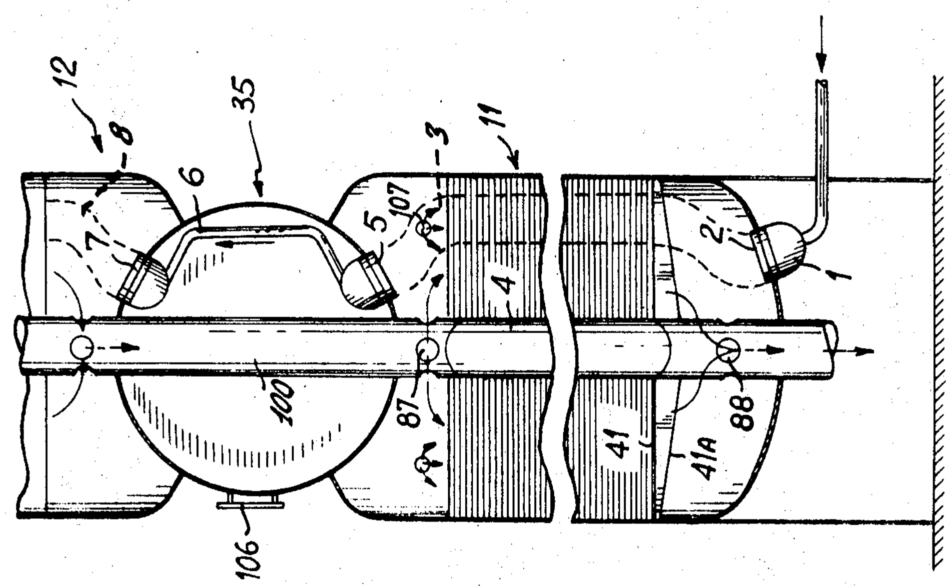



Fig. 4A

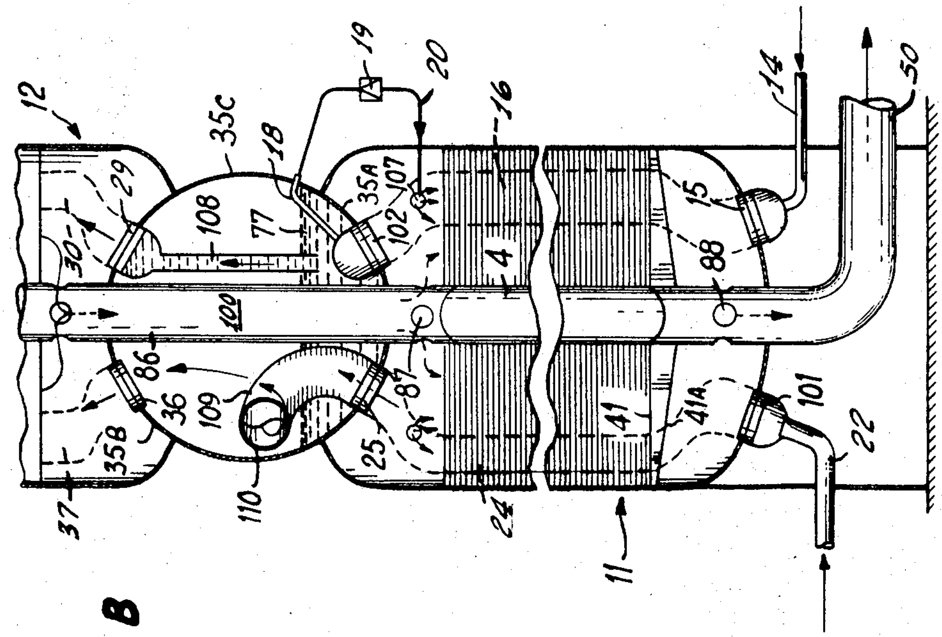



Fig. 4B

INVENTOR

MAURICE BOSQUAIN

By Young + Thompson

ATTYS.

## HEAT EXCHANGE APPARATUS WITH INTEGRAL FORMATION OF HEAT EXCHANGERS AND SEPARATORS

The present invention relates to a countercurrent indirect heat exchange assembly between a gaseous mixture undergoing fractionated condensation and at least partially liquid fractions undergoing vaporization and heating under a lower pressure, comprising superimposed heat exchangers with nests of tubes and liquid separators disposed between these exchangers.

Such heat exchange assemblies are particularly necessary in installations for the liquefaction of relatively complex gaseous mixtures, such as natural gas. These mixtures are generally liquefied by heat exchange with several successive refrigerating fluids, using a process known as the "cascade cycle."

However, it is more advantageous to ensure the refrigeration by means of liquid fractions separated during the fractionated condensation of the gaseous mixture to be liquefied, then expanded at lower pressure, which fractions are recompressed and recombined with the gaseous mixture to be liquefied after the revaporization thereof. It is also possible to effect the refrigeration by means of a complex refrigerating fluid, comprising the same constituents as the gaseous mixture to be liquefied, by cooling this refrigerating fluid concurrently with the gaseous mixture to be liquefied, and in this way assuring its fractionated condensation, and then in revaporizing the liquid fractions as thus formed, each in different temperature zones in heat exchange with the gaseous mixture to be liquefied and the complex refrigerating fluid. These refrigeration cycles are generally called "incorporated cascade cycles." Improvements in these cycles, which make it possible to reduce to a minimum the energy expenditure necessary for assuring the refrigeration and providing a high yield of liquid products, have formed the subject of the French Pat. No. 1,302,989 of the 1st June, **1961**, in the name of the applicants and its two certificates of addition Nos. 80,924 of the 5th Sept. 1961, and 86,485 of the 18th Sept. 1964.

These processes of fractionated condensation by means of "cascade" or "incorporated cascade" cycles are generally employed for the liquefaction of high rates of flow, because the saving in separation energy then justifies the use of a relatively complex installation, comprising exchangers which ensure the condensation of the various fractions, in countercurrent with the liquid fractions undergoing vaporization, separators permitting the condensed fractions to be extracted after each exchanger, and the multiple pipe conduits connecting the various nests of tubes of these exchangers and the separators. The complexity of this installation does however make it cumbersome as regards the floor area occupied, and also relatively costly and of difficult assembly.

The indirect heat exchange assembly according to the invention has for its object to obviate the aforementioned disadvantages and to provide an installation of a particularly compact structure which is easy to insulate against heat leaks and is relatively simple, thereby reducing to a minimum the connecting pipe conduits between its different elements.

This arrangement does in addition make it possible to limit the dimensions of the tubular plates normally disposed at each end of the heat exchangers and also to dispense with the bottoms of these exchangers.

The separators can then be disposed entirely inside the heat exchange system, equipped with a common shell. However, in order to facilitate access, and for the purpose of possible checking or repair operations, it is preferable to arrange the separators in such a way that their bases are common with those of the adjacent exchangers, but that their lateral walls are outside these exchangers; these latter can then be fitted with inspection holes.

When it is desired to cause the gaseous mixture subjected to the fractionated condensation to circulate from top to bottom, and because of the reduction of the specific volume of the gases with the temperature, such an arrangement of the exchangers and separators generally leads to the heat exchange assembly being given a general reversed pyramidal form, formed by several cylinders of decreasing diameters, from the hottest heat exchange zone to the coldest zone.



According to a modification of the invention, the different exchangers are fitted into a common shell of uniform diameter by the two successive exchangers of which the exchange surfaces are the smaller being disposed concentrically inside the said shell.

Heat exchange assemblies of liquefaction installations for natural gas according to the invention are hereinafter described as nonlimiting examples and by reference to the accompanying drawings.

FIG. **1** represents the general circulation diagram of the fluids in the heat exchange assembly.

FIG. **2** represents the heat exchange and fluid-separation assembly corresponding to the heat exchange zones **11** and **12** and the separator **35** of FIG. **1**.

FIGS. **3A**, **3B** and **3C** represent a heat exchange assembly in a natural gas liquefaction installation, in which the separators are accessible from outside and the two heat exchangers with coiled tubes in the coldest zone are concentrically arranged; the circulation of the gases under pressure occurs from top to bottom, and the circulation of the low-pressure recycling gas from bottom to top. FIGS. **3A** and **3B** are sections through different axial planes, one showing the natural gas circulation and the other the circulations of the cycle gas under pressure and of the condensed liquid to be subcooled.

FIGS. **4A** and **4B** represent the least cold elements of the heat exchange assembly in a manner similar to FIGS. **3A** and **3B**, but the circulation of the gases is under pressure takes place here from bottom to top, and that of the low-pressure cycling gas from top to bottom.

Referring to FIG. **1**, the natural gas to be liquefied arrives by way of the pipe **1** under a pressure of about 40 bars in the heat exchange element **11**, in which it is cooled in countercurrent with the low-pressure refrigerating gaseous mixture entering via the pipe **100**, which will hereinafter be called for greater simplicity the "cycling gas." The natural gas then passes successively through the pipes **6**, **51** and **70** into the exchange elements **12**, **13** and **21**; it is evacuated in liquefied form through the conduit **98** towards a storage vessel.

The reheated cycling gas leaving the heat exchange element **11** through the pipe **50** under the absolute pressure of about 3 bars is brought by the compressor **53** to an absolute pressure of 30 bars and directed into a water condenser **54** (the circulation of water is represented diagrammatically at **55**). A first liquid fraction is condensed. The cycling gas passes through the pipe **56** into the separator **57**. The liquid fraction is evacuated therefrom through the pipe **14**, is subcooled in the heat exchange element **11** in countercurrent with the low-pressure cycling gas, is then expanded in the valve **19** and reunited inside of the exchange element **11** with the low-pressure cycling gas entering via the pipe **100** the cold end of the element **11**.

The uncondensed cycling gas under high pressure passes through the pipe **22** into the element **11**, where it is once again cooled and undergoes a partial condensation. It is sent through the pipe **25** to the separator **35**. The condensed fraction is introduced through the pipe **29** into the second heat exchange element **12**, in which it is subcooled. It is reunited inside of the exchange element **12** through the pipe **32** and the expansion valve **33** with the low-pressure cycling gas arriving by way of the pipe **94** at the cold end of the heat exchange zone **12**.

The uncondensed cycling gas under high pressure passes from the separator **35** via the pipe **36** into the element **12**, where it is once again cooled and undergoes a new partial condensation, before being introduced through the pipe **38** into the separator **40**. As before, the separated liquid fraction passes through the pipe **91** into the third heat exchange element **13**, is subcooled therein, and is then reunited inside of the exchange element **13** via the expansion valve **92** with the low-pressure cycling gas arriving by way of the pipe **99** at the cold end of the element **13**. The residual gas of the separator

40 passes through the pipe 95 into the element 13, is partially condensed therein, and then goes on via the pipe 96 to the fourth heat exchange element 21, to be condensed and subcooled therein, and then it is expanded in the valve 97 and returns to be vaporized in countercurrent with gases under higher pressure in the same exchange element. The low-pressure cycling gas is discharged through the pipe 99, then passes successively through the pipes 94 and, 100 into the elements 13, 12 and 11.

Referring now to FIG. 2, it is appropriate to note firstly that the fluids under high pressure (natural gas, cycling gas under high pressure and liquid fractions to be subcooled) circulate in nests of tubes coiled around mandrels 10, 10A, while the cycling gas under low pressure circulates inside the external shell 111, between the tubes.

The heat exchange element 11, disposed in the least cold zone of the heat exchange assembly and in the top part of the latter, comprises at its hot end an axial admission pipe 1 for the natural gas to be liquefied and a collector 2 for the admission thereof into the nest of tubes 3, coiled around the core 10 inside the shell 111. In addition, it comprises at this same end admission tubes 22 and corresponding tubular plates 23 for the cycling gas under high pressure. Connected to these tubular plates are coiled nests of tubes 24. Finally, an admission pipe 14 and a corresponding tubular plate 15 for the liquid fraction originating from the separator 57 of FIG. 1 are connected to a third nest of tubes 16, and the perforated plate 41 ensuring the distribution of the low-pressure gas in the liquid bath 20A and its three nests of tubes are supported by brackets, such as 41A.

AT the cold end of the element 11, the nest of tubes 3 for the natural gas opens via a collector or header 5 into the axial conduit 6, the nests of tubes 24 for the cycling gas open in 25 onto the upper wall of the separator 35 and the nest of tubes 16 via a header 17 into a radial conduit 18, connected to an expansion valve 19 and an inlet pipe 20 to the interior of the shell 111, around nests of tubes and above the liquid bath 20A. As a result, the natural gas circulates axially through the separator 35, the partially liquefied cycling gas penetrates into this latter, and the subcooled liquid fraction returns into the exchange element 11 in countercurrent with the gases to be cooled and liquefied; there is formed a homogeneous mixture of liquid and vapor with the low-pressure cycling gas reaching the cold end of the element 11 through openings in the perforated plate 41 between its shell and its nests of tubes, and it is progressively vaporized in heat exchange with the hotter fluids circulating in these latter, and is discharged through conduit 50.

The separator 35 comprises an annular channel or gutter 26 adapted to receive the liquefied fraction, an annular conduit 27 for the discharge of the residual gas around the pipe 6 and the deflecting plate 28 designed to avoid any entrainment of liquid towards the discharge conduit for the vapors. The gutter 26 is provided with headers 29 for the discharge of the separated liquid fraction into the subcooling nest of tubes of of the element 12 and the bottom of the separator is provided with headers 36 for the discharge of the residual gas towards the element 12. On the other hand, the axial conduit 6 is provided below the separator 35 and before the exchange element 12 with an inlet header 7 for natural gas into this element.

The heat exchange element 12 is of structure similar to that of the element 11. It comprises the external shell 43 and the center core 10A, around which are coiled the nests of tubes 8 for the natural gas, nests of tubes 37 of the high-pressure cycling gas and nests of tubes 30 for that liquid fraction of the cycling gas which is to be subcooled, these nests being supported by brackets 42.

The structure shown in FIG. 2 normally leads to the use of heat exchange elements of smaller surfaces in the coldest zones, because of the decrease in the gas volumes, and consequently the use of shells of smaller diameter in these zones. In the case where the circulation of the gases under high pressure takes place from top to bottom, the heat exchange assembly then has the general form of an inverted cone, this necessitating certain precautionary measures to ensure its mechanical resistance. On the other hand, the liquid separators are only accessible after dismantling the shell of the exchange elements.

These disadvantages are avoided by the arrangement of the heat exchange elements and separators as shown in FIGS. 3A, 3B and 3C. FIGS. 3A and 3B represent axial sections of the element 11 and of the separator 35, respectively passing through the axes of the inlet pipes for the natural gas, on the one hand, and of the cycling gas under high pressure and the condensed liquid to be subcooled, on the other hand, while FIG. 3C is an axial section of the elements 13 and 21. The heat exchange assembly comprises the elements 11, 12, 13 and 21 and the separators 35 and 40. The separators 35 and 40 are of a general spherical form and directly accessible from outside. The elements 13 and 21 are coaxial, the element 21 being disposed inside the element 13, of which the external shell can for this reason have the same diameter as that of the shells of the elements 11 and 12, although its heat exchange surface is smaller. The inner casing 79A serves as core for the coiled nests of tubes of the element 13.

The heat exchange element 11 in the least cold zone comprises an inlet tube 1 for the natural gas to be liquefied and a tube plate 2 for admitting this gas into a nest of tubes 3 coiled around the core 4. The nest of tubes 3 is connected at its cold end to a header 5 disposed in the wall 35A common to the element 11 and to the separator 35. Pipes 22 and tube plates 101 ensure the admission of the high-pressure cycling gas at the hot end of the element 11 into a coiled nest of tubes 24 which is connected at its cold end to tube plates, such as 25, for admission into the separator 35, while the pipes and tube plates such as 14 and 15 ensure at this point the admission of a liquid fraction to be subcooled into a third nest of tubes 17, connected at the cold end to a header 102 ensuring its discharge towards an expansion valve 19 and a recycling pipeline 20 in the exchange element 11 between its shell and its nests of tubes 3, 17, 24. Finally, the openings such as 87 at the cold end and openings 88 at the hot end of the core 4 ensure the arrival of the low-pressure cycling gas around the nests of tubes and its discharge through the end 50 of the core after heating.

The separator 35 is of generally spherical form and has plates 35A and 35B which are respectively common with the elements 11 and 12, and a lateral zone 35C externally of the elements 11 and 12. The said lateral zone can be formed with an inspection hole 106.

A pipeline 6, provided to ensure the circulation of the natural gas through the separator, connects the tube plate 5, disposed on the part 35A of the element 11 to the tube plate 7 arranged on the part 35B of the element 12. This latter pipe has been shown inside the separator 35, but the tube plates 5 and 7 can also be placed on the external shells of the elements 11 and 12 and the pipeline 6 can be positioned outside the separator. The axial conduit 100 ensures the circulation from the element 12 towards the element 11 of the low-pressure cycling gas undergoing heating. The separator comprises a pipe 75 for the discharge of the residual gas, a deflecting plate 76 preventing the liquid fraction of the partially liquefied mixture reaching the element 11 through the tube plates such as 25 from penetrating into the pipe 75. The liquid fraction is collected at the bottom of the separator in a bath 77. It is discharged through the tube plates 105 towards a nest of tubes 30 of the element 12. The residual gas on its part penetrates through the tube plates such as 36 into the element 12.

The element 12 is of a structure similar to that of the element 11, and will not be described in greater detail. It also comprises three nests of tubes 8, 30, 37 coiled around a core.

The separator 40 is of a structure similar to that of the separator 35, and its parts for the separation between liquid and residual gas have not been shown. It also comprises plates such as 40B common with the element 13 and a lateral zone 40C, which can have an inspection hole, not shown. A pipeline 51 connects the tube plates for the outlet of the natural gas from the element 11 to the tube plates 60 for the admission of this gas into the element 13. Tube plates such as 91 ensure the admission of the liquid fraction to be subcooled into the element 13 and tube plates (not shown) the admission of the cycling gas under pressure into this same element. The low-pressure cycling gas circulates in the axial conduit 83.

The element 13 comprises an external sleeve 68 of the same diameter as that of the elements 11 and 12. Its core is formed by a jacket 79A which surrounds the connecting pipes with the element 21, disposed coaxially and internally. The nest of tubes 112 for the natural gas is connected to the tube plates such as 69 at the cold end of the element, whence a pipeline 70 passing between the jacket 79A and the shell 79 of the element 21 conducts the natural gas to a tube plate 71 at the hot end of the exchanger 21. The nest of tubes 113 is connected in its top end to an admission tube plate not shown of the cycling gas under pressure is in its turn connected to tube plates such as 62, whence a pipeline 96 conducts the cycling gas under pressure to tube plates 64 at the hot end of the element 21. Finally, tube plates (not shown) ensure the discharge of the subcooled liquid fraction passing through the nest of tubes 114 and coming from tube plate 91 which, after expansion, is reintroduced at the cold end of the element 13 through valve 92 and conduit 93, around the coiled nests of tubes. The admission of the low-pressure cycling gas into this element is assured by openings such as 81, opening on to the annular space between the jacket 79 and the external shell 79A while openings 82 ensure the discharge of this gas at the hot end of the element 13.

The heat exchange element 21 comprises nests of tubes 115,116 coiled around the core 74. The nest of tubes 115 for the natural gas is connected at its cold end to tube plates 73 and then to a pipeline 98 leading to a storage reservoir. The nest of tubes 116 of the cycling gas is connected at its cold end to a tube plate 66 and to a pipe 80 for discharging this gas in the subcooled liquid state. After expansion in a valve 97, the cycling gas returns via the pipe 65 and the openings 89 into the element 21, around its nests of tubes. The free annular zone 90 at the upper part of the element 21 permits the passage of the cycling fluid at low pressure into the annular space between the shell 79 and the jacket 79A, towards the inlet openings 81 in the element 13.

FIGS. 4A and 4B show the least cold heat exchange elements 11 and 12, in which the circulation of the gases under pressure is on the contrary from bottom to top, and that of the low-pressure cycling gas is from top to bottom.

The circulation of the natural gas is similar to that shown in FIGS. 3A and 3B.

The heat exchange element 11 comprises an inlet pipe 1 for the natural gas and an inlet tube plate 2 for this gas into a nest of tubes 3 coiled around the core 4. The nest of tubes 3 is connected at its cold end to a header 5 disposed in the wall 35A which is common with the element 11 and the separator 35. A conduit 6 connects the header 5 to an inlet tube plate 7 in a nest of tubes 8 of the following element 12.

Pipes 22 and tube plates 101 ensure the admission of the cycling gas into another nest of tubes 24 coiled around the core 4. A header 25 ensures the introduction of the partially liquefied cycling gas into the separator 35.

Finally, pipes 14 and tube plates 15 permit the introduction of the liquid condensed in the water cooler into a nest of tubes 16 coiled around the core 4. A header 102 ensures the outlet from the element 11 of the subcooled liquid, which is expanded in the lower-pressure valve 19 and returns into the element 11 via the pipe 20 and sprinkling devices shown diagrammatically at 107. These latter ensure the distribution of the subcooled liquid in the low-pressure cycling gas circulating around the nests of tubes of the element 11, for the purpose of its progressive vaporization within this gas.

The structure of the separator 35 is slightly different from that of FIGS. 3A and 3B. The introduction of the cycling gas thereinto is in fact ensured by a header 25, connected to a pipe 109 provided at its end with a tangential distribution device 110, permitting the separation of the liquid and gaseous fractions. Tube plates 36 ensure the introduction of the cycling gas into the following element 12, while the liquid collected in a bath 77 is in its turn introduced into the element 12 through the conduits 108 and tube plates 105.

It will be understood that various modifications can be incorporated into the heat exchange assembly which has just been described, without departing from the scope of the invention. The number of heat exchange elements and separators for the liquid fraction, and also the number of gas circuits, depend on the composition of the gas to be treated and the range of temperatures between which the heat exchange is effected. Furthermore, the liquid separators can be of different structure. Certain nests of tubes at least can be straight tubes, and it is possible to arrange, between the nest of tubes, auxiliary devices or fittings which ensure a better heat transmission between the gases inside the nests of tubes and the gas externally of the latter.

I claim:

1. A vertical heat exchange assembly operating in countercurrent comprising a warm exchanger (11,12), a cold exchanger (13,21);

a. said warm exchanger comprising superimposed warm end (11) and cold end (12) exchangers, a first separator (35) therebetween, a second separator (40) between said cold end exchanger and said cold exchanger, a core (4) along which said exchangers are spaced;

b. each of said first and second separators having a lateral wall (35C,40C), a cold closure wall (35B,40B), a warm closure wall (35A,40A), said core passing through warm and cold closure walls and being connected thereto;

c. said warm end exchanger (11) comprising a substantially cylindrical shell which is coaxial with said core and which has a warm closure wall traversed by said core and having three tube plates (2, 101, 15), said shell having a cold closure wall formed by at least a part of said warm closure wall (35A) of said first separator, a horizontal plate (41) positioned inside of said shell, said plate having a plurality of openings therethrough and being connected to said shell and said core which passes therethrough, one of said shell and said cold closure wall having a first header (5) and a liquid header (102) in fluid communication through an expansion valve (19) with a discharge point located above said plate (41), a first nest of tubes (3) helically coiled around said core and connected at one end with a first tube plate (2) of said warm closure wall of said warm end exchanger and at the other end with said first header (5), a second nest of tubes (24) helically coiled around said core and connected at one end with a second tube plate (101) of said warm closure wall of said warm end exchanger and opening at the other end through a part (25) of a wall of said first separator in contact with the gaseous phase contained by said first separator, a third nest of tubes (17) helically coiled around said core and connected at one end with a third tube plate (15) of said warm closure wall of said warm end exchanger and at the other end with said liquid header, all said tubes passing through said plate (41);

d. the components of said cold end exchanger (12) being substantially identical to those of said warm end exchanger, said cold end exchanger comprising a shell, a warm closure wall being formed by at least a part of said cold closure wall (35B) of said first separator (35), a cold closure wall being formed by at least a part of said warm closure wall (40B) of said second separator, one of said shell and said warm closure wall comprising a second header in fluid communication with said first header (5) of said warm end exchanger, one of said shell and said cold closure wall comprising a third header, a first nest of tubes (8) connected at one end to said second header and at the other end to said third header, a second nest of tubes (37) opening at one end onto a part (36) of a wall of said first separator in contact with the gaseous phase contained by said first separator and opening at the other end onto a part of a wall of said second separator in contact with the gaseous phase contained by said second separator, a third nest of tubes (29) opening in the end opposite to a liquid header, onto a part of a wall of said first separator in contact with the liquid phase contained by said first separator;

e. said core being gastight in its parts where the three nests of tubes are coiled around and hollow in the remaining parts, said core having openings in its hollow parts inside of said warm end and cold end exchangers;

f. said cold exchanger comprising at least an inner exchanger (21) and an outer exchanger (13);

g. said outer exchanger comprising a substantially annular housing comprising an outer casing (61), an inner casing (79A), both substantially cylindrical, a cold closure wall connecting the cold ends of said inner and outer casings, said cold closure wall comprising two tube plates (62,69), said outer casing being connected along its warm end to the cold closure wall (40B) of said second separator, a warm closure wall closing said inner casing, said core of said warm exchanger extending outside of said second separator between the cold closure wall of said first separator and the warm closure wall of said housing; a horizontal plate having openings therethrough and disposed inside of said housing and being connected to said outer and inner casings; three nests of tubes helically coiled around said inner casing, inside of said housing, one of said outer casing and said cold closure wall of said second separator comprising a fourth header (60) in fluid communication with said third header, one of said outer casing and said cold closure wall of said housing comprising a liquid header in fluid communication, through an expansive valve (92), with a discharge point located above said plate, tubes of a first nest (112) being connected at one end to said fourth header and at the other end with first tube plate (69) of said cold closure wall of said housing, tubes of a second nest (113) opening at one end onto a part of a wall of said second separator in contact with the gaseous phase contained by said second separator and being connected at the other end with said second tube plate (62) of said cold closure wall of said housing; tubes of a third nest (114) opening at one end onto a part (91) of a wall of said second separator in contact with the liquid phase contained by said second separator and being connected at the other end with said liquid header, all said tubes passing through said plate; said core of the warm exchanger being hollow and having openings (82) in its part extending outside of said second separator;

h. said inner exchanger comprising a shell (79) positioned inside of said inner casing of said outer exchanger and spaced therefrom to form an annular passageway therebetween, said shell having a substantially cylindrical casing (79) coaxial with said inner casing, a cold closure wall, said casing being open in its warm end and said cold closure wall comprising two tube plates (73,66); another core (74) coaxial with said inner casing, passing at one end through said cold closure wall, a fifth header in fluid communication with said first tube plate of said cold closure wall of said outer exchanger, a gaseous header in fluid communication with said second tube plate of said cold closure wall of said outer exchanger, both headers being disposed at the warm end of said inner exchanger; first and second nests of tubes (115, 116) helically coiled around said another core inside of said shell, tubes of said first nest (115) being connected at one end with said fourth header and at the other end with the first tube plate of said cold closure wall of said shell of said inner exchanger, tubes of said second nest (116) being connected at one end to said gaseous header in the other end with the second tube plate of the cold closure wall of said inner inner exchanger; said another core being gastight where tubes are coiled around and hollow in the remaining part and having openings (89) in its cold hollow part; the cold end of said another core being in fluid communication with said second tube plate (66) of said cold closure wall through an expansive valve; said inner casing of said outer exchanger having openings (81) at a level located between said plate and said cold closure wall of said outer exchanger; and an annular plate closing said passageway (90) at the end opposite to said warm closure wall of said outer exchanger.

2. A vertical heat exchange assembly operating in countercurrent comprising warm exchanger means (11,12), cold exchanger means (13,21), a substantially cylindrical shell (43) inside of which said cold and warm exchangers are positioned:

a. said warm exchanger comprising a substantially hollow core (1) coaxial with said shell; from warm end to cold end, a warm end exchanger (11), a first separator (35), a cold end exchanger (12), a second separator (40) spaced along said core, a casing (111) inside of which are disposed said separators and exchangers, said casing including the warmer part of said shell and a warm closure wall having two tube plates (14, 22) and a discharge conduit (50), said warm closure wall being traversed by said core and connected thereto;

b. each of said first and second separators having a lateral wall, a cold closure wall, a warm closure wall, said core passing through said warm and cold closure walls and being connected thereto;

c. said warm end exchanger (11) comprising a horizontal plate (41) disposed inside of said casing, said plate having a plurality of openings therethrough and being connected to said casing and said core which passes therethrough, a liquid header (17) positioned in the warm end of said warm end exchanger, in fluid communication through an expansion valve (19) with a discharge point located above said plate, three nests (5, 24, 16) of tubes helically coiled around said core, all said tubes passing through said plate, said core being gastight where tubes are coiled around to form inside of said warm end exchanger a warm header (2) and a cold header (5), said tubes of a first said nest (3) opening at one end onto the walls of said warm header and at the other end onto the walls of said cold header, said tubes of a second said nest (24) being connected at one end to the first tube plate (23) in said warm closure wall of said casing and opening at the other end onto a part (25) of a wall of said first separator in contact with the gaseous phase contained by said first separator, said tubes of a third said nest (16) being connected at one end to the second tube plate (15) in said warm closure wall of said casing and at the other end with said liquid header;

d. said cold end exchanger (12) being substantially identical to said warm end exchanger, said cold end exchanger comprising three nests of tubes (8, 37, 30), said tubes of a second said next (37) opening at one end onto a part (36) of a wall of said first separator in contact with the gaseous phase contained in said first separator and at the other end with a part of a wall of said second separator in contact with the gaseous phase contained by said second separator, said tubes of a third said nest (30) opening in the end opposite to a liquid header onto a part (29) of a wall of said first separator in contact with the liquid phase contained by said first separator;

e. said cold exchanger comprising an inner exchanger (21) and an outer exchanger (13);

f. said outer exchanger (13) comprising a substantially annular housing comprising an outer casing (61) formed by the cold part of said shell of said heat exchange assembly, an inner casing (79A) substantially cylindrical and coaxial with said shell, a cold closure wall connecting the cold ends of said inner and outer casing, said cold closure wall comprising two tube plates (**62,69**), a warm closure wall closing said inner casing, said core of said warm exchanger extending outside of said second separator between said cold closure wall of said second separator and said warm closure wall of said housing; a horizontal plate having openings therethrough, positioned inside of said housing and being connected to said inner and outer casings; one of said outer casing and said cold closure wall of said annular housing having a liquid header in fluid communication through an expansion valve (**92**) with a discharge point located above said plate of said outer exchanger; three nests of tubes (**112, 113, 114**) helically coiled around said inner casing, inside of said housing, said tubes of a first said nest being in fluid communication at one end (**60**) with said cold header of said cold end exchanger and being connected at the other end with the first tube plate (**69**) of said cold closure wall of said outer exchanger housing, said tubes of a second said nest (**113**) opening at one end onto a part of a wall of said second separator in contact with the gaseous phase contained by said second separator and being connected at the other end with said second tube plate (**62**) of said cold closure wall of said outer exchanger housing; said tubes of a third said nest (**114**) opening at one end onto a part (**114**) of a wall of said second separator in contact with the liquid phase contained by said second separator and being connected at the other end with said liquid header of said annular housing, all said tubes of the three said nests passing through said plate;

g. said inner exchanger (**21**) comprising a shell (**79**) disposed inside of said inner casing (**79A**) of said outer exchanger and spaced therefrom to form an annular passageway therebetween, said shell comprising a substantially cylindrical casing coaxial with said outer casing of said outer exchanger, a cold closure wall, said casing being open at its warm end and said cold closure wall comprising two tube plates (**73, 66**), another hollow core (**65**) coaxial with said inner exchanger shell and passing at one end through said cold closure wall and connected thereto and limited at the other end by said warm closure wall of said outer exchanger; a header (**71**) and a gaseous header (**64**) respectively in fluid communication with said first tube plate (**69**) and said second tube plate (**62**) of said cold closure wall of said outer exchanger (**13**), both said header and said gaseous header being disposed at the warm end of said inner exchanger; two nests of tubes (**115, 116**) helically coiled around said another core inside of said shell, said tubes of a first said nest (**115**) being connected at one end to said header (**71**) and at the other end with the first tube plate (**73**) of said cold closure wall of said shell of said inner exchanger, said tubes of a second said nest (**116**) being connected at one end to said gaseous header and at the other end with the second tube plate (**66**) of the cold closure wall of said inner exchanger shell; said another core being gastight where tubes are coiled around, hollow in the the remaining part, and having openings in its part extending from said cold closure wall of said inner exchanger to said nests of tubes; the cold end of said another core being in fluid communication through an expansion valve (**97**) with said second tube plate (**66**) of said cold closure wall of said inner exchanger; said inner casing (**79A**) of said outer exchanger having openings at a level located between said plate of said outer exchanger and said cold closure wall of said outer exchanger; and an annular plate closing said passageway at the end opposite to said warm closure wall of said outer exchanger.