Total installed refrigerant capacity shall thus not be less than 427kW plus sufficient redundancy to meet the requirements set forth by international classification societies and the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, the IGC Code. Based on operational issues the ship owners have typically additional requirements for further increased refrigerant capacity.

As a consequence a VLGC is typically equipped with four reliquefaction units, each unit normally with a reliquefaction capacity above 220 kW. Typically, each unit is capable of handling 2230 kg propane vapour per hour. Total evaporation from a VLGC carrying only propane typically amount to 3890 kg/hr. Capacities are naturally a function of ambient temperatures and type of cargo and change accordingly.

For the same VLGC carrying iso-butane the total heat leakage is 240 kW and each reliquefaction unit has a reliquefaction capacity of typically 340 kW. Total evaporation from a VLGC carrying only iso-butane typically amount to 1350 kg/hr.

When the VLGC carries both of the above cargoes a segregated operation applies. Assuming iso-butane loaded in liquid tight container A & B and propane loaded in liquid tight container C & D, the vapour flow of propane and iso-butane is approximately 1895 kg/hr and 690 kg/hr, respectively. For such a scenario, two reliquefaction units are in operation, one for propane and one for iso-butane. If the LPG carrier has propane in three cargo tanks, three reliquefaction units are in operation, two for propane and one for iso-butane.

Due to excessive capacity for each of the reliquefaction units in operation, operation of these units are normally intermittent, e.g. 12 hours operation 12 hours standby.

Thus, the main object of the present invention is to propose a simplified solution minimizing the number of reliquefaction units needed to take properly care of all vapours of the different cargo types.

This is according to one aspect the invention achieved by a method for storage and transport of LPG on LPG carriers, in particular two cargoes of different LPG types on same shipment, having reliquefaction units in which vaporized gases are condensed and then returned into at least one cargo tank for the respective LPG cargo type, comprising:

using the reliquefaction units, at a minimum one running, so as to condense vapour from the first cargo type;

passing the condensed vapour through a heat exchanger;

simultaneously flowing vapour from the second cargo type through the heat exchanger so as to condense the vapour by means of heat exchanging with the condensed vapour; and

returning the condensed vapours leaving the heat exchanger back into the respective cargo types.

Moreover, the invention relates to a system for storage and transport of LPG on LPG carriers, in particular two cargoes of different LPG types on same shipment, having reliquefaction units in which vaporized gases are condensed and then returned into at least one cargo tank for the respective LPG cargo type, wherein:

the reliquefaction units, at a minimum one running, is used to condense vapour from the first cargo type;

the condensed vapour is passed through a heat exchanger;

vapour from the second cargo type is simultaneously flowed through the heat exchanger to condense the vapour by means of heat exchanging with the condensed vapour; and

the condensed vapours leaving the heat exchanger is returned back into the respective cargo types.

Some of the benefits by the proposed method and system are that the number of running reliquefaction is reduced to a minimum of one unit and that condensed vapour leaving the running reliquefaction unit can be used as a refrigerant in the heat exchanger.

To meet the pressure in the respective cargo tank for the first cargo type, the condensed vapour from the reliquefaction unit can be throttled upstream or downstream of the heat exchanger. The throttling can alternatively be performed in two stages.

The heat exchanger can be installed on a high point location on the LPG carrier so as to allow the condensed vapours to freely flow back into the cargo tanks. However, if free flow back to a respective cargo tank for the second cargo type is impeded, the condensed vapour to be returned into the second cargo type could be pumped.

To provide an elevated condensation pressure and, thus, allow for a more flexible location of the heat exchanger, vapour of the second cargo type can be compressed upstream of the heat exchanger.

Patent claims

1.

A method for storage and transport of LPG on LPG carriers, in particular two cargoes of different LPG types on same shipment, having reliquefaction units (300, 400) in which vaporized gases are condensed and then returned into at least one cargo tank (100) for the respective LPG cargo type, characterized in that the method is comprising:

using the reliquefaction units (300, 400), at a minimum one running, so as to condense vapour from the first cargo type;

passing the condensed vapour through a heat exchanger (500);

simultaneously flowing vapour from the second cargo type through the heat exchanger (500) so as to condense the vapour by means of heat exchanging with the condensed vapour; and

returning the condensed vapours leaving the heat exchanger back into the respective cargo types.

2.

A method according to claim 1, characterized in that the method is further comprising:

throttling the condensed vapour from the reliquefaction units (300, 400) upstream or downstream of the heat exchanger (500) as to meet the pressure requirements.

3.

A method according to claim 1, characterized in that the method is further comprising:

throttling the condensed vapour in two stages as to meet the pressure requirements.

4.

A method according to any of the preceding claims, characterized in that the method is further comprising:

installing the heat exchanger (500) on a high point location on the LPG carrier so as to allow the condensed vapours to freely flow back into the cargo tanks (100, 200).

5.
A method according to any of the preceding claims 1 to 3, c h a r a c t e r i z e d i n that the method is further comprising:
if free flow back to at least one cargo tank (200) for the second cargo type is impeded, pumping the condensed vapour to be returned into the second cargo type.

6.
A method according to any of the preceding claims, c h a r a c t e r i z e d i n that the method is further comprising:
compressing vapour of the second cargo type upstream of the heat exchanger (500) so as to provide an elevated condensation pressure and, thus, allow for a more flexible location of the heat exchanger (500).

7.
A method according to any of the preceding claims, c h a r a c t e r i z e d i n that the method is further comprising:
passing the condensed vapour of the first cargo type returned from the heat exchanger (500) through a separator as to separate vapour and liquid phase; and
returning liquid back into the first cargo type.

8.
A method according to any of the preceding claims, c h a r a c t e r i z e d i n that the method is further comprising:
operating a reciprocating compressor (2.000) in the reliquefaction units (300, 400) by means of an electric motor (1.900) and, when allowable, speeding up the motor above normal so as to use the power potensial thereof.

9.
A system for storage and transport of LPG on LPG carriers, in particular two cargoes of different LPG types on same shipment, having reliquefaction units (300, 400) in which vaporized gases are condensed and then returned into at least one cargo tank (100) for the respective LPG cargo type, c h a r a c t e r i z e d i n that:
the reliquefaction units (300, 400), at a minimum one running, is used to condense vapour from the first cargo type;
the condensed vapour is passed through a heat exchanger (500);

vapour from the second cargo type is simultaneously flowed through the heat exchanger (500) to condense vapour by means of heat exchanging with the condensed vapour; and

the condensed vapours leaving the heat exchanger is returned back into the respective cargo types.

10.
A system according to claim 9, c h a r a c t e r i z e d i n that one of the reliquefaction units (400) is arranged in stand by operation.

11.
A system according to claim 9, c h a r a c t e r i z e d i n that the heat exchanger is a free flow condenser (500).

12.
A system according to any of the preceding claims 9 to 11, c h a r a c t e r i z e d i n that the cargo types are held in cargo tanks, at least one separate tank (100, 200) for the respective cargo type.

13.
A system according to any of the preceding claims 9 to 12, c h a r a c t e r i z e d i n that the condensed vapour from the reliquefaction units (300, 400) is throttled using a throttle valve (600) arranged in flow lines upstream or downstream of the heat exchanger (500), respectively.

14.
A system according to any of the preceding claims 9 to 12, c h a r a c t e r i z e d i n that the condensed vapour from the reliquefaction units (300, 400) is throttled in two stages.

15.
A system according to any of the preceding claims 9 to 14, c h a r a c t e r i z e d i n that the heat exchanger (500) is installed on a high point location on the LPG carrier.

16.
A system according to any of the preceding claims 9 to 14, c h a r a c - t e r i z e d i n that if free flow back to at the least one cargo tank (200) loaded with the second cargo type is impeded, the condensed vapour is pumped by means of a pump (700) situated in the piping (7).

17.
A system according to any of the preceding claims 9 to 15, c h a r a c - t e r i z e d i n that vapour of the second cargo type is compressed by means of a compressor (800) arranged upstream of the heat exchanger (500).

18.
A system according to any of the preceding claims 9 to 17, c h a r a c - t e r i z e d i n that the condensed vapour of the first cargo type returned from the heat exchanger (500) is passed through a separator, and separated liquid is returned back into the at least one tank (100) for the first cargo type.

19.
A system according to any of the preceding claims 9 to 18, c h a r a c - t e r i z e d i n that a reciprocating compressor (2.000) in the reliquefaction units (300, 400) is operated by means of an electric motor (1.900) and, when allowable, the motor is speeded up above normal.

AMENDED CLAIMS
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1.

A method for storage and transport of LPG on LPG carriers, in particular two cargoes of different LPG types on same shipment, having reliquefaction units (300, 400) in which vaporized gases are condensed and then returned into at least one cargo tank (100) for the respective LPG cargo type, c h a r a c t e r i z e d i n that the method is comprising:

using the reliquefaction units (300, 400), at a minimum one running, so as to condense vapour from a first one of the cargo types to yield a first condensed vapour;

passing the first condensed vapour through a heat exchanger (500);

simultaneously flowing vapour from a second one of the two cargo types through the heat exchanger (500) so as to condense the vapour to yield a second condensed vapour by means of heat exchanging with the first condensed vapour; and

returning the first and second condensed vapours leaving the heat exchanger back into the respective cargo types.

2.

A method according to claim 1, c h a r a c t e r i z e d i n that the method is further comprising:

throttling the first condensed vapour from the reliquefaction units (300, 400) upstream or downstream of the heat exchanger (500) as to meet the pressure requirements.

3.

A method according to claim 1, c h a r a c t e r i z e d i n that the method is further comprising:

throttling the condensed vapour in two stages as to meet the pressure requirements.

4.
A method according to any of the preceding claims,
c h a r a c t e r i z e d i n that the method is further comprising:

installing the heat exchanger (500) on a high point location on the LPG carrier so as to allow the first and second condensed vapours to freely flow back into the respective cargo tanks (100, 200).

5.
A method according to any of the preceding claims 1 to 3,
c h a r a c t e r i z e d i n that the method is further comprising:

if free flow back to at least one cargo tank (200) for the second cargo type is impeded, pumping the second condensed vapour to be returned into the second cargo type.

6.
A method according to any of the preceding claims,
c h a r a c t e r i z e d i n that the method is further comprising:

compressing vapour of the second cargo type upstream of the heat exchanger (500) so as to provide an elevated condensation pressure and, thus, allow for a more flexible location of the heat exchanger (500).

7.
A method according to any of the preceding claims,
c h a r a c t e r i z e d i n that the method is further comprising:

passing the first condensed vapour of the first cargo type returned from the heat exchanger (500) through a separator as to separate vapour and liquid phase; and

returning liquid back into the first cargo type.

8.
A method according to any of the preceding claims, c h a r a c t e r i z e d i n that the method is further comprising:

operating a reciprocating compressor (2.000) in the reliquefaction units (300, 400) by means of an electric motor (1.900) and, when allowable, speeding up the motor above normal so as to use the power potensial thereof.

9.
A system for storage and transport of LPG on LPG carriers, in particular two cargoes of different LPG types on same shipment, having reliquefaction units (300, 400) in which vaporized gases are condensed and then returned into at least one cargo tank (100) for the respective LPG cargo type, c h a r a c t e r i z e d i n :

the reliquefaction units (300, 400) being configured, at a minimum one running, to condense first vapour from a first one of the two cargo types;

a heat exchanger (500) configured to let the condensed first vapour pass therethrough; the heat exchanger (500) being further configured to allow vapour from a second one of the cargo types to simultaneously flow therethrough to condense the vapour to yield a second condensed vapour through heat exchange with the first condensed vapour; and

the heat exchanger having an outlet enabling the first and second condensed vapours leaving the heat exchanger to return back into the respective cargo types.

10.
A system according to claim 9, c h a r a c t e r i z e d i n that one of the reliquefaction units (400) is arranged in stand-by operation.

11.
A system according to claim 9, c h a r a c t e r i z e d i n that the heat exchanger is a free flow condenser (500).

12.
A system according to any of the preceding claims 9 to 11, c h a r a c t e r i z e d i n that the cargo types are held in cargo tanks, at least one separate tank (100, 200) for the respective cargo type.

13.
A system according to any of the preceding claims 9 to 12, c h a r a c t e r i z e d i n that the first condensed vapour from the reliquefaction units (300, 400) is throttled using a throttle valve (600) arranged in flow lines upstream or downstream of the heat exchanger (500), respectively.

14.
A system according to any of the preceding claims 9 to 12, c h a r a c t e r i z e d i n that the first condensed vapour from the reliquefaction units (300, 400) is throttled in two stages.

15.
A system according to any of the preceding claims 9 to 14, c h a r a c t e r i z e d i n that the heat exchanger (500) is installed on a high point location on the LPG carrier.

16.
A system according to any of the preceding claims 9 to 14, c h a r a c t e r i z e d i n that if free flow back to at the least one cargo tank (200) loaded with the second cargo type is impeded, the second condensed vapour is pumped by means of a pump (700) situated in the piping (7).

17.
A system according to any of the preceding claims 9 to 15, c h a r a c t e r i z e d i n that vapour of the second cargo type is compressed by means of a compressor (800) arranged upstream of the heat exchanger (500).

18.
A system according to any of the preceding claims 9 to 17, c h a r a c t e r i z e d i n that the first condensed vapour of the first cargo type returned from the heat exchanger (500) is passed through a separator, and separated liquid is returned back into the at least one tank (100) for the first cargo type.

19.
A system according to any of the preceding claims 9 to 18, c h a r a c t e r i z e d i n that a reciprocating compressor (2.000) in the reliquefaction units (300, 400) is operated by means of an electric motor (1.900) and, when allowable, the motor is speeded up to above normal speed.

Total installed refrigerant capacity shall thus not be less than 427kW plus sufficient redundancy to meet the requirements set forth by international classification societies and the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, the IGC Code. Based on operational issues the ship owners have typically additional requirements for further increased refrigerant capacity.

As a consequence a VLGC is typically equipped with four reliquefaction units, each unit normally with a reliquefaction capacity above 220 kW. Typically, each unit is capable of handling 2230 kg propane vapour per hour. Total evaporation from a VLGC carrying only propane typically amount to 3890 kg/hr. Capacities are naturally a function of ambient temperatures and type of cargo and change accordingly.

For the same VLGC carrying iso-butane the total heat leakage is 240 kW and each reliquefaction unit has a reliquefaction capacity of typically 340 kW. Total evaporation from a VLGC carrying only iso-butane typically amount to 1350 kg/hr.

When the VLGC carries both of the above cargoes a segregated operation applies. Assuming iso-butane loaded in liquid tight container A & B and propane loaded in liquid tight container C & D, the vapour flow of propane and iso-butane is approximately 1895 kg/hr and 690 kg/hr, respectively. For such a scenario, two reliquefaction units are in operation, one for propane and one for iso-butane. If the LPG carrier has propane in three cargo tanks, three reliquefaction units are in operation, two for propane and one for iso-butane.

Due to excessive capacity for each of the reliquefaction units in operation, operation of these units are normally intermittent, e.g. 12 hours operation 12 hours standby.

Any discussion of the prior art throughout the specification should in no way be considered as an admission that such prior art is widely known or forms part of common general knowledge in the field.

It is an object of the present invention to overcome or ameliorate at least one of the disadvantages of the prior art, or to provide a useful alternative.

Thus, the present invention proposes a simplified solution minimizing the number of reliquefaction units needed to take proper care of all vapours of the different cargo types.

According to a first aspect, the invention provides a method for storage and transport of LPG on LPG carriers, in particular two cargoes of different LPG types on same shipment, having reliquefaction units in which vaporized gases are condensed and then returned into at least one cargo tank for the respective LPG cargo type, wherein the method comprises:

using the reliquefaction units, at a minimum one running, so as to condense vapour from a first one of the cargo types to yield a first condensed vapour;

passing the first condensed vapour through a heat exchanger;

simultaneously flowing vapour from a second one of the two cargo types through the heat exchanger so as to condense the vapour to yield a second condensed vapour by means of heat exchanging with the first condensed vapour; and

returning the first and second condensed vapours leaving the heat exchanger back into the respective cargo types.

According to a second aspect, the invention provides a system for storage and transport of LPG on LPG carriers, in particular two cargoes of different LPG types on same shipment, having reliquefaction units in which vaporized gases are condensed and then returned into at least one cargo tank for the respective LPG cargo type, wherein:

the reliquefaction units being configured, at a minimum one running, to condense first vapour from a first one of the two cargo types;

a heat exchanger configured to let the condensed first vapour pass therethrough; the heat exchanger being further configured to allow vapour from a second one of the cargo types to simultaneously flow therethrough to condense the vapour to yield a second condensed vapour through heat exchange with the first condensed vapour; and

the heat exchanger having an outlet enabling the first and second condensed vapours leaving the heat exchanger to return back into the respective cargo types.

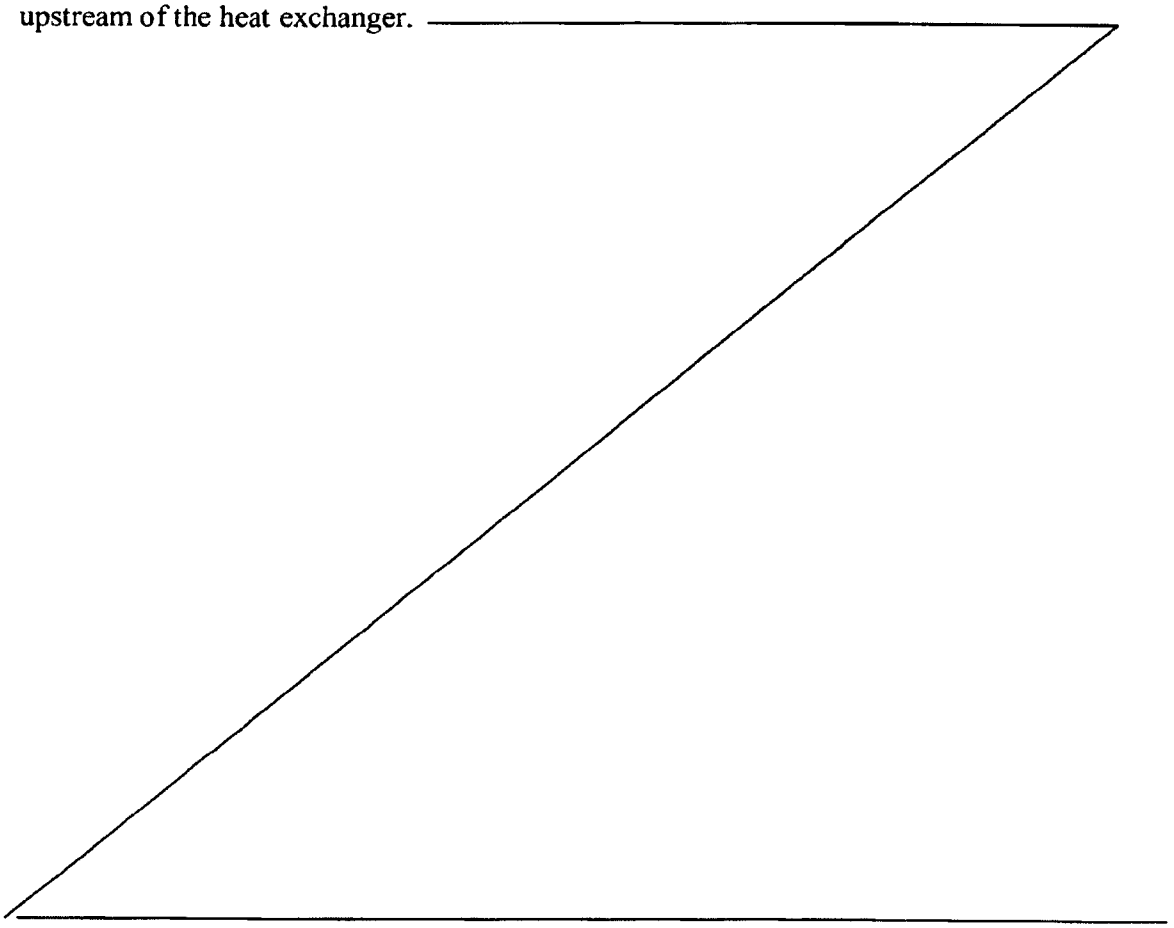
Unless the context clearly requires otherwise, throughout the description and the claims, the words "comprise", "comprising", and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to".

Some of the benefits by the proposed method and system are that the number of running reliquefaction is reduced to a minimum of one unit and that condensed vapour leaving the running reliquefaction unit can be used as a refrigerant in the heat exchanger.

To meet the pressure in the respective cargo tank for the first cargo type, the condensed vapour from the reliquefaction unit can be throttled upstream or downstream of the heat exchanger. The throttling can alternatively be performed in two stages.

The heat exchanger can be installed on a high point location on the LPG carrier so as to allow the condensed vapours to freely flow back into the cargo tanks. However, if free flow back to a respective cargo tank for the second cargo type is impeded, the condensed vapour to be returned into the second cargo type could be pumped.

To provide an elevated condensation pressure and, thus, allow for a more flexible location of the heat exchanger, vapour of the second cargo type can be compressed upstream of the heat exchanger.



THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. A method for storage and transport of LPG on LPG carriers, in particular two cargoes of different LPG types on same shipment, having reliquefaction units in which vaporized gases are condensed and then returned into at least one cargo tank for the respective LPG cargo type, wherein the method comprises:

using the reliquefaction units, at a minimum one running, so as to condense vapour from a first one of the cargo types to yield a first condensed vapour;

passing the first condensed vapour through a heat exchanger;

simultaneously flowing vapour from a second one of the two cargo types through the heat exchanger so as to condense the vapour to yield a second condensed vapour by means of heat exchanging with the first condensed vapour; and

returning the first and second condensed vapours leaving the heat exchanger back into the respective cargo types.

2. A method according to claim 1, further comprising:

throttling the first condensed vapour from the reliquefaction units upstream or downstream of the heat exchanger as to meet the pressure requirements.

3. A method according to claim 1, further comprising:

throttling the condensed vapour in two stages as to meet the pressure requirements.

4. A method according to any one of the preceding claims, further comprising:

installing the heat exchanger on a high point location on the LPG carrier so as to allow the first and second condensed vapours to freely flow back into the respective cargo tanks.

5. A method according to any one of claims 1 to 3, further comprising:

if free flow back to at least one cargo tank for the second cargo type is impeded, pumping the second condensed vapour to be returned into the second cargo type.

6. A method according to any one of the preceding claims, further comprising:

compressing vapour of the second cargo type upstream of the heat exchanger so as to provide an elevated condensation pressure and, thus, allow for a more flexible location of the heat exchanger.

7. A method according to any one of the preceding claims, further comprising:

passing the first condensed vapour of the first cargo type returned from the heat exchanger through a separator as to separate vapour and liquid phase; and

returning liquid back into the first cargo type.

8. A method according to any one of the preceding claims, further comprising:

operating a reciprocating compressor in the reliquefaction units by means of an electric motor and, when allowable, speeding up the motor above normal so as to use the power potensial thereof.

9. A system for storage and transport of LPG on LPG carriers, in particular two cargoes of different LPG types on same shipment, having reliquefaction units in which vaporized gases are condensed and then returned into at least one cargo tank for the respective LPG cargo type, wherein:

the reliquefaction units being configured, at a minimum one running, to condense first vapour from a first one of the two cargo types;

a heat exchanger configured to let the condensed first vapour pass therethrough; the heat exchanger being further configured to allow vapour from a second one of the cargo types to simultaneously flow therethrough to condense the vapour to yield a second condensed vapour through heat exchange with the first condensed vapour; and

the heat exchanger having an outlet enabling the first and second condensed vapours leaving the heat exchanger to return back into the respective cargo types.

10. A system according to claim 9, wherein one of the reliquefaction units is arranged in stand-by operation.

11. A system according to claim 9, wherein the heat exchanger is a free flow condenser.

12. A system according to any one of the preceding claims 9 to 11, wherein the cargo types are held in cargo tanks, at least one separate tank for the respective cargo type.

13. A system according to any one of the preceding claims 9 to 12, wherein the first condensed vapour from the reliquefaction units is throttled using a throttle valve arranged in flow lines upstream or downstream of the heat exchanger, respectively.

14. A system according to any one of the preceding claims 9 to 12, wherein the first condensed vapour from the reliquefaction units is throttled in two stages.

15. A system according to any one of the preceding claims 9 to 14, wherein the heat exchanger is installed on a high point location on the LPG carrier.

16. A system according to any one of the preceding claims 9 to 14, wherein if free flow back to at the least one cargo tank loaded with the second cargo type is impeded, the second condensed vapour is pumped by means of a pump situated in the piping.

17. A system according to any one of the preceding claims 9 to 15, wherein vapour of the second cargo type is compressed by means of a compressor arranged upstream of the heat exchanger.

18. A system according to any one of the preceding claims 9 to 17, wherein the first condensed vapour of the first cargo type returned from the heat exchanger is passed through a separator, and separated liquid is returned back into the at least one tank for the first cargo type.

19. A system according to any one of the preceding claims 9 to 18, wherein a reciprocating compressor in the reliquefaction units is operated by means of an electric motor and, when allowable, the motor is speeded up to above normal speed.