June 9, 1959 J. W. L. KÖHLER 2,889,686

GAS FRACTIONATING SYSTEM INCLUDING A VAPOR LIFT PUMP

Filed June 25, 1954 4 Sheets-Sheet 1

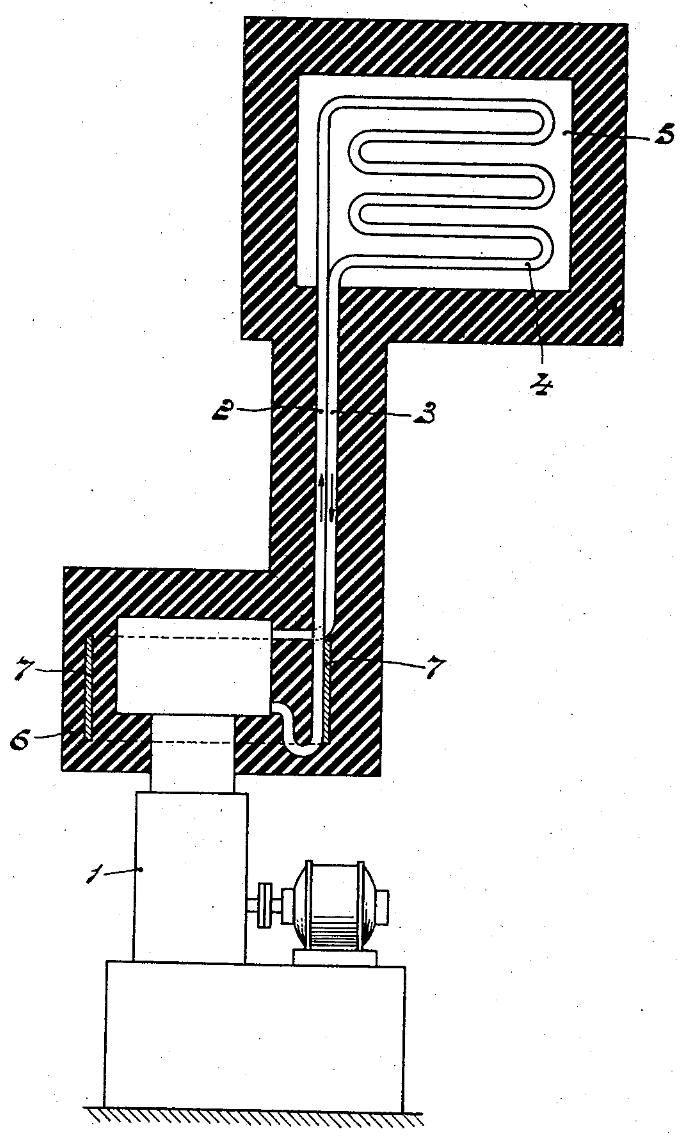

Fig. 1

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GAS FRACTIONATING SYSTEM INCLUDING A VAPOR LIFT PUMP

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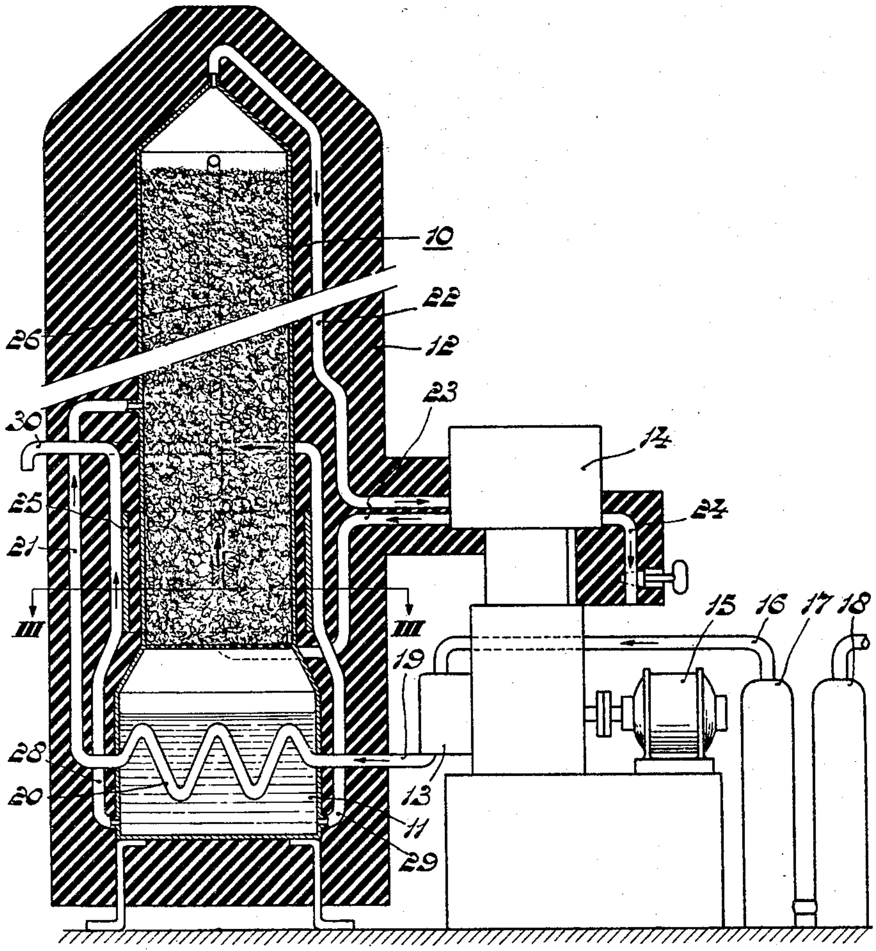

Fig. 2

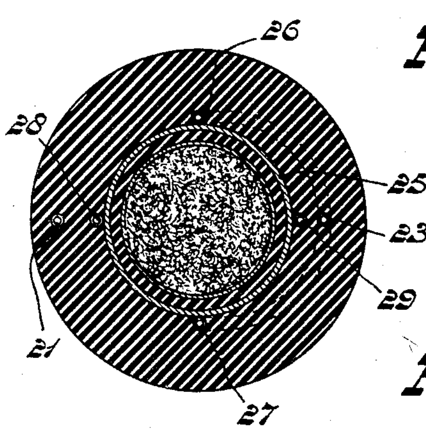

Fig. 3

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GAS FRACTIONATING SYSTEM INCLUDING A VAPOR LIFT PUMP
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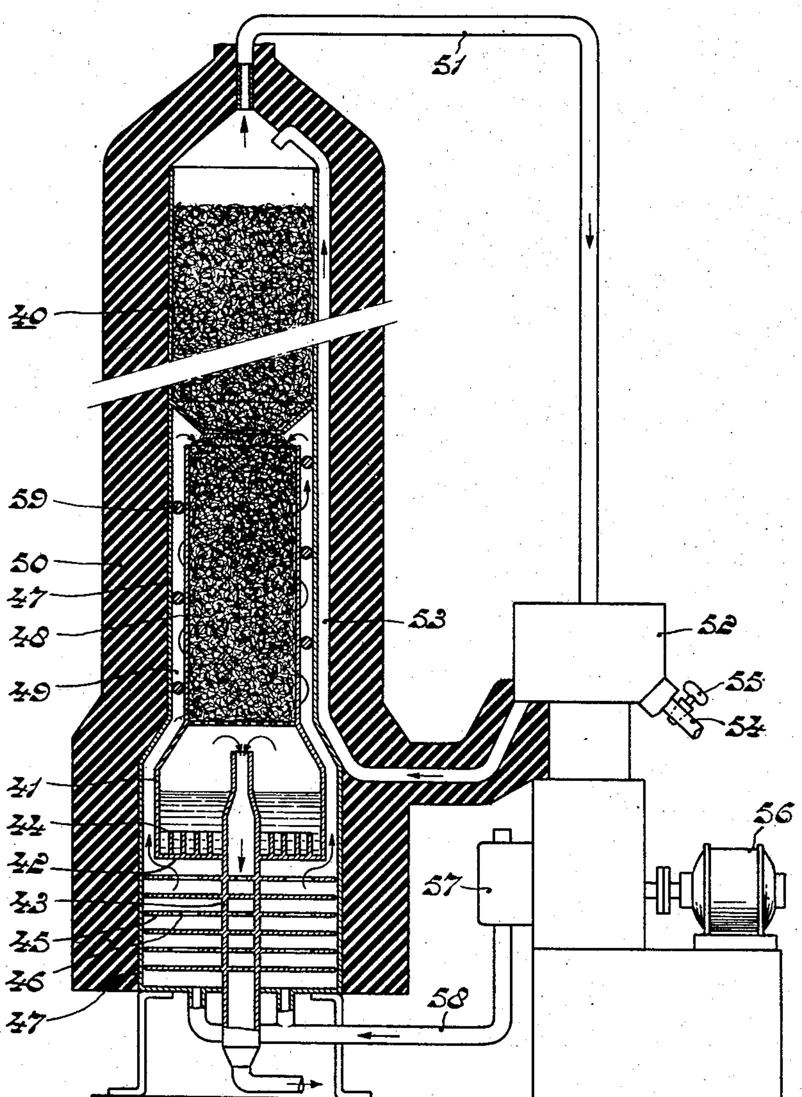

Fig. 4

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GAS FRACTIONATING SYSTEM INCLUDING A VAPOR LIFT PUMP

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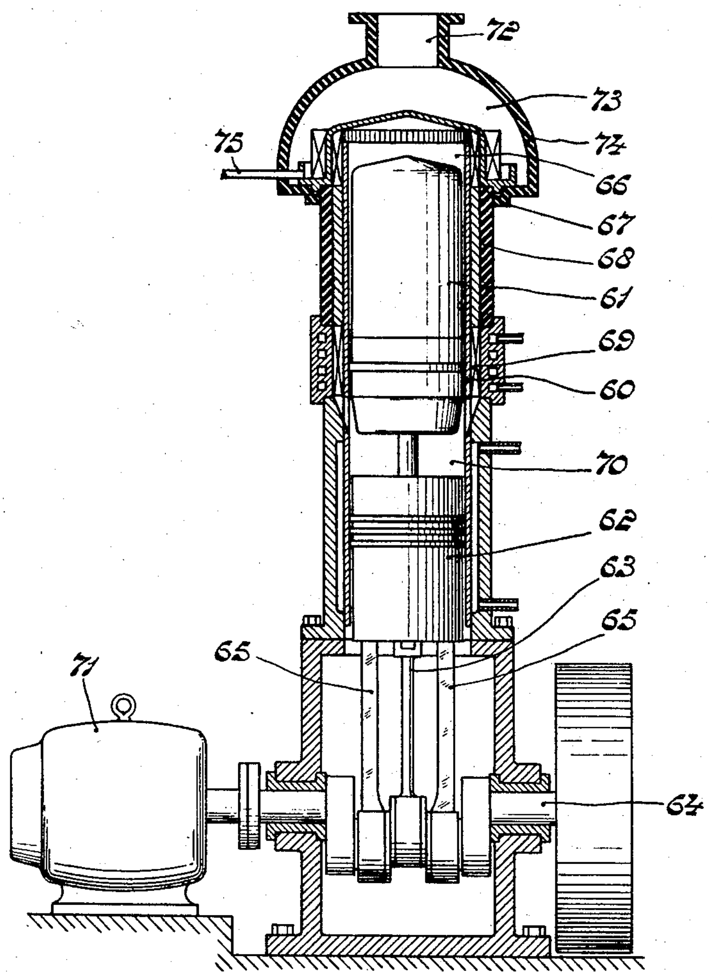

Fig. 5

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GAS FRACTIONATING SYSTEM INCLUDING A VAPOR LIFT PUMP

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Claims priority, application Netherlands July 2, 1953

6 Claims. (Cl. 62—6)

The invention relates to a system comprising a cold-gas refrigerator, in which a liquid furnished by the cold-gas refrigerator is transported by means of a vapor lift pump from a lower position to a higher position. A cold-gas refrigerator is to be understood herein to mean a refrigerator operating on the reverse hot-gas engine principle. These cold-gas refrigerators may have different forms, for example that of a displacer-piston machine, a double-acting machine, a machine in which the cylinders are arranged in the form of a V or a machine, the working space of which is combined with that of a hot-gas engine. Such cold-gas refrigerators permit of obtaining very low temperatures of for example −200° C. in one operational stage. These refrigerators may therefore be used in systems for liquifying gaseous media, for example air, in gas fractionating systems or in systems by means of which a low temperature is to be produced in particular spaces. Where reference is made herein to a liquid furnished by a cold-gas refrigerator, this is to be understood to mean the condensate produced by the cold supplied by the cold-gas refrigerator directly or indirectly, for example through an intermediate medium, to a vapour.

In the aforesaid systems it will often be necessary to lift by pumping a liquid having a very low boiling point, for example of lower than −120° C., over a given height. This could be carried out by means of the pumping systems hitherto known, for example by means of centrifugal pumps. However, these pumps form a part of the system which requires constant supervision. In the system according to the invention use is made of a vapor lift pump to raise the liquid.

It should be noted that the use of vapor lift pumps is known, for example in laboratory systems and in continuously operating absorption refrigerators. The vapor lift pump is to be distinguished from the air-lift pump in which a gas of high pressure is blown into a liquid; an example thereof is the so-called mammouth pump. In the vapor lift pump the vapour plugs are produced by the evaporation of the liquid to be transported.

The use of a vapor lift pump in a system comprising a cold-gas refrigerator, in which a liquid furnished by the cold-gas refrigerator is to be transported from a lower area to a higher area, may be considered as a matter of course. However, it will, in general, not be desirable, to use such a vapor lift pump, since its output is very low.

According to the present invention a construction has been designed in which the use of a vapor lift pump is justified.

Further in accordance with the invention the liquid is heated by thermal contact with parts of the system which have a higher temperature than the liquid owing to the process performed in the system. Thus the cold withdrawn from the liquid to be evaporated may be used effectively. Therefore in spite of their comparatively low output these pumps may be used successfully.

The liquid may, for example, be heated by means of a flow of heat due to the temperature difference between the surroundings and parts of the system.

According to one aspect of the invention the insulation loss of the system is utilized at least partly for heating the liquid.

According to a further aspect of the invention a medium to be cooled may be used for heating. In a gas fractionating system this medium to be cooled may for example be the medium to be fractionated.

The system according to the invention may be employed with particular success, if it comprises a rectification column, in which a liquid associated with the gas fractionating system is transported by means of a vapor lift pump.

If the system comprises a rectification column from which cold is withdrawn by means of a cold-gas refrigerator, while the point where at least part of the liquid furnished by the refrigerator is supplied to the column is positioned over the outlet port of this liquid in the cold-gas refrigerator, the liquid may be transported from the refrigerator to the column by means of a vapor lift pump. It is thus possible to mount the cold-gas refrigerator and the gas fractionating column on the same base. The liquid to be pumped back to the column may be an intermediate medium circulating between the column and the refrigerator.

In an advantageous embodiment of the invention, in which the gaseous fraction having the lowest boiling point emanating from the rectification column is condensed by the cold-gas refrigerator, at least part of the liquid thus obtained is supplied back to the column by means of a vapor lift pump.

According to a further aspect heat is withdrawn from the rectification column by means of an auxiliary medium which evaporates in the condenser of the column, this vapour being condensed by means of the cold supplied by the cold-gas refrigerator, the liquid thus formed being transported by means of a vapor lift pump to the condenser of the column which occupies a higher position.

A simple construction is obtained, if in the insulating jacket of the rectification column at one or more areas where a temperature prevails which is higher than that of the liquid to be transported, provision is made of one or more elements with which the duct containing the liquid is in thermal contact in a manner such that vapour plugs are formed in the liquid. This construction permits of utilizing at least partly the insulation losses of the system.

A structurally simple system is obtained, if in a system in which the gaseous mixture to be fractionated is in thermal contact with the liquid part of the fraction with the highest boiling point contained in the boiling vessel. This system comprising a communication duct linking the heat exchanger with the column, the communication duct extending on the outer side of the boundary wall, at least through part of its height. This arrangement operates so that the gaseous mixture flowing through this communication duct is in thermal contact through the boundary wall with the medium contained in this part of the column, while the gaseous mixture flowing through this communication duct is moreover in thermal contact with the liquid part of the fraction with the lowest boiling point in a manner such that in this part a vapor lift pump effect is obtained.

In a further embodiment of the invention the boundary wall is surrounded by a second wall, while the space comprised between these walls constitutes the communication duct and on the outer side of the second wall provision is made of one or more ducts for the fraction with the lowest boiling point.

In order to prevent the gaseous mixture flowing through the communication duct from condensing at the area of the vapor lift pump and from subsequently flowing downwards and in order to provide that all the gas is in thermal contact with the liquid to be transported, the communication duct in a further advantageous embodiment of the invention contains a helical wall by means of which the medium to be fractionated flows through the communication duct in a helical line.

The invention will now be described more fully with reference to the accompanying drawing, which shows a few embodiments.

Fig. 1 shows a system in which a required low temperature is obtained in a space by means of a cold-gas refrigerator.

Figs. 2 and 3 show a gas fractionating system in which a metal screen is provided in the insulating jacket of a gas fractionating column, by means of which screen heat is transferred to the liquid to be transported. Fig. 3 is a cross-sectional view taken on the line III—III of Fig. 2.

In the gas fractionating system shown in Fig. 4 heat is withdrawn from a medium to be cooled, this heat being transferred to the liquid to be transported and

Fig. 5 shows a cold-gas refrigerator.

The system shown in Fig. 1 comprises a cold-gas refrigerator which communicates through ducts **2** and **3** with a higher positioned heat exchanger **4**, arranged in the space **5** to be cooled. The ducts **2** and **3**, the heat exchanger **4** and a space in the head of the cold-gas refrigerator constitutes a closed circuit in which an auxiliary medium circulates. This auxiliary medium for example nitrogen withdraws heat from the heat exchanger **4**, the medium being thus evaporated and heated. The overheated vapour flows through duct **3** to the cold-gas refrigerator and is condensed by this refrigerator. The condensate is transported through duct **2** to the heat exchanger **4**. In the insulating jacket **6** of the cold-gas refrigerator provision is made of a metal screen **7** to which the duct **2** is secured. The screen is positioned at an area where a sufficiently high temperature prevails, so that a vapor lift pump effect is obtained in the condensate in the duct **2**. The ducts **2** and **3** extend through part of their length side by side, so that the liquid in the duct **2** is heated by the vapour in the duct **3** and vapour plugs are formed in this section.

The system shown in Figs. 2 and 3 comprises a gas fractionating column **10**, filled with filling material and having a boiling vessel **11**; the structure is surrounded by an insulating jacket **12**. The gaseous mixture to be fractionated is supplied by a compressor **13**, seated on the shaft of a cold-gas refrigerator **14**. The cold-gas refrigerator and the compressor are driven by an electric motor **15**. The compressor comprises a suction duct **16**, having vessels **17** and **18**, in which the gaseous mixture to be fractionated can be purified. If, for example, air is to be fractionated it will be desirable to extract first the water vapour and the carbon acid from the air prior to the cooling of the air, this extraction being performed in the vessels **17** and **18**.

The compressor **13** comprises, moreover, a delivery duct **19**, linked with a heat exchanger **20**, housed in the boiling vessel **12**. In this heat exchanger the gaseous mixture to be fractionated is in thermal contact with the liquid in the boiling vessel, so that the gaseous mixture is cooled and the liquid in the boiling vessel evaporates. The gaseous mixture cooled in the heat exchanger **20** flows through a duct **21** to the column, where it is fractionated. At the top the fraction with the lowest boiling point is conducted away from the column and transported through a duct **22** to the cold-gas refrigerator **14**, where it is condensed. Part of the liquid thus obtained is fed as a reflux to the column through a duct **23** and a further part is conducted away from the system through a duct **24**. In the insulating jacket **12** provision is made of a metal screen **25**, to which ducts **26** and **27**, in which the duct **23** is branched off, are soldered (Fig. 3). This metal screen is positioned in a manner such that, if it does not give off heat, it assumes a higher temperature than that of the liquid to be transported by means of a vapor lift pump. Owing to the metal screen **25**, the flow of heat from the outside to the interior via the insulating jacket will be used effectively for producing vapour plugs. Consequently, heat is transferred to the ducts **26** and **27**, so that the condensate in these ducts will evaporate and a vapor lift pump effect is obtained in each of these ducts. Thus the liquid is pumped upwards and supplied at the top to the column. It is thus possible to use effectively the insulation losses of the column.

The column shown may be used for obtaining the liquid fraction with the highest boiling point. To this end the boiling vessel **11** is provided with two outlet ducts **28** and **29**. It will in general be desirable to drain off the liquid at an area which is not too low, since otherwise this would be inconvenient to the operator. The ducts **28** and **29** therefore extend in a vertical direction and communicate with a common duct **30**. For transporting the liquid upwards use is made also in this case of vapor lift pumps, obtained by soldering the ducts **28** and **29** to the metal screen **25**.

Fig. 4 shows a gas fractionating system suitable for obtaining a fraction with the lowest boiling point.

The system comprises a gas fractionating column **40**, filled with filling material, for example Raschig rings. At the bottom the column has a boiling vessel **41**, having a bottom **42** through which a duct **43** is taken, linking the space in the boiling vessel with the open air. The bottom **42** is provided with vanes **44** and the tube **43** is provided with vanes **45**. The latter vanes have apertures **46**, which are provided in staggered position in successive vanes. The vanes **45** extend up to the wall **47**, the prolongation of which surrounds concentrically a wall **48**, which constitutes the boundary wall of the column, so that between the two walls a space **49** is left, which serves as a communication duct between the column and the space between the vanes **45**. The wall **47** is surrounded by an insulating jacket **50**. At the top the column communicates through a duct **51** with a cold-gas refrigerator **52**, which, moreover, communicates with the column through the duct **53**, extending along the outer side of the wall **47** and secured thereto by soldering. The cold-gas refrigerator comprises, moreover, an outlet duct **54** with a cock **55**, through which part of the condensate produced by the cold-gas regrigerator can be drained off. The cold-gas refrigerator is driven by the electric motor **56**; a compressor **57** is seated on the shaft of the cold-gas refrigerator, this compressor communicating through a duct **58** with the heat exchanger formed by the vanes **45**.

The system operates as follows. The gaseous mixture to be fractionated, for example air, is supplied through the compressor **57** via the duct **58** to the heat exchanger formed by the vanes **45**. The air is thus cooled and the impurities contained in the air are separated out on the vanes. Part of the heat withdrawn from the air is transferred through the duct **43**, the bottom **42** of the boiling vessel **41** and the vanes **44** to the liquid in the boiling vessel, so that this liquid evaporates. A further part of the heat is transferred through the duct **43** with the vanes provided therein to the part of the vapour flowing from the boiling vessel into the duct.

The air cooled and purified is supplied to the column through the space **49** between the walls **47** and **48**. In the column the air is fractionated. A liquid rich in oxygen flows downwards in the column and vapour from the boiling vessel rises in the column. By means of heat withdrawn from the air to be fractionated the liquid collected in the boiling vessel again evaporates, while part of the vapour thus formed is conducted away through the tube **43**. At the top of the column vapourous nitrogen is obtained and this vapour is supplied through the duct **51** to the cold-gas refrigerator **52** and thus condensed. Part of the condensate is conducted away through the duct **54** and a further part is re-supplied to the column through the duct **53**. By way of the wall **47** the liquid nitrogen having a temperature of —196° C. in the duct **53** is in thermal contact with the air to be fractionated, so that in the condensate in the duct **53** vapour plugs are formed and the liquid nitrogen is thus pumped upwards. Owing to the helically wound wall **59** the air moves helically through the duct **59**, so that condensed oxygen is prevented from flowing downwards along the contact area of the duct **43** and the wall **47**, while all the medium is in thermal contact with the duct **53**.

Fig. 5 shows on a different scale a cold-gas refrigerator suitable for use in the systems described above. The cold-gas refrigerator shown is of the so-called displacer-piston type; of course, use may be made of other types of cold-gas refrigerators, for example double-acting machines.

The machine comprises a cylinder **60**, in which a displacer piston **61** and a piston **62** are adapted to move to and fro with substantially constant phase difference. To this end the displacer piston is coupled by means of a connecting rod mechanism **63** with a crank of a crank shaft **64**, while the piston **62** is coupled by way of a connecting-rod system **55** with two cranks of the same crank shaft **64**. Owing to the movement of the displacer piston **61** the volume of the freezing space **66** is varied. This space communicates with the cooled space **70** through a freezer **67**, a regenerator **68** and a cooler **69**; the volume of the cooled space is varied both by the movement of the displacer piston **61** and the movement of the piston **62**.

The refrigerator is driven by an electric motor **71**. Cold-gas refrigerators permit of obtaining in one stage low temperatures of for example —200° C.

A medium to be cooled may be supplied through ports **72** to a space **73**, which is surrounded by a jacket **74** having heat insulating properties. In this space **73** the medium is cooled, after which the cooled medium leaves the refrigerator through a duct **75**. If a vapour, for example nitrogen having a pressure of about 1 atm. is supplied to the space **73**, this nitrogen can be condensed in this space. The condensate can be conducted away through the duct **54** and be supplied partly to a gas fractionating column.

What is claimed is:

1. In combination, a system comprising a cold gas refrigerator, a heat exchanger, a delivery duct for supplying a gaseous mixture to said heat exchanger, a rectification column for fractionating said gaseous mixture and having a boiling vessel, said heat exchanger being located in said boiling vessel, means for conducting said gaseous mixture from said heat exchanger to said column, a downwardly directed supply duct for the fraction with the lowest boiling point in said column and an upwardly directed return duct connecting said column with said cold gas refrigerator whereby said fraction is cooled by said cold gas refrigerator to produce a condensate which is conducted away from said cold gas refrigerator through said return duct, a metal wall abutting a part of said return duct and located in a region where a relatively high temperature prevails whereby the condensate of said mixture in said part of said return duct due to thermal contact with said metal wall flows to said column by a vapor-lift pump effect.

2. A system as set forth in claim 1 wherein the gaseous fraction having the lowest boiling point emanating from said rectification column is condensed by means of said cold gas refrigerator, and at least part of the liquid thus formed being re-supplied to said column by means of said vapor-lift pump effect, and means for conducting away another part of said liquid from the system.

3. A system as set forth in claim 1 further comprising an insulating jacket for said rectification column, said metal wall being located in said insulating jacket in a region wherein there exists a prevailing temperature which is higher than the liquid to be transported, said metal wall being in thermal contact with the liquid in the part of said return duct whereby vapor plugs are produced in said liquid.

4. In combination, a system comprising a cold gas refrigerator, a heat exchanger, a delivery duct for supplying a gaseous mixture to said heat exchanger, a rectification column for fractionating said gaseous mixture and having a boiling vessel, said heat exchanger being located in said boiling vessel, means for conducting said gaseous mixture from said heat exchanger to said column, a downwardly directed supply duct for the fraction with the lowest boiling point in said column and an upwardly directed return duct connecting said column with said cold gas refrigerator whereby said fraction is cooled by said cold gas refrigerator to produce a condensate which is conducted away from said cold gas refrigerator through said return duct, a metal wall abutting a part of said return duct and located in a region where a relatively high temperature prevails whereby the condensate of said mixture in said part of said return duct due to thermal contact with said metal wall flows to said column by a vapor-lift pump effect, an insulated jacket for said column, the gaseous mixture to be fractionated being in thermal contact with the fraction having the highest boiling point upon being conducted from said heat exchanger to said column, said conducting means for said gaseous mixture extending in said insulated jacket juxtaposed to at least part of the boundry wall of the column whereby the gaseous mixture flowing through said conducting means is in thermal contact through said boundary wall with the medium in said column whereby a vapor-lift pump effect is obtained.

5. A system as set forth in claim 4 further comprising a second wall surrounding said boundary wall whereby the space between said walls constitutes a communicating duct, and at least one duct for the condensate of the mixture being provided on the outside of said second wall.

6. A system as set forth in claim 4 further comprising a helically wound wall in said space whereby the gaseous mixture to be fractionated moves helically through said space.

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