(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 142 209**
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 84201623.0

(22) Date of filing: 09.11.84

(51) Int. Cl.⁴: F 25 B 41/00
F 25 B 43/00

(30) Priority: 11.11.83 NL 8303877

(43) Date of publication of application:
22.05.85 Bulletin 85/21

(84) Designated Contracting States:
AT BE CH DE FR GB IT LI LU NL SE

(71) Applicant: GRASSO'S KONINKLIJKE MACHINEFABRIEKEN N.V.
Parallelweg 27
NL-5223 AL 's-Hertogenbosch(NL)

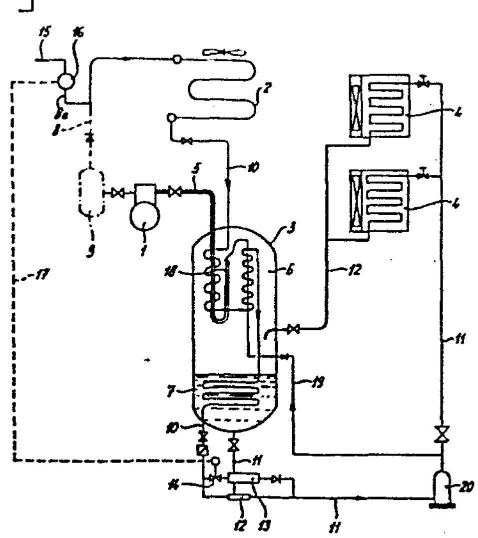
(72) Inventor: Romijn, Johannes Gerardus
Rouppe van der Voortlaan 52
NL-5262 HG Vught(NL)

(74) Representative: van der Beek, George Frans et al,
Nederlandsch Octrooibureau Johan de Wittlaan 15 P.O. Box 29720
NL-2502 LS 's-Gravenhage(NL)

(54) Plant, such as cooling plant or heat pump.

(57) Plant consisting of a circuit system with one or more compressors (1), one or more condensers (2), one or more evaporators (4), a separation vessel (3) for liquid and vaporous refrigerants, and an ejector system (12, 13) to use the high pressure from the liquid refrigerant coming from the condenser(s)(2) for conveyance of the liquid refrigerant from the separation vessel (3) to the evaporator(s)(4), whereby the ejector system (12, 13) has more than one ejector, connected in parallel, and there are means (14, 15, 16) for putting into operation the second or further ejector (13) if more liquid than can be discharged collects in the condenser (2).

Fig-1



EP 0 142 209 A2

0142209

Plant, such as cooling plant or heat pump

The invention relates to a plant consisting of a circuit system with one or more compressors, one or more condensers, one or more evaporators, a separation vessel for liquid and vaporous refrigerants, and an ejector system to use the high pressure from the liquid refrigerant coming from the condenser(s) for conveyance of the liquid refrigerant from the separation vessel to the evaporator(s). Such plants are known in the literature. For example, Dutch Patent Application 8105395 shows a cooling plant in which an ejector is used instead of a throttle device and a centrifugal pump or the like. With an ejector system, the energy which would otherwise be destroyed in the throttle device during throttling of the liquid refrigerant coming under high pressure from the condenser can be used effectively to convey the low-pressure liquid refrigerant from the separation vessel to the evaporator(s).

This saves energy which would otherwise be necessary to drive the pump. It is particularly important if the plant is used as a heat pump, where as little energy as possible should be used unnecessarily.

A plant with a centrifugal pump or the like can, if necessary, be very simply adjusted by changing the speed of the pump. The pump is, however, generally dimensioned for the maximum capacity of the plant. If a lower capacity is required, the pump continues to run at the same speed, which is a disadvantage from the point of view of energy consumption.

Besides, the capital outlay is very great for a pump in small plants. An ejector system then has advantages. The disadvantages are that an ejector is geared to a particular capacity of the plant and is difficult or impossible to regulate. Another complication here is that the mass flow of the liquid which is circulated through the ejector depends on the pressure difference over the ejector and increases with increasing pressure difference.

The mass flow fed through the compressor also depends on the pressure difference, but this mass flow decreases with increasing pressure difference.

Nevertheless, both mass flows must remain the same, since the circuit is closed.

The object of the invention is now to produce, in a plant with ejector circulation, regulation which is loss-free as far as possible, and this is achieved according to the invention by the ejector system having more than one ejector, connected in parallel, with means being provided to put the second or next ejector into operation if more liquid collects in the condenser than can be discharged.

The invention therefore saves on capital outlay and on energy consumption, while good adaptation to the required capacity is possible.

Further features and advantages of the invention will emerge from the description and claims which now follow.

The invention will be explained in greater detail with reference to the drawings, in which:

Fig. 1 is the diagram of the plant according to the invention with two ejectors; and

Fig. 2 is a longitudinal section through one of the ejectors.

The compressor is indicated by 1, the condensor by 2, the separation vessel by 3, and the evaporators by 4, in this case two of them.

The suction line of the compressor 1 is indicated by 5 and debouches in a U-shape into the vapour chamber 6 of the separation vessel 3. The liquid chamber of the vessel 3 is indicated by 7.

The line between compressor 1 and condenser 2 is indicated by 8. A conventional oil separator 9 can also be set up in this line 8. The necessity for this depends on the type of compressor 1 used.

A line 10 discharges liquid refrigerant under high pressure from the condenser 2.

From the liquid chamber 7 of the separation vessel 3 a line 11 goes to the evaporator(s) 4. From the evaporator(s) 4 a line 12 leads to the vapour chamber 6 of the separation vessel 3.

In this line 11 there is a circulation device, consisting of two ejectors 12 and 13 connected in parallel and being the same or differing in size.

The line 10 coming from the condenser connects with the lefthand inlet of the ejector 12. Through this high-pressure liquid, low-pressure liquid is sucked in from the liquid part 7 via the line 11 and taken to the evaporator(s).

In order to prevent vapour from arising in the ejector 12, which would stop the ejector from working, the high-pressure liquid from the condenser is first supercooled in the liquid bath 7.

Since an ejector is designed for one capacity, when the required capacity of the plant is increased a second ejector 13, and possibly a third one, is switched on in parallel by opening a valve 14.

The valve 14 of the second ejector 13 is opened if too much liquid accumulates in condenser 2. This excess liquid can be determined using a level gauge in the condenser which opens and closes the valve 14 with known means. This level gauge is not shown.

Fig. 1 does show another arrangement, in which another ejector is switched on when the quantity of liquid in the condenser 2 becomes too high.

If the evaporators 4 have to produce more cold, more vapour which has formed is conducted via the line 12 to the vessel 3. This vapour is sucked in by the compressor 1 and taken to the condenser 2, where the vapour converts to liquid. The condenser 2 cannot discharge this larger quantity of liquid, on account of the limited capacity of the ejector in operation. Liquid therefore accumulates in the condenser.

When liquid collects in the condenser 2 , the surface available for condensing is reduced. The temperature - and thus the pressure - increases in the condenser.

Assuming that the condenser is set up in the open air, the temperature difference between the condenser and the outside air must remain constant as far as possible, being preferably of the order 11 °K ± 1 °K.

Since it is technically not easy to measure the temperature of the vapour in the condenser 2, but it is possible to measure the pressure, the difference in pressure between the vapour in the condenser and the saturation pressure of the refrigerant at the temperature of the outside air is used as the signal for switching on a second or further ejector.

A small quantity of liquid refrigerant is to this end enclosed in a sensor 15, which is exposed to the outside air. Part of the liquid evaporates, and the pressure of the saturated vapour is passed on to an instrument 16, to which the condenser 2 is also connected via a line 8a.

As soon as the pressure difference becomes greater than desired, this means that liquid accumulates in the condenser 2. When the desired temperature difference of preferably 11 °K ± 1 °K is exceeded, a signal is given via a line 17 to the operating element of the valve 14, as a result of which the latter is opened.

When the temperature of the outside air changes, the temperature of the condenser also changes, so that the desired difference is maintained.

As can be seen from Fig. 1, the line 10 runs from the condenser 2 into the vapour chamber 6 of the vessel 2 which is in heat exchanging contact with the U-shaped inlet 18 of the suction line 5 of the compressor, as a result of which the inlet 18 is heated. The vapour sucked up by the compressor is in this way considerably preheated by the warm high-pressure liquid from the condenser 2, as a result of which any liquid droplets formed convert to vapour form, so that no liquid is fed to the compressor.

The line 10 is conducted further in heat exchanging contact, with a capillary line 19, which connects with the line 11 and debouches above the inlet 18.

Through this capillary line 19, owing to the pressure difference present, part of the refrigerant, in which there is oil, is taken from the ejector(s) to the inlet 18. The refrigerant from the line 19 evaporates through the heat of the refrigerant flowing through the line 10, while the oil is returned to the compressor 1.

The line 10 then runs in heat exchanging contact through the liquid bath 7 of the vessel 3.

Through contact with this cold liquid, the high-pressure liquid in the line 10 is supercooled, in order to prevent evaporation in the ejector(s) 12, 13.

There are, therefore, as it were, three heat exchangers set up in vessel 3, which greatly improves the compactness of the plant.

It is also possible to set up in the line 11 a filter drier 20, which is known per se, and which removes impurities and moisture from the liquid refrigerant.

Fig. 2 shows a longitudinal section through one of the ejectors according to the invention, for example ejector 13.

This consists of a massive element 21, which is preferably hectagonal in transverse section, and is made of brass or the like, with four connections.

Connected to the uppermost connection is the line 11 from the liquid bath 7. Liquid low-pressure refrigerant is therefore fed in here.

The bottom connection is for connection to the ejector 12 set up below it. If the ejector is the lowest one, this connection is closed off with a cap or the like.

The line 10 connects with the lefthand connection, and the line part 11 leading to the evaporator(s) connects with the righthand connection.

Unlike known ejectors with converging-diverging passage, in the ejector according to the invention the passage is formed by stepped cylindrical channels 22, 23 and 24 and a wider mixing part 25.

In the channel part 22 before the mixing part 25 there is a hard steel bush 26 to prevent damage to the channel wall through cavitation.

A passage made up of cylindrical bores is considerably simpler to produce than a double conical passage. The bores can be made with a conventional drilling device.

C L A I M S

1. Plant consisting of a circuit system with one or more compressors, one or more condensers, one or more evaporators, a separation vessel for liquid and vaporous refrigerants, and an ejector system to use the high pressure from the liquid refrigerant coming from the condenser(s) for conveyance of the liquid refrigerant from the separation vessel to the evaporator(s), characterised in that the ejector system has more than one ejector, connected in parallel, and there are means for putting into operation the second or further ejector if more liquid than can be discharged collects in the condenser.

2. Plant according to Claim 1, characterised in that the means are designed in such a way that the pressure of the vaporous refrigerant in the condenser is compared with the saturation pressure of the refrigerant at the ambient temperature in which the condenser is set up, and if a previously set pressure difference is exceeded, the second and/or a further ejector is switched on.

3. Plant according to Claim 1 or 2, characterised in that each ejector is formed by an oblong element in which are provided stepped cylindrical bores lying in one line.

4. Plant according to one or more of the preceding claims, characterised in that the line between the condenser and the ejector system is in indirect heat exchanging contact with the bath of liquid refrigerant in the separation vessel.

5. Plant consisting of a circuit system with one or more compressors, one or more condensers, one or more evaporators, a separation vessel

for liquid and vaporous refrigerant and a circulation device to take the liquid refrigerant from the separation vessel through the evaporator(s), characterised in that in the vapour chamber of the separation vessel two heat exchangers are set up, through which in series the liquid refrigerant is conducted from the condenser as a heating medium, the vaporous refrigerant sucked up by the compressor from the separation vessel being heated in one heat exchanger, while part of the liquid refrigerant coming out of the circulation device is heated in the other heat exchanger.

6. Plant according to Claim 5, characterised in that the part of the liquid refrigerant mentioned is fed to the vapour chamber of the separation vessel via a line which debouches in the vapour chamber above the open inlet of the suction line to the compressor and which has a throttling action.

0142209

fig-1

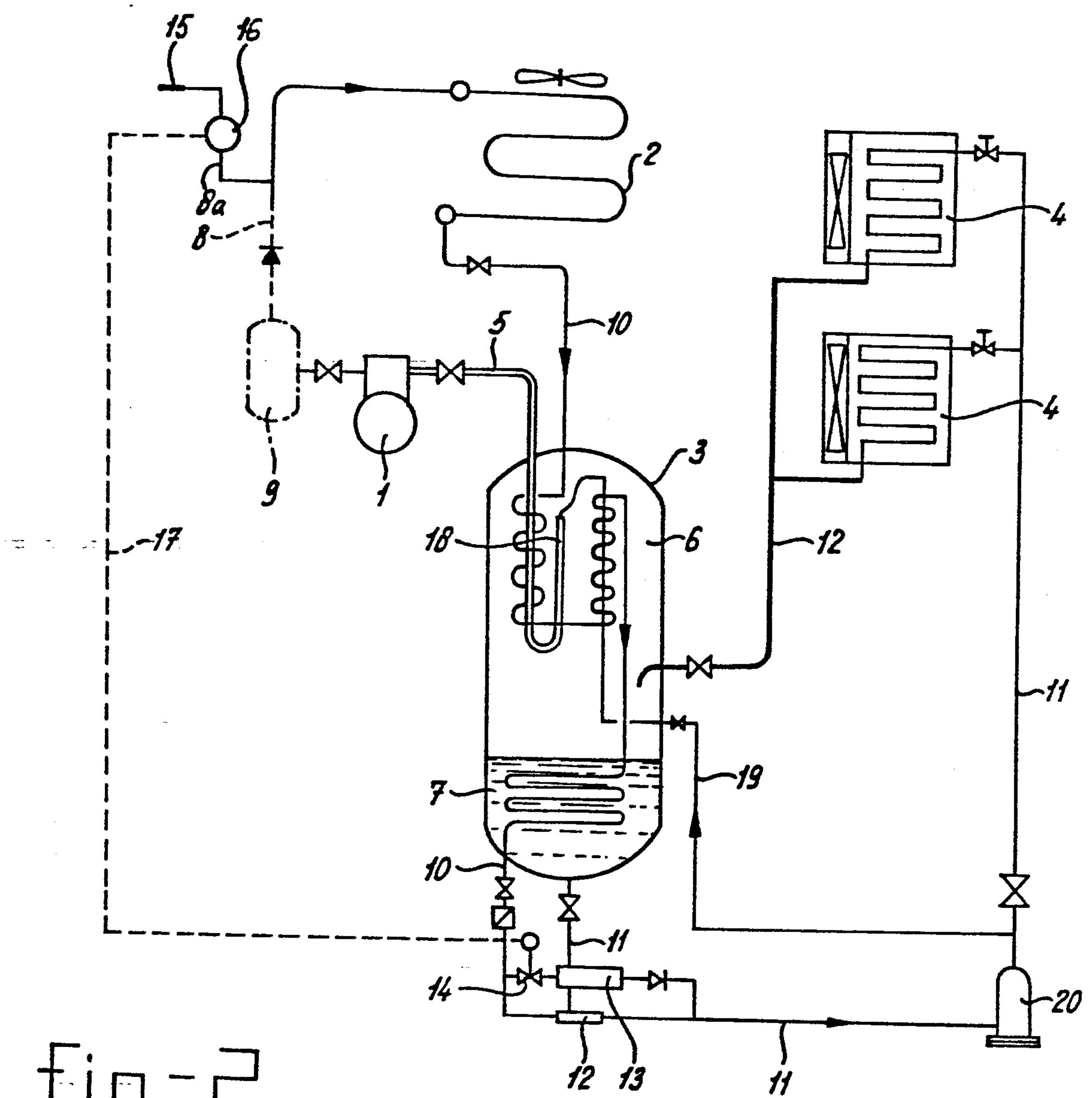


fig-2