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(54) **Refrigeration apparatus**

Kühlvorrichtung

Appareil de réfrigération

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a refrigeration apparatus using a flammable refrigerant.

BACKGROUND ART

[0002] Nonflammable chlorofluorocarbon refrigerants have been conventionally used as refrigerants of refrigeration apparatuses. However, since chlorofluorocarbon refrigerants have a harmful influence on the natural environment, alternative refrigerants have been sought for. Hydrocarbon (HC) refrigerants such as methane, ethane, propane, butane, pentane and the like are attracting our attention as alternative refrigerants replacing said chlorofluorocarbon refrigerants. However, since the HC refrigerants are flammable, a maximum filling amount (150 g) per one refrigeration circuit unit is regulated by law (for example, see Japanese Unexamined Patent Publication No. 2004-198062).

[0003] The publication of the European Patent application EP 1 326 057 A 1 discloses a multi-type refrigerator which executes refrigerating cycles by circulating R32 as refrigerant through a refrigerant circuit including a compressor, a condenser, expansion means and evaporators. In one embodiment, the volume of the condenser is set to be smaller than 0.75 liters.

PROBLEM OF THE PRIOR ART

[0004] In a refrigeration apparatus using a conventional chlorofluorocarbon refrigerant, the filling amount of the refrigerant has a relatively small effect on refrigeration capacity. Thus, a condenser and the like were designed to take precedence over the downsizing of a machine, and no particular consideration was made for the filling amount of the refrigerant. Accordingly, if a construction similar to that of a refrigeration apparatus using a conventional chlorofluorocarbon refrigerant is adopted for a refrigeration apparatus using the above flammable refrigerant, the refrigerant may be filled more than the filling amount regulated by law. Furthermore, a desired refrigeration capacity may not be exhibited if the refrigerant is filled more than the legally regulated amount.

[0005] Accordingly, in view of the above problem inherent in the refrigeration apparatus using the prior art, the present invention was proposed to solve the problem, and an object thereof is to provide a refrigeration apparatus capable of ensuring a desired refrigeration capacity while observing a legal regulation on the filling amount of a flammable refrigerant.

MEANS FOR SOLVING THE PROBLEM

[0006] In order to overcome the above problem and accomplish the desired object, an aspect of the invention

of the present application is directed to a refrigeration apparatus, having a refrigeration circuit comprising a compressor, a condenser, a decompression means and an evaporator each of which is connected by pipes and a flammable refrigerant is circulated therethrough, wherein volume per circuit in the refrigeration circuit is set equal to or smaller than $2200 \times 10^{-6} \text{ m}^3$ and volume of the condenser is set equal to or smaller than $750 \times 10^{-6} \text{ m}^3$.

EFFECT OF THE INVENTION

[0007] According to the refrigeration apparatus of the present invention, a desired cooling capacity is ensured while a legal regulation on the filling amount of a flammable refrigerant is observed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Fig. 1 is a schematic diagram showing an auger-type ice making machine having a refrigeration apparatus according to the first embodiment of the present invention,

Fig. 2 is a front view showing a condenser of the first embodiment,

Fig. 3 is a sectional side view of the condenser of the first embodiment,

Fig. 4 is an enlarged plan view showing an essential part of the condenser of the first embodiment, and

Fig. 5 is a schematic diagram showing an auger-type ice making machine having a refrigeration apparatus according to the second embodiment.

EMBODIMENTS OF THE INVENTION

[0009] Next, preferred embodiments of a refrigeration apparatus according to the present invention are explained with reference to the accompanying drawings. In the following explanation, a refrigeration apparatus in an auger-type ice making machine is illustrated.

FIRST EMBODIMENT

[0010] As shown in Fig. 1, an ice making machine 10 is provided with an ice making mechanism 12 for producing ice and a refrigeration apparatus 30 for refrigerating said ice-making mechanism 12. The ice-making mechanism 12 includes a cylindrical refrigeration casing 14, an auger 16 rotatably arranged inside of said refrigeration casing 14, a driving means (not shown) for rotating said auger 16 and an ice-making water tank 18 for supplying ice-making water to the refrigeration casing 14.

[0011] An evaporator EP which will be described later constituting the refrigeration apparatus 30 is arranged on the outer circumference of the refrigeration casing 14. In the ice-making mechanism 12, the interior of the refrigeration casing 14 is filled with the ice-making water supplied from the ice-making water tank 18 and this refrigeration casing 14 is cooled by the evaporator EP to cause ice to grow on an inner surface (ice-making surface) of the refrigeration casing 14. The auger 16 is rotated by the driving means to scrape off the ice grown on the ice-making surface, convey the scraped ice upward and discharge it to an ice storage chamber (not shown) via a guide 20 provided atop the refrigeration casing 14.

[0012] The refrigeration apparatus 30 includes one so-called vapor compression type refrigeration circuit 34 (see Fig. 1) in which devices such as a compressor CM, a condenser CD to be cooled by a cooling fan FM, an expansion valve EV as a decompression means and an evaporator EP are connected by refrigerant pipes (piping) 32. In the refrigeration apparatus 30, a refrigerant is circulated in a pipe system of the refrigeration circuit 34 by driving the compressor CM and the cooling fan FM. In the refrigeration circuit 34, after the vaporized refrigerant compressed by the compressor CM is condensed and liquefied in the condenser CD, the refrigerant decompressed by the expansion valve EV is allowed to flow into the evaporator EP, where the decompressed refrigerant is expanded and evaporated to cool the refrigeration casing 14 to below the freezing point. The vaporized refrigerant heat-exchanged with the refrigeration casing 14 by the evaporator EP returns to the compressor CM and is circulated in the refrigeration circuit 34 after being compressed again in the compressor CM. In the refrigeration apparatus 30 of the first embodiment, copper pipes are used as the refrigerant pipes 32. Reference numeral 36 in Fig. 1 denotes a drier for removing moisture from the liquefied refrigerant flowing from the condenser CD into the expansion valve EV. Volume per circuit in the refrigeration circuit 34 is set equal to or smaller than $2200 \times 10^{-6} \text{ m}^3$.

[0013] As the refrigerant to be filled into the refrigeration circuit 34, a hydrocarbon (HC) refrigerant such as methane, ethane, propane, butane or pentane or ammonia or the like is employed. These refrigerants have good refrigerant characteristics such as heat of vaporization and saturation pressure. Now, in the first embodiment, isobutane or propane is used.

[0014] As shown in Fig. 1, the condenser CD is of the air-cooled type and disposed in a machine room (not shown) defined inside of the ice making machine 10. The condenser CD is arranged downstream of the compressor CM and upstream of the evaporator EV in the refrigeration circuit 34. Further, outside air taken into the machine room by the cooling fan FM comes into contact with the condenser CD, which then liquefies the high-temperature and highpressure vaporized refrigerant from the compressor CM by heat exchange with the outside air.

[0015] As shown in Figs. 2 and 3, the condenser CD

includes a plurality of heat exchanger units 38, 38 (two units in the first embodiment) each composed of a tube 40 serving as a refrigerant path for permitting the flow of the refrigerant, and a fin 42 extending radially outward from the outer circumference of said tube 40. A so-called spiral fin tube, in which the fin 42 is spirally wound around the outer circumference of the tube 40, is employed as each heat exchanger unit 38 of the first embodiment, and each heat exchanger unit 38 is formed to meander in such a manner that horizontally or substantially horizontally extending straight sections are placed one over another (see Fig. 2).

[0016] In the refrigeration circuit 34, the refrigerant pipe 32 at an upstream side is branched off into as many pipes as the heat exchanger units 38 in the condenser CD, the branched pipes are connected with the respective tubes 40, and the refrigerant pipes 32 connected with the downstream sides of the tubes 40 of the respective heat exchanger units 38 are joined so that one refrigerant tube 32 is connected with the expansion valve EV. Namely, the condenser CD includes two independent refrigerant paths for the respective heat exchanger units 38 and connected in parallel with the refrigeration circuit 34. In the condenser CD, the two systematic heat exchanger units 38, 38 are arranged in front and behind in an air flowing direction in the machine room (see Fig. 2 or 3). In other words, the condenser CD is so arranged that the straight sections of the respective heat exchanger units 38, 38 intersect with the flow of air caused by the cooling fan FM.

[0017] The volume of the condenser CD is set equal to or smaller than $750 \times 10^{-6} \text{ m}^3$. Namely, a total interior volume of the tubes 40 (refrigerant paths) in the two heat exchanger units 38, 38 is the volume of the condenser CD. Thin tubes made of metal having good thermal conductivity such as copper and having a diameter of 1.0 mm to 6.35 mm are employed as the tubes 40. As compared with a conventional refrigeration apparatus having a comparable refrigeration capacity in which volume of a condenser is set at about $1100 \times 10^{-6} \text{ m}^3$, the volume of the condenser CD of the first embodiment is reduced by 30 % or more.

[0018] A fixing means 44 is so formed as to hold the adjacent two heat exchanger units 38, 38 as a pair and so arranged as to hold substantially central parts of the respective heat exchanger units 38, 38 in a lateral direction (extending direction of the straight sections) (see Fig. 2). The fixing means 44 is formed by combining a pair of supporting members 46, 46 arranged to face each other with the adjacent two heat exchanger units 38, 38 located therebetween and holding members 48 provided on the respective supporting members 46 for holding the corresponding heat exchanger units 38 (see Fig. 3). The fixing means 44 tightly holds the adjacent two heat exchanger units 38, 38 in contact by using the holding members 48, 48 respectively provided on the facing supporting members 46, 46. Here, the condenser CD may be such that fin 42 of the other heat exchanger unit 38 are inserted between corresponding fin 42 of one heat exchanger unit

38 to mesh the fins 42 of the both heat exchanger units 38, 38 with each other (see Fig. 4).

[0019] As shown in Figs. 2 and 3, the supporting member 46 is a long plate member whose longer sides extend in a vertical direction and are longer than a vertical dimension of the facing heat exchanger unit 38, so that the supporting member 46 is arranged to vertically extend over the heat exchanger unit 38. Each supporting member 46 is set to have a smaller width than the straight sections of the corresponding heat exchanger unit 38. Further, the respective supporting members 46 are separated in front and behind in the air flowing direction in the machine room and located at the central parts of the straight sections of the corresponding heat exchanger units 38.

[0020] In the first embodiment, a temperature operation-type expansion valve having a temperature-sensitive tube TH is employed as the expansion valve EV. The temperature-sensitive tube TH is mounted on the refrigeration pipe 32 connected with the exit of the evaporator EP and is nearly positioned to the exit of the evaporator EP. The expansion valve EV is opened and closed according to the temperature of the vaporized refrigerant flowing in the refrigeration pipe 32 detected by the temperature-sensitive tube TH and efficiently operates by regulating the pressure of the evaporator EP. Further, the evaporator EP is made of an evaporation pipe 50 spirally provided on the outer circumferential surface of the refrigeration casing 14.

FUNCTION OF FIRST EMBODIMENT

[0021] Next, the function of the refrigeration apparatus 30 according to the first embodiment is explained. The refrigeration apparatus 30 of the first embodiment can suppress a filling amount of a flammable refrigerant required for one refrigeration circuit 34 to or below a specified value by (1) setting the volume per circuit in the refrigeration circuit 34 equal to or smaller than $2200 \times 10^{-6} \text{ m}^3$ and (2) setting the volume of the condenser CD equal to or smaller than $750 \times 10^{-6} \text{ m}^3$. Here, the refrigerant is present in a gaseous state or a liquid state in the refrigeration circuit 34 and a reduction in the volume of the refrigerant in the liquid state largely contributes to a reduction in the filling amount of the refrigerant. The compressor CM, the condenser CD and the evaporator EP can be cited as constituent devices with large volume ratios in the refrigeration circuit 34. However, since the refrigerant is present in the liquid state in the condenser CD, the device that influences the filling amount of the refrigerant most out of the constituent devices is the condenser CD. Namely, the filling amount of the refrigerant in the refrigeration circuit 34 can be reduced more by suppressing the volume of the condenser CD to or below $750 \times 10^{-6} \text{ m}^3$ as in the refrigeration apparatus 30 of the first embodiment than by reducing the volume of the compressor CM or the evaporator EP. Since the condenser CD can be easily changed in shape as compared with

the compressor CM having a driving mechanism and the evaporator EP needed to conform to the refrigeration casing 14, costs required for a volume change can be suppressed.

[0022] The refrigeration apparatus 30 of the first embodiment can avoid the filling of the refrigerant more than the specified value into the refrigeration circuit 34 by setting the volumes of the refrigeration circuit 34 and the condenser CD as described above. Thus, the refrigeration apparatus 30 can ensure a desired refrigeration capacity even if the volumes of the refrigeration circuit 34 and the condenser CD are reduced. Note that the use of an HC refrigerant in a refrigeration apparatus having a refrigeration capacity of 300 W or lower is generally said to be possible. However, a refrigeration capacity equal to or higher than 300 W and equivalent to that of 650 W can be ensured per one refrigeration circuit 34 by setting the volumes of the refrigeration circuit 34 and the condenser CD as described above. Theoretically, even if the filling amount of the refrigerant is equal to or smaller than the legally regulated value, a refrigeration capacity equivalent to 1300 W can be obtained from one refrigeration circuit 34.

[0023] In the refrigeration apparatus 30 of the first embodiment, the volume of the condenser CD is reduced by narrowing the tubes 40 constituting the refrigerant paths in the condenser CD. In this condenser CD, if the tubes 40 are set to be narrow, a pressure loss of the refrigerant paths increases and also a heat exchange area decreases, wherefore a condensation capacity decreases. However, by separately arranging the heat exchanger units 38, 38 in parallel in two systems, the condenser CD of the first embodiment can ensure a heat exchange area without increasing lateral or vertical dimensions of the individual heat exchanger units 38, 38. Further, the condenser CD can have a compact construction as a whole. In addition, since the two heat exchanger units 38, 38 are connected in parallel with the refrigeration circuit 34 in the condenser CD of the first embodiment, lengths of the tubes 40 of the individual heat exchanger units 38, 38 can be shortened and the refrigerant in the refrigerant paths can be smoothly circulated by reducing the pressure loss. Thus, even if the volume of the condenser CD of the first embodiment is reduced by narrowing the tubes 40, a required condensation capacity can be ensured.

[0024] Since the condenser CD is so constructed that parts of the straight sections of the heat exchanger units 38, 38 are held by the fixing means 44, areas of the heat exchanger units 38, 38 covered by the fixing means 44 can be made smaller as compared with the case where curved sections of the heat exchanger units are held. Namely, in the condenser CD, the flow of air through the heat exchanger units 38, 38 is not hindered by the fixing means 44 and the curved sections are also effectively utilized, wherefore heat exchange efficiency in the respective heat exchanger units 38, 38 can be improved. Further, since the fixing means 44 is for holding the heat

exchanger units 38, 38 while vertically displacing one heat exchanger unit 38 and the other heat exchanger unit 38, air can be properly brought into contact with the straight sections of the other heat exchanger unit 38 exposed between the straight sections of the one heat exchanger unit 38 and heat exchange can be more efficiently performed.

SECOND EMBODIMENT

[0025] Although the refrigeration apparatus 30 of the first embodiment includes one refrigeration circuit 34, a plurality of refrigeration circuits may be provided. A refrigeration apparatus 60 of a second embodiment shown in Fig. 5 includes two refrigeration circuits 34, each of which is mutually independent. Each refrigeration circuit 34 of the second embodiment includes a compressor CM, a condenser CD, an expansion valve EV and an evaporator EP, each of which are connected by refrigerant pipes 32 and has a similar construction to the refrigeration circuit 34 of the first embodiment. However, in an auger-type ice making machine 11 including the refrigeration apparatus 60 of the second embodiment, since the evaporators EP of the respective refrigeration circuits 34 are provided in a refrigeration casing 14, two evaporators EP are provided on the outer circumference of the refrigeration casing 14. Further, volume per circuit in each refrigeration circuit 34 of the second embodiment is set equal to or smaller than $2200 \times 10^{-6} \text{ m}^3$, and volume of the condenser CD is set equal to or smaller than $750 \times 10^{-6} \text{ m}^3$.

[0026] Since a filling amount of a flammable refrigerant per one refrigeration circuit is legally regulated, the two refrigeration circuits 34 are mutually independent in the refrigeration apparatus 60 of the second embodiment. Also, since the volume per circuit is set equal to or smaller than $2200 \times 10^{-6} \text{ m}^3$ and the volume of the condenser CD is set equal to or smaller than $750 \times 10^{-6} \text{ m}^3$ for each refrigeration circuit 34, the filling amount of the flammable refrigerant required for each refrigeration circuit 34 can be suppressed to or below a specified value. In addition, by providing the two refrigeration circuits 34, 34, the refrigeration apparatus 60 can increase its refrigeration capacity as a whole and cope with the large-size ice making machine 11. Further, an operation of the refrigeration apparatus 60 can be changed to a refrigeration operation using the both refrigeration circuits 34, 34 and that using only one refrigeration circuit 34, so that the refrigerating capacity can be controlled in a stepwise manner. Therefore, if one refrigeration circuit 34 breaks down, the other refrigeration circuit 34 can be used as a backup means.

MODIFICATIONS

[0027] The present invention is not limited to the constructions of the above embodiments and may be modified as follows.

- (1) The refrigeration apparatus is also applicable to so-called storages such as refrigerators, freezers, refrigerator-freezers, showcases and prefabricated structures, air-conditioning equipments and the like.
- (2) The expansion valve is used as a decompression means in the above embodiments, but a capillary tube may be employed.
- (3) The condenser including two refrigerant paths is taken as an example in the above embodiments, but the condenser may include three or more refrigerant paths.
- (4) The example of providing two refrigeration circuits is described in the second embodiment, but three or more refrigeration circuits may be provided.

Claims

1. A refrigeration apparatus, having a refrigeration circuit (34) comprising a compressor (CM), a condenser (CD), a decompression means (EV) and an evaporator (EP) each of which is connected by pipes (32) and a flammable refrigerant is circulated there-through, wherein:

a volume per circuit in the refrigeration circuit (34) is set equal to or smaller than $2200 \times 10^{-6} \text{ m}^3$;

a volume of the condenser (CD) is set equal to or smaller than $750 \times 10^{-6} \text{ m}^3$,

wherein the condenser (CD) includes a plurality of heat exchanger units (38) connected in parallel, **characterized in that** each heat exchanger unit (38) is composed of a tube (40) serving as a refrigerant path and a fin (42) extending radially outward from an outer circumference of the tube (40), said fin (42) being spirally wound around the outer circumference of said tube (40),

wherein each heat exchanger unit (38) is formed to meander in such a manner that straight sections are placed one over another, and

wherein the condenser (CD) is such that the fin (42) of another heat exchanger unit (38) is inserted between the corresponding fin (42) of one heat exchanger unit (38) to mesh the fins (42) with each other.

2. The refrigeration apparatus according to claim 1, comprising a plurality of refrigeration circuits (34).
3. The refrigeration apparatus according to claim 1 or 2, wherein the condenser (CD) includes a plurality of refrigerant paths arranged in parallel.

Patentansprüche

1. Kühleinrichtung, die einen Kühlkreis (34) hat, der einen Kompressor (CM), einen Kondensator (CD), ein Dekompressionsmittel (EV) und einen Verdampfer (EP) aufweist, die alle durch Rohre (32) verbunden sind, und durch die ein entflammbares Kältemittel zirkuliert, wobei ein Volumen pro Kreis in dem Kältemittelkreis (34) gleich oder kleiner als $2200 \times 10^{-6} \text{ m}^3$ gewählt ist; ein Volumen des Kondensators (CD) gleich oder kleiner als $750 \times 10^{-6} \text{ m}^3$ gewählt ist, wobei der Kondensator (CD) eine Mehrzahl von Wärmetauschereinheiten (38) enthält, die parallel verbunden sind, **dadurch gekennzeichnet, dass** jede Wärmetauschereinheit (38) aus einem Rohr (40), das als ein Kältemittelpfad dient, und einer Rippe (42), die sich von einem äußeren Umfang des Rohrs (40) radial nach außen erstreckt, wobei die Rippe (42) spiralförmig um den äußeren Umfang des Rohrs (40) gewunden ist, zusammengestellt ist, wobei jede Wärmetauschereinheit (38) gebildet ist, sich in einer solchen Weise zu schlängeln, dass gerade Abschnitte übereinander platziert sind, und wobei der Kondensator (CD) so ist, dass die Rippe (42) einer anderen Wärmetauschereinheit (38) zwischen die entsprechende Rippe (42) der einen Wärmetauschereinheit (38) eingebracht ist, so dass die Rippen (42) ineinander eingreifen.
2. Kühleinrichtung gemäß Anspruch 1, eine Mehrzahl von Kühlkreisen (34) aufweisend.
3. Kühleinrichtung gemäß Anspruch 1 oder 2, wobei der Kondensator (CD) eine Mehrzahl von parallel angeordneten Kältemittelpfaden enthält.

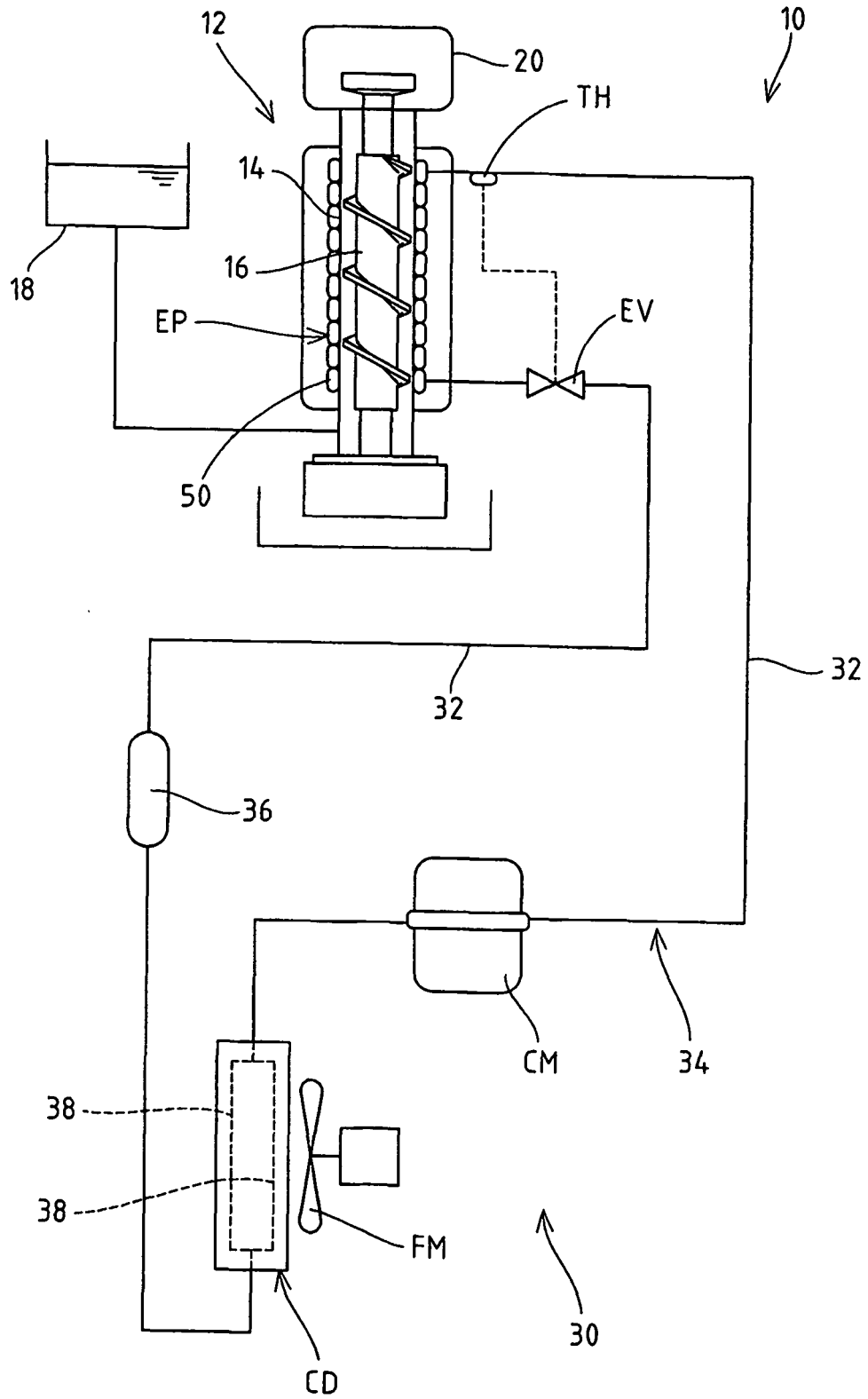
Revendications

1. Appareil de réfrigération ayant un circuit de réfrigération (34) comprenant un compresseur (CM), un condensateur (CD), un moyen de décompression (EV) et un évaporateur (EP), dont chacun est raccordé par des tuyaux (32) et on fait circuler un réfrigérant inflammable à travers ces derniers, dans lequel :
un volume par circuit, dans le circuit de réfrigération (34) est égal ou inférieur à $2200 \times 10^{-6} \text{ m}^3$;
un volume du condensateur (CD) est égal ou inférieur à $750 \times 10^{-6} \text{ m}^3$,
dans lequel le condensateur (CD) comprend une pluralité d'unités d'échangeur de chaleur (38) raccordées en parallèle, **caractérisé en ce que** chaque unité d'échangeur de chaleur (38) est composée d'un tube (40) servant de trajec-

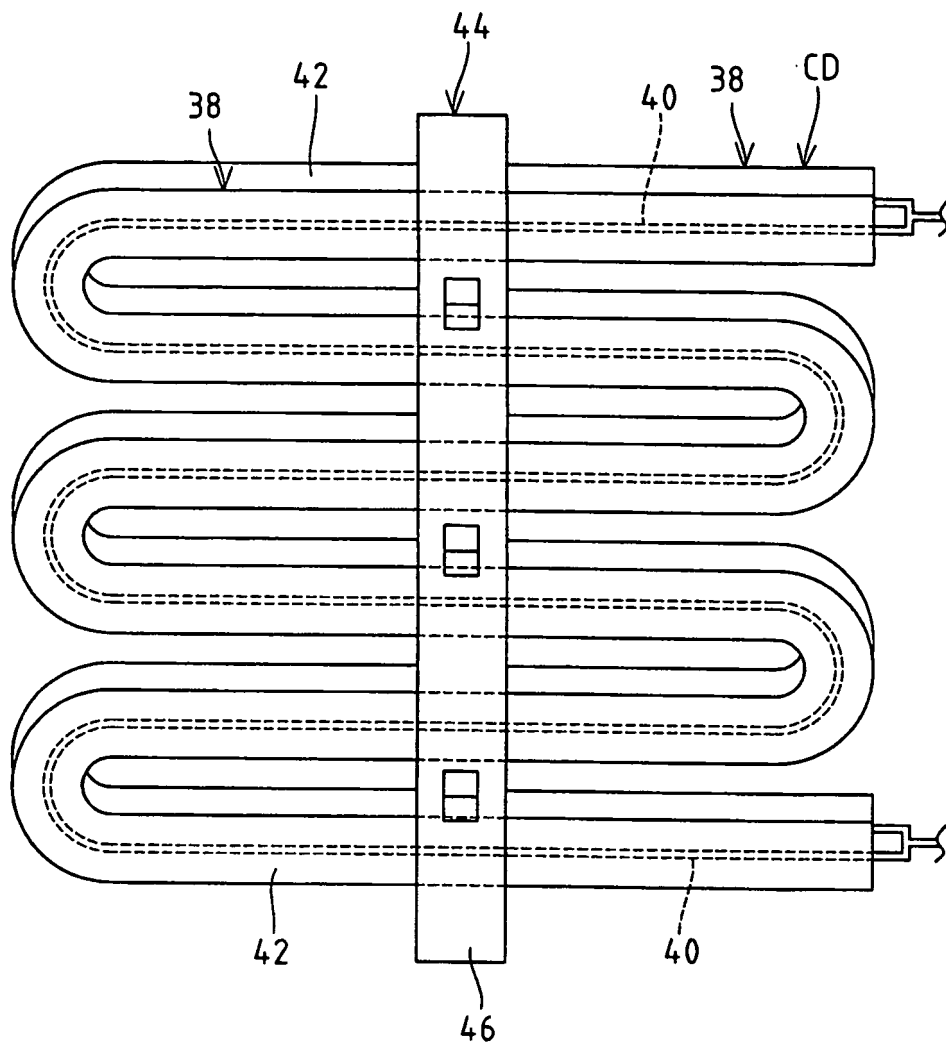
toire de réfrigérant et d'une ailette (42) s'étendant radialement vers l'extérieur à partir d'une circonférence externe du tube (40), ladite ailette (42) étant enroulée en spirale autour de la circonférence externe dudit tube (40), dans lequel chaque unité d'échangeur de chaleur (38) est formée pour décrire des méandres de sorte que des sections droites sont placées les unes sur les autres, et dans lequel le condensateur (CD) est tel que l'aillette (42) d'une autre unité d'échangeur de chaleur (38) est insérée entre l'aillette (42) correspondante d'une unité d'échangeur de chaleur (38) pour engrener les ailettes (42) les unes avec les autres.

2. Appareil de réfrigération selon la revendication 1, comprenant une pluralité de circuits de réfrigération (34).
3. Appareil de réfrigération selon la revendication 1 ou 2, dans lequel le condensateur (CD) comprend une pluralité de trajectoires de réfrigérant agencées en parallèle.

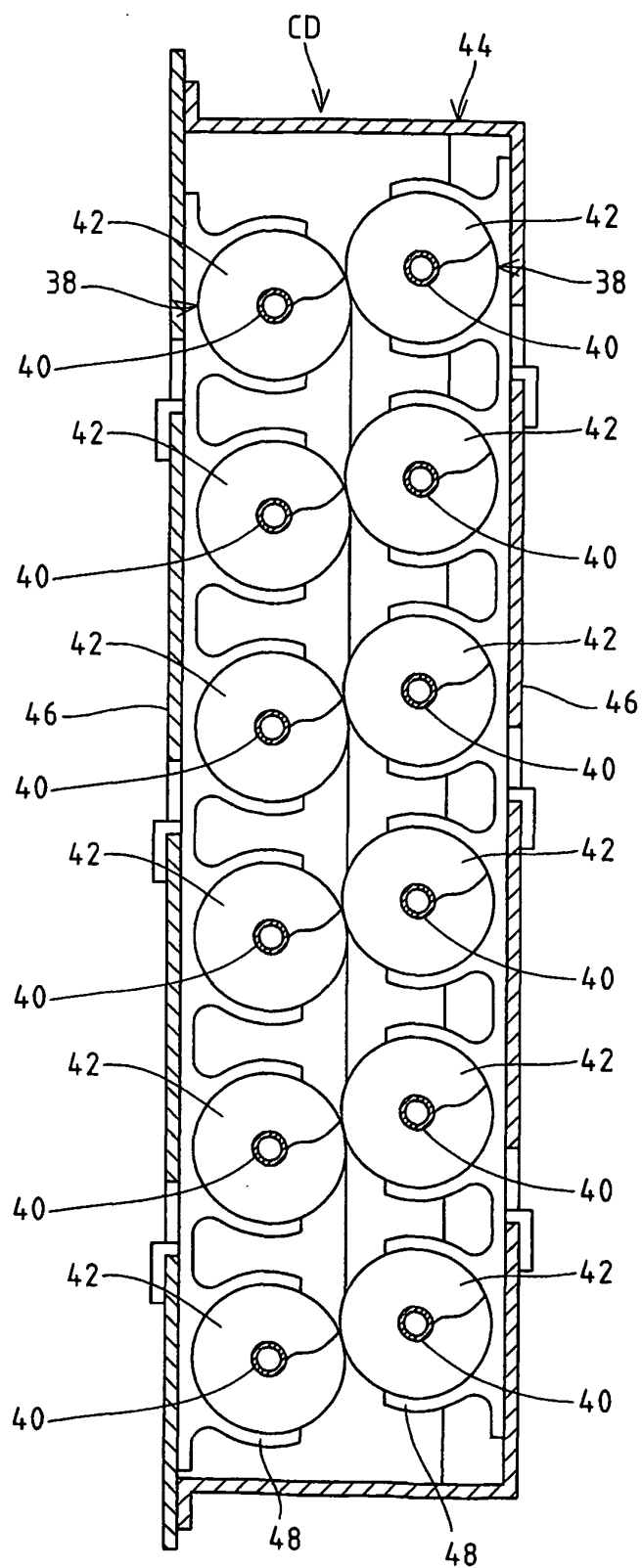
F i g . 1



F i g . 2



F i g . 3



F i g . 4

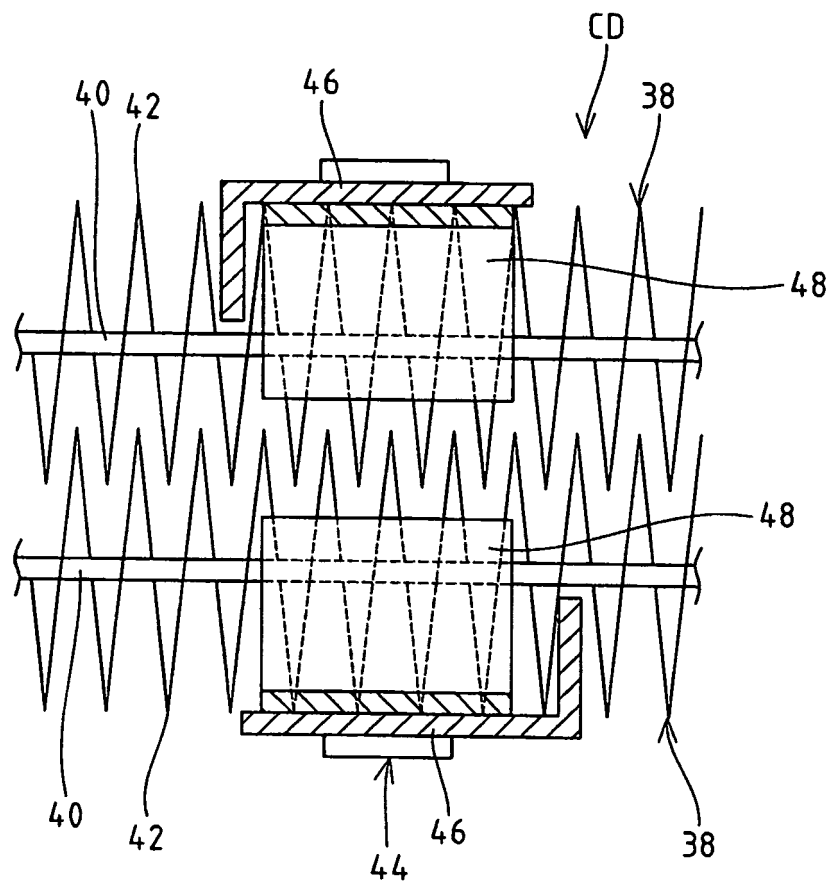
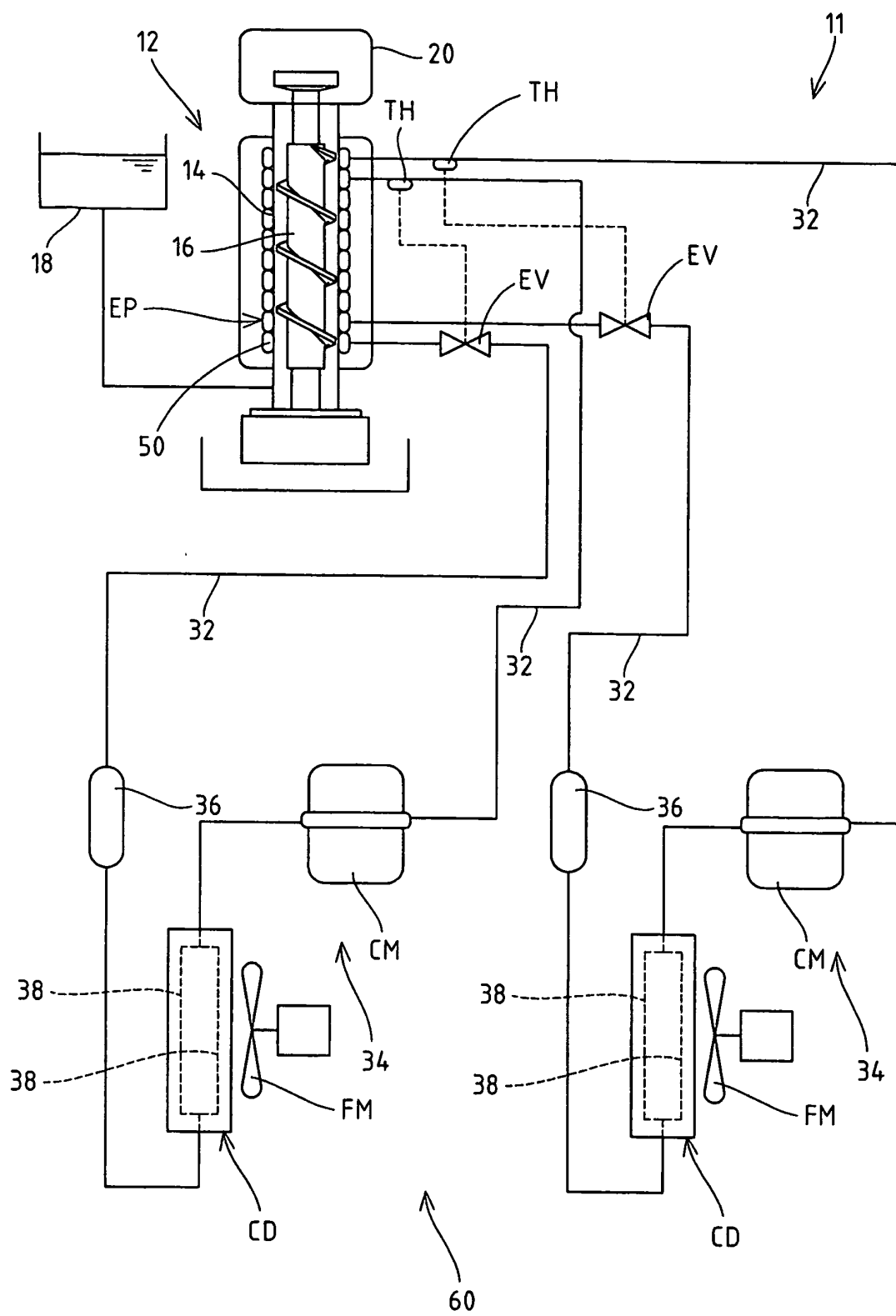


Fig. 5



REFERENCES CITED IN THE DESCRIPTION

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