The present invention relates to refrigerating machines, and more particularly to refrigerating machines of the compression type.

In order to allow a refrigerating machinery of the compression type to operate at acceptable efficiencies in the event of a great difference between the condensing temperature and the evaporating temperature is is necessary to effect the compression in two or more stages. Hitherto known refrigerating machineries of this type in which two compression stages are used, comprise as a rule either two compressors or a single special compressor the volume of stroke of which is afforded by a high pressure cylinder or cylinders and a low pressure cylinder or cylinders. An example of such a well known refrigerating machinery having two compressors is diagrammatically illustrated in Fig. 1 of the accompanying drawings. Referring to this figure, the reference character H indicates the high pressure compressor, L is the low pressure compressor, HF is the evaporator of the high pressure system, and LF is the evaporator of the low pressure system. The two pressure systems are connected in cascade, the evaporator HF of the high pressure system cooling the condenser of the low pressure system, while the evaporator LF of the low pressure system yields the cooling effect desired.

The present invention has for its object to provide a refrigerating machinery of the compression type or a heat pump unit, the characteristic feature of which resides in the use of a single compressor alternately operating as a high pressure compressor and a low pressure compressor if more than two compressor stages are used). Thus, in other words, the invention resides in replacing the well-known division of the compression on space basis by a division of the compression on time basis.

A comparison between a plant according to this invention and a well-known plant, such as, for instance, the cascade coupled two-stage plant above mentioned, shows amongst others that the refrigerating capacity will be the same in both cases provided the total volumes of stroke are equal in both cases. It is thus seen that the relation between the running periods of the plant according to the invention will correspond to the relation between the volumes of stroke of the high and low pressure compressors of the well-known plant. In addition, it will be found that the average power consumption will be the same for both plants.

It is thus seen that under the conditions above mentioned the invention affords a plant equivalent with a well-known plant having two compressors but only requiring a single compressor of standard type. This in its turn permits a considerable reduction of the cost of erection of the plant and a more simple control as compared with a unit having two separate compressors or a special type of two stage compressor.

The invention is illustrated by some examples in Figs. 2-5 of the accompanying drawings. Fig. 2 is a diagrammatic view of a principal scheme for an intermittently operating two stage machinery according to the invention. Fig. 3 is a working diagram for the unit shown in Fig. 2. Fig. 4 is a diagrammatic view of a fully automatic refrigerating unit according to the invention. Fig. 5 is a diagrammatic view of a heat pump unit to which the present invention has been applied.

With reference to Fig. 2, the reference numeral I indicates the compressor, which may be of standard type, as hereinafter stated. Extending from the compressor is a circulation conduit 2 leading to the condenser coil 3, from there via an expansion valve 4 to an evaporator coil 5 and thence via a shut off valve 6 back to the compressor. Inserted in a shunt pass said valve 4 is a shut off valve 7 and inserted in a shunt past valve 6 is a second evaporator coil 8 between an expansion valve 9 in front of the coil and a shut off valve 10 behind the coil. The evaporator coil 5 is located in a heat insulated receptacle A and the evaporator coil 8 is disposed in a heat insulated receptacle B.

This refrigerating unit operates in two time spaced stages, hereinafter referred to as the high pressure stage and the low pressure stage, respectively. In the high pressure stage the shut off valves 7 and 10 are closed and the shut off valve 6 is open.

The compressor pumps hot high pressure gas into the coil 3, where the gas condenses. The liquid resulting passes through the expansion valve 4 and evaporates in coil 5. The evaporated refrigerant is drawn back to the compressor via valve 6. After the heat magazine A is cooled to a temperature about midway between the condensing temperature and the evaporating temperature desired in the low pressure stage, the low pressure stage starts.

Shifting to the low pressure stage is effected by opening the valves 7 and 10 and closing the valve 6. The compressor I forces the evaporated refrigerant through coil 3 and via valve 7 to coil 5 now acting as a condenser. The condensate
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passes through the expansion valve $9$ to coil $3$ located in the insulated receptacle $B$. In coil $8$ the refrigerant evaporates in coil $8$ located in the insulated receptacle $B$. As soon as this way the magazine $A$ has received a predetermined amount of heat shifting to the high pressure stage is effected, followed after a predetermined time by a shifting back to the low pressure stage, and so on. It is then seen that the heat is pumped from $B$ to $A$ and thence to the condenser $3$ which delivers its heat contents to air or cooling water.

The relation between the durations of the periods at a given condensing temperature in the condenser $3$ and a given evaporating temperature in the evaporator $3$ is determined substantially by the average temperature prevailing in the heat magazine $A$. The real duration of the period depends on the heat capacity of the insulated volumes $A$ and $B$ and the allowable variations of temperature therein. In order to obtain within a small volume a sufficient heat capacity the coils $5$ and $8$ may be immersed in a brine of such a concentration as to allow accumulation of cold by ice production. In connection with the receptacle $B$ incoming and outgoing contents are indicated at $11$ and $12$, respectively. In Fig. 2, belonging to a conduit for passing brine between a cooling place and the receptacle $B$.

If an eutectic brine is used, then an approximately constant temperature may be obtained in the magazines $A$ and $B$.

Fig. 3 shows a TS-diagram for indicating the changes of state during the two working stages appearing at the plant shown in Fig. 2, and a similar diagram is obtained in case of a well-known plant in cascade connection; it is thus seen that the plant according to the invention from a thermodynamic point of view is equivalent to the well-known plant.

In order to reduce the leakage of heat through the insulations it is preferred to arrange the receptacle $A$ concentrically around the receptacle $B$, so that $B$, which affords the lowest temperature will be in the centre. Fig. 4 illustrates such a unit and also shows an example of an automatic plant.

In Fig. 4 the same reference characters are used as in Fig. 2 to indicate elements common to both plants. It is assumed that, for the rest, the system shown in Fig. 4 may be best understood from a description of its operation which is, principally, equal to that described in connection with Fig. 2.

A thermostat $13$ is adjusted to maintain the temperature in $A$ between two predetermined limits. When the machinery operates on the low pressure stage the flow of the refrigerant takes place as indicated by the full arrows. As a result, the magazine $A$ is heated and the magazine $B$ is cooled. As soon as the temperature in $A$ reaches the upper limit for which the thermostat $13$ is adjusted, the thermostat operates the solenoid valves $7$ and $8$ for shifting to the high pressure stage, during which the flow of the refrigerant takes place in the direction indicated by the dotted arrows. During the high pressure stage the magazine $A$ is cooled, and this continues until the temperature in $A$ reaches the lower limit determined by the thermostat which then controls shifting to the low pressure stage.

Also in respect of the magazine $B$ a thermostat $14$ is provided for maintaining the temperature in $B$ within the limits desired. Said thermostat $14$ controls the magnet valve $10$. If the temperature in $B$ rises beyond the predetermined upper limit, then the thermostat opens valve $10$; if the temperature in $B$ falls below the predetermined lower limit, the thermostat closes valve $10$.

It is to be noted, however, that the thermostat $14$ and the valve $10$ are required only if an exact adjustment of the temperature in $B$ is desired, since a high and low pressure relay $15$ for shifting and stopping the shading controls the temperature prevailing in the magazine $B$.

In addition to the elements above referred to, the unit shown in Fig. 4 includes a motor $16$ for driving the compressor $1$ and a rheostat $17$ for this motor. Furthermore, an oil separator may be inserted in the conduit $2$ behind the compressor, as indicated at $18$.

Instead of effecting the shifting between the low pressure stage and the high pressure stage by means of thermostat controlled valves, as hereinbefore described with reference to Fig. 4, other controlling mechanisms may be used, as for instance, a time clock, which effects shifting from one pressure stage to another at certain predetermined intervals. Another expedient is to utilize the variations of the evaporating pressures for determining limits by the aid of pressure relays or magnet valves.

In a refrigerating machine heat is absorbed at low temperature in the evaporator and pumped to a higher temperature level where the same amount of heat together with the heat produced by the compression is supplied to the condenser.

If, instead of the cooling effect obtained in the evaporator it is desired to utilize the heat effect obtained in the condenser, the plant is generally termed a heat pump. As there is no difference of principal nature as regards the operation of those two kinds of machinery, it is evident that the invention may also be applied to heat pumps. An example of such a plant is illustrated in Fig. 5 in a diagrammatic way similar to that used in Fig. 2.

In Fig. 5 the numeral $1$ indicates the compressor of the plant. Leading from said compressor is a conduit $2$ which extends to and through the condenser $3$ and from there via an expansion valve $4$ to the evaporator coil $5$, from where the conduit via the shut off valve $6$ leads back to the compressor. As in Fig. 2 an evaporator coil $3$ is inserted in a shunt past valve $6$, said shunt also containing an expansion valve $9$ in front of said coil and a shut off valve $10$ behind the coil. In this case coil $5$ is positioned in an insulated tank $B$ which represents a heat magazine, and coil $8$ is positioned in a magazine $A$ which may comprise some suitable source of heat, for instance, sea or river water.

During the low pressure stage heat is pumped by the compressor from the source of heat $A$ directly through an additional conduit $20$ into the coil $5$ in the heat magazine $B$, as indicated by the full arrows. During the high pressure periods the flow takes place in the direction indicated by the dotted arrows. It is thus seen that the heat is pumped from source $A$ via magazine $B$ to the condenser $3$ where the heat of the warm water is recovered to be used for heating purposes, as for instance, by means of radiators for room heating.

If in case of heat pumps for room heating purposes the intermediate temperature in the magazine $B$ is adjusted to a value approximately equal to that of the room temperature (the tank $B$ may be assumed to be located in a cellar having a temperature approximately equal to the
room temperature) the losses to which the heat magazine B may be subjected may be, practically, fully eliminated. The heat magazine may, if built in a suitable size, be utilized for equalizing of variations of load.

What I claim is:

In refrigerating machinery of the compression type for operation at two pressure stages, the combination of a compressor for alternate operation as a low pressure compressor and as a high pressure compressor during successive periods, a circulation system for the refrigerant acted on by the compressor, two evaporators included in said circulating system, one for each pressure stage, two concentric cold magazines concentrically surrounding each other, the inner magazine being provided for enclosing the evaporator belonging to the low pressure stage and for storing the cold developed during said stage, the outer magazine being provided for enclosing the evaporator belonging to the high pressure stage and for storing the cold developed during said high pressure stage, and means adapted upon the shifting from the high pressure stage to the low pressure stage by setting the evaporator of the low pressure stage into operation, to effect a simultaneous setting of the evaporator of the high pressure stage into operation to act as a condenser for the low pressure stage.

TORE BRANDIN.

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