

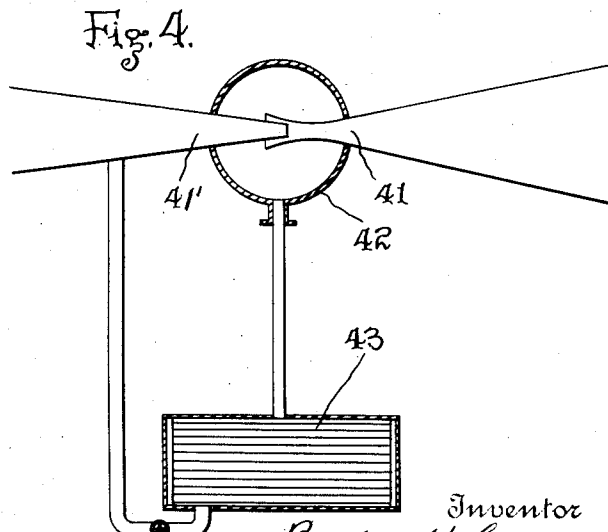
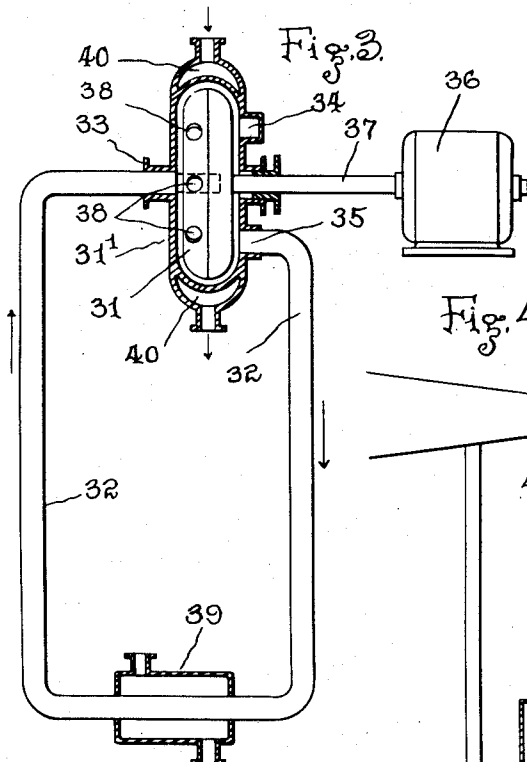
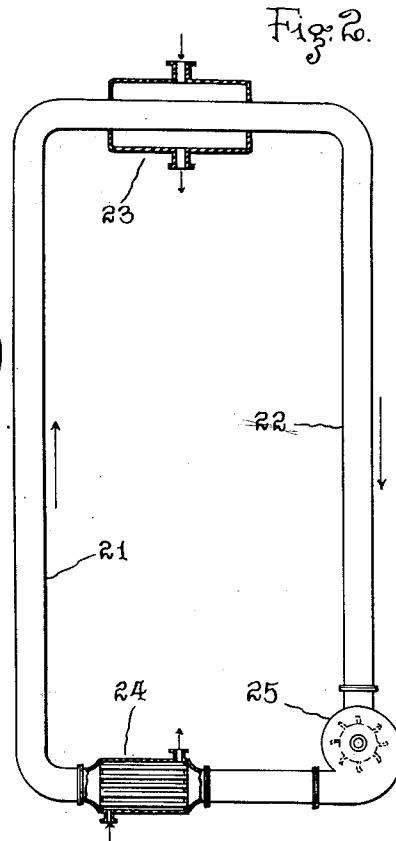
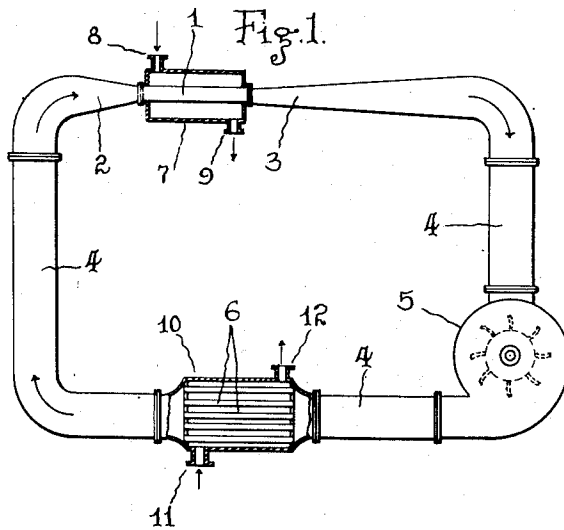
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ART OF REFRIGERATION

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UNITED STATES PATENT OFFICE

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ART OF REFRIGERATION.

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To all whom it may concern:

Be it known that I, BARTON H. COFFEY, a citizen of the United States, and resident of the city of New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Art of Refrigeration, of which the following is a specification.

My invention relates to improvements in the art of refrigeration and particularly to the compression method of refrigeration in which is employed the evaporation of liquids to effect the heat flow. In this method the refrigerating liquid such as sulphur dioxide, ammonia, carbonic acid or the like at a given temperature and corresponding pressure flows directly into a lower pressure and corresponding temperature, evaporation takes place at this temperature, the required heat being drawn from the liquid or medium, and the cooling body, thus lowering their temperatures. The vapor formed is then compressed and condensed to the original pressure and temperature, the heat being absorbed by the cooling water. The cycle thus reveals a closed circuit of refrigerating liquid and vapor in contact but not mixed, one section of which is kept at a high pressure, and the other at a low pressure accompanied by two heat currents at different thermometric levels and in opposite directions, i. e. at the lower level the heat current passes into the refrigerating liquid and at the higher pressure the heat current passes from it, all of which is in conformity with the recognized laws of thermodynamics.

Though rotary compressors have been proposed the compression in the cycle has heretofore, to my knowledge, been accomplished only with reciprocating compressors of various types possessing the complications and objections inherent in devices of this character. The expansion has generally been through orifices or cocks which divide the circuit and direct from the high to the low pressure sections, thus losing the external energy possessed by the expanding vapor.

The object of my invention is to eliminate the compressor expansion cock and divided circuit to save the energy of the expanded vapor, thus producing the Carnot cycle and to attain the desired effect by gradually producing the required variation of pres-

sure and temperature in an undivided closed circuit of refrigerating liquid and vapor (which thus itself performs the compressing function) enclosed in a conduit free from valves, expansion cocks and compressors. I attain this object by either of the several optional forms of my device illustrated in the accompanying drawings but modifications may be made therein without departing from the spirit of my invention.

Referring to the drawings: Figure 1 is the preferred form of a device embodying my invention.

Figure 2 is an optional form of a device embodying my invention.

Figure 3 is a further optional form of the same, and

Figure 4 is an optional form of a detail of the cooling section of the device shown in Figure 1.

Similar characters refer to similar parts throughout the several views.

In the optional form of my device illustrated in Figure 1, I present a method of applying to the art of refrigeration the theorem that in a continuous conduit through which liquid and vapor is flowing adiabatically, the sum of the heat energy and kinetic energy at every section is constant, in other words, variations of pressure and temperature may exist of a magnitude corresponding to variations in velocity which in turn can be produced by variations in the area of successive cross sections of the conduit. As is obvious, the conduit may be a closed circuit without affecting this law, and if a centrifugal or other type of pump be introduced in the conduit to overcome frictional resistances and supply energy equivalent to the net work of adiabatic compression, the circulation becomes continuous and it is apparent that if low temperature heat is absorbed at the low pressure point of the circuit and if it, plus the heat of adiabatic compression, is discharged at the high pressure point a refrigerating cycle of the compression type results.

Referring to the drawings, application of the principles above described is shown diagrammatically in Figure 1 in which the conduit containing the closed circuit of refrigerating liquid comprises the evaporation throat or section 1, the converging nozzle 2, the diverging nozzle 3, connecting piping 4,

a centrifugal or other suitable circulating pump 5 and cooler tubes 6. A brine cooler 7 with an admission port 8 and discharge port 9 surrounds the throat 1 and in the space within the cooler 7 the brine circulates. The cooler tubes 6 of any desired type are contained in a cooler or casing 10 which is provided with an admission port 11 and a discharge port 12 for cooling water in the usual manner. The circulating pump 5 is of any desired design capable of circulating the cooling medium in the system.

In this form of the device the conduit in operation will be filled with the refrigerating liquid or medium, and all air expelled from the conduit, and a uniform pressure corresponding to the temperature will then exist while the refrigerating liquid is at rest. A small quantity of the liquid or medium is then drawn off, and the refrigerant will evaporate to immediately fill the space thus created with vapor at this temperature. The refrigerating fluid or medium will be circulated by the operation of a pump 5 and the water and brine in the coolers 6 and 7 respectively will also be set in motion. The minimum pressure will be created at the throat section 1 which is the zone of maximum velocity and minimum pressure, and the initial vapor will be swept along by the current of refrigerating liquid compressed in the zone of higher pressure and condensed while passing through the cooler 10. The space thus left will be filled by evaporation in the throat by reason of the heat supplied by the brine cooler 7, the bubbles of vapor thus formed will be carried along by the current and compressed and condensed as before, thus forming a continuous refrigerating cycle as above described.

In the optional form of the device illustrated in Figure 2, I make application of the hydraulic principle that the pressure in a column of liquid varies directly with the height of the column.

In the form shown in Figure 2, 21 and 22 are the risers, 23 is the brine cooler or source of heat, and 24 is a condenser of any desired type. A pump 25 is provided in the system. It is obvious that any desired hydraulic pressure can be attained in the condenser 24 by extending the height of the risers 21 and 22 and that the hydraulic pressure at the brine cooler 23 will be zero. The circuit is filled with refrigerating liquid or medium to a point where there is left only sufficient space to permit evaporation. Any desired type of brine cooler 23 and condenser 24 may be used. The circulation of the refrigerating liquid or medium is maintained by means of the pump 25 and the addition and subtraction of heat is attained as above described.

In the optional form of device illustrated

in Figure 3, I attain the compression desired by the use of centrifugal force in a rotating member 31, the force varying directly with the mass and square of lineal velocity and inversely as the radius of curvature. In this form of the device I provide in a conduit or pipe 32, a circular casing 31' having an axial inlet port 33 and an annular discharge chamber 34 from which the refrigerating medium is discharged at the port 35 to the conduit 32. The rotating mass of liquid in the rotating member 31' can thus be made to show within itself any reasonable variations of pressure from center to circumference.

The refrigerating liquid or medium enters the rotating member 31 at its axis or point of zero pressure 33. The rotating member 31 is preferably in the form of a bladed rotor driven by a motor 36 through the medium of a shaft 37, and is preferably provided with suitable discharge orifices 38 through which connections are made with the annular discharge chamber 34. The circuit of the cooling medium is through the pipe 32 and the brine cooler of any desired type 39, to the axial admission port 33 in the rotating member 31 and thence through the orifices 38 to the annular chamber 35 from which it is again discharged into the pipe 32. Within the casing 31' I provide a circumferential annular space or chamber 40 surrounding the rotating member 31' through which cooling water circulates, thus constituting the chamber 40 a condenser.

The system is supplied with refrigerating liquid and the rotor 31 set in motion, the liquid within the rotor will be rotated producing compression by centrifugal force which will progressively increase from the center of the rotor to its periphery, thus setting up various pressures within the body of the liquid. As the liquid leaves the rotor or compression chamber at the discharge port 35, positioned near the circumference, the pressure at that point will be greater than at the axial port of entry, whereby a circulation will be established in the circuit. If a small portion of the liquid is withdrawn, space will be provided for evaporation, and heat supplied by the cooler 39 will be drawn off by the condenser 40 and a refrigerating cycle results as above described.

In the form of the device illustrated in Figure 3 the circulation pump and condenser are combined but it is obvious that the pressure producing apparatus and the circulation pump can be separated as described above or in any other suitable manner.

The fundamental principle of these methods is essentially identical, consisting broadly in setting up various pressures in an integral body of refrigerating liquid in mo-

tion, supplying low temperature heat to the system at the points of low pressure and withdrawing high temperature heat at points of high pressure, the liquid serving as a transporting agent to move the vapor thus formed from point to point and to compress it all in exact accordance with the theoretical compression refrigeration cycle. In my system the heat transfer surfaces, the pressures and the brine temperature, the cooling water, and the refrigerating liquid circulation will all be so proportioned to the quantity of low temperature heat supplied and its temperature, that the refrigerating liquid leaving the condenser will be entirely free from vapor in suspension, at or below the temperature corresponding to the maximum pressure in the system, in other words, the heat in the liquid leaving the condenser will be in the sensible form only. As the liquid passes on, the pressure grows less and vapor will form, withdrawing heat from the liquid in the latent form in sufficient quantity to make pressures and temperatures conform arriving at the brine cooler with minimum pressure and corresponding temperature, heat will be received at constant temperature accompanied by a proportionate formation of vapor containing latent heat in quantity to balance that received. As the liquid passes on it enters the zones of increasing pressure with this added quantity of vapor in suspension.

Referring now to the optional form of the device shown in Figure 2, which is the simplest embodiment of the system, it is obvious that the circuit can be divided into two parts or legs, the section 21 from condenser to cooler in the direction of the flow, and the section 22 from cooler to the condenser. If no heat was added or subtracted from the system it is apparent that, neglecting friction, the refrigerating medium once set in motion, would continue to circulate indefinitely exhibiting the changes of temperature and pressure above described, and the decreasing scales of pressure and temperature in riser 21 would be duplicated in inverse order in riser 22, the net result being a perfect hydraulic balance. The heat supplied from the cooler 23, however, disturbs this balance and the quantity of heat in transit in riser 22 as well as the vapor in suspension becomes proportionately greater, the effect of which is to reduce the mean density of the refrigerating medium in said riser, and consequently the columns no longer balance. In order then to maintain the circulation, energy must be supplied which is the function of the circulating pump 25. The energy thus supplied is that necessary to compress the additional vapor generated by the cooler 23 and after traversing the condenser the circuit is thus restored to its original state.

In the forms of the devices illustrated in Figures 1 and 3 the effect of the decreased density between the brine cooler and the condenser in unbalancing the circuit is precisely similar, though in both cases the forces in action are of a different character, but in all the methods shown the circulating pump performs the same function. I have shown the simplest form of cooler in Figures 1 and 2 but it is obvious that a straight pipe or cooling surface is not economically adapted to all systems of refrigeration and any desired type of cooler may be used. An optional form is illustrated in Figure 4 in which the throat is broken and comprises two sections 41' and 41, the section 41' being inserted somewhat in the form of an injector within the mouth of section 41 and both contained within the casing 42 which is connected with a suitable coil 43 illustrated diagrammatically in Figure 4.

As will be apparent the liquid medium circulating in the system in each of the forms of the device shown, will serve as a carrier to convey in suspension the vapor produced in the section of low pressure to the section of high pressure.

As I employ in my system no valve, cock, compressor or the like, the circuit may be said to be an undivided circuit and I thus use that term in my specification.

In the devices of the prior art, the refrigerant is expanded suddenly at a needle valve, expansion cock or the like and is suddenly compressed in a compressor, while in my system, these steps are produced gradually or along a gradient and are produced, not by physical intervention but by kinetic, gravitational or centrifugal forces acting on the mass of the dense circulating refrigerant, a pump being employed merely to keep the refrigerant in circulation.

The pump may be located at any convenient point in the system. In Figures 1 and 2, the pump is shown diagrammatically in advance of the cooler or condenser. The pump may, however, be advantageously positioned at a point beyond the cooler.

As my system employs kinetic, gravitational or centrifugal forces to separate the zones or areas of different pressures and temperatures in the refrigerant and no physical barrier is employed to separate these zones or areas, I have used the term "pressure of the mass" to describe either or all of said forces.

Having thus described my invention, what I claim is:

1. The process of refrigeration which consists in gradually reducing the pressure on a liquid refrigerant, vaporizing a part of the liquid refrigerant during the reduction of pressure substantially without heat exchange, vaporizing a further part of the

liquid refrigerant at low pressure and temperature to produce the refrigerating effect, gradually increasing the pressure on the resulting mixture of liquid and vapor, thus
5 condensing part of the vapor, substantially without heat exchange, and condensing the remaining vapor at the higher pressure and at a higher temperature.

2. A refrigerating apparatus including
10 means for gradually and substantially adiabatically compressing a mixture of refrigerant liquid and vapor, means for abstracting heat from the resulting mixture at a comparatively high temperature, to
15 condense substantially all the vapor, means for gradually and substantially adiabatically reducing the pressure on the liquid refrigerant and means for adding heat to the resulting low pressure mixture of liquid and
20 vapor at a lower temperature to produce refrigeration all arranged in a closed circuit

3. In a refrigeration apparatus, a continuous undivided conduit, a refrigerating medium therein comprising a refrigerating liquid and its vapor, means for producing
25 a zone of high pressure and means for producing a zone of low pressure in the refrigerating medium and merging one into the other without the intervention of any physical barrier between the zones. 30

4. In a refrigeration apparatus, a continuous undivided conduit, a refrigerating medium therein comprising a refrigerating liquid and its vapor, means for producing
35 areas of varying pressure within the conduit without the intervention of any physical barrier between the areas.

Signed at New York in the county of New York and State of New York this 24th day of July A. D., 1920.

BARTON H. COFFEY.