MAURICE LEBLANC

By EurIng Brian Roberts, CIBSE Heritage Group

Maurice Leblanc, 1857-1923

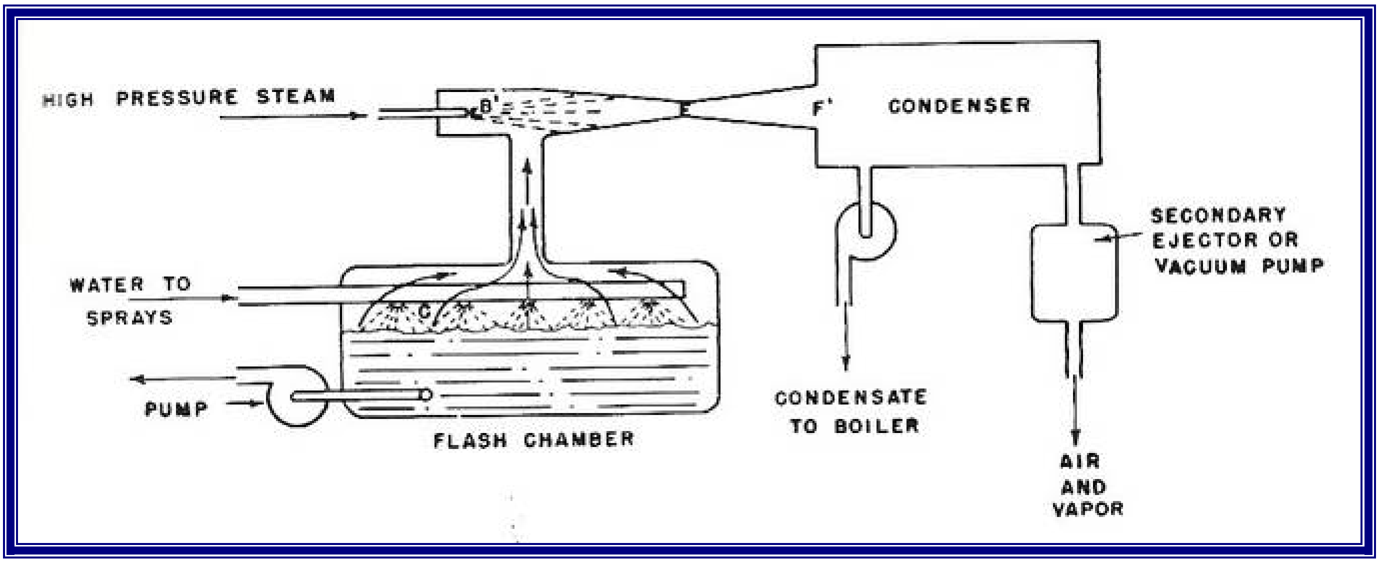
Maurice Leblanc was a French engineer and industrialist who was born in Paris in 1857 and educated at the Ecole Polytechnique. He began his career on the railway and then worked in several industries. He developed an improved vacuum pump and worked in the area of refrigeration. He invented the steam ejector refrigerating machine. He also obtained a patent for a centrifugal compressor in 1910, predating the introduction of a practical machine in 1922 by Willis Carrier by some 12 years.

However, Leblanc worked primarily in improving induction motors and alternators and carried out significant investigations into the requirements for a television system. He was awarded the *Prix Poncelot* by the French Academy of Sciences in 1913 for “the totality of his work in mechanics.”
He died in 1923.

Steam Jet Refrigeration

The possibility of using a jet machine for the production of cold was envisaged in a patent of 1884. In about 1902, Charles Parsons (inventor of the steam turbine) worked on steam-jet cooling. In 1905 Leblanc independently invented his steam ejector refrigerating apparatus. In Paris, with the help of Westinghouse, he built the first successful machine around 1907-1908 and in 1911 obtained US Patent 1005851.

In 1755, the Scottish physicist William Cullen had published his *Essay on Cold Produced by Evaporating Fluids* which included showing how to freeze water by its evaporation *in vacuo*. Leblanc used steam to speed the process. Steam at high pressure was ejected from nozzles over a tank of water and thus maintained the partial vacuum needed for high evaporation rates. This type of plant was intended to find its chief use in air conditioning on account of its relative safety and low first cost, but these machines need substantial quantities of cooling water, thus limiting their application.



Basic elements of a steam-jet refrigeration machine

From 1928 onwards, by using multistage evaporation and compression, it became possible to achieve significant economies in both steam and cooling water. The passenger liners *RMS Queen Mary* and *RMS Queen Elizabeth* were among the first ships to be fitted with steam jet refrigeration. Manufacturers of this type of machine included Ingersoll-Rand, Foster Wheeler and Worthington.

Footnote

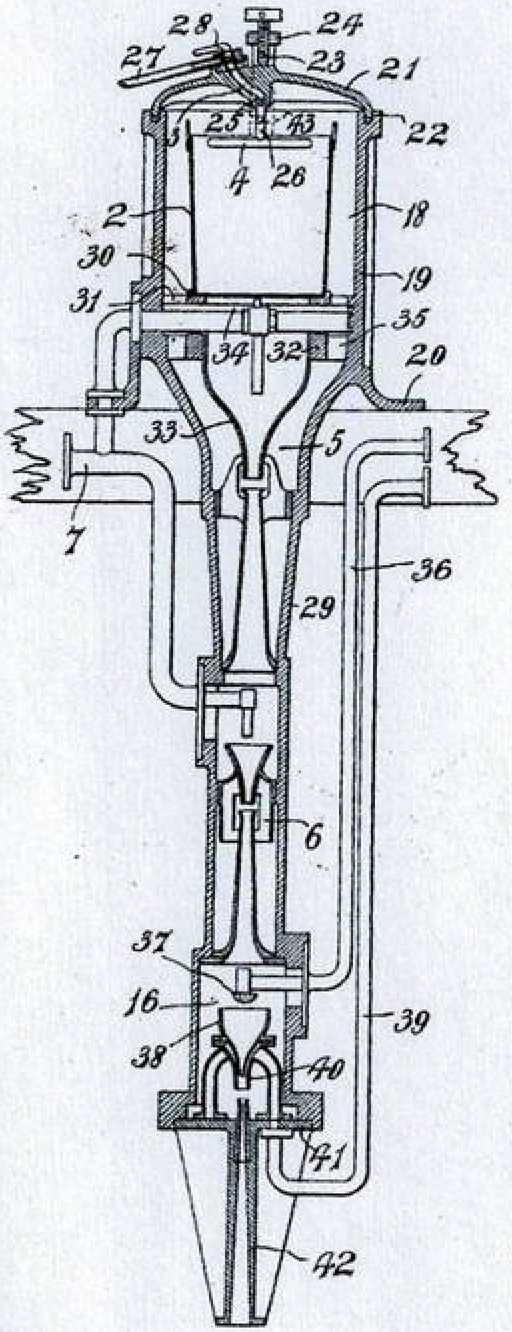
In 1929, Willis Carrier with Alfred Stacey and Carlyle Ashley developed a small steam-jet refrigerating unit for railway passenger coaches. Their surveys suggested that, at least in the USA, steam-jet refrigeration was used mainly in industrial applications.

M. LEBLANC.

REFRIGERATING MACHINE.

APPLICATION FILED FEB. 15, 1905.

1,005,851. Patented Oct. 17, 1911.



WITNESSES:

G. L. Ryder

E. W. McCallister

INVENTOR.

Maurice Leblanc

by Jno. S. Green

Atty.

Leblanc’s US Patent 1005851 for a Steam-Jet (Ejector) Refrigerating Machine

Patent Application 15 February 1905: Granted 17 October 1911

UNITED STATES PATENT OFFICE.

MAURICE LEBLANC, OF PARIS, FRANCE, ASSIGNOR TO SOCIETE ANONYME POUR L'EXPLOITATION DES PROCEDES WESTINGHOUSE-LEBLANC, OF PARIS, FRANCE.

REFRIGERATING-MACHINE.

1,005,851. Specification of Letters Patent. Patented Oct. 17, 1911.

Application filed February 15, 1905. Serial No. 245,719.

To all whom it may concern:

Be it known that I, MAURICE LEBLANC, a citizen of the Republic of France, residing at Villa Montmorency, Auteuil, Paris, France, have invented a new and useful Improvement in Refrigerating-Machines, of which the following is a specification.

This invention relates to refrigerating apparatus and has for its object to provide a refrigerating machine which will operate with a rapidity and efficiency hitherto unattainable.

In the accompanying drawings, the figure is a vertical section showing the arrangement of the apparatus.

In the drawings a removable mold or receptacle 2 is shown as inserted into an inclosed air-tight vacuum chamber 18 consisting of a stationary cylinder 19 supported on a flange 20 and a removable cover 21 which is inserted into a groove 22 provided in the upper end of the cylinder 19 for the reception of packing. The joint between the cover 21 and the cylinder 19 is maintained by means of a screw 23 working in a removable yoke 24 supported on trunnions 43 on the cylinder 19. The pipe-ring or rose 4 is carried by the cover 21 to which it is attached by means of a short length of tubing 26 screwed into a central boss 25 and in connection with the inlet passage 3. Connection between the inlet passage 3 and a suitable source of liquid supply is made by means of a flexible pipe 27 and a cock 28 which is secured to the outside of the cover 21 by means of a bayonet joint. The relative positions of the ports in the cock 28 and of the jaws of the bayonet joint are so arranged that when the tongues of the bayonet joint are free the cock is closed. The lower end of the cylinder 19 terminates in a trunk 29 in which are inclosed and supported a series of two ejectors 5 and 6 and the condenser 16. The removable mold 2 is supported on a seating ring 30 provided at the lower end of the cylinder 19. At a suitable distance below the seating ring 30 a second supporting ring 32 is provided for carrying the first ejector cone 33. Free communication between the interior of the cylinder 19 and the space 34 between the two supporting rings 30 and 32 is provided by means of a suitable number of orifices 31 in the supporting ring 30, and free communication between the space 34 and the trunk 29 is provided by means of suitable orifices 35 in the supporting ring 32.

Steam is admitted to the two ejectors 5 and 6 by a common inlet pipe 7 and the condensing water is admitted by a pipe 36 to a rose 37 arranged above a cone 38 of the condenser 16. Water under pressure, which may be of the same temperature as that of the condensing water at its exhaust, is conveyed by a pipe 39 to a second cone 40 arranged below the first cone 38, and is intended to convey with it all the products of condensation. The cones 38 and 40 are supported on a flange 41 which closes the lower end of the trunk 29 and carries the reverse cone 42 of the condenser 16.

Although in the drawings a jet condenser 16 is shown, a condenser of any type may be employed.

When condensing water is plentiful and of low temperature so that a high degree of vacuum can be obtained in the condenser, the series of ejectors may be operated by steam at atmospheric pressure.

The operation is as follows: When a vacuum, or partial vacuum, is created in the head and mold 2 by the combined action of the ejectors 5 and 6, the liquid as it is gradually introduced by the pipe-ring 4 is partially evaporated, causing a fall in the temperature sufficient to cool or freeze the remainder of the liquid on falling into the mold 2, the vapor given off being meanwhile exhausted by the ejectors.

What I claim is:

1. A freezing machine comprising a vacuum chamber, a primary fluid ejector communicating with said chamber, an auxiliary fluid ejector communicating with the exhaust of said primary ejector, a jet condenser communicating with the exhaust of said auxiliary ejector and a liquid ejector communicating with the exhaust of said auxiliary ejector, coaxially alined therewith and arranged to discharge the liquid from said condenser.

2. A freezing machine comprising a vacuum chamber, a primary fluid ejector communicating therewith, a secondary fluid ejector communicating with the exhaust of said primary ejector, a jet condenser communicating with the exhaust of the secondary ejector and a liquid ejector located coaxially with said fluid ejectors and com-

municating with the exhaust of said secondary ejector and arranged to receive and discharge the liquid from said condenser.

3. A freezing machine comprising a vacuum chamber, a primary fluid ejector communicating therewith, a secondary fluid ejector communicating with the exhaust of said primary ejector, a condenser communicating with the exhaust of the secondary ejector and a liquid ejector located co-axially with said fluid ejectors and communicating with the exhaust of said secondary ejector and arranged to receive and discharge the fluid from said condenser.

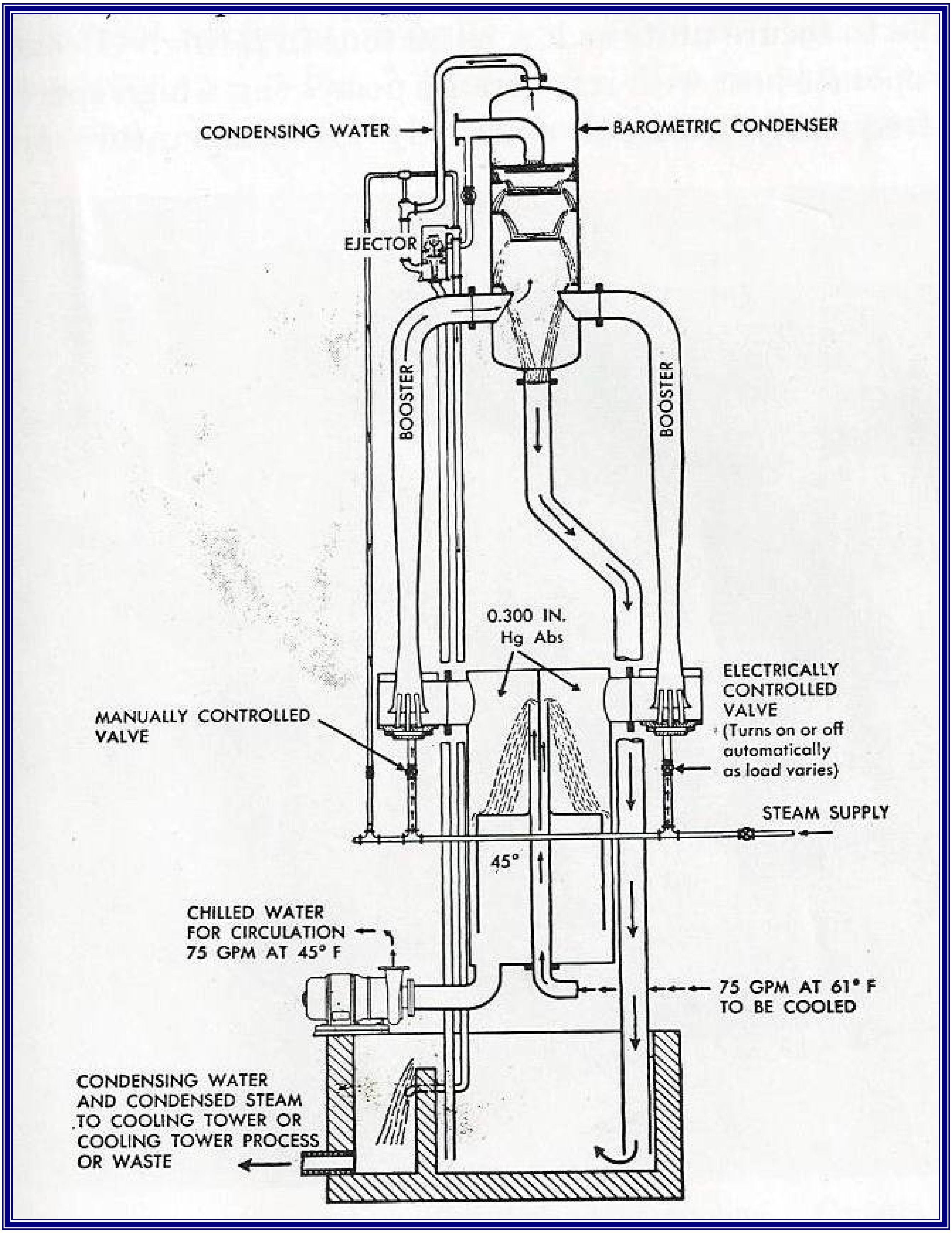
4. A freezing machine comprising a vacuum chamber, a primary fluid ejector communicating with said chamber, a secondary fluid ejector communicating with the exhaust of said primary ejector and a liquid ejector communicating with the exhaust of said secondary ejector and coaxially alined with said fluid ejectors.

5. In a freezing machine, an evaporating chamber, a jet condenser connected to said chamber and a plurality of steam ejectors between said condenser and said chamber for withdrawing vapor from said chamber; said vapor passing through said ejectors in series whereby a pressure is maintained in said chamber less than the pressure corresponding to the vapor tension of ice.

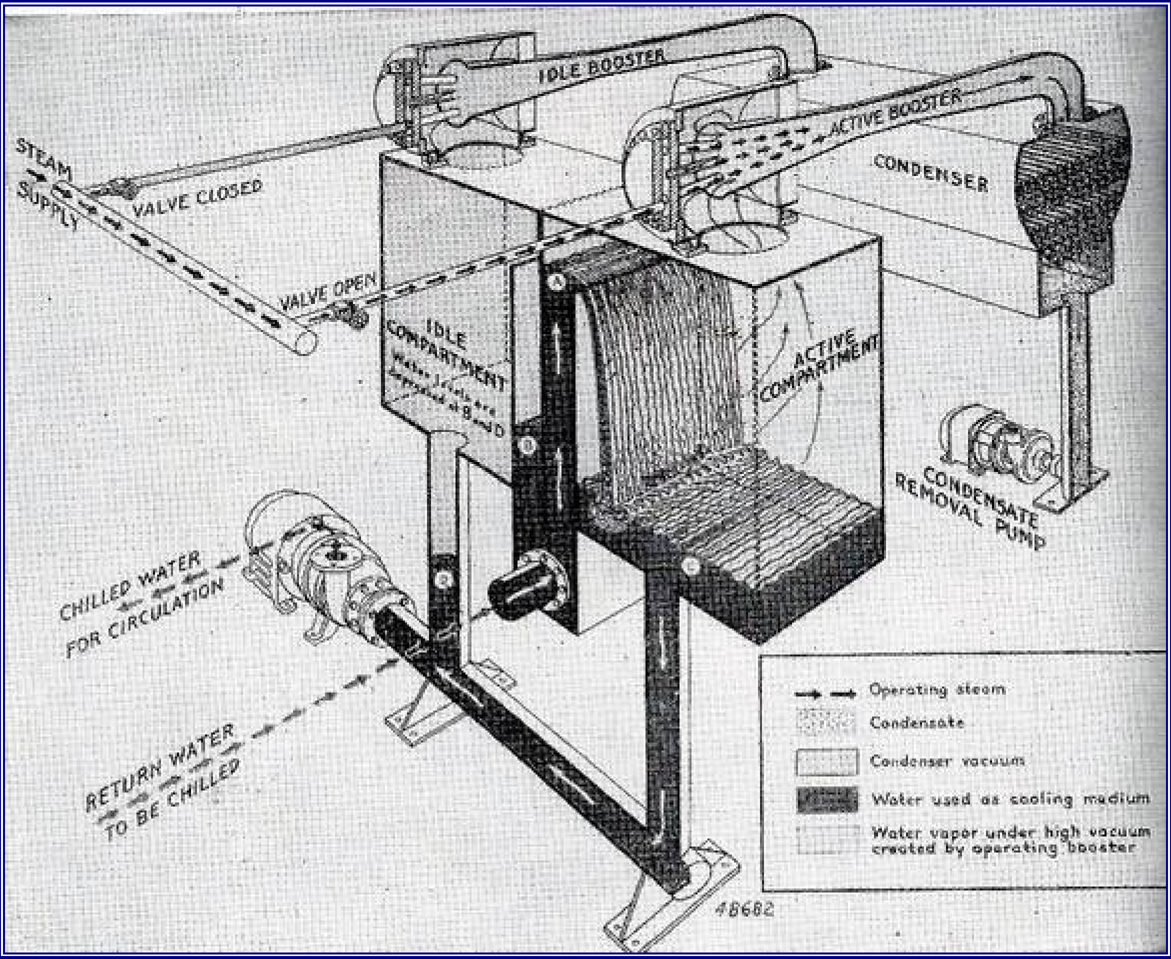
In testimony whereof I have hereunto subscribed my name this 27th day of January, 1905.

MAURICE LEBLANC.

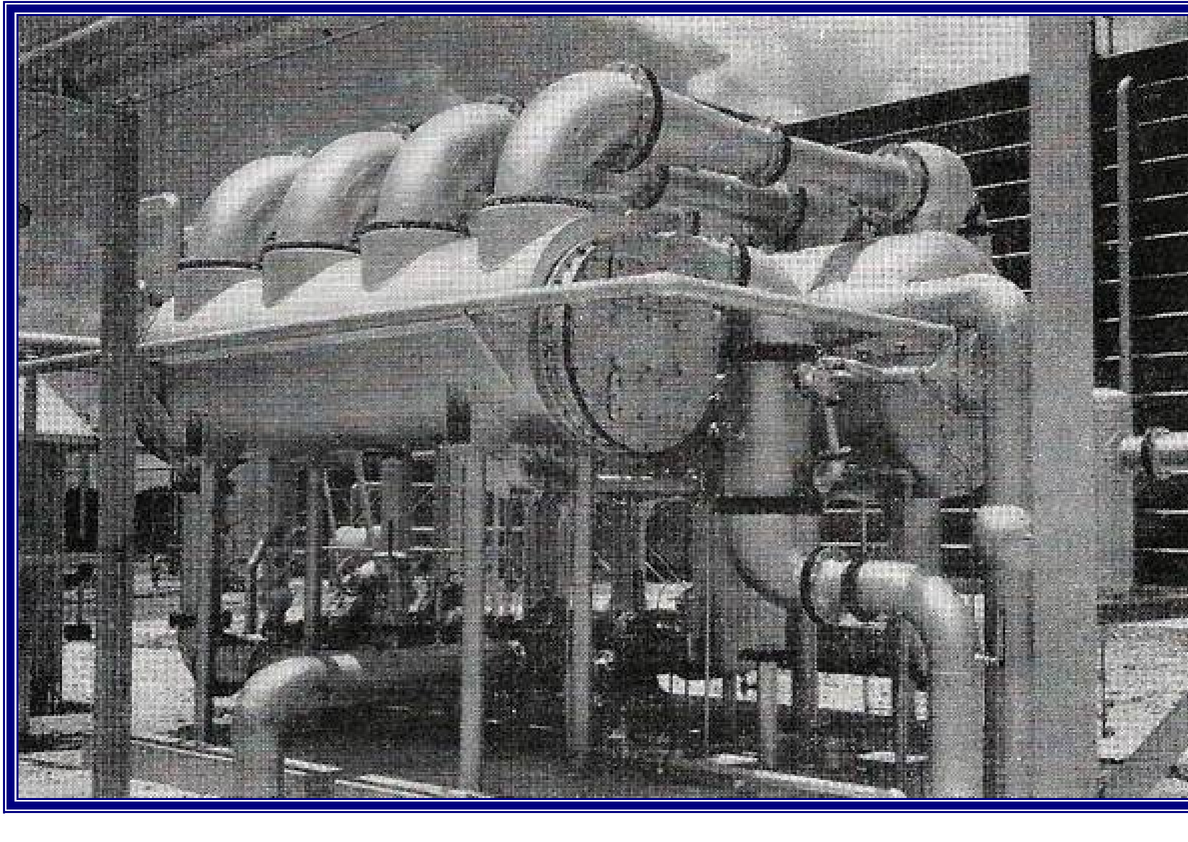
Witnesses:
ALBERT DELAS,
HANSON C. COXE.



Steam-Jet Unit with Barometric Condenser by Ingersoll-Rand Company, 1940's



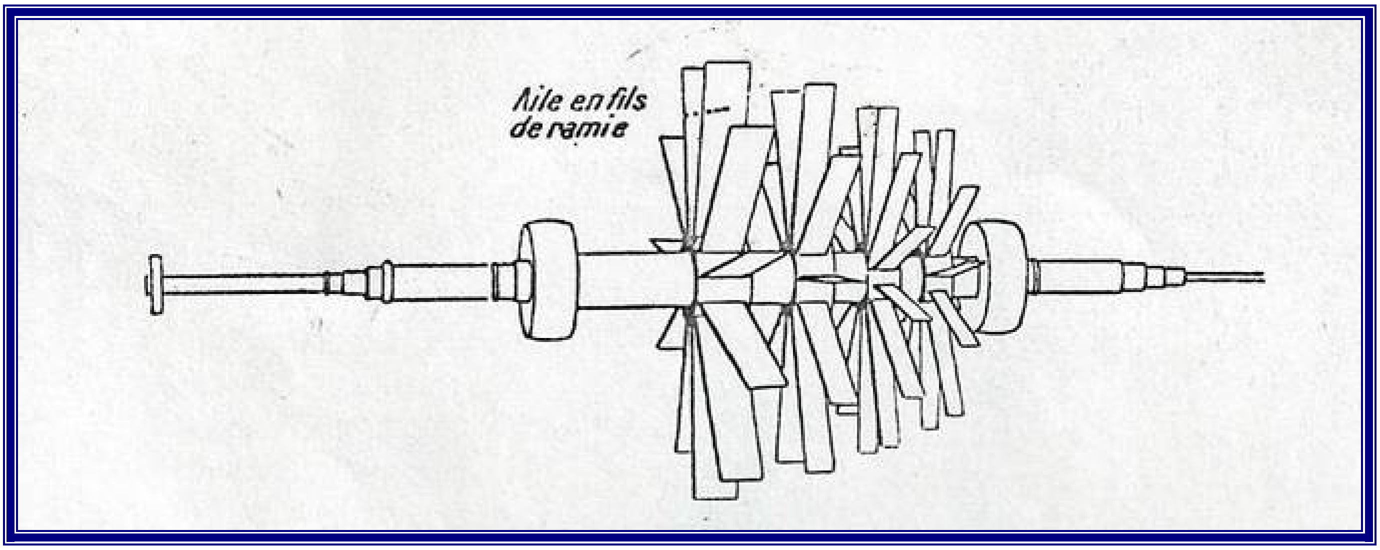
Steam-Jet Water-Cooling System with Surface Condenser by Ingersoll-Rand Company, 1940's



A 250 ton (875 kW) steam-jet unit in an oil refinery, Worthington Pump & Machinery Corp, 1940's

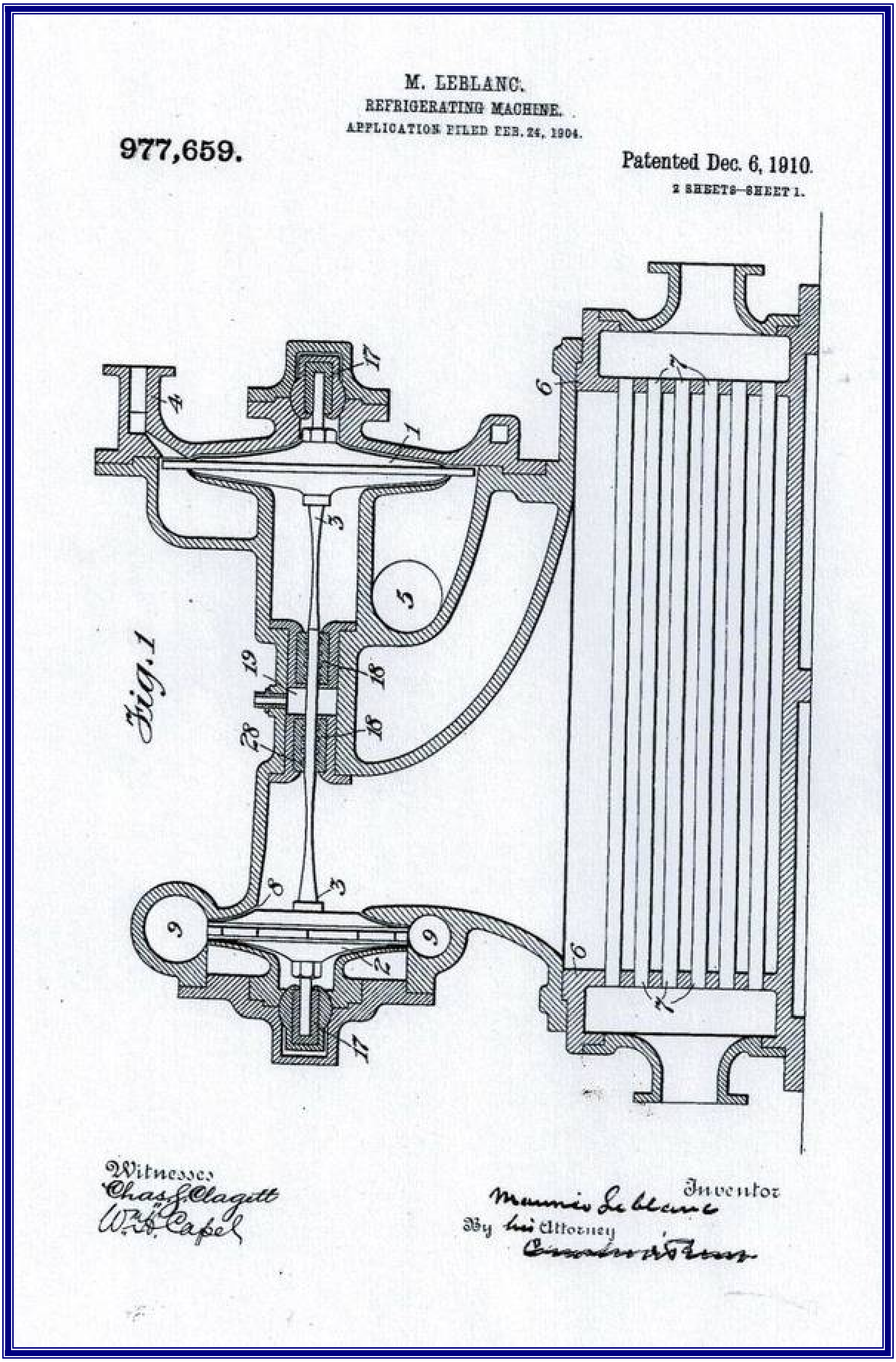
Centrifugal Refrigeration Compressor

The centrifugal or turbo-compressor has been in use for over a century. Development was due largely to Rateau for use as an air compressor. The first attempt to use them as refrigerating machinery was made in 1910-11 by Lorenz and by Elgenfeld who computed the lower limit of size for the various refrigerants then available.



Leblanc centrifugal rotor

About the same time, Leblanc, in France, obtained a broad patent for his centrifugal compressor and built a workable experimental machine, using water vapour as the refrigerant. Water vapour has a low molecular weight and Leblanc was unable to design an impeller of sufficient mechanical strength for the necessary high rotating speeds. He also experimented with carbon tetrachloride and here he was on the right track, for it had most of the desirable properties, including a high molecular weight. But carbon tetrachloride was unstable and dissociated to form decomposition products which ruined the compressor. Leblanc also had other problems, notably with shaft seals, and he was unable to keep air out of the refrigerating system. (Around 1916, Willis Carrier became interested in the possibilities of centrifugal refrigeration, but experienced similar problems to Leblanc, finally overcoming these and demonstrating his first working machine in 1922, shortly before the death of Leblanc).



Leblanc's US Patent 977659 for a Refrigerating Machine with Centrifugal Compressor
Patent Application 24 February 1904: Granted 6 December 1910

M. LEBLANC.

REFRIGERATING MACHINE.

APPLICATION FILED FEB. 24, 1904.

977,659.

Patented Dec. 6, 1910.

2 SHEETS—SHEET 2.

Fig. 3

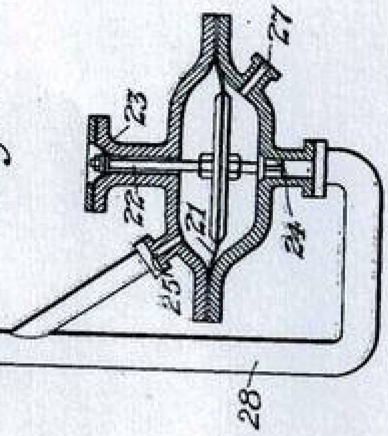
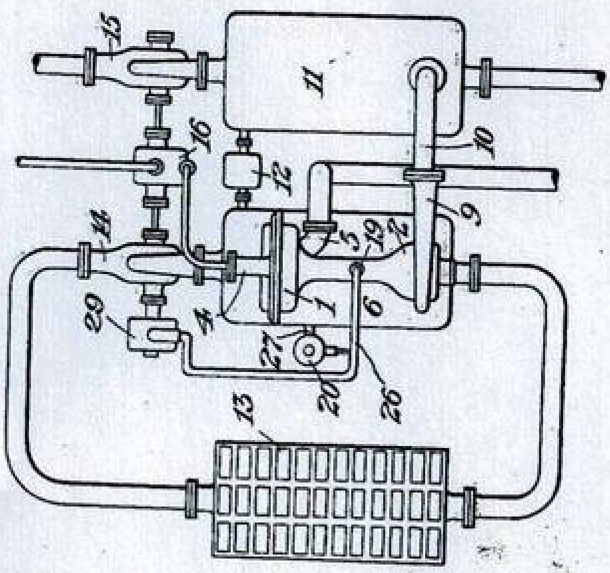


Fig. 2



Witnesses

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Wm. J. Cabel

Inventor

Maurice Leblanc

By his Attorney

Charles A. Terry

UNITED STATES PATENT OFFICE.

MAURICE LEBLANC, OF PARIS, FRANCE, ASSIGNOR TO SOCIETE ANONYME POUR L'EXPLOITATION DES PROCEDES WESTINGHOUSE-LEBLANC, OF PARIS, FRANCE.

REFRIGERATING-MACHINE.

977,659. Specification of Letters Patent. Patented Dec. 6, 1910.

Application filed February 24, 1904. Serial No. 195,009.

To all whom it may concern:

Be it known that I, Maurice Leblanc, a citizen of the Republic of France, and resident of Paris, France, have invented certain new and useful Improvements in Refrigerating-Machines, of which the following is a specification.

This invention relates to refrigerating apparatus.

In a number of types of refrigerating apparatus now common, a motor, generally worked by steam is utilized for driving a compressor which draws vapor from the expansion or refrigerating chamber given off by non-freezing liquid with which it is partially filled and forces the liquid into a condenser where it is condensed by a current of cold water. The liquid formed by condensation returns to the expansion chamber where it is again evaporated, thus completing the cycle.

The difference of temperatures maintained between the expansion chamber and the condenser is generally small and rarely exceeds 50° centigrade and the quantity of heat which the liquid returning from the condenser imparts to the expansion chamber is always small compared to that which it absorbs when vaporized. The temperature of the expansion chamber, therefore, continues to be lowered below that of the condenser until the body which it is required to cool provides it with as much heat as it loses during a given time.

The pressures within the expansion chamber and within the condenser are respectively equal to the tension of the liquids which they contain at the temperatures at which they are maintained. The pressure in the condenser is therefore greater than that in the expansion chamber and that is why it is necessary to have a compressor to pass the vapor from the expansion chamber into the condenser.

An object of this invention is to produce a simple and efficient form of refrigerating apparatus.

As the turbine is the simplest form of steam engine and the blower the simplest form of compressor, I have utilized them in constructing my organized apparatus.

In the drawings: Figure 1 represents in section the principal portion of my refrigerating apparatus; Fig. 2 is a diagrammatic plan view of an organized apparatus embodying my invention; and, Fig. 3 is a sectional view of one of the details employed in the apparatus.

A turbine 1 is connected so as to drive a blower 2 by means of shaft 3. The turbine receives steam through inlet 4 and exhausts through outlet 5. An expansion chamber provided with heads 6—6 and through tubes 7—7 is connected to the inlet 8 of the blower. As shown in the drawings the frames for the turbine and blower preferably rest upon the walls of the expansion chamber. The blower draws vapor from the expansion chamber and delivers it into volute 9 which, by means of pipe 10, is connected to the upper part of a condenser 11 (see Fig. 2). The condenser is preferably of the surface type and may be similar to the expansion chamber, the tubes thereof being traversed by cold water instead of a saline solution. The lower part of the condenser 11 communicates with the expansion chamber by means of a float-controlled valve of any well known type, (not shown but located within chamber 12).

I have illustrated the apparatus as utilized for the manufacture of blocks of ice, the molds, filled with water, of which are arranged in the several compartments of the refrigerator 13. The refrigerator is so coupled up to the pipes 7 of the expansion chamber that a stream of salt water may be circulated through said pipes and around the molds of the refrigerator by means of a circulating pump 14. A circulating pump 15 is utilized for passing the cooling water through the pipes of the condenser.

As it is necessary in order to have a centrifugal blower which will give sufficient pressure, (one-half of an atmosphere or five meters of water pressure) to have a peripheral speed of the pump runner of 270 meters per second, it is necessary to have a turbine of high speed. As it is impracticable to drive the circulating water and saline solution pumps at turbine speeds, I employ a special motor 16 for that purpose, preferably of the rotary type geared down like Behren's motor. Rotary motors of this type, while not efficient, are simple, have no distributing valves and are cheap. The work, however, which the motor to drive the circulating pump has to do is small compared to the work done by the turbine. I preferably arrange the motor and turbine so as to operate on the steam in series and in this way the turbine will not only utilize the available energy of the steam which exhausts from the motor but the turbine and motor will operate simultaneously and when the work done by the turbine is varied, the work done by the motor will vary in practically the same proportion.

One of the objects of this invention has been to produce an apparatus in which tetrachlorid of carbon may be used as the refrigerant. As the vapor of tetrachlorid of carbon has a density 7.5 times greater than that of air, it may be utilized with advantage even when the peripheral speed of the blower does not exceed 270 meters per second, as with this speed a suitable pressure of the vapor may be obtained.

Carbon tetrachlorid, $C.Cl_4$, is especially suitable for refrigerating apparatus because it is a perfectly stable liquid, inoffensive, incombustible, and does not attack metals. Its cost is not high and as it does not vaporize under 78° centigrade at atmospheric pressure, it may be stored and transported as easily as water. Its freezing point is extremely low, but as it dissolves greasy matters, it is necessary to provide special means of lubricating the bearings of the apparatus in which it is utilized. It will be found that a blower, which, having a peripheral speed of 270 meters per second, is capable of increasing the pressure of air half an atmosphere or five meters of water, will suffice to pass the vapor of tetrachlorid of carbon from the expansion chamber to the condenser of my apparatus with a temperature of 50° centigrade maintained between them, the average temperature maintained in the expansion chamber and the condenser being very near to that of melting ice. The expansion chamber is filled or partially filled with liquid tetrachlorid of carbon and the blower 2 tends to create a vacuum in the chamber by exhausting the vapor given off from the liquid. This vapor it compresses into the condenser where it is condensed by having its temperature lowered by the water circulating through the tubes thereof. The float operating the valve within the chamber 12 regulates the flow of liquid tetrachlorid of carbon from the condenser to the expansion chamber so as to maintain a predetermined level of liquid in said chamber.

As tetrachlorid of carbon dissolves greasy matters, I preferably construct the bearings 17—17, 18—18 for the turbine and blower of graphite and arrange these in bronze sleeves. As the pressures per square centimeter to which the bearings are subjected are extremely small and as the bearings are cooled, they forming a part of the refrigerating apparatus, the wear therein will be very small and their life long.

In order that the tetrachlorid of carbon may give off a vapor in the expansion chamber, it is necessary that a vacuum be maintained both in the expansion chamber and in the condenser and in order to avoid leakage of air or steam from the turbine to the expansion chamber, special means are provided between the bearings 18—18 whereby any leakage through said bearings to the expansion chamber may be avoided. Annular grooves 28 are provided in the graphite bearings so as to form a labyrinth packing system and a space or chamber 19 is also provided between the bearings. This chamber, by means of pipe 26, is connected to a pump or exhauster 29 preferably driven by motor 16 so that a less pressure is maintained in chamber 19 than in the expansion chamber. As it is necessary to provide a vacuum at the moment the apparatus is started and to quickly reëstablish it in case of accidental entrance of air to the expansion chamber, I employ the device illustrated at 20 in Fig. 2 and illustrated in detail in Fig. 3. The device comprises a casing divided into two chambers by a diaphragm 21. This communicates motion to a spindle 22, the upper part of which is connected to another diaphragm 23 and the lower part of which carries a valve 24. The upper part of diaphragm 23 is exposed to the atmosphere and the space between the two diaphragms communicates by means of pipe 25 with pipe 26 and, therefore, with pump 29 and chamber 19. The space between the diaphragm 21 and the valve 24 is connected by means of pipe 27 with the expansion chamber and the opening which valve 24 controls communicates with pipe 26 by means of pipe 28. The areas of the diaphragms 21 and 23, and the area of the valve 24 are so proportioned that for a given or predetermined pressure in the expansion chamber, the diaphragms will stand so that valve 24 is open, placing the expansion chamber in communication with the vacuum pump 29 while the pressure in the expansion chamber is normal, valve 24 will be kept seated by means of diaphragms 21 and 23 and communication between the expansion chamber and the vacuum pump 29 cut off.

Throughout the foregoing, I have assumed that the apparatus is to be used for freezing water. I reserve the right, of course, to employ it for cooling any substance whatever, whether to be frozen or not. I have illustrated only one blower for compressing the vapor of tetrachlorid of carbon, but, of course, a number of blowers may be coupled up in series if desired. It will also be seen that if desired the steam turbine may be replaced by a turbine of any other type or by an electric motor.

Having thus described my invention, what I claim is:

1. In a refrigerating apparatus, an expansion chamber, a vacuum pump communicating therewith, and auxiliary means, controlled by the pressure within said chamber, for discharging fluid therefrom.

2. In a refrigerating apparatus, an expansion chamber, a vapor delivery means therefor, an auxiliary vacuum creating agent communicating with said chamber, a valve between said agent and said chamber, and means, dependent on the pressure within said chamber, for controlling the operation of said valve.

3. In a refrigerating apparatus, an expansion chamber, a vapor delivery means therefor, an auxiliary vacuum creating agent communicating with said chamber and means, sensitive to pressure within said chamber, for establishing communication between said chamber and said auxiliary agent.

4. In a refrigerating apparatus, a turbine, an exhauster direct connected thereto, an expansion chamber communicating directly with said exhauster, a bearing for the shaft of said exhauster located between said chamber and the working passages of said turbine and a leakage passage located adjacent said bearing and communicating with an auxiliary exhauster.

5. In a refrigerating apparatus, a turbine, a vacuum pump directly connected thereto, an expansion chamber in direct communication with said pump, a bearing for the shaft of said turbine located between said chamber and the working passages of the turbine, a leakage passage located adjacent to said bearing and means, dependent on the variations of pressure within said chamber, for maintaining a vacuum within said passage.

6. In a refrigerating apparatus, an expansion chamber, a vacuum creating agent communicating directly therewith, an auxiliary vacuum creating agent, a valve between said chamber and said agent and means, dependent on the pressure within said chamber, for controlling the operation of said valve.

7. In a refrigerating apparatus, an expansion chamber, a vacuum creating means directly connected therewith, an auxiliary vacuum creating means, a passage between said chamber and said auxiliary means, a valve in said passage and means, controlled by the pressure within said chamber, for establishing communication between said auxiliary means and said chamber by opening said valve.

Signed at Paris France this twentieth day of January A. D. 1904.

MAURICE LEBLANC.

Witnesses:
HANSON C. COXE,
JEAN COTTIER.

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