

REFRIGERATING MACHINE.

1,280,101.

2 SHEETS—SHEET 1.

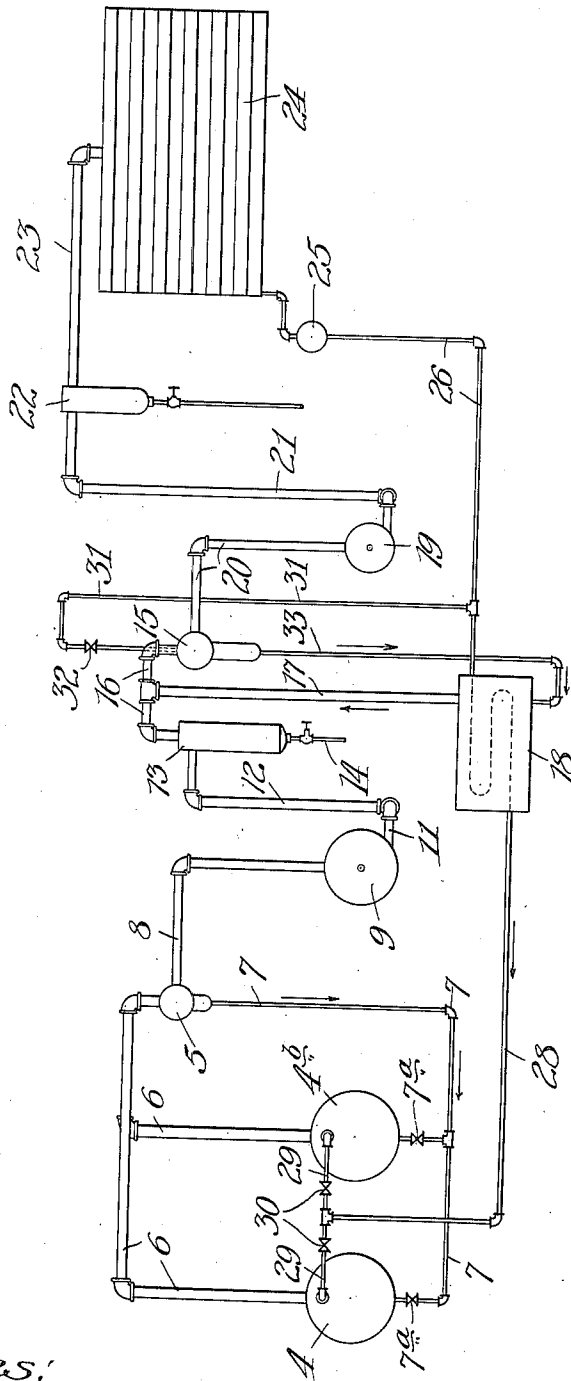


Fig.

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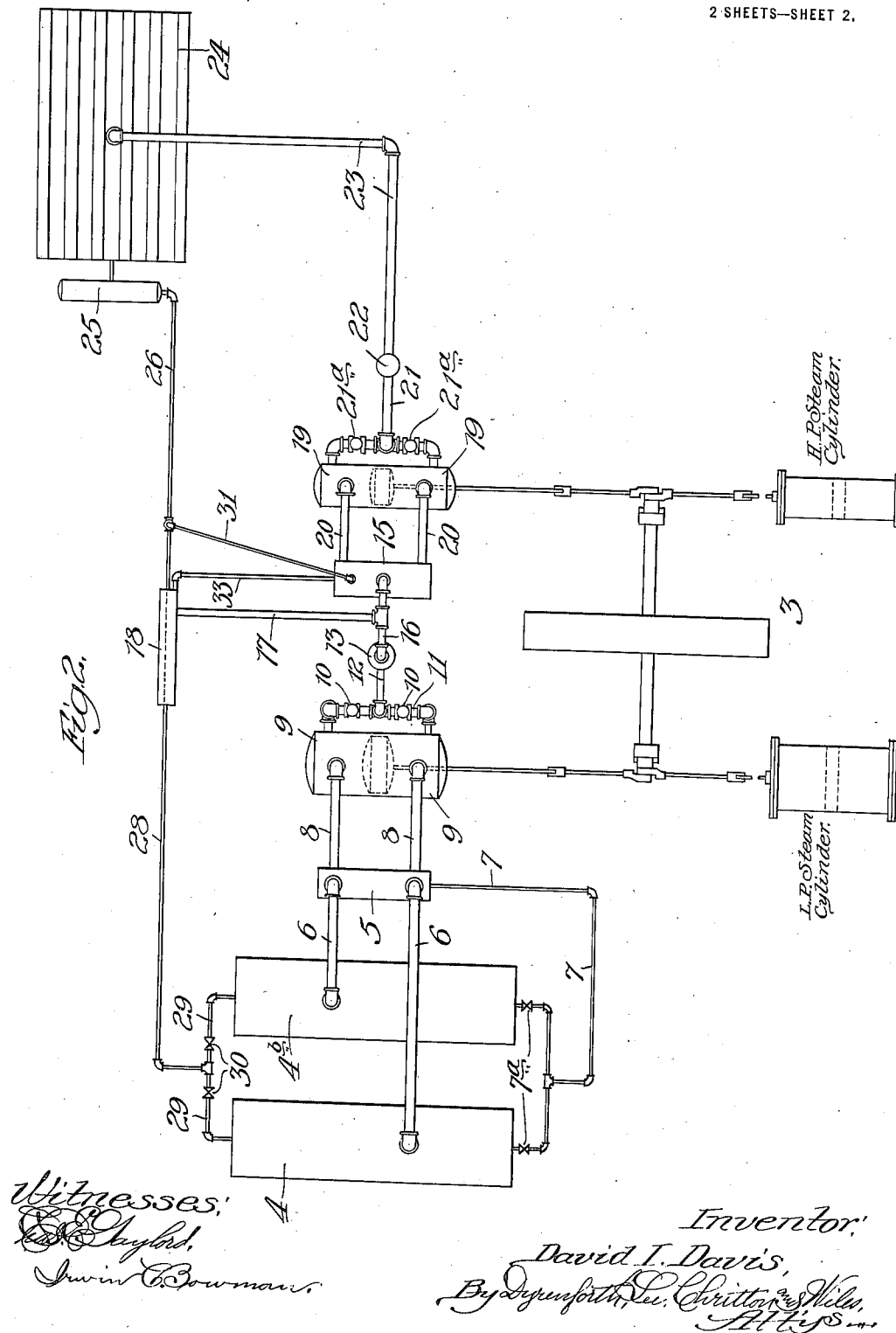
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Patented Sept. 24, 1918.

2 SHEETS—SHEET 2.



UNITED STATES PATENT OFFICE.

DAVID I. DAVIS, OF CHICAGO, ILLINOIS.

REFRIGERATING-MACHINE.

1,280,101.

Specification of Letters Patent. Patented Sept. 24, 1918.

Application filed June 15, 1916, Serial No. 103,810. Renewed April 8, 1918. Serial No. 227,399.

To all whom it may concern:

Be it known that I, DAVID I. DAVIS, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented a new and useful Improvement in Refrigerating-Machines, of which the following is a specification.

My invention relates to improvements in the compression system of refrigeration, wherein a refrigerant is employed in liquefied form and becomes gaseous, in the cycle of operation of the system, by heat and the relief of pressure, and is again liquefied by cooling after compression.

The primary object of my invention is to reduce the amount of power required for, and the expense of, operating the system. This and other objects hereinafter explained are accomplished by my invention, which is illustrated, in a preferred form of its embodiment, in the accompanying drawings, in which—

Figure 1 is a view representing my improved refrigerating systems diagrammatically in side elevation, and Fig. 2 is a similar representation of the same in plan and showing a cross-compound steam engine as the source of power, but which is omitted in Fig. 1.

It is well-known in the art that as the relative pressure is reduced on the contained refrigerant in any conduit or holder, the vaporizing point is lowered in temperature and the density of the resultant gas becomes more and more attenuated as the relative pressure is lessened and approaches a vacuum.

It is a not uncommon practice to operate a compression system with a pressure of one pound to five pounds gage pressure upon the vaporizing liquid refrigerant, producing a temperature of the gas liberated of -26° F. and -17° F. respectively. Under these extreme conditions, the vaporizing gas in the container continues to extract heat from the surrounding liquid or gas (including air), and reduces its temperature to a comparatively low degree, but the quantity by weight, of gas withdrawn by the compressor is comparatively small. Consequently, in ordinary practice, the capacity of a refrigerating compression-system is very greatly reduced in total output of duty performed by reason of the highly attenuated gas being so small in weight, while the

quantity of power required is practically the same, all other conditions remaining.

For example, the size of a compressor adapted to perform a certain quantity of cooling duty upon a non-congealing solution, such as saturated calcium chlorid brine, where it is desired to reduce a given quantity in a given time from a temperature of from -15° F. to -20° F., or thereabout, would probably have to be twice as large as if it were desired to cool an equal quantity in equal time from plus 15° F. to plus 10° F., or thereabout; and in the practice of extracting heat to produce cold, it is required and desirable to maintain the specified low temperature.

In the ordinary method, one or more compressors would withdraw the gaseous vapor from the containers and discharge the gas through a suitable oil extractor to a condenser and operate against a variable head or condensing pressure of from 125 to 250 lbs. gage, depending upon conditions.

By my improvement, now to be described, the gaseous refrigerant is received into a relatively large compressor, which discharges the gas, initially or partially compressed therein, into another relatively small compressor, or successively into two or more such compressors of progressively smaller size, to complete the compression, and thence to the condenser, and thereby materially reduce the power required for operating the system, say to the extent of 25 to 30 per cent., more or less, depending upon conditions.

My improved system, as illustrated in the drawings, is a two-stage equipment, though it may involve more than two stages or compressors. A cross-compound steam engine is shown for operating the two-stage compressor, though the power employed may be any other that is desired, and the compressor-cylinders, whether double acting, as represented, or single, as they might be, may be relatively disposed in any suitable manner.

Two sources of gas supply are indicated at 4 and 4^b. The source 4 may be any form of holder or evaporator in which a non-freezing solution, say brine, is adapted to be cooled by a suitable refrigerant within a conduit or container in any form, for instance, a pipe coil within a cylinder or any combination of a refrigerant container and

a liquid container. The evaporator 4^b may be a chamber or chambers in any form, containing air or gas to be cooled by coming in contact with a refrigerant container of any kind, used in conjunction with the cycle above referred to.

From each evaporator 4 and 4^b the gas enters a drum 5 through a separate pipe 6, these pipes discharging into the drum respectively near its opposite ends. The pipes 6 may, however, be connected directly to the compressor, hereinafter described, without the interposition of the drum, the function of which will be understood to be that of separating the liquid from the gas, should any liquid be entrained.

If any of the refrigerant gas from the evaporators 4 and 4^b be carried to the trap in liquid form, the entrained liquid is returned through branches of a pipe 7 to the respective source, to vaporize or gasify therein, these branches containing expansion valves indicated at 7^a. From the trap 5 the gas passes through a pipe 8, or preferably through two such pipes, as represented in Fig. 2, into the cylinder of a compressor 9, which is preferably of the double-acting type indicated, having its piston rod connected with one end of the crank shaft of the engine 3, the same end of the crank shaft being also connected with the rod of the piston working in the low-pressure steam cylinder of the engine.

It is advantageous to lead a separate pipe from the drum 5 to each end of the cylinder of a double-acting compressor, as represented, rather than to lead only a single pipe from the drum and fork or branch it to such cylinder, because the last-named ordinary practice produces unequal conditions in the two ends of the one cylinder, while by avoiding that practice in the manner referred to, the efficiency and capacity of the compressor, and particularly of one of the double-acting type, are greatly increased.

The piston of the compressor 9 compresses the gas introduced therein until the pressure generated overcomes the resistance of the discharge valves provided in the ends of the cylinder; these discharge-valves communicating through their chambers with a discharge-pipe 12 leading from between its ends into an oil-separator 13, provided with a valved draw-off pipe 14, (Fig. 1). The discharge pressure from the compressor-cylinder is ordinarily 20 or 25 lbs. gage. It may be any desired pressure, however, though pressure and temperature conditions should be the same in the separator 13 as in the compressor, if this separator be provided; which, however, is not necessary.

A second drum 15 is connected with the pipe 12 through the oil-separator 13 (if the latter be provided), by a pipe 16, which has a branch-pipe connection 17 with a lower

liquid cooler 18 serving the purpose herein-after described.

From the drum 15 the gaseous refrigerant enters the cylinder of a second compressor 19 through pipes 20 leading into its opposite end-portions from those of the trap 15, when the compressor is of the preferred double-acting type indicated. The piston-rod of this compressor is connected with the opposite end of the engine crank-shaft, with which is also connected the rod of the piston, which works in the high-pressure steam-cylinder of the engine 3. The second stage of gas-compression is produced in the compressor 19, the pressure of this compressing being about 170 or 180 pounds gage, more or less, and the temperature about 210° F., more or less, depending on usual limiting or controlling conditions, such as the available supply of condenser-water and its temperature.

The gas from the compressor 19 discharges through an oil-separator 22 into any suitable type of condenser, by way of a pipe 21 branching from the end-portions of the compressor-cylinder and leading to the oil-separator. This compressor is provided with a discharge-valve at 21^a, the same as described for cylinder 9. Provision of the separator 22 enables the similar separator 13 to be dispensed with, if desired. The condenser, indicated at 24, has a pipe-connection 23 with the separator 22.

The refrigerant liquefied in the condenser discharges into a liquid-receiver 25, whence it passes by way of a pipe 26, through the supplemental liquid-cooler or heat-exchanger 18, which discharges through a pipe 28, terminating in branches 29, leading, respectively, to the evaporators 4 and 4^b to abstract heat from a surrounding liquid solution or gas; each branch 29 containing an expansion-valve, indicated at 30.

A branch 31 of the pipe 26 contains an expansion-valve, indicated at 32 (Fig. 1), and leads to the drum 15. Liquid refrigerant from the receptacle 25 in this pipe 26 enters the branch and is gasified by the release of pressure through the expansion-valve; and this gas intermingles with that discharged from the compressor 9 and absorbs heat of compression generated in the latter, increasing the volumetric efficiency of the compressor 19 by contracting and saturating the gas introduced thereinto from the first compressor. Moreover, as will be seen, thus indirectly introducing cooled refrigerant for cooling and contracting the gas passing from the low-stage into the high-stage compressor, avoids the danger, which would be incurred by introducing it immediately into the high-stage cylinder, of possibly wrecking the machine. The refrigerant from the receptacle 25 which is not thus evaporated into gaseous form flows in liquid

form through a pipe 33 leading from the drum 15 into the liquid cooler 18, which may be of the pipe-coil variety indicated in Fig. 1, or of any other known or suitable type.

The purpose of the supplemental cooler or heat exchanger 18 is the following:

Before a liquid refrigerant can perform effective duty, it must be cooled to the temperature to adapt it for effective refrigeration by its expansion. The liquid refrigerant passing through the pipe 26 is at a comparatively high temperature—say about 80° F. This liquid in circulating through the exchanger 18 is surrounded by a vapor of comparatively low temperature, say about 12° F. and is thereby reduced to a much lower temperature than in the condenser, namely to about, say, 16° F., at which temperature it is introduced into the evaporators 4 and 4^b.

Gas produced in the supplemental cooler 18 passes into the drum 15 through the pipe 17 by way of the pipe 16; and the supplementally cooled liquid from that cooler passes through the pipe 28 and its valved branches 29 into the evaporators 4 and 4^b. Gas remaining in the clearance space between the piston and cylinder-head of each compressor must expand to the suction-pressure before the compressors begin to fill through their ordinary spring controlled suction valves, and the higher the compression, the greater the space that will be occupied by this gas which was not forced out of the compressor-cylinders. In the case of the low-pressure or first-stage compressor cylinder, the remaining gas may be at 25 to 30 lbs. pressure as against ordinary practice of 180 lbs., more or less.

As will thus be apparent, the volumetric efficiency of my improved system involving the operating of a series of compressors progressively decreasing in size, is much higher than where but one compression is employed.

I realize that considerable variation is possible in the details of construction thus specifically shown and described, and I do not intend by illustrating a single, specific or preferred embodiment of my invention to be limited thereto, my intention being in the following claims to claim protection upon all the novelty there may be in my invention as fully as the state of the art will permit.

What I claim as new and desire to secure by Letters Patent is:

1. In a refrigerating machine, the combination of an evaporator, a low-stage compressor, to which the evaporator discharges, for initially compressing the gaseous refrigerant, a high-stage compressor to which the low-stage compressor discharges, a condenser to which the high-stage compressor

discharges and discharging to the evaporator, means for introducing refrigerant from the condenser into the line of communication between said compressors, and means for mixing said last-named refrigerant with the gas passing from the low-stage to the high-stage compressor whereby the volumetric efficiency of the high-stage compressor is increased.

2. In a refrigerating machine, the combination of an evaporator, a low-stage compressor, to which the evaporator discharges, for initially compressing the gaseous refrigerant, a high-stage compressor to which the low-stage compressor discharges, a condenser to which the high-stage compressor discharges and discharging to the evaporator, a liquid-cooler interposed in the discharge-line from the condenser, and means for mixing refrigerant from said cooler with the gas passing from the low-stage to the high-stage compressor, whereby the volumetric efficiency of the high-stage compressor is increased.

3. In a refrigerating machine, the combination of an evaporator, a low-stage compressor, to which the evaporator discharges, for initially compressing the gaseous refrigerant, a high-stage compressor to which the low-stage compressor discharges, a condenser to which the high-stage compressor discharges and discharging to the evaporator, a liquid-cooler interposed in the discharge-line from the condenser, means for mixing refrigerant from said cooler with the gas passing from the low-stage to the high-stage compressor, whereby the volumetric efficiency of the high-stage compressor is increased, and means communicating with said mixer for separating liquid refrigerant therein and introducing it into said cooler.

4. In a refrigerating machine, the combination of an evaporator, a low-stage compressor, to which the evaporator discharges, for initially compressing the gaseous refrigerant, a high-stage compressor to which the low-stage compressor discharges, a condenser to which the high-stage compressor discharges and discharging to the evaporator, a receiver for cooled refrigerant from the condenser, a liquid-cooler communicating with said receiver, a drum interposed in the communication between the compressors, said drum communicating with said receiver and discharging to said cooler, and a pipe connecting said cooler with the gas-passage from the low-stage compressor to said drum.

5. In a compression refrigerating machine, a holder for the cooling medium, a compressor for the gaseous refrigerant discharged from said holder, a second compressor of smaller size than the first-named compressor and communicating therewith, a drum interposed in the communication between said compressors, a condenser to which said

smaller compressor discharges, and discharging to said holder, a supplemental cooler interposed in the discharge-line between the condenser and holder, a gas-conducting pipe
5 connecting said drum and supplemental cooler, and a valved pipe-connection between said drum and discharge-line.

10 6. A compression refrigerating machine comprising a holder for the cooling medium, a drum having valved pipe-connection with said holder, a series of compressors having their cylinders of progressively decreasing size, a pipe-connection between said drum and the first compressor, a second drum between the first and second compressors, into

which the first compressor discharges and discharging into the second compressor, a condenser to which the last compressor of the series discharges and having valved pipe-connection with said holder, a supplemental
20 cooler interposed in said pipe-connection, a fluid-conducting pipe connecting said second drum and supplemental cooler, and a valved fluid-conducting pipe connecting said
25 discharge-line from the condenser with said second drum and a refrigerant line leading from the supplemental cooler to the communication between compressors.

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