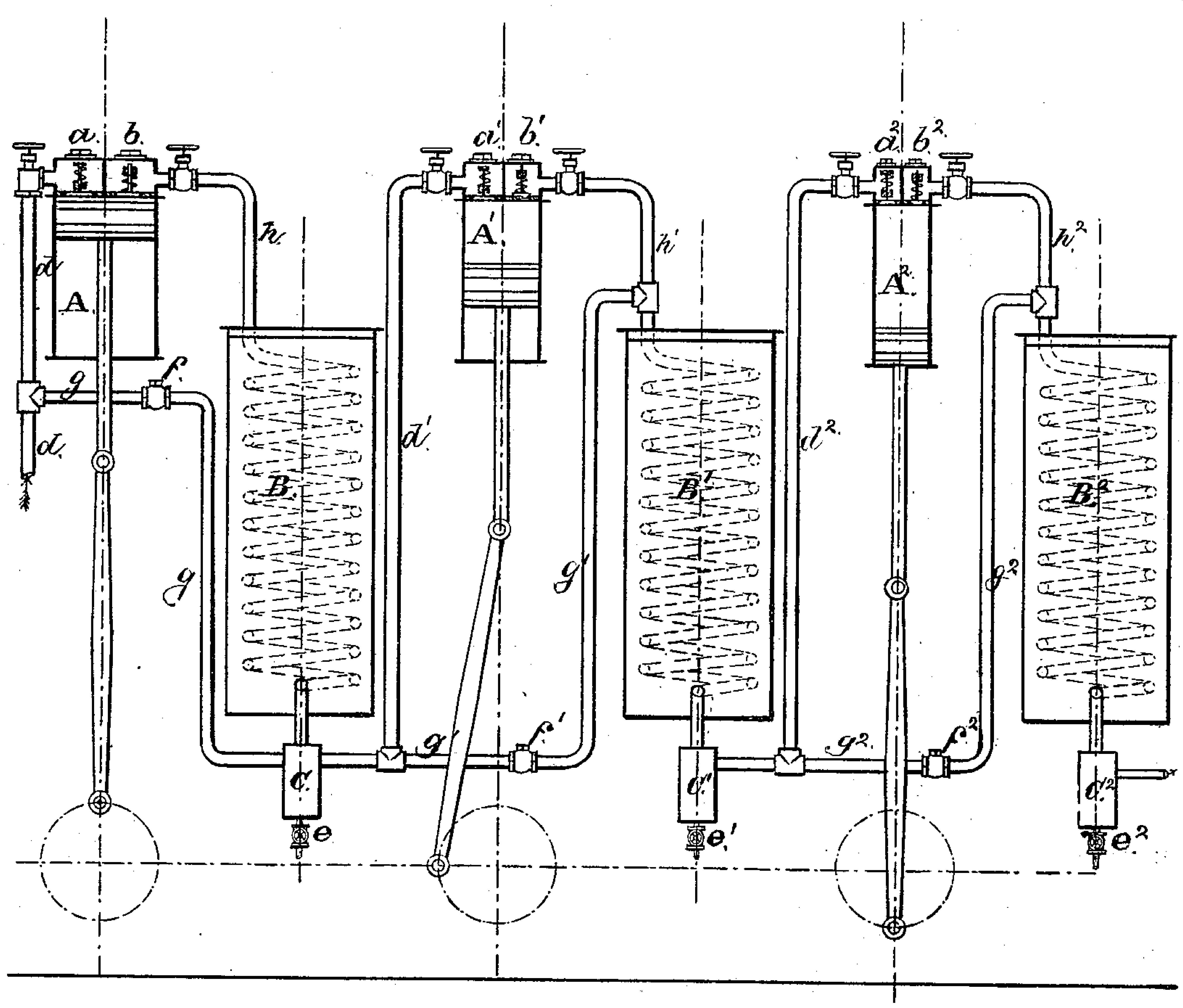
(No Model.)

G. O. RINMAN.

ICE MACHINE.

No. 335,386. Patented Feb. 2, 1886.



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UNITED STATES PATENT OFFICE.

GUSTAF OSCAR RINMAN, OF CINCINNATI, OHIO.

ICE-MACHINE.

SPECIFICATION forming part of Letters Patent No. 335,386, dated February 2, 1886.

Application filed November 9, 1885. Serial No. 182,184. (No model.)

To all whom it may concern:

Be it known that I, GUSTAF O. RINMAN, of the city of Cincinnati, Hamilton county, and State of Ohio, have invented certain new and useful Improvements in Ice-Machines, of which the following is a specification.

My invention relates to ice making and refrigerating machinery in which volatile liquids are used for producing cold by the absorption of heat from objects in contact with them (surrounding objects) during their (said liquids') evaporation, and also the machinery whereby the gas thus produced is converted into a liquid by a compression gas-pump.

In the usual form of gas pumps or compressors the gas enters the pump at a low pressure from the refrigerator. The pump then compresses it to a pressure at which it will liquefy. This pressure is different for different volatile liquids, and depends upon the temperature to which the gas can be cooled in the condenser, into which latter it is forced by the pump. From the condenser it is collected in a liquid form in a vessel called the "recipient." From this latter vessel, where the liquid is held under high pressure, it is allowed to escape through a very small opening into the refrigerator. In this latter vessel it is relieved from the pressure to which it has been subjected in the recipient and changes into a gas or evaporates, and by so doing absorbs heat from the objects with which it is in contact—viz., such objects are ordinarily the pipes that contain the evaporated liquids in the refrigerator.

Liquid ammonia is the most common volatile liquid used for producing cold in an ice making or refrigerating machine. Its pressure of liquefaction is very high—viz., from one hundred and twenty to two hundred pounds, depending upon the temperature of cooling water in the condensers. The gas is by the compression aforementioned heated to a temperature that is proportionate to the mechanical equivalent of the power expended in compressing the gas; or, in other words, the greater the pressure to which the gas is subjected the higher will its temperature be. The gas, which enters the compressor through the induction-valve at a comparative low pressure, is compressed by the reciprocating motion of the piston or plunger. It is gradually compressed in the pump, and the pressure increases therein until it reaches a pressure that is a little above that in the condenser, when it opens the relief-valve, and by the force of the pump enters the condenser. It is only during a small portion of the stroke of the pump that there is great power required to compress the gas. Suppose, for instance, that the gas enters the pump at a pressure of fifteen pounds, when the piston has traveled half its stroke the gas will have attained a pressure of thirty pounds, at three-fourths of the stroke sixty pounds, at seven-eighths of the stroke one hundred and twenty pounds. It is only during the last part of the stroke that the most power is required to compress the gas. This unequal work of a compression-pump requires more powerful motive power than if the work could be equally distributed, or nearly so, during the stroke of the piston or plunger. The unequal and sudden strains upon the machinery shorten its life considerably.

My invention consists in a serial or gradual compression and cooling of the gas. In place of using one compression-pump and a condenser, I use two or more pumps, and so reduce their diameters or their relative speeds that each one will have about the same amount of work to do as the other, and each pump provided with its separate condenser and the pumps working in a succession—that is, the first pump taking the gas from the refrigerator, compressing it to a certain pressure into its condenser, where the gas is cooled, the second pump taking it from this condenser and compressing the gas into the second condenser to a higher grade of pressure, and so on until the gas is liquefied. The work done by each pump will depend upon the number of pumps employed.

Referring to the drawings, A A′ A^2 represent pump-cylinders of different diameters with their respective induction and relief valves, *a b a′ b′* a^2 b^2.

B B′ B^2 represent the condensers.

C C′ C^2 are receivers for the condensers. They are provided with valves *e e′* e^2, through which they can be cleaned from the impurities that are carried with the gas in traveling through pipes in refrigerator and condensers. The expanded gas from the refrigerator or other receptacle enters the pump A through the pipe d and induction-valve A. In being compressed the gas is forced through the relief-valve b and pipe h into condenser B where it is cooled and gradually forced into the receiver C. From thence it is passed through pipe d' and induction-valve a' into pump A, where it is still further compressed and forced through the relief-valve b' and pipe h', and through cooler or condenser B' into the receiver C'. From thence it passes in the same described way through the other series of pumps and condensers that may be connected with the plant or mechanisms. If, as is a prominent feature of my invention, the areas of each pump are so proportioned that the volume of the cooled compressed gas for each stroke will be equal to the cubic contents of the next smallest pump, an equal amount of work will be done by each pump, and the strain and consequent wear and tear on each pump will be comparatively small. Suppose we assume three pumps the areas of whose pistons are respectively ten inches, five inches, and two and one-half inches, the stroke of the piston of each pump being the same, and suppose also that the gas enters the ten-inch pump at fifteen pounds, and after it has been compressed to half its volume, or to thirty pounds, it enters the second pump, its volume will be just enough to fill this pump, (if we do not take into consideration the effect of the intervening condenser or cooler, which will reduce the volume still more.) Assume that in this second pump it will here be compressed to half its volume again, or to sixty pounds, when it will enter the third pump, which latter will be exactly filled. If it here is compressed to half its volume it will attain the pressure of one hundred and twenty pounds. Suppose, also, that the incoming gas has also access to the other side of the piston, which it always has in a double-acting pump, and in most single-acting ones, then the actual pressure on the piston that has to be overcome in each pump respectively in compressing the gas will be for the ten-inch pump $30-15=15$ pounds, for the five-inch pump $60-30=30$ pounds, and for the two-and-one-half-inch pump $120-60=60$ pounds. If the resisting pressure in each pump is multiplied by the areas of each piston, the product will be the highest resistance to be overcome in each, or for the first $10\times15=150$ pounds, in the second $5\times30=150$ pounds, and in the third $2\frac{1}{2}\times60=150$ pounds, or the same resistance to be overcome in each pump. If, now, we had only the large pump to do the work with, the gas enters at fifteen pounds, and is expelled at one hundred and twenty pounds, the highest pressure to be overcome will be $120-15=105$ pounds to the square inch. The resistance on the piston at the point the gas escapes through the relief-valve will be $10\times105=1050$ pounds. The pump must be constructed strong enough to work under such a heavy strain. If we take the sum of the highest resistance to be overcome by the three pumps we get four hundred and fifty pounds, or two and one-third less than with a single pump. Consequently these pumps can be constructed much lighter, and will last much longer, because there is no sudden heavy strain on them, as it is during each stroke with a single pump. I know that the mechanical work performed by the motive power to compress the gas through the large pump is equal to the mechanical work performed through the three pumps if the resistance by the heated gas in the large single pump is not taken into consideration, but that in itself forms a large factor in the resistance to be overcome by the old system of compressing gases. The interposing condensers that I have introduced in my system will to a great extent overcome the resistance produced by the heat produced in compressing gases.

Another objectionable point in the old style of gas-compressors is overcome by my system of a series of pumps, and that is the clearances at each end of the stroke. In the compression of gases with one pump the piston has as a general thing to travel three-fourths inch to one and one-half inch on its back-stroke before the pressure in the clearance has been so reduced as that any gas can enter into the pump through the induction-valve. With my series of pumps the pressure in the clearance-space is so little that the piston only travels about one-eighth inch before the gas enters through the induction-valve into the pump. Consequently the cylinder receives more gas for each stroke than the single pump with equal piston area and stroke.

During the hot season of the year a refrigerator or ice-machine has as a general thing to work up to its full capacity; but toward and during the cold season its full capacity is not often required. In such a case by stopping the largest size pump the capacity of the machine can be reduced one-half, and in case of an accident—such as choking or clogging of the valves, leaking of the packing, repacking of the stuffing-boxes, or any other cause—any of the pumps can be stopped by the introduction of check-valves $f\ f'\ f''$ and pipes $g\ g'\ g''$ between the induction-pipe for each pump and its condenser; or, suppose the pump A is stopped to reduce the capacity of the machine, the pump A' will keep on drawing from the condenser B till the pressure of the gas in it has been reduced to a little below the pressure in the refrigerator, when the gas from the refrigerator will enter through the check-valve f into the receiver C, and so on to the pump A, and in case (during the working of the machine to its full capacity) something should happen that would require the stoppage of either pump A' or A'', the check-valves f' and f'' would respectively come into play.

When desired, the receivers C C' C'' can be connected to the condensers by globe-valves, and can be connected to their respective pipes, as $d\ d'\ d''$, by globe-valves. Each of the pipes

$g\ g'\ g''$ may be provided with and controlled by a globe-valve.

My invention is useful not only for refrigerating-machines, but also for compressing air or permanent gases.

While the several features of my invention are preferably employed together, one or more of said features may be employed without the remainder, and in so far as applicable one or more of said features may be employed in connection with condensers other than those specially hereinbefore set forth.

What I claim as new and of my invention, and desire to secure by Letters Patent, is—

1. The process of serial or gradual compression of the gas or air in successive condensers or chambers containing gas under different degrees of pressure, substantially as and for the purposes specified.

2. The process of serial or gradual compression of the gas or air by successive pumps and successive condensers or chambers containing gas under different degrees of pressure, substantially as and for the purposes specified.

3. The combination of two or more pumps and two or more condensers, each provided with receiver C, substantially as and for the purposes specified.

4. The combination of two or more pumps and condensers and pipes, as $g\ g'$, and check-valve f, substantially as and for the purposes specified.

5. The combination of two or more pumps of different areas and condensers and pipes, as $g\ g'\ g^2$, and check-valve f, substantially as and for the purposes specified.

6. The combination of pumps A A′ A^2 and condensers B B′ B^2, and pipes $g'\ g^2$, and check-valve f, substantially as and for the purposes specified.

7. The combination of the condenser, receiver, and valve, as e, substantially as and for the purposes specified.

GUSTAF OSCAR RINMAN.

Attest—

GEO. M. LUCKEY,

JNO W. STREHLI.