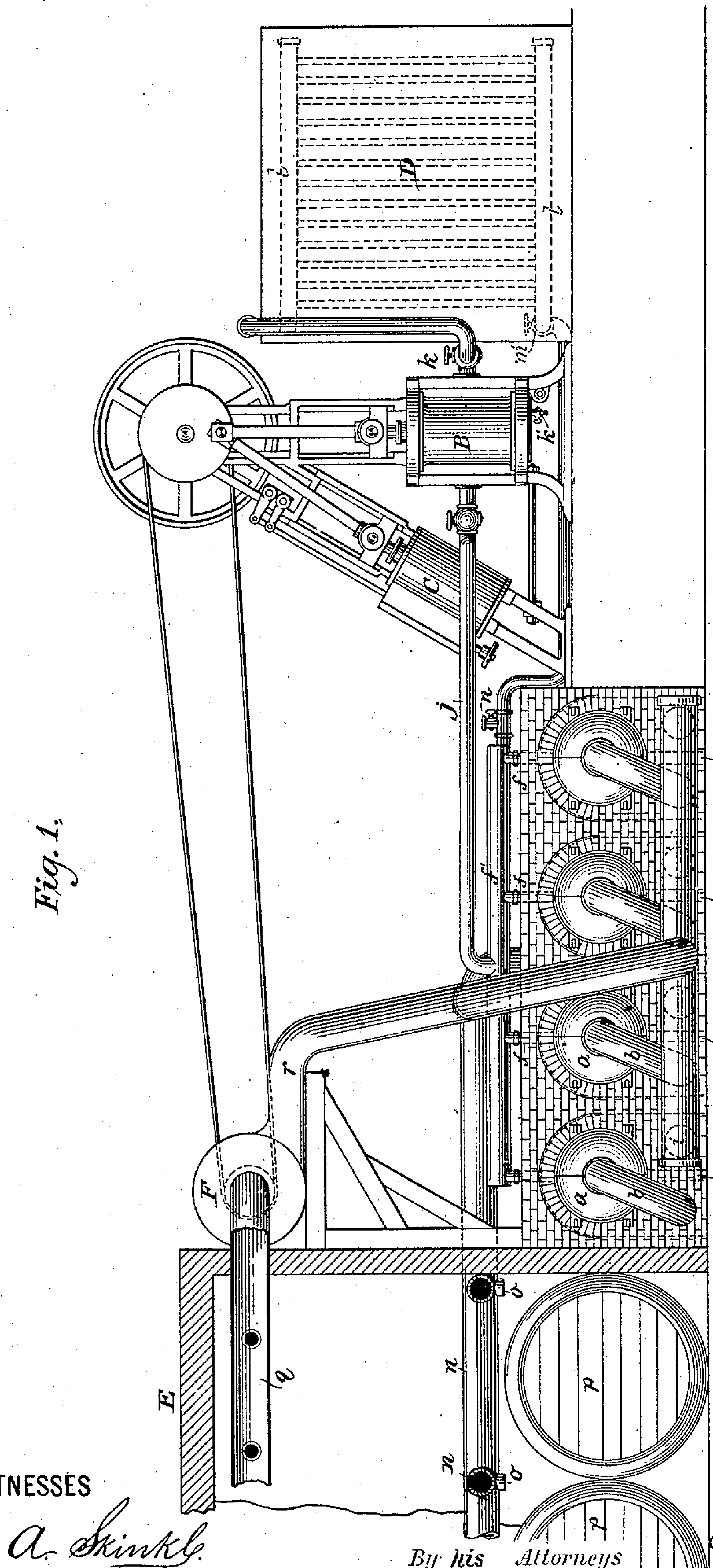
(No Model.)

3 Sheets—Sheet 1.

C. C. PALMER.

REFRIGERATING APPARATUS.

No. 290,794. Patented Dec. 25, 1883.



WITNESSES

Wm A. Skinkle

Geo W. Breck.

INVENTOR

Cassius C. Palmer

By his Attorneys

Gifford & Gifford

N. PETERS. Photo-Lithographer, Washington, D. C.

(No Model.)

3 Sheets—Sheet 2.

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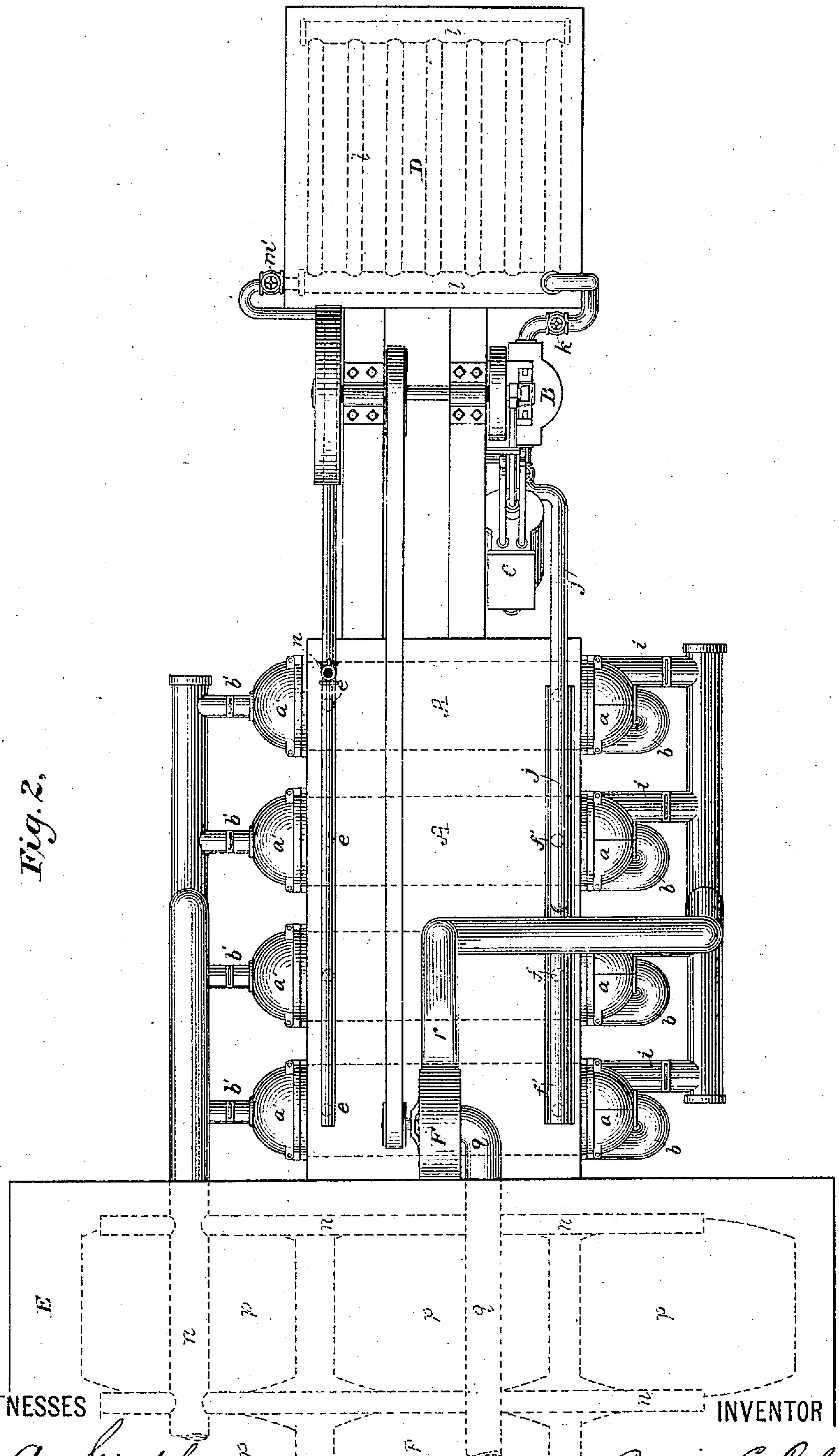

Fig. 2.

WITNESSES

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(No Model.) 3 Sheets—Sheet 3.

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REFRIGERATING APPARATUS.

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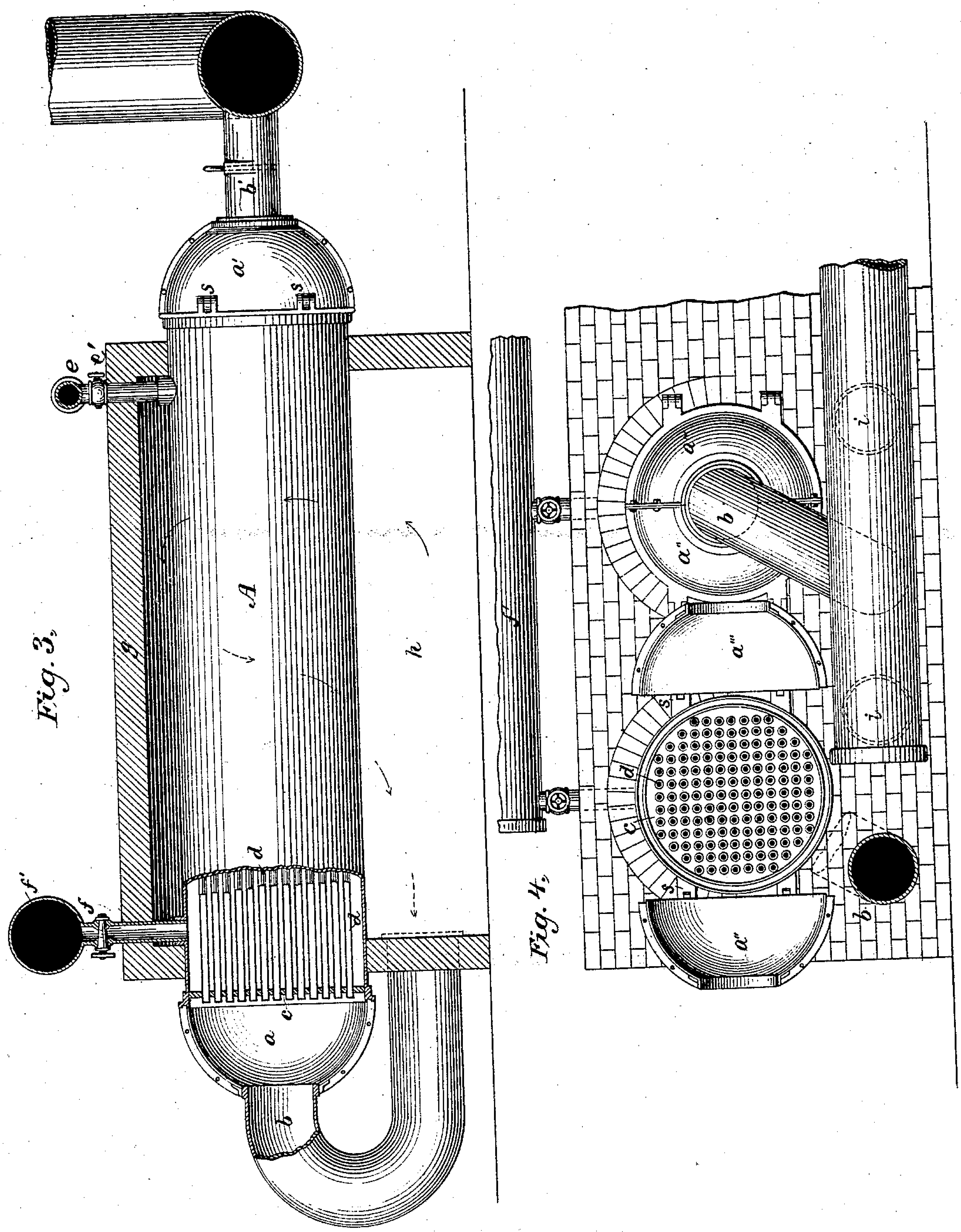

Fig. 3. Fig. 4.

WITNESSES

Wm A. Skinkle.

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UNITED STATES PATENT OFFICE.

CASSIUS CLAY PALMER, OF OAKLAND, CALIFORNIA.

REFRIGERATING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 290,794, dated December 25, 1883.

Application filed December 30, 1882. (No model.) Patented in England April 29, 1880, No. 1,752; in France April 29, 1880, No. 136,416; in Victoria May 13, 1880, No. 2 828, and in New South Wales June 30, 1880, No. 3,960.

To all whom it may concern:

Be it known that I, CASSIUS CLAY PALMER, of Oakland, Alameda county, in the State of California, have invented a new and useful Improvement in Refrigerating Apparatus, of which the following is a specification.

Heretofore various methods for refrigerating air have been in use, with more or less success, most prominent among which may be mentioned apparatus for circulating the air in direct contact with ice; also, apparatus for circulating the air in contact with the exterior of vessels or pipes containing a freezing-mixture or brine; also, apparatus for compressing the air, cooling it in the compressed state, and expanding it; also, apparatus for circulating the air in contact with the exterior of receptacles containing expanded ammonia-gas. All of these methods, however, are open to serious objections which are very familiar to those acquainted with their use.

My improvement consists, primarily, in refrigerating air by the agency of chloride of ethyl, which I have found to possess substantial advantages, hereinafter referred to, over any of the refrigerating agents which have heretofore been employed for the purpose.

My improvement also consists in the construction of certain apparatus by the operation of which great advantages are acquired in the manipulation of a volatile fluid as an agent for the refrigeration of the atmosphere.

My improvement may be applied to the refrigeration of air for any purpose, such as the preservation of putrescible substances; but I have ascertained that it has especial features of utility when employed for the refrigeration of the air contained within compartments within which beer is placed for storage or fermentation.

Figure 1 of the accompanying drawings represents an elevation of a form of apparatus which I prefer to use in practicing my invention. Fig. 2 represents a plan view. Figs. 3 and 4 represent detailed views of the refrigerator and its connections, the cap *a* being represented in both its opened and closed positions in Fig. 4.

My apparatus may be divided into five parts—namely, the refrigerator, the condenser, the compressor, the pressure-blower, and the chill-room.

The refrigerator may consist of any number of parts like that which I am about to describe, the number of such parts being regulated in accordance with the space required to be cooled by the apparatus. In Figs. 1 and 2 I have shown the refrigerator as containing four of these parts. Figs. 3 and 4 show the construction of each of these parts.

A represents a cylinder, which I prefer to construct of copper when chloride of ethyl is used as the refrigerating agent. This cylinder is made sufficiently strong to withstand the atmospheric pressure upon its exterior when in use, and is provided at each of its ends with a cap, *a a'*, joined to the cylinder in such a way as to prevent the escape of the air, which is forced through the apparatus by the pressure-blower. These caps I also prefer to construct of copper. Each of these caps is provided (preferably at its center) with a pipe, *b b'*, one for conducting air into the cylinder and the other for conducting it out.

Two perforated plates, *c c'*, are situated within the cylinder—one at each end—and in such position that an air-space is left between each perforated plate and the cap inclosing it. These perforated plates are so connected at their edge with the interior of the cylinder as to prevent any communication between the air which is contained within the caps *a a'* and the fluid which is contained between the perforated plates. From one of these perforated plates to the other extend tubes *d*, which are fitted at each end into the perforations of the plates by tight joints, which tubes afford communication from the air-space at one end of the cylinder to the air-space at the other end of the cylinder. These tubes and the perforated plates are also made, preferably, of copper when chloride of ethyl is used. The pipe *e* serves to conduct the fluid into the space around the tubes in the cylinder, this pipe being preferably located at the top and near one end of the cylinder. Another pipe, *f*, serves to conduct the fluid in its expanded state away from the cylinder, and is situated, preferably, near the other end of the cylinder, at its top, the second pipe being somewhat larger than the first pipe, so as to provide for the difference in volume of the fluid caused by its expansion in the cylinder. The nozzle of the pipe b', which conducts the air away from the cylinder, is made, preferably, smaller than the pipe b, which conducts the air to the cylinder, so as to assist the pressure-blower in keeping up a certain amount of pressure of air within the tubes d in the cylinder, and thereby causing the air within the tubes throughout their whole length to be kept in intimate contact with the interior of the tubes. The cylinders A are each surrounded by a masonry inclosure, which is so built as to leave the caps a a' projecting outside, and so as to leave a space around outside each cylinder A on all sides. This space is divided by a longitudinal partition, h, (shown in dotted lines, Fig. 1,) connecting the bottom of the cylinder with the floor; and the air which is to pass through the refrigerator before entering the pipe b is conducted by the pipe i into the inclosed space around the cylinder A on one side of the partition h, and passes around the cylinder to enter the pipe b, which connects with the inclosed space on the other side of the partition h, as shown. The object of thus conducting the air taken from the chill-room around the exterior of the cylinder before it is passed through the tubes d is for economy, because the air received from the chill-room is colder than atmospheric air, and thus presents a barrier to the entrance of heat from the atmosphere into the refrigerator. Another object is to cause the air to leave considerable of its moisture condensed on the cold exterior of the cylinder A before it enters the tubes d.

As means of access to the interior of the pipes d, the caps a a' are preferably each constructed in two equal parts, a'' a''', Fig. 4, said parts being hinged at s, and when closed meeting together, so as to make a tight joint around the pipes b b' and with each other. When closed, they may be secured together by bolts or in any other suitable manner. Each of the pipes f connects with the cylinder or pipe f', which is in turn connected with the compressor by the pipe j. The pipe f' is preferably somewhat larger in area than the combined area of all the pipes f, for the purpose of distributing the suction of the compressor equally to all the cylinders and preventing the beats or strokes of the compressor being felt in the cylinder A. The compressor is represented in Figs. 1 and 2, the compression-cylinder being lettered B and the steam-cylinder C. No detailed description of this compressor is necessary, since it is constructed similar to pumps for compressing gases, which have been heretofore in use. The compression of the chloride of ethyl requires a power of only about fifteen pounds. The refrigerating-fluid, in an expanded condition, is drawn from the refrigerator to the compression-pump through the exhaust-pipes f, f', and j, and from the compressing-pump the fluid, in a compressed state, is conducted through the pipe k to the condenser, where it is converted from a gas to a liquid.

The condenser consists of a tank, D, to contain a cooling-liquid, (generally water of ordinary temperature,) within which are immersed the coil of pipes l, through which the referigerating-fluid passes after leaving the compressing-pump, for the purpose of having its temperature reduced and being converted from the gaseous to the liquid state preparatory to being returned to the refrigerator through the pipe m. Of course, the condenser may be varied in many ways, and the cooling agent by which the condenser-pipes are surrounded may be varied in many ways, in accordance with the amount of cold which it is desired to secure.

The chill-room may be a beer-cellar in a brewery, or it may be the chamber of a provision-refrigerator. It is constructed, preferably, with non-conducting walls E, and contains a system of distributing-pipes, n, connected with the air-pipes b', containing openings o, arranged at various points in the chill-room, so that the cold air may be equably distributed to all parts of the chill-room, or wherever required. In the drawings these openings are shown as located between the rows of beer-barrels p, about on a level with their tops, though of course it might be discharged at other points, if required. q is the pipe through which the air is drawn out of the chill-room, which may be connected with distributing-openings, as shown.

In the fermenting-room of a brewery when cooled by my apparatus, the open tubs of fermenting beer are stood in the positions occupied by the barrels p in the drawings, and the cold air, being thus discharged from the openings o in the position shown, meets with and absorbs the carbonic-acid gas flowing over the edges of the tubs; but at the same time the draft of air is so directed by the nozzles o as to produce the lowest temperature at the bottoms of the tubs, whereby the beer at the bottoms of the tubs is kept as cold as or colder than the beer at the surface, so that the gas which is thrown off by the fermentation of the beer at the bottom of the tubs will not be reabsorbed by the beer above in passing through it.

The pressure-blower F is constructed like the pressure-blowers heretofore in use—such as the Baker or Root blowers—and hence need not be specifically described. It is driven by a belt or other means of connection with the engine. It draws the air from the chill-room through the pipe q and forces it into the refrigerator through the pipes r and i. Of course other air-forcing apparatus might be used in lieu of the pressure-blower, though I think not to so great an advantage. The connections of the pressure-blower might be reversed, so as to discharge the cold air from the pipe *q* and exhaust it through the pipes *n* *n* and openings *o*.

By arranging valves in the pipes *i* and *b'* and *e* and *f* connected with each of the cylinders A, I can throw any one or more of the cylinders into or out of operation at will, so that any one of them can be cleaned or repaired while the others are in operation, both the refrigerating-fluid and the air being diverted from entering the cylinder for the time being. The number and length of the tubes and the frequency of compression and expansion of the refrigerating-fluid for securing the proper degree of cold will of course depend upon the size of the chill-room and the influence of external heat and the amount of heat given off by the contents of the chill-room; but for a chill-room having ten thousand cubic feet capacity, with ordinary non-conducting walls, and containing barrels of fermenting beer, I have found that a temperature of 38° Fahrenheit could be secured by refrigerators containing eighty-four tubes, each tube one and one-fourth inch in diameter and seven feet long, the cylinder being thirty inches in diameter, and the amount of chloride of ethyl in use being about eight hundred pounds, and being compressed and expanded about once in every two or three hours, the condenser also containing water at about 76° Fahrenheit temperature, and the air in the chill-room being conducted through the cooling-tubes about once every hour.

In operating my apparatus I prefer to have at least one of the cylinders A all the time idle while the others are in operation, so that if any of those in operation require cleaning or repairs its valves can be closed, and the valves of the idle cylinder can be opened, so that the number of cylinders in operation will not be reduced. In operating the apparatus shown in Figs. 1 and 2, therefore, I open the valves of three of the cylinders, leaving the valves of the fourth one closed. I then start the operation of the pressure-blower and the compressing-pump. Before introducing the chloride of ethyl into the apparatus, the valve *k*, Fig. 1, is closed and a pet-cock, *k'*, is opened, so that by operating the compression-pump the air is exhausted from all parts of the apparatus intended for the volatile fluid. The chloride of ethyl, which under atmospheric pressure is in the form of a liquid, is then allowed to flow into the apparatus through the petcock *u*, and, expanding, fills the apparatus with its vapor, and during the operation of the apparatus the condenser and the space around the tubes *d* and the connecting-pipes contain only the chloride of ethyl and its vapors. The petcock *k'* is next closed and the valve *k* is opened. The exhaust-pipe of the compressor exhausts the gas from the cylinder A, and the compressing-pump compresses it and forces it into the condenser, where it is cooled and reduced to the liquid state, ready to be returned to the cylinder A, and there caused to expand again by the agency of the partial vacuum, which is retained therein by the exhaust of the compressor. From the condenser the liquefied chloride of ethyl passes through the pipes *m* and *e* into the cylinders A, where (the cylinders containing a partial vacuum) it expands into a gas around the tubes *d*, thereby correspondingly reducing its temperature, so as to extract the heat from the pipes *d* and the air passing through them. In the expanded state the chloride of ethyl is drawn by the exhaust of the compressor through the pipes *f* *j* back to the cylinder B, where it is compressed, and then goes through the same operation over again. While the treatment of the chloride of ethyl is progressing, as above described, the pressure-blower draws air out of the chill-room and forces it under a slight pressure through the pipes *r* and *i* into the inclosed spaces surrounding the cylinders A. Thence the air, still under a slight pressure, passes through the pipes *b* within the space between the caps *a* and the perforated plates *c*, and thence through the tubes *d* and into the space between the cap *a'* and perforated plate *c'*. From this space the air is conducted through the pipes *b'* and *t* back to the chill-room, into which it is distributed by the pipes *n* from the openings *o*. In its turn this air is again drawn into the pipe *q* and the same operation upon it is repeated.

In making the excursion above described the air is not finally cooled till it reaches the tubes *d*; but as it passes through the tubes *d* the difference in area between the pipes *b* and *b'*, already mentioned, assists the pressure-blower in keeping the air under a slight pressure, which aids in bringing it into intimate contact with the interior of the tubes *d*, and its heat is taken up by the pipes and given by them to the chloride of ethyl surrounding them, which carries it to the condenser and leaves it there, preparatory to returning to take away the heat of any other air which may be passing through the tubes, when it returns to the cylinders A. Not only is the air in this manner deprived of its heat as it passes through the tubes, but by reason of its loss of heat it also loses its capacity to hold moisture, and its moisture is therefore deposited on the interior of the tubes in the form of ice or snow, the air in the chill-room being thus kept very dry. Still another impurity which the air leaves in the tubes in case the apparatus is applied to refrigerating fermenting-rooms is the carbonic-acid gas resulting from the fermentation, which gas is very soluble in the moisture held by the air when it enters the tubes, but is very slightly soluble by the dry air as it leaves the tubes. The gas is therefore dropped by the air and left in solution in the snow or ice deposited in the tubes. So marked is this result that fermenting-rooms, which, when refrigerated as heretofore, habitually contained so much carbonic-acid gas that a lamp could starcely be burned in them, when refrigerated by my apparatus, are kept practically free from any carbonic-acid gas whatsoever. The presence of the gas in the snow or ice deposited in the tubes is shown by the acid reaction it has upon litmus-paper. The moisture and impurities taken up by the air in the chill-room being thus deposited on the interior of the tubes *d*, those tubes, after long-continued operation, require to be cleaned out. To do this to the tubes in any cylinder, I close the valves in the connecting-pipes of that cylinder, and at the same time open the valves in the cylinder which was previously idle. Of the cylinder thus cut off I open the caps *a a'* by swinging the two halves of each cap back on their hinges. The tubes within the cylinder are thus exposed at both ends, and to clean them out I cause water of the ordinary temperature, or steam or other comparatively-temperate fluid, to flow through them. This water thaws the snow and ice deposited in the tubes and washes them all out clean. The caps of the cylinder are then closed, and the cylinder is ready to be put into operation again whenever needed. In this manner I am enabled, without interfering with the operation of the apparatus, to keep it free from obstructions.

In order to produce a temperature below the boiling-point of the refrigerating-fluid, (which for chloride of ethyl is 52°,) it is necessary that the capacity of the compressing-pump and the relative areas of the pipes leading from the compressor to and from the refrigerator should be so regulated that in operation a partial vacuum is continually preserved around the tubes *d* within the cylinders A. The extent of vacuum required will depend upon the lowness of the temperature desired for the air.

In practice I have found that when the air being delivered into the chill-room showed a temperature of 40° Fahrenheit a vacuum-gage connected with the interior of the cylinder A registered about fifteen inches, and when the air being delivered to the chill-room was at about 28° Fahrenheit the vacuum-gage stood at twenty inches, though the vacuum-gage in these instances would have registered less if the air from the chill-room had been passed more frequently through the pipes *d* than it was in fact, the air in the chill-room in the examples referred to being passed through the tubes *d* once every hour. In order to provide for producing this partial vacuum within the cylinders A, I place in the branch pipes leading from the pipe *e* to each refrigerator check-valves *e'* near the point where each branch pipe empties into its refrigerator, by partially closing which I am enabled to so impede the passage of the fluid from the condenser to the refrigerator as to prevent its being supplied to the refrigerator sufficiently fast to fully supply the place of the gas which is exhausted from the refrigerator by the compressing-pump. Thus the extent of vacuum produced within the refrigerator, and consequently the temperature communicated to the air passing through the tubes *d*, may be regulated at will by simply varying the position of the check-valve *e'*, and the fluid does not begin to vaporize practically until after it has passed the valve *e'*.

I have described the apparatus which I prefer to use in practicing my invention; but it will be apparent that the apparatus may be varied in many features without departing from the scope of my invention.

So far as I know, previous to my invention no apparatus was known practically adapted for the application of chloride of ethyl as a refrigerating agent to the refrigeration of air, and I believe myself to be the first one to refrigerate air by means of chloride of ethyl. I furthermore believe that my apparatus contains certain novel features which might be used to advantage in refrigerating with other agents than chloride of ethyl.

Some of the advantages of my method are the following: Very little pressure is required to compress the chloride of ethyl, thus requiring little power or strength of machinery, and producing little wear of machinery and little liability of breakage, leakage, and loss of the fluid. The chloride of ethyl is neutral, and attacks no metal; therefore any metal can be used in the construction of the machine, and I am enabled to use copper for the tubes *d*, (one of the best conductors of heat,) while with some other fluids only iron can be used, which is one of the poorest conductors, and does not make tight joints, as does copper. Chloride of ethyl is not noxious to the smell or injurious to the health.

In my machine all of the parts of the apparatus traversed by the refrigerating-fluid may be in the machine-room, readily accessible to the engineer. The tubes *d* can be readily cleaned of any moisture frozen in them which tends to impair their conductivity or obstruct them. Access to the apparatus does not require the chill-room to be opened. The atmosphere of the chill-room is deprived of carbonic-acid gas and other impurities. Chloride of ethyl, when expanded so as to produce cold, deposits crystals on any substance with which it may be in contact, which crystals accumulate so as to have the appearance of frost or snow. It also expands slowly when volatilized.

I am aware that attempts have heretofore been made to use chloride of ethyl for freezing liquids; but I do not know of any attempts prior to my inventions in this direction which were practically successful.

One of the principal reasons why the apparatuses before known could not be used with practical advantage with chloride of ethyl has been because the expansion of the chloride of ethyl took place in a passage of restricted sectional area—in fact of a sectional area not greater than the supply-pipe for the compressed fluid. When expanded in such a passage, the tendency of the gas to form the crystals referred to and the slowness of its expansion form unsurmountable obstacles to its successful use, because the formation of the crystals quickly fills up the area of the passage when the gas first begins to expand and prevents further circulation, and the slowness of the expansion of the gas prevents its being diffused quickly throughout the remote end of the expansion - passage, and thereby prevents a uniform distribution of cold. In my method and apparatus provision is made for introducing the fluid to be expanded within a chamber of large sectional area in comparison with the sectional area of the supply-pipe, so that whatever crystals may be created within the chamber and deposited therein will occupy so small a space in comparison with the sectional area of the expanding passage or chamber as not to materially obstruct the passage of the expanded gas through the same. These crystals spontaneously volatilize when exposed to a temperature higher than the temperature at which they are formed, so that whenever the apparatus is stopped any accumulation of them which has been formed in the expansion-chamber will spontaneously disappear. By having the expansion-chamber of large sectional area, my method is also adapted for the slowness with which the fluid expands, and the gas is diffused throughout all portions of the chamber with sufficient rapidity.

It will be noticed that the bottom of the condenser is above the level of the bottom of the refrigerator, so that in the relationship of the apparatus shown in the drawings the chloride of ethyl would exist throughout the greater part of the condenser in a gaseous condition, which will be converted into a liquid as it becomes cool, and will collect in a liquid form to a comparatively small extent at the bottom of the condenser. This liquid, running through the connecting-pipe into the refrigerator, will collect therein to a considerable depth, where, as it gradually absorbs heat from the air-tubes, it will be converted into a gas, which accumulates in the upper portion of the refrigerator. This gas apparently is generated in various portions of the liquid, where it comes in contact with the heating - surfaces, and as it bubbles up through the liquid chloride of ethyl from the points at which it is generated it readily escapes from the large area of exposed surface, and the gas produces a boiling effect in the refrigerator.

The apparatus I have described may be located outside the chill-room with pipes connecting therewith, or it may be located within the chill-room, or partly inside and partly outside.

I have made an application of even date herewith for certain features of the above invention, and I therefore do not claim those features in this application.

I am aware of the patent granted to Charles Tellier, dated January 5, 1869, and numbered 85,719, and do not make claim to anything therein described. That patent states that it is necessary in cooling air by the Tellier method not to allow the air to be cooled below the freezing-point in the apparatus. This would not reduce the temperature of a chill-room sufficiently for practical purposes, and together with other features renders the Tellier method incapable of accomplishing the results for which mine is adapted.

I am also aware of the patent to J. G. Wolf, dated March 9, 1879, No. 213,487, and make no claim to anything shown therein.

I claim—

1. The method or process, substantially as described, of cooling air, which consists in compressing chloride of ethyl, cooling it when compressed, volatilizing it in a chamber of sufficient area wherein to deposit its crystals without obstructing the passage of gas, and causing the volatilized gas to circulate in contact with a conductor of heat, on the opposite side of which conductor the air circulates, whereby the heat communicated by the air to said conductor is carried off by the gas.

2. The method or process, substantially as described, of cooling air, which consists of compressing chloride of ethyl, cooling it when compressed, volatilizing it in a chamber of sufficient area wherein to deposit its crystals without obstructing the passage of gas, and causing the air to circulate through a passage adjoining the passage through which said volatilized chloride of ethyl is passed.

3. The improvement in the art of cooling air by the agency of a volatile fluid which is compressed and cooled and volatilized in such manner as to absorb the heat from the air, which improvement consists in volatilizing chloride of ethyl within a closed chamber of sufficient sectional area to prevent the passage of volatilized fluid through the same being obstructed by the crystals which may be deposited upon the wall of the chamber by the fluid undergoing volatilization.

4. The process of refrigerating by means of chloride of ethyl, which consists of compressing and condensing it and then allowing it to vaporize within a receptacle, constructed substantially as described, whereby sufficient area of surface of the liquefied fluid is exposed to permit the gas which is formed therein to escape freely into the upper portion of the receptacle.

5. The improvement in the art of cooling air by the agency of a volatile fluid, which consists in subjecting the air as it passes through tubes to the cooling action of the fluid volatilized within a vessel surrounding said tubes by the agency of a partial vacuum, substantially as described.

6. In a refrigerator, the combination of the cylinder A, the tubes *d*, opening into air-spaces at each end, inlet and outlet air-passages *b*

and b', connecting said air-spaces with the chill-room, the pressure-blower connected with the pipe b, for driving the air through the tubes d under pressure, and suitable connections for conducting the volatile fluid to and from the cylinder A, substantially as described.

7. In combination with the pressure-blower, the vessel A, having the air-tubes d and inlet and outlet air-passages to and from said tubes, the area of the outlet-passage being less than the area of the inlet-passage, substantially as and for the purpose described.

8. In combination, a refrigerator provided with tubes for the passage of air, and a closed chamber surrounding said tubes, constructed to hold a volatile fluid, inlet and outlet pipes connecting said air-tubes with the chill-room, pipes connecting the closed chamber with a compressor constructed to draw the volatilized fluid from said closed chamber, and a condenser for cooling the same when compressed, substantially as described.

9. The process of keeping the air of a chill-room at a temperature below 50° Fahrenheit for preserving purposes, which consists in passing the same through tubes adjoining a chamber connected with a gas compressor and condenser, and preserving in said chamber a partial vacuum, thus causing a volatile fluid to volatilize therein at a low temperature.

10. In combination, the tubes for the passage of the air being cooled, the adjoining volatilizing-chamber, the fluid-compressor having exhaust and pressure passages connecting the compressor with the volatilizing-chamber, said passages being provided with means for making the pressure-passage of less area than the exhaust-passage, whereby the compressor may produce a partial vacuum within the volatilizing-chamber for volatilizing the fluid.

11. The chill-room, the air-cooling tubes connected by inlet and outlet air-passages with the chill-room, the air-forcing apparatus for forcing the air over and over again through the air-cooling tubes, the volatilizing-chamber surrounding the air-cooling tubes, and connected with the exhaust and pressure passages of the compressor, and means for regulating the relative areas of said passages, all combined substantially as described.

CASSIUS CLAY PALMER.

Witnesses:

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W. F. HAPGOOD.