No. 610,276. Patented Sept. 6, 1898.

E. C. NICHOLS.

AIR PURIFYING AND REFRIGERATING SYSTEM FOR REFRIGERATOR CARS, &c.

(Application filed Apr. 24, 1897.)

(No Model.) 3 Sheets—Sheet 1.

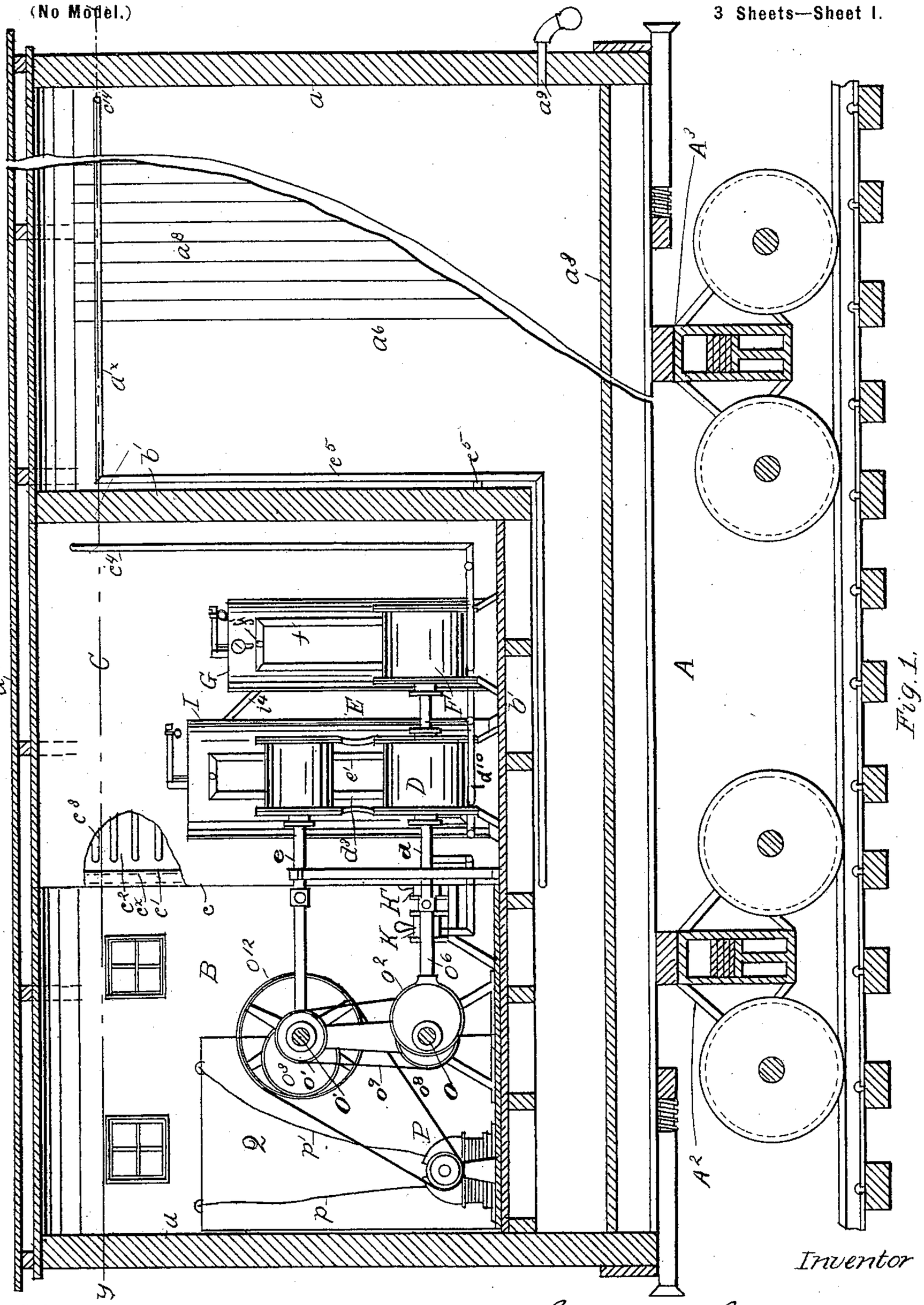

Fig. 1.

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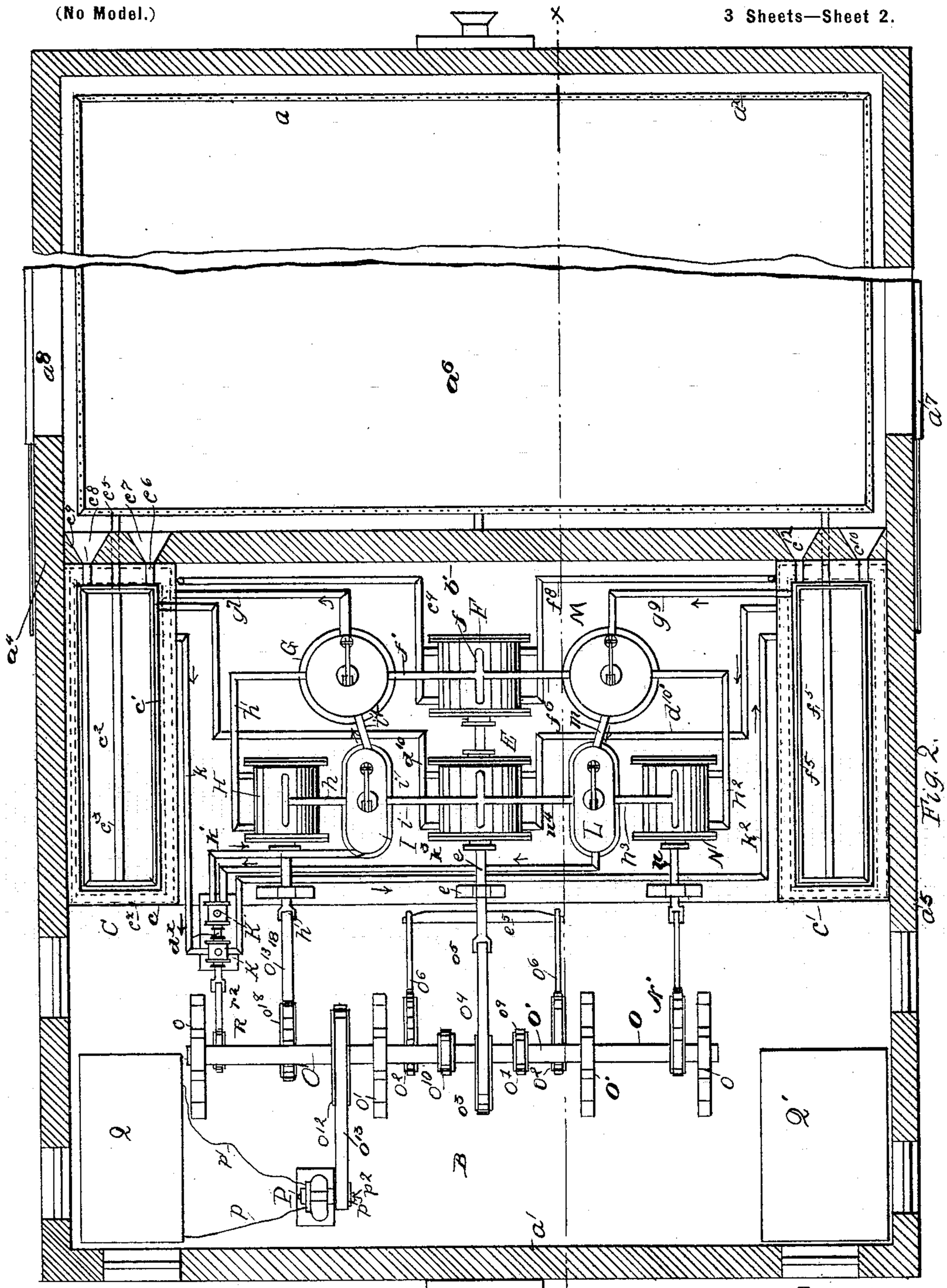

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(Application filed Apr. 24, 1897.)

(No Model.) 3 Sheets—Sheet 3.

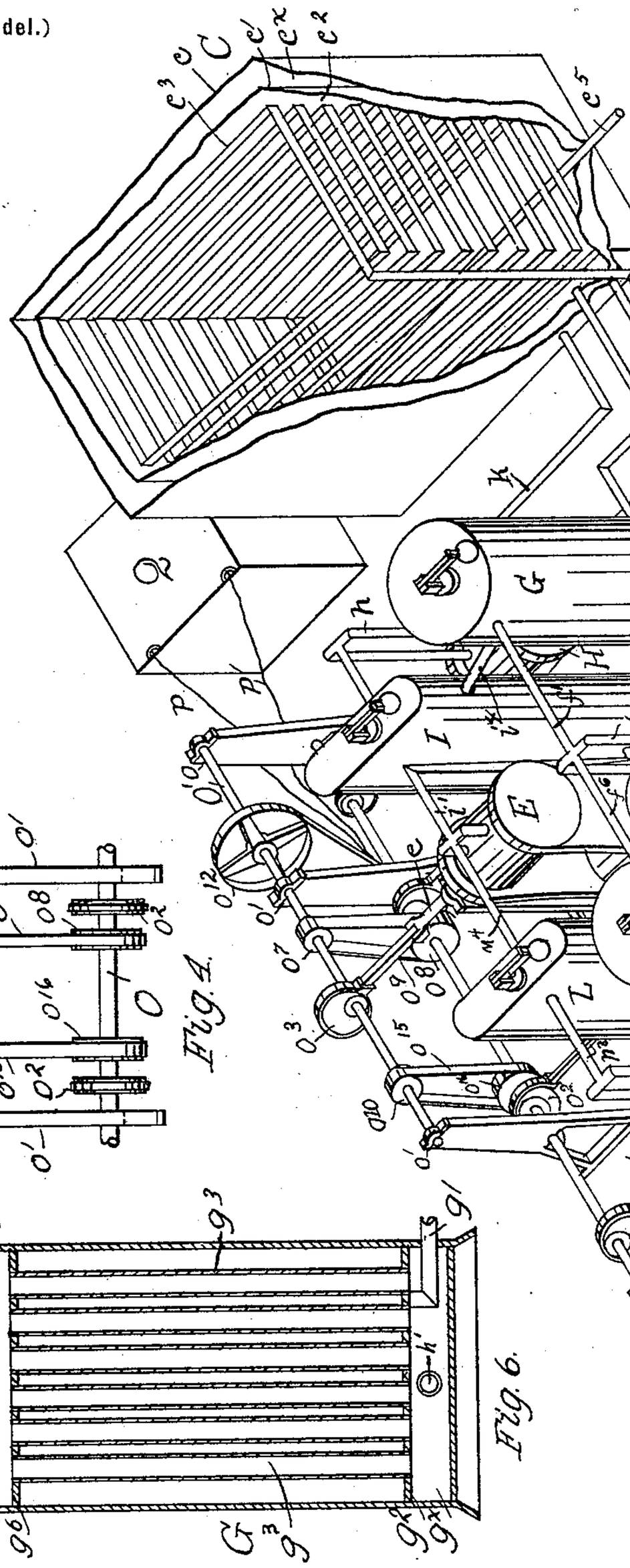

Fig. 3.

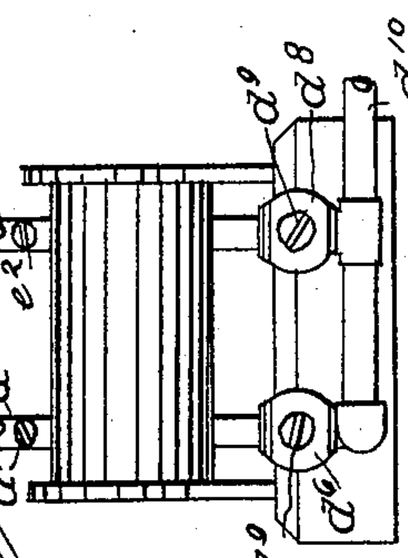

Fig. 5.

Fig. 4.

Fig. 6.

Witnesses

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UNITED STATES PATENT OFFICE.

EDWIN C. NICHOLS, OF TOPEKA, KANSAS, ASSIGNOR OF ONE-HALF TO WM. C. SMITH, OF SAME PLACE.

AIR PURIFYING AND REFRIGERATING SYSTEM FOR REFRIGERATOR-CARS, &c.

SPECIFICATION forming part of Letters Patent No. 610,276, dated September 6, 1898.

Application filed April 24, 1897. Serial No. 633,829. (No model.)

To all whom it may concern:

Be it known that I, EDWIN C. NICHOLS, a citizen of the United States, residing at Topeka, in the county of Shawnee and State of Kansas, have invented a certain new and Improved Air Purifying and Refrigerating System for Refrigerator-Cars, &c.; and I do hereby declare that the following is a full, clear, and exact description of the invention, reference being had to the accompanying drawings, forming a part of this specification.

My improved system of refrigeration relates more specifically to the economic and hygienic treatment of the impurities in the air within the compartment for sustaining the healthful condition of perishable goods in transit or in permanent storage, as well as the confined air in all conditions and places, and has for its object, first, the absorption of the moisture in the air impregnated with the deleterous odors from the perishable goods stored for preservation or overheated stagnated confined air and renewing dry sterilized air at a refrigerating temperature; second, the congelation of the moisture in separate air-receivers after withdrawal from the refrigerator, and, third, the economic circulation and reduction in temperature of the air-cooling medium and the maintenance of a fixed degree of refrigerating temperature in the refrigerating-chambers.

My invention consists in the novel means employed and the system of procedure hereinafter more fully described, and specifically pointed out in the claims.

In the drawings, Figure 1 is a longitudinal sectional view of a refrigerator-car, taken upon the line $x\,x$ of Fig. 2, showing the air-tight compartment for storing perishable goods and the compartment containing the refrigerating plant, also showing the water-tank upon one side of the chamber partially broken away to show the air-cooling pipes and the air-cooling chamber, the air-compressors, and motor of the plant upon the corresponding side of the chamber. Fig. 2 is a horizontal sectional view of the car, taken upon the line $y\,y$ of Fig. 1, and of the separate compartments for receiving the perishable goods and containing the refrigerating plant and also the combined water-tanks and air-cooling chambers on each side of the car, showing the conduits from the air-cooling apartments to the storage-apartment, also showing the refrigerating plant and the storage batteries on each side of the plant. Fig. 3 is an enlarged perspective view of the refrigerating plant in detail, showing the water-tank partially broken away and the cold-air-circulating pipes within the chamber conveying cold air to the storage-compartments, the water-circulating space between the inner side of the tank and the air-cooling chamber, and also the end of the pipe leading to the storage-compartment and the pipe leading to the air-expanding engine, also showing the pumps, the air-cylinders, and the respective water and air circulating pipes connected with the water-tank and also with the air-cooling chambers. Fig. 4 is a view in elevation of the shafts opening the separate air-compressors. Fig. 5 is a detail side view of one of the main air-compressors, showing the induction-pipes and valves. Fig. 6 is a vertical sectional view of one of the air-cooling receivers.

Similar letters of reference indicate corresponding parts in all the figures.

Referring to the drawings, A represents a refrigerator-car for transportation of perishable goods—such as meats, fruits, &c.—mounted at one end on the trucks A^2 and upon truck A^3 at the other end.

a is the forward end, and a' is the rear end, of the car. a^2 is the top, and a^3 the bottom, of said car.

a^4 represents one side, and a^5 the other side, of the car.

a^6 is the air-tight storage refrigerator or compartment for perishable goods.

a^7 is one door to compartment a^6, and a^8 the other door. The respective sides, ends, and top and bottom of the car are hermetical in construction and suitably packed in the well-known manner, so as to exclude heat.

In the rear and upper portion of the car is a separate compartment B. The bottom b of said compartment B, which is heavily timbered, extends horizontally from the inner surface of the side a^4 at a point about one-third the described height from the bottom of the car in the direction of the top to the inner

surface of the end a' of the car to a point nearly one-fifth the described distance between the said ends a a', the ordinary length of the car being about forty-three feet. In a vertical line with the inner end of the bottom b of compartment B and extending to the roof of the car and in a transverse direction to the car from the inner surface of the side a^4 to the inner surface of the side a^5 is a wall or partition b'.

In the compartment B and close in position to the side a^4 is a combined water-tank and air-cooling chamber C. Said tank consists of a water-tight box c, comparatively narrow in width, which extends from the bottom b of compartment B upwardly nearly to the roof of the car and from the partition b' about one-half the distance from said partition to the rear end of the car. Within the tank or box c is a case c', (see Fig. 3,) composed, preferably, of metal. The case c' is smaller in dimensions than the tank c, and extending entirely around the case on the inner side of the tank is a wide space $c^\times$ for the reception of the water. Within the case c' is an air-cooling chamber c^2, and within said chamber is a coil of pipe c^3, arranged close in position to the inner surface of the sides and ends of said case. The upper end of said pipe c^3 extends through the side of the case c' near the top of said case and the tank c near the upper end of the said tank and is connected with the cold-air-conducting pipe c^4. The lower end of the pipe c^3 extends through the forward end of the case c' near the bottom and at a point equidistant from the sides of said case, thence through the end of the tank c and the wall b' into the compartment a^6, thence from the four-way joint c^5 upwardly nearly to the roof of the car, and bent at right angles and extended near to and entirely around the inner side of the car and perforated, as at $a^\times$. In the end of tank c, adjacent to the wall or partition b' and near one side of the tank, is inserted a short length of pipe c^6, which extends through the end of the tank c' and communicates with the chamber c^2 of tank C. In the wall b' and communicating with the pipe c^6 is an outwardly-flaring V-shaped opening c^7, which opens into the chamber c^2. Near the other side of the tank and at the same described height as that of opening c^7 is a pipe c^8 and a V-shaped opening c^9, communicating with the chamber c^2 in the same manner as described of the opening c^7 and pipe c^6. Upon the other side of the car, in department B, is a combined water-tank and air-chamber C', which is constructed precisely in the manner described of the combined tank and chamber C and also provided with the pipes c^{10} c^{12}, which afford communication with the chamber a^6 of the car, as described of the pipes c^6 c^8.

Upon the floor of compartment B, at a point equidistant from the tanks C C', is an air-compressor D, having the piston-rod d. Above the cylinder D is an air-compressing cylinder E, smaller in size than the cylinder D and having the piston-rod e. With the upper side portion of the cylinder D and at one end is connected one end of a short air-conducting pipe d^3, the other end of which pipe is connected with the under side portion of the cylinder E. An air-conducting pipe e' is connected with the cylinder D at the other end of said cylinder and also with the cylinder E in the same manner as the pipe d^3. In the pipe d^3 is a valve d^4, and in the pipe e' is a valve e^2. (See Fig. 5.)

Between the cylinder D and the wall b' and in direct line with the compressor D is an air-expanding engine F, which is larger than the compressor D, the piston d of which compressor D is connected with the piston-rod of said air-expanding engine or cylinder. With the eduction-openings in the air-expanding engine F is connected the other end of the heretofore-mentioned cold-air-conducting pipe c^4, leading to the coil c^3, said pipe being closed at the extreme outer end and provided with openings in the side registering with the eduction-openings in said engine.

Between the tank C and the engine F is an air-cooling receiver G. Said receiver G consists of a hollow case, circular in form, in the lower part of which case is a diaphragm g^2, separating the chamber from the tank above. Within the body of the receiver are vertical pipes g^3. The lower end of each pipe g^3 is extended through the diaphragm g^2 and in line with the under surface of said diaphragm. Between the diaphragm g^2 and the bottom of the receiver G is a space or chamber $g^\times$ for the reception of the compressed air, which passes upwardly through the said pipes g^3 from the said air-chamber $g^\times$. In the upper part of the said receiver G, above the vertical pipe g^3, is a diaphragm g^6, through which the upper ends of the pipes g^3 extend, and between the said diaphragm and the top of the receiver is an air-chamber g^0, of the same dimensions as the air-chamber $g^\times$ in the base of said receiver, into which chamber g^0 the air passes from the pipes g^3.

In the top portion of the air-expanding engine F and into one of the induction-openings for the expanded cold air is inserted one end of a connecting-pipe f, the other end of which pipe is bent at right angles, and thence parallel with the other portion and extended into the other induction-opening of the engine F. With the pipe F is connected one end of a pipe f', the other end of which pipe is connected with the side of receiver G and the air-chamber g^0 above the diaphragm g^6. With the bottom portion of said receiver G and the chamber $g^\times$ below the diaphragm g^2 is connected one end of the pipe g^7, the other end of which pipe is extended through the tank C into the space $c^\times$ for the water between the case c' and the said tank. With the induction-opening of the air-compressor D and with the pipes d^6 d^8, which are extended downwardly from said openings, is connected the pipe d^{10}, (see Fig. 5,) which is closed at its

extreme end. In each one of the pipes d^6 d^8 is a valve d^9. The other end of said pipe d^{10} is extended through the tank c and into the chamber c^2, and the air in said chamber is exhausted therethrough by the action of the compressor D.

Upon the side of the air-compressors D E, in the direction of the tank C and at a point equidistant from said tank and compressors, is an air-expanding cylinder H, which is larger in size than the air-compressor D and nearly as large as the engine F. Between the air-expanding cylinder H and the compressors D E is an air-cooling receiver I, which is constructed precisely the same as described of the receiver G. With the induction-openings of said air-expanding cylinder H is connected one end of a pipe h, in the same manner as the pipe f with the pipe f' on the engine F, the other end of which pipe h is connected with the upper air-chamber of the receiver I. With the side of the receiver I, a considerable distance above the lower diaphragm, is connected one end of a water-conducting pipe i^4, the other end of which pipe is connected with the body of the receiver G at the same described distance above the diaphragm g^2. With the eduction-openings of the air-expanding cylinder H is connected in the same manner as described of the pipe c^4 with the engine F one end of a pipe h', the other end of which pipe is connected with the base of the receiver G and the air-chamber $g^\times$ in said receiver. With the eduction-openings in the cylinder E, which are connected as described of the engine F, is connected one end of the compressed-air-conducting pipe i', the other end of which pipe is connected with the receiver I, and with the air-chamber below the lower diaphragm in said receivers K K' are separate double-acting suction and force pumps arranged in a single line and at one side of a line extending longitudinally through the air-expanding cylinder H in the direction of the tank C and having a single piston-rod $d^\times$ extending through both pumps. With the induction-opening of the pump K is connected one end of a water-supply pipe k, the other end of which pipe extends through the sides and near the bottom of the water-tank C and into the space $c^\times$ between said tank and the case c'. With the eduction-opening of the pump K' is connected one end of a water-supply pipe k', the other end being extended through the side of the receivers I, a short distance beneath the upper diaphragm of said receivers. Upon the other side of the air-compressors D E, in the direction of the tank C', are the receivers L and M, which are precisely the same in construction as the receivers I and G, and also an air-expanding cylinder N, which is the same in size as the cylinder H and is provided with a piston-rod n, said air-expanding cylinder and receivers being connected as hereinafter described. With the opposite side of the engine F to that having the connecting-pipe c^4 is connected one end of a pipe f^3, which is the same as pipe c^4, and the other end is connected with the coil of pipe f^5 in the cold-air chamber of the tank C'. With the pipe f on said engine F is connected one end of a pipe f^6, the other end of which pipe is connected with the upper air-chamber of the receiver M. With the water-chamber of receiver M is connected one end of a pipe g^9, the other end of which pipe is connected with the water-space in the tank C'. With the side of the receiver L is connected one end of a water-conducting pipe m, the other end of which pipe is connected with the receiver M, as described of the pipe i^4, between receivers I and G. With the other side of the air-compressor D from that having pipe d^{10} is connected one end of a pipe $d^{10'}$, the other end of which pipe extends within the cold-air chamber of the tank C', as described of the pipe d^{10}. With the eduction-openings to the air-expanding cylinder N is connected one end of a pipe n^2, the other end of which pipe enters the lower air-chamber of receiver M in the same manner as the pipe h' in the receiver G. With the induction-openings of the air-expanding cylinder N is connected one end of a pipe n^3, the other end of which pipe is connected with the upper air-chamber of the receiver L. With the eduction-opening of the air-compressor E is connected one end of a pipe n^4, the other end of which pipe is connected with the lower air-chamber of receiver L. With the pump K and the eduction-opening is connected one end of a pipe k^2, the other end of which pipe is connected with the tank C' and the space or chamber for the water in said tank, as described of the pipe k with the space $c^\times$ of the tank C.

The pipe k^3 is connected at one end with the induction-opening of the pump K' and is connected at the other end with the receiver L at a corresponding point between the upper and lower diaphragms, as described of the pipe k', so as to draw the water through said receiver. The air-compressors and expanding-cylinders and the pumps for the water are operated in the following manner:

At a point nearly equidistant from the air-compressors D E and expanding-cylinders H and N and the wall a' of the car in compartment B is a line-shaft O, mounted in the journal-boxes o o at each end, which journal-boxes are elevated a short distance above the floor of the compartment and upon a line horizontal with the piston-rod d of the compressor D.

Between the journal-boxes o o are journal-boxes o' o', which extend in height to the level of the piston-rod in the air-compressor E, and in which boxes, directly above the shaft O, is journaled a shaft O', which shaft is smaller in diameter than the shaft O. On shaft O' is an eccentric o^3, with which eccentric is connected an eccentric-rod o^4, which rod is connected by a hinge-joint o^5 with the piston-rod e of the chamber E. Upon shaft O are sepa-

rate eccentrics o^2 o^2, each having an eccentric-rod o^6 hinged to one end of the cross-bar e^5, which bar is connected with the piston-rod d of the air-compressor D. Upon shaft O′, on one side of the eccentric o^3, is a pulley o^7, and upon the shaft O, directly beneath the pulley o^7, is a pulley o^8. Over pulley o^8 is extended one end of a belt o^9, the other end of which belt is extended over the pulley o^7 and the two ends connected together in the usual manner. Upon the other side of the eccentric o^3 is a pulley o^{10}, which is connected by a belt o^{15} with the pulley o^{16} on the shaft O in the same manner as described of the pulley o^7, the pulleys on shaft O being larger than on shaft O′. Upon the shaft O is an eccentric o^{18}, which is pivotally connected with the piston-rod h' of the air-expanding cylinder H. Upon the other end of shaft O and opposite the air-expanding cylinder N is an eccentric N′, the eccentric-rod of which is connected with the piston-rod n of said cylinder. Near the shaft O and between said shaft and rear of the car and secured to the floor of compartment B is a motor P. At one end of the compartment B, in rear of the combined water-tank and air-cooling chamber C, is a storage battery of electricity Q. With the storage battery Q are connected conductors p p', which are also connected with the respective poles of the motor P.

p^2 is the driving-shaft of the motor P, upon which is a pulley p^3.

On shaft O is a pulley o^{12}. Over the pulley o^{12} is extended one end of a belt o^{13}, the other end of which belt is extended over the pulley p^3 on the shaft p^2 of the motor P. In rear of the air-cooling chamber C′ is a storage battery Q′, which may be employed when found necessary for other motors. On the end of shaft O, in rear of the pumps K K′, is an eccentric R and rod r^2, the forward end of which rod is pivotally connected with the piston-rod $d^\times$ of the double-acting suction and force pumps K K′.

In operation the space $c^\times$ in each tank C C′ is filled with water. The goods to be kept from deterioration are placed in the compartment a^6 and the doors a^7 a^8 closed, so as to prevent any admission of air except in the manner hereinafter described. The current from the storage battery Q is then admitted to motor P and power transmitted to the shafts O O′, and the air-compressors D E and the air-expanding cylinders H N are placed in operation, the speed of shaft O′ being greater than that of shaft O, and consequently the air drawn through the induction-pipes d^6 d^8 within the cylinder D is subjected to recompression in the compressor E and its volume reduced, and with the rapid momentum of the piston a high degree of heat is attained. The action of the compressor D draws the air from the chamber a^6, containing the perishable goods and which is charged in some cases with animal heat and matter, into the cold-air chamber c^2 of each tank C C′, when the moisture is chilled and precipitated, and the air so dried passes thence through the pipes d^{10} $d^{10'}$ to the air-compressing cylinder D, where the first compression is given to the air and the deleterious odors and matter are condensed and driven off by the heat.

During the movement of the driving-shafts O O′ to operate the pistons of the air-compressors D E the movement is communicated to the pistons of the air-expanding cylinders H N and also to the double-acting pumps K K′, in which movement the pump K draws the water from the space $c^\times$ of the tank C into said pump and forces the water out into the space for water in tank C′ through the pipe k^2.

The temperature of the air-chamber c^2 of tank C from the cold air introduced from the engine F is therefore a refrigerating temperature or nearly that required to form ice, and the water drawn into the pump K and then forced into the water-space of the tank C′ is nearly of the same degree of temperature. The pump K′ during the operation of the pump K draws the water from the water-chamber in the air-cooling receiver L into said pump and forces the same into the water-chamber of the air-cooling receiver I, in which movement the water in receiver I is forced through the pipe i^4 into the water-chamber of receiver G and passes through the pipe g^7 into the water-chamber of the tank C, and thus a circulation of cold water is kept through said receivers G and I. On the other hand, the water drawn from the receiver L into the pump K′ causes the water from the water-space of tank C′ to pass through the pipe g^9 into the water-chamber of the tank M and thence through the pipe m into the water-chamber of the receiver L in the same manner as through the receivers I and G, and a uniform water circulation is maintained throughout the plant. The recompressed air heated by recompression and which is ejected from the compressor E passes through the pipes i n^4 into the bottom of the receivers E and L and thence upwardly within the vertical air-cooling pipes in said receivers, which are surrounded by the cold water from the water-chambers of the respective tanks C C′, and thence passes through pipes h n^3 to the air-expanding cylinders H N, which are larger than the air-compressor E, and consequently the air expands while doing work in each cylinder and causing the rapid fall of temperature and cooling the air. The air from the cylinders H N then passes through the pipes h' n^2 to the respective air-cooling receivers G and M and the heat is further abstracted from the air, thence through pipes f' f^6 to the air-expanding cylinder or engine F, which is larger than either one of the air-cylinders H N and in which the compressed air works expansively while doing work, and thereby following the first expansion of the air in cylinders H and N, and a consequent refrigerating temperature nearly

sufficient to cause the congelation of water results, which cold air passes from engine F, through the pipes c^4 f^8, through the coils of pipe in chamber c^2 of the tank C, and also through the coils of pipe f^5 in the chamber of tank C′, thence through the pipes c^5 in chamber a^6 from each coil in each air-chamber of the respective tanks C C′, and is liberated through the perforations $a^\times$ in said pipe c^5, causing a degree of cold in said chamber sufficient to preserve the contents without freezing. In passing through the coil of pipe in the chamber c^2 of tanks C C′ the cold air in the chamber reduces the temperature of the water in the space $c^\times$ and also gives the first chill to the air as it enters the chamber c^2 from the chamber a^6. The temperature of the water being thus kept constantly reduced in the space $c^\times$, the degrees of cold maintained in said chamber reduces the temperature of the air while passing through the pipes on each air-cooling receiver, which are subjected, as heretofore described, to the cold circulating water from the tanks C C′. In the engine F refrigeration will consequently follow in a greater degree after the first expansion in the cylinders H N owing to the rapid elimination of the heat from the highest degree of compression in cylinder E. The air taken from the chamber a^6 is therefore freed from germs in the repeated compression and cooling of the air, and a supply of sterilized air is supplied to the chamber a^6 and the temperature kept so as to preserve the contents of the car. Through the pipe a^9 in the forward end of the car a pipe may be extended from the chamber a^6 for conducting cold air outside of chamber a^6 in such direction as may be desirable.

In the improved refrigerating system transportation of perishable goods long distances is attained at a small percentage of cost compared with the usual modes of cooling the temperature of a refrigerator-car.

Having fully described my invention, what I now claim as new, and desire to secure by Letters Patent, is—

1. In an air purifying and refrigerating system, a refrigerator and a tank, having separate water-circulating and air-cooling chambers, and a passage for the air from the refrigerator to said air-cooling chamber in said tank, a water suction and forcing apparatus, and separate conductors connected with said apparatus and the water-circulating chamber in said tank, and a cold-air-generating apparatus, a conductor leading from the air-cooling chamber in said tank to the said cold-air-generating apparatus, and a separate conductor leading from said apparatus to said refrigerator through the air-cooling chamber in said tank.

2. In a refrigerator-car, a refrigerating-chamber and a tank, having separate water-circulating and air-cooling chambers, and a passage for the air from the refrigerator to said air-cooling chamber in said tank, a water suction and forcing apparatus, and separate conductors connected with said apparatus and the water-circulating chamber in said tank, an air-compressor and a conductor of air connected with the said air-cooling chamber of said tank and said compressor, an air-expanding engine and a conductor of compressed air connected with said engine and said air-compressor, a coil of pipe for the cold air within the air-cooling chamber of said tank connected with said refrigerating-chamber, and a conductor of cold air connected with the said coil in said air-cooling chamber, and also with the said air-expanding engine, as and for the purpose set forth.

3. In an air purifying and refrigerating system, a refrigerator and a tank having separate water-circulating and air-cooling chambers and a passage for the air from the refrigerator to said air-cooling chamber in said tank, an air-compressor and an air-cooling receiver for cooling the compressed air ejected from the compressor, and a water suction and forcing apparatus, having separate conductors connected with the water-circulating chamber in said tank and also with the air-cooling receiver and a separate conductor connected with said air-cooling receiver and the water-circulating chamber in said tank, an air-expanding engine, a conductor of compressed air connected with said air-compressor and said engine, a coil of pipe for the cold air within the air-cooling chamber of said tank connected with the refrigerating-chamber, and a conductor of cold air connected with the said coil of pipe and the air-expanding engine, as and for the purpose set forth.

4. In an air purifying and refrigerating system, a refrigerator and a tank having separate water-circulating and air-cooling chambers, and a passage for the air from the refrigerator to said air-cooling chamber in said tank, an air-cooling receiver having separate upper and lower chambers for the expansion of the compressed air, and an intermediate water-chamber and pipes in said chamber connected with both of said air-chambers, a water suction and forcing apparatus, a conductor connected with said apparatus and the water-chamber in said receiver, and separate conductors connected with said apparatus, and also with the water-chamber in said air-cooling receiver and said water-circulating tank, a duplex air-compressor and separate conductors of compressed air, one of which is connected with one of said compressors and with the air-cooling chamber in said tank, and the other connected with the other compressor, and also with the air-expanding chamber in the lower part of said receiver, an air-expanding engine and separate conductors of compressed air connected with the upper air-expanding chamber in said air-cooling receiver, and also with the coil of pipe in the air-cooling chamber in said tank, for the purpose described.

5. In an air purifying and refrigerating system a refrigerator and a tank having separate water-circulating and air-cooling chambers and a passage for the air from the refrigerator to said air-cooling chamber in said tank, a coil of pipe for cold air within said air-cooling chamber in said tank connected with said refrigerator, an air-cooling receiver having separate upper and lower air-expanding chambers, and an intermediate water-chamber and pipes extending from one air-chamber of said air-cooling receiver to the other, a water suction and forcing apparatus and separate conductors, one of which is connected with the water-circulating chamber in said tank, and the other with the water-chamber in said air-cooling receiver, an air-expanding engine and separate conductors connected with said engine, one of which is connected with the coil of pipe in said air-cooling chamber of said tank, and the other with the upper air-cooling chamber of said air-cooling receiver, and separate air-compressors having separate pipes conducting the air from one compressor to the other, and a conductor of recompressed air connected with one of said compressors and with the lower air-expanding chamber in the air-cooling receiver, and a separate conductor connected with the air-cooling chamber in the said tank, and also with the other air-compressor, and means for operating both compressors at different degrees of speed, as set forth.

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