(No Model.)

3 Sheets—Sheet 1.

# H. F. STARBUCK.

## AIR COOLING AND ICE MAKING MACHINE.

No. 266,547. Patented Oct. 24, 1882.

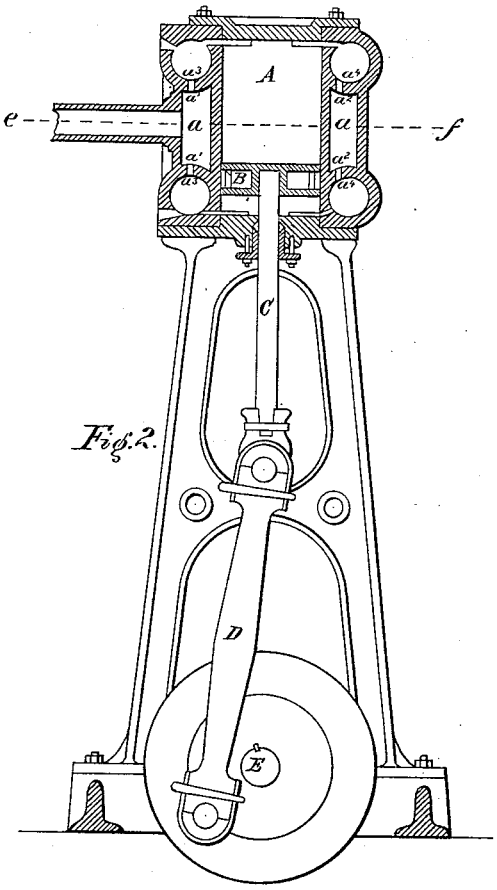


Fig. 2.

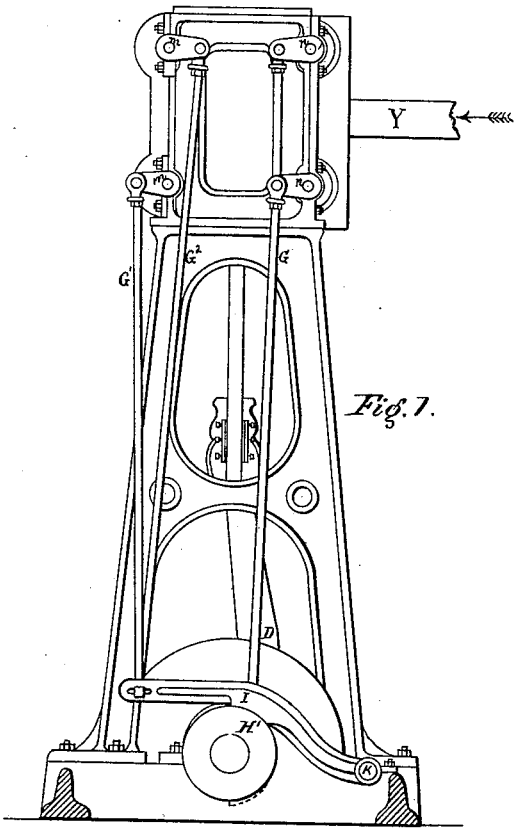


Fig. 1.

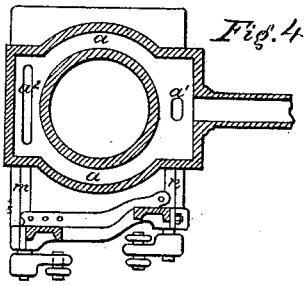


Fig. 4.

WITNESSES:

Isabel L. Burnett

Dwight Wright

INVENTOR.

Henry F. Starbuck,

BY William A. Reynolds.

ATTORNEY.

(No Model.) 3 Sheets—Sheet 2.

# H. F. STARBUCK.

## AIR COOLING AND ICE MAKING MACHINE.

No. 266,547. Patented Oct. 24, 1882.

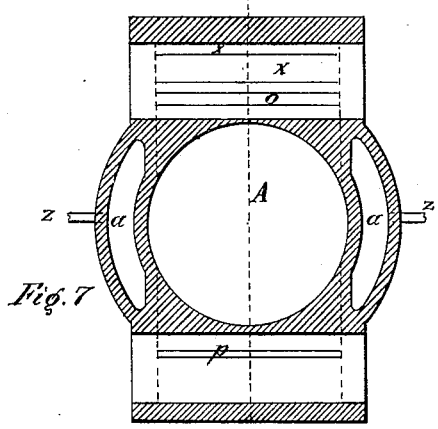


Fig. 7

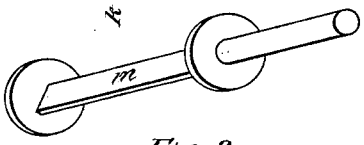


Fig. 8


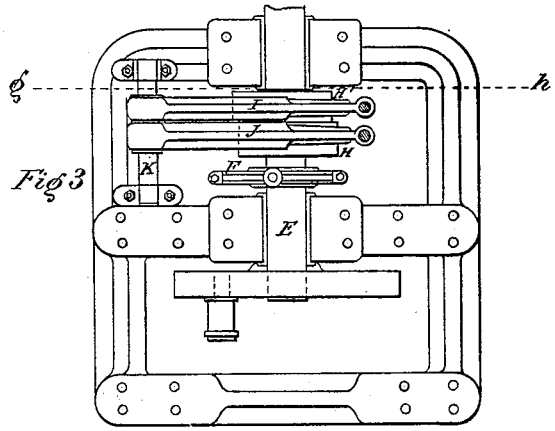


Fig 3

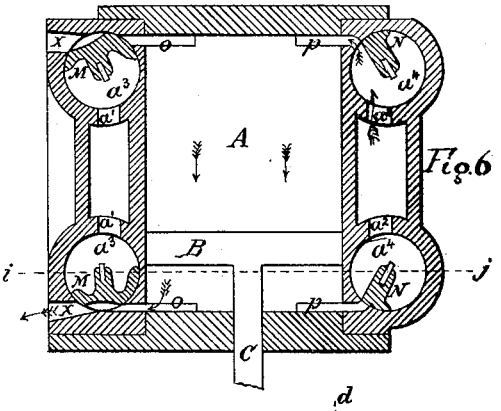


Fig. 6

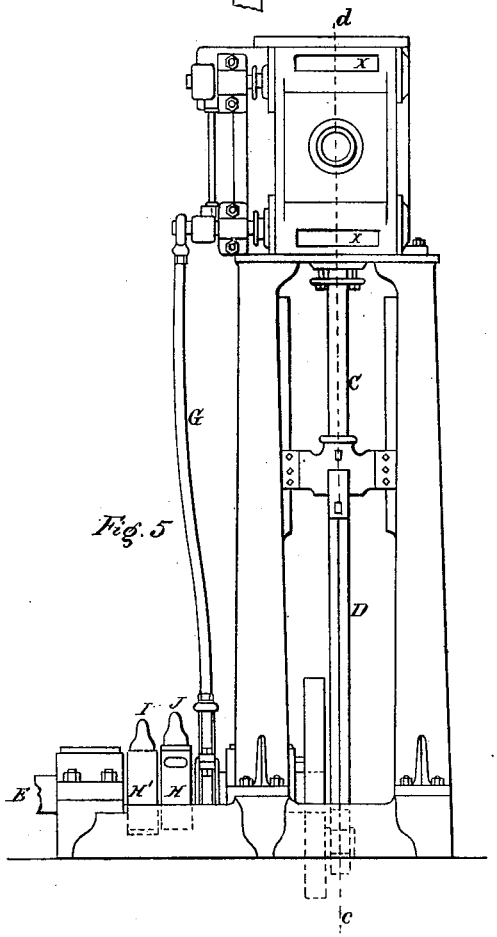


Fig. 5

WITNESSES:

Isabel M. Bennett

Dongke Tripp

INVENTOR

Henry F. Starbuck,

BY William A. Reynolds

ATTORNEY

(No Model.) 3 Sheets—Sheet 3.

# H. F. STARBUCK.

## AIR COOLING AND ICE MAKING MACHINE.

No. 266,547. Patented Oct. 24, 1882.

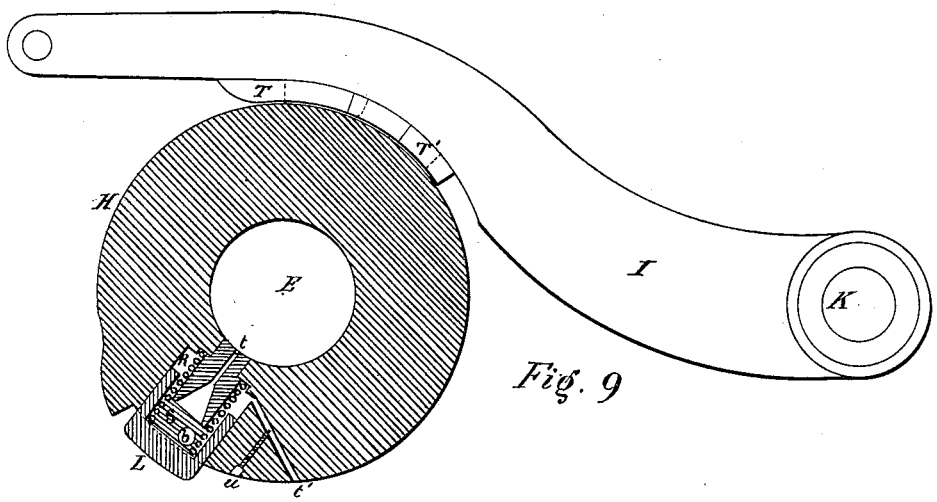


Fig. 9

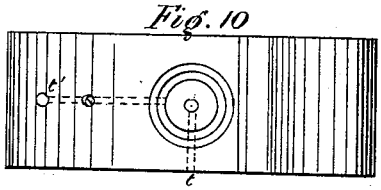


Fig. 10

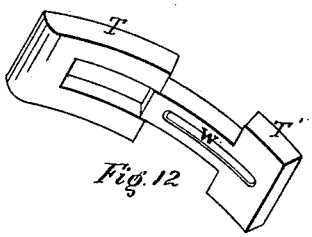


Fig. 12

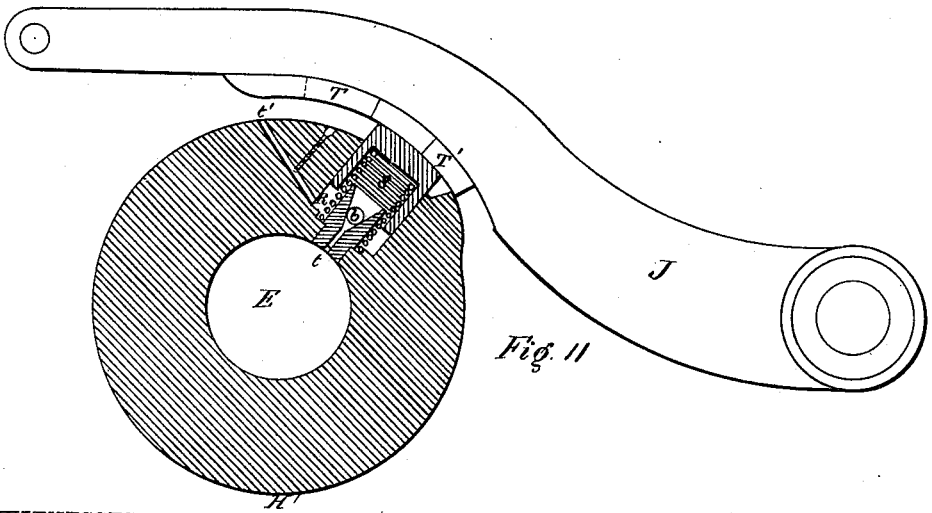


Fig. 11

WITNESSES:

Isabel A. Bennett

Dwight K. Tripp

INVENTOR

Henry F. Starbuck,

BY

William A. Reynolds

ATTORNEY

# UNITED STATES PATENT OFFICE.

HENRY F. STARBUCK, OF CHICAGO, ILLINOIS, ASSIGNOR TO W. A. REYNOLDS, OF SAME PLACE.

## AIR-COOLING AND ICE-MAKING MACHINE.

SPECIFICATION forming part of Letters Patent No. 266,547, dated October 24, 1882.

Application filed January 3, 1882. (No model.)

*To all whom it may concern:*

Be it known that I, HENRY F. STARBUCK, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Air-Cooling and Ice-Making Machines, of which the following is a specification.

It is also designed to use the said improvements in air or gas motors, and in engines operated by steam.

My inventions relate more particularly to improvements in that class of machines in which air is cooled by mechanical action, and these improvements consist of certain parts of machines for such purpose.

The objects of my improvements are, first, to provide an independent cooling-engine separate and perfect in itself, which can be placed in the chamber to be cooled or where ice is to be formed; second, to pass the air around a cylinder surrounded by a jacket or chamber in which the compressed air is cooled, and to take the moisture out of the compressed air, and to further lower the temperature of the air while under compression; third, to provide an exhaust-valve to receive the pressure upon the back side of the valve, and so to obviate the usual clearance or lost space, and to secure an open, unobstructed discharge-port; fourth, to provide a perfect automatic movement of the valves in the expanding-cylinder in opening and closing the same; fifth, to secure an adjustable trip-piece on a cam-lever, by which the valves in the air-chamber are opened and closed; and, sixth, to secure a perfect air-cushion in the surface of cams operating cam-levers. I attain these objects by the mechanism illustrated in the accompanying drawings, in which—

Figure 1 is a side view of the machine, with a partial section taken on line *g h* of Fig. 3. Fig. 2 is a vertical section on line *c d* of Fig. 5. Fig. 3 is a plan of the bed or base of the machine. Fig. 4 is a horizontal section through the cylinder on line *e f* of Fig. 2. Fig. 5 is a front view of the machine. Fig. 6 is a vertical section of the cylinder and valves on line *k l* of Fig. 7. Fig. 7 is a horizontal section on line *i j* of Fig. 6. Fig. 8 is a perspective view of the exhaust-valves removed from the stem which turns them. Figs. 9, 10, 11, and 12 are different views of the cams and levers which regulate the opening and closing of the inlet-valves.

Similar letters refer to similar parts throughout the several views, and to prevent confusion the rods connecting the cam-levers with the valves are omitted in Fig. 5.

In each of the figures, A represents the cylinder of the machine, in which moves the piston B, connected with the piston-rod C, and the connecting-rod D, and actuating by a reciprocal motion the crank-shaft E. On this crank-shaft is fixed the eccentric F, operating in the ordinary manner the exhaust-valves M M, and the cams H H′, operating by means of the cam-levers I J, working on the shaft K, and the rods G′ G², and the inlet-valves N N. The piston rods, crank-plate, shaft, and eccentric are of ordinary construction and exactly the same in operation as in the ordinary high-pressure steam-engine.

The parts which I claim as novel in construction are the cylinder, the exhaust-valves, and the cams operating the inlet-valves and the trip-pieces on the cam-lever.

As seen by Figs. 2, 4, 6, and 7, the cylinder consists of its inside chamber, A, and an exterior chamber or jacket, *a a*, extending entirely around the inner case or shell, which jacket is connected by openings *a′* and *a²* with the valve-chambers *a³* and *a⁴*. These chambers are connected with the inside cylinder, A, by the ports *o o*, Fig. 6, and *p p*, which are controlled by the valves M M and N N. The inlet-valve N is of ordinary construction. The outlet or exhaust valve M is shown in its different positions in Fig. 6, in which the lower valve is open and the upper one closed. This valve is so constructed that it has no clearance or lost space except the portway, and when open is a straight passage from the cylinder to the outside air. The purpose of this is to obviate the freezing up of the discharge-ports, which are cleaned in each movement of the valve, and offer no point for the accumulation of ice. This valve is kept in its place by the pressure on its back from the chamber *a a*. The inlet-valves N N are moved by the cams and connecting-rods, the peculiar parts of which are shown in Figs. 9, 10, 11, and 12, in which L is

a movable plunger or piston in the surface of the cam H, operating as an air-cushion for the cam-lever I, moving up and down in the chamber R, where *b* is a ball-valve; S, a spring. *t* and *t'* are air-holes, and *u* a screw regulating the escape of air at *t'*. An ordinary check-valve may be used instead of the ball-valve *b*. On the under side of the cam-lever I is a movable trip-piece, T', held in its place by a screw in the slot W, and by means of which slot and screw the trip-piece may be moved at pleasure. X X are the discharge-ports. Y is the inlet-pipe for air to be cooled, and *m* and *n* are valve-stems connected with rocker-arms for operating their respective valves. Z Z are drip-pipes for conveying the condensed moisture away from the chamber *a a*.

Having described the various parts of the machine in detail, I will describe its operation.

As before stated, this machine is only part of the system required for cooling air. The air is first compressed, when it is passed through coils surrounded by water in some place adjacent to the motive power which drives the compressor. This compressed air may be carried any reasonable distance and introduced into the cooling-engine at the pipe Y, having been first reduced to the temperature of the cooling medium through which it has passed. The compressed air first fills the jacket or chamber, where it exerts a pressure on the backs of the valves M M and N N, holding them in place. The air is confined before expansion in the surrounding chamber or jacket, and is made to come in contact with the cold surfaces of the expanding-cylinder A and the chamber *a a*, thus both cooling the air and drying it, as the air will have its moisture condensed by contact with the cold surfaces of the cylinders, and is thence drained off from the chamber by the pipes Z Z. By the movement of either of the valves N N air is admitted to the cylinder on one side of the piston B, and, exerting pressure, drives it the length of the cylinder exactly as the piston is driven in an ordinary steam-engine. On the reciprocal motion the valve M on the same side is opened, and the air is driven out through the port O, the valve M, and the discharge-port X, from which point it is carried, if need be, to the place to be cooled, or exhausted directly into the room where the engine stands. On the return-stroke the same operation is performed on the opposite side of the piston B by use of the opposite set of valves.

The operation of the cams H H' in controlling the movements of the valves N N is as follows: There being two exactly alike, one for each valve being set directly opposite, so as to work alternately. Referring to Figs. 9, 10, 11, and 12, it will be seen that as the cam turns with the main shaft, to which it is attached, it raises the cam-lever by acting upon the trip-piece T, attached to the lever I, raising it, as shown in Fig. 11, thus opening the inlet-valve N. As the cam turns it reaches the point shown in Fig. 11, where it is ready to drop from the trip-piece, shutting the valve N. As it drops its fall is checked by the air-cushion L, which operates as follows: The ball-valve *b* being in place, the escape of air is shut off, except by a regulated aperture, *t'*, and the fall of the cam-lever is made less sudden, according to the size of this aperture. On the turning of the cam to the position shown in Fig. 9 the ball-valve opens automatically, the spring, aided by the weight of the piston, pushes it out, and it again takes the position shown in Fig. 11. The movement of the fall of the cam-lever is regulated by the adjustable trip-piece T', which is held in place by a screw in the slot W, Fig. 12, and may be moved as required.

It is a well-known principle of thermodynamics that air or any permanent gas, when compressed and cooled, will, upon expansion, be still further deprived of its heat in the direct ratio that it is made to perform mechanical work.

I am aware that prior to my invention there have been machines constructed for cooling air by the same process that I do in my engine; but it has been common heretofore to combine in one machine all the parts necessary to compress the air and to cool it. The air was first compressed, and in that state was cooled by being passed through water, or by other means, and was then expanded in a cylinder in close conjunction with the compressing-cylinder and motive power, generally a steam-engine, all of which made the machine cumbersome and expensive, and required the cooling-engine to be in a warm room and away from the cooling-chambers, thus losing much capacity of the machine for cooling.

I claim as my invention and desire to secure by Letters Patent—

1. In an independent expanding-engine for cooling air, as described, to be operated by compressed air, the combination of a jacket or chamber, *a a*, with the expanding-cylinder A, and surrounding the latter, for the purpose substantially as set forth.

2. In a cooling-engine operated by compressed air, an exhaust-valve, M, made, as described, so as to receive the pressure upon the back side of the valve, and to leave a straight portway, so as to offer no obstruction to the free passage of air in its discharge, substantially as set forth.

3. In any engine using independent oscillating exhaust-valves, the valve M, constructed so as to receive the pressure on the back side of the valve, thus obviating the usual clearance or lost space, and operating substantially in the manner described.

4. In a cooling-engine operated by compressed air or gas, in which cams are used to operate the inlet-valves, an air-cushion within the surface of the cam, for the purpose as set forth and described.

5. In a cooling-engine operated by compressed air or gas, in which cams are used for

moving the inlet-valves, movable trip-pieces T and T′ for regulating the automatic movements of such inlet-valves, as described and set forth.

6. A revolving cam, with automatic air-cushion within the surface of the cam, with valve within air-cushion, for the purpose as described and set forth.

7. A ball-valve in the pocket of an air-cushion of a cam, as described and set forth.

8. An automatic air-cushion within the surface of a cam, in which an ordinary check-valve may be used, as set forth and described.

9. In a revolving cam operating the valves of an engine, the combination of a plunger, L, a valve, *b*, the air-holes *t* and *t′*, and the regulating-screw *u*, together with the movable trip-pieces T and T′.

10. In a cooling-engine operated by compressed air or gas, the combination of the cylinder A, the jacket or chamber *a a*, the valve-chamber $a^3$ and $a^4$, the valves M M N N, and the exhaust-ports X X, substantially as set forth.

11. In a cooling-engine operated by compressed air or gas, the combination of the cylinder A, the valves M M and N N, together with the cams H H′ and the automatic air-cushion L L, substantially as and for the purpose set forth.

HENRY F. STARBUCK.

Witnesses:
DWIGHT SHIPP,
ASAHEL F. BENNETT.