(No Model.)

2 Sheets—Sheet 1.

T. B. LIGHTFOOT.

REFRIGERATING APPARATUS.

No. 325,097. Patented Aug. 25, 1885.

Fig. 1

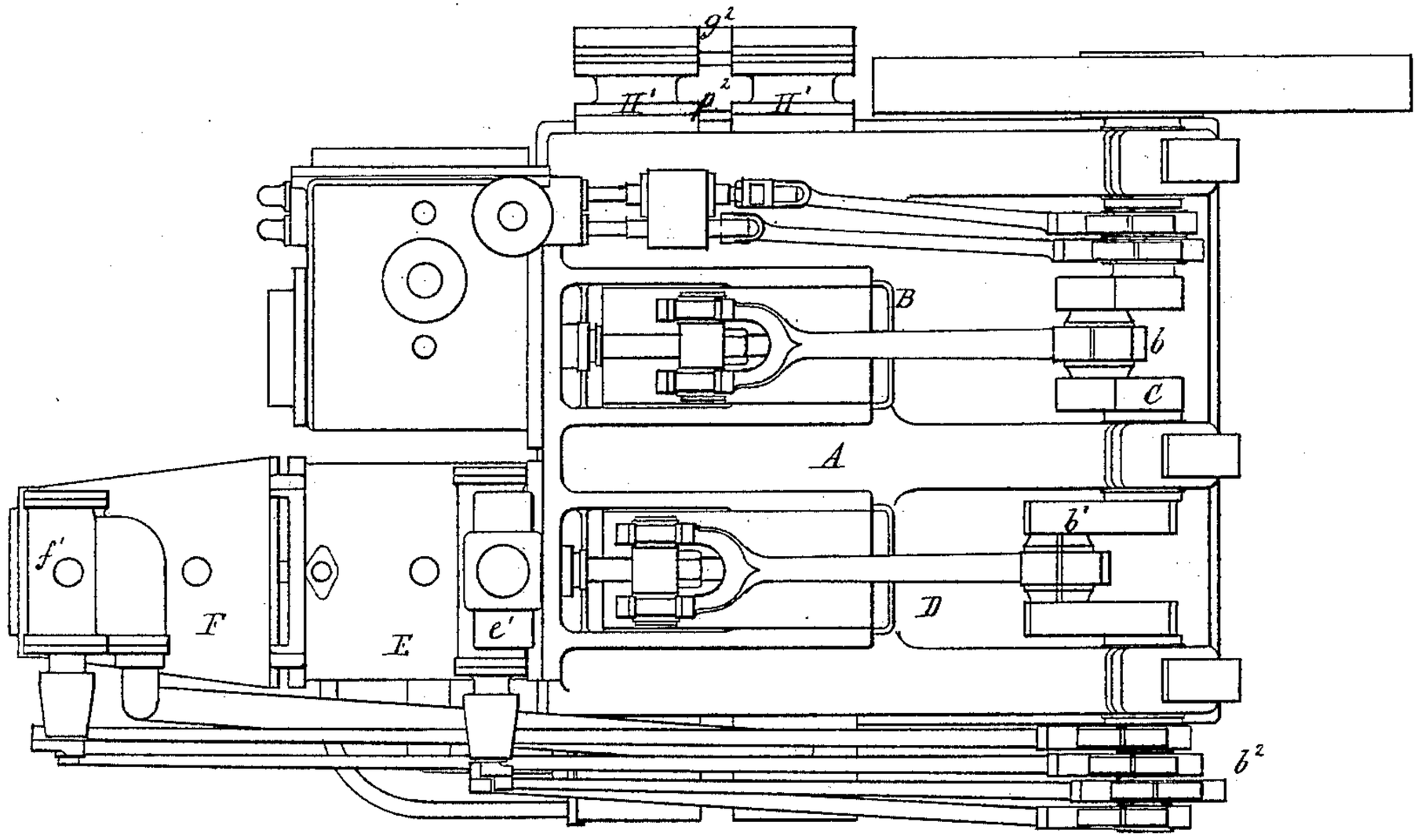
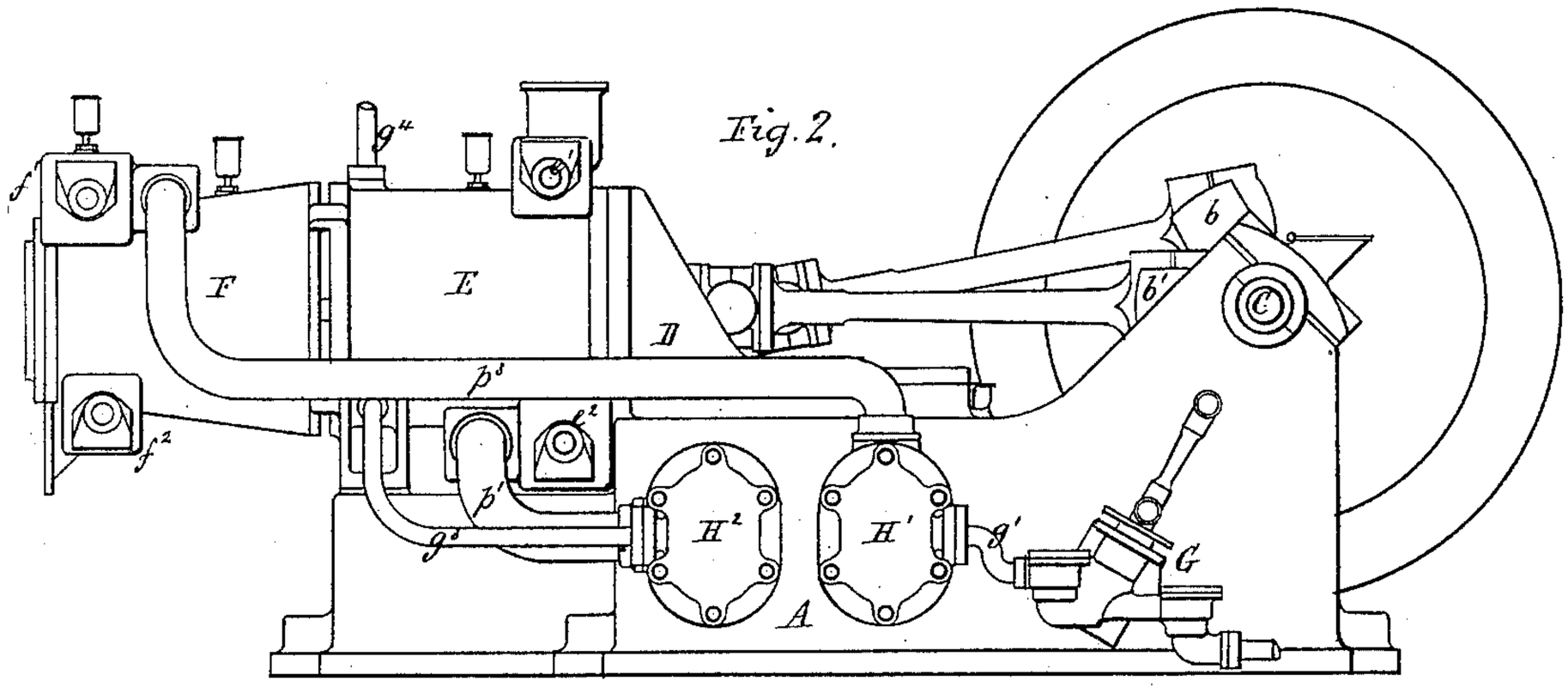


Fig. 2.



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(No Model.) 2 Sheets—Sheet 2.

T. B. LIGHTFOOT.

REFRIGERATING APPARATUS.

No. 325,097. Patented Aug. 25, 1885.

Fig. 3.

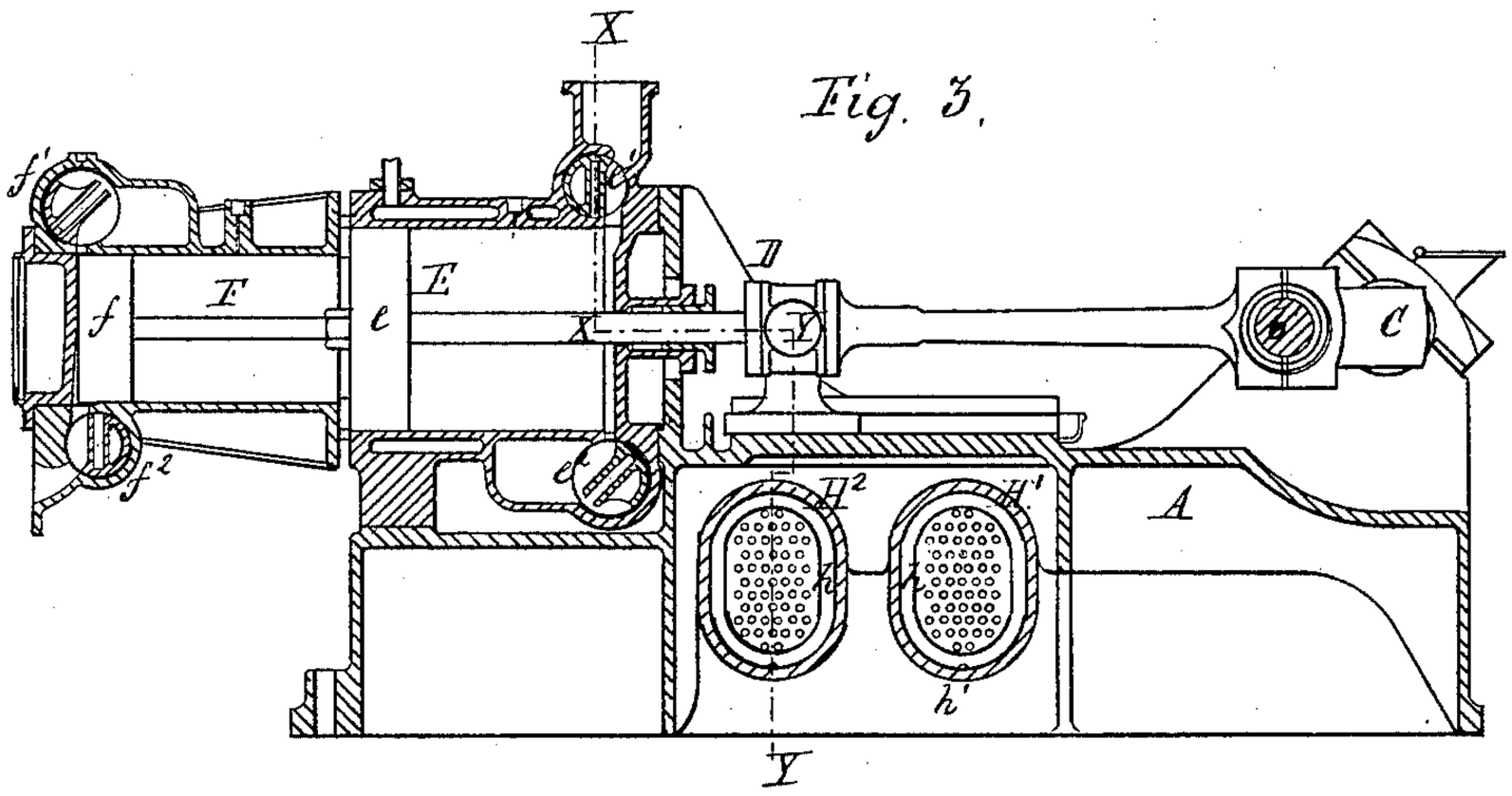


Fig. 4.

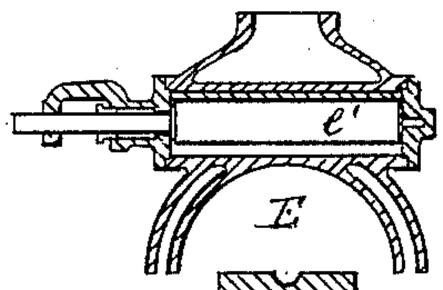
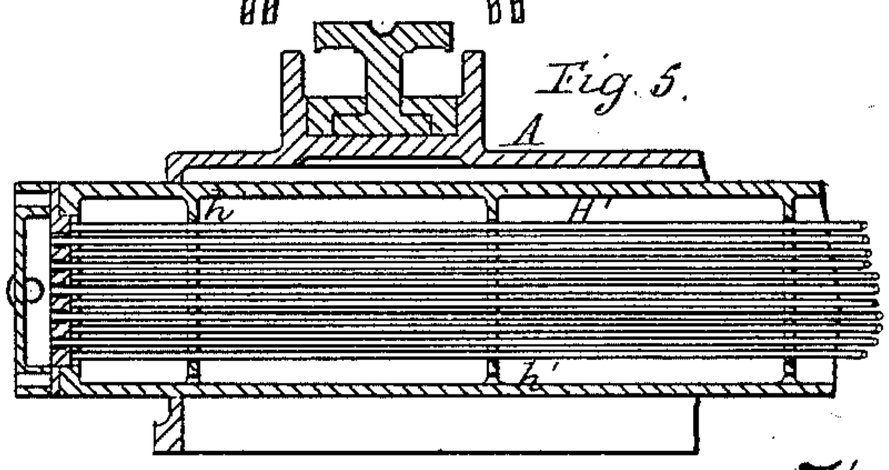


Fig. 5.



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UNITED STATES PATENT OFFICE.

THOMAS BELL LIGHTFOOT, OF FENCHURCH-STREET, LONDON, ENGLAND.

REFRIGERATING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 325,097, dated August 25, 1885.

Application filed July 19, 1884. (No model.) Patented in England February 11, 1882, No. 673.

To all whom it may concern:

Be it known that I, THOMAS BELL LIGHTFOOT, a citizen of England, residing at Fenchurch Street, in the city of London, England, have invented an Improvement in Refrigerating Apparatus, (for which I have obtained a patent in Great Britain, No. 673, dated February 11, 1882,) of which the following is a specification.

This invention relates to compressed air refrigerating apparatus.

The object of the invention is to provide a simple and compact apparatus of this character.

Figure 1 is a plan of combined engine and refrigerating apparatus. Fig. 2 is a side elevation, and Fig. 3 is a longitudinal section, of the refrigerating apparatus. Fig. 4 is a part transverse section on line X X of Fig. 3, and Fig. 5 is a part transverse section on Y Y.

On a base, A, is fixed a horizontal direct-acting steam-engine, B, of ordinary construction, its piston working a crank, *b*, on the shaft C. On the same base, A, is fixed the refrigerating apparatus D, which is constructed as follows: A water-cased cylinder, E, fitted with a piston, *e*, constitutes a single-acting air-compressing pump, taking in air by a partially-rotating valve, e', and discharging it, compressed, by a similar valve, e^2. Another cylinder, F, in line with E, and having its piston *f* rigidly connected to the piston *e*, receives cooled compressed air by an induction-valve, f', and discharges the air, after it has expanded, performing work in the cylinder F, by the eduction-valve f^2. Both the pistons *e* and *f* are connected to a crank, b', on the shaft C, this crank being set at about sixty degrees to the crank *b*. The four valves e', e^2, f', and f^2 are worked from four eccentrics, b^2, on the shaft C, and from one of these is worked a water-pump, G, for effecting circulation of water through the cooling-chambers and the casing of the cylinder E. The cooling-chambers H' H^2 are arranged in the base A. They are vessels of oval or circular form, having a number of water-tubes passing through them from end to end, and within the vessels there are a number of annular ribs projecting internally, so as to check and break up any direct current of the air through them. This has the effect of causing deposition of a considerable part of the moisture carried in or with the air, which moisture can flow along the bottom of each cooler, holes h' being provided for its passage through the ribs *h*.

The action of the apparatus is as follows: The steam-engine B causing the shaft C to revolve, this works the piston *e*, the valves e' e^2 f' f^2, and the water-pump G. The air compressed by the pump E passes by the pipe p' into the cooling-vessel H^2, flows along that vessel in contact with the water-tubes, crosses by a communication, p^2, into the vessel H', flows along it again in contact with water-tubes, passes by the pipe p^3 to the cylinder F, in which it expands, aiding in propelling the compressing-piston *e*, and it finally issues past the valve f^2, whence it may be led by pipes to any chamber or place where it can be applied for refrigeration. While the compressed air is taking the course described through the cooling-vessels H^2 and H', water delivered by the pump G through the pipe g' passes along the tubes of H', crosses by a passage, g^2, to those of H', returns along these, passes by the pipe g^3 to the water-casing of E, and is finally discharged by a pipe, g^4. As the course of the water through the tubes of H' and H^2 is opposite to the course of air along these tubes, the air which is to pass along the pipe p^3 to the expansion-cylinder F leaves H' at the end where the tubes are coldest, and its expansion, while performing work in propelling the piston *f*, has the effect of reducing its temperature to a very low degree. In cases where the cold air is used for cooling a closed chamber, the inlet air-valve e' may be supplied by air returning from the chamber.

I have shown the space between the pistons *e* and *f* as being empty. I prefer, however, to fill it mostly up with a plunger of wood or other material that is a bad conductor of heat. It is also to be understood that though I have shown the cylinder E in front of F their relative position might be inverted—that is to say, F might be in front toward the crank, the pipes p', p^3, and g' being altered to suit the altered position of the cylinders. One advantage of this inversion would be that, the cylinder E being necessarily larger than F, both pistons might be taken out at the back by removing the bottom cover of E and disconnecting from the cross-head of the piston-rod.

Having thus described the nature of my in-

vention and the best means I know of carrying it out in practice, I claim—

1. The combination of a bed-plate, a crank-shaft supported thereon transversely thereto, an engine connected to said crank-shaft, and an air-compressing and an air-expanding cylinder arranged longitudinally of said bed-plate axially in line with each other, each of said cylinders being provided with an inlet and an outlet valve, the piston-rods of said cylinders being axially in line and rigidly connected, a connecting-rod connecting one of said piston-rods with said crank-shaft, cooling-chambers arranged transversely of said bed-plate, and valved pipes connecting said cylinders and chambers, substantially as described.

2. The combination of a bed-plate, a crank-shaft supported thereon transversely thereto, an engine connected to said crank-shaft, and an air-compressing and an air-expanding cylinder arranged longitudinally of said bed-plate axially in line with each other, each of said cylinders being provided with an inlet and an outlet valve, the piston-rods of said cylinders being axially in line and rigidly connected, a connecting-rod connecting one of said piston-rods with said crank-shaft, cooling-chambers arranged transversely of said bed-plate, valved pipes connecting said cylinders and chambers, a series of eccentrics on said crank-shaft, and connecting-rods connecting said valves with said eccentrics, substantially as described.

3. The combination of a bed-plate, a crank-shaft supported thereon transversely thereto, an engine connected to said crank-shaft, and an air-compressing and an air-expanding cylinder arranged longitudinally of said bed-plate axially in line with each other, each of said cylinders being provided with an inlet and an outlet valve, the piston-rods of said cylinders being axially in line and rigidly connected, a connecting-rod connecting one of said piston-rods with said crank-shaft, cooling-chambers arranged transversely of said bed-plate, systems of cooling-pipes within said cooling-chambers, valved pipes connecting said cylinders and chambers, a series of eccentrics on said crank-shaft, connecting-rods connecting said valves with said eccentrics, and a pump also connected to said crank-shaft for circulating water within said cooling-pipes, substantially as described.

4. A cooling-chamber for ice-machines, provided with a series of cooling-pipes within said chamber, and with flanges on its interior for directing the air onto said pipes, said flanges being perforated at the bottom of the chamber, to permit the passage of water of condensation, substantially as described.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 26th day of June, A. D. 1884.

THOMAS BELL LIGHTFOOT.

Witnesses:

JNO. P. M. MILLARD,

DANIEL H. ROGERS.