(No Model.) 3 Sheets—Sheet 1.

T. B. LIGHTFOOT.

Air Refrigerating Apparatus.

No. 238,408. Patented March 1, 1881.

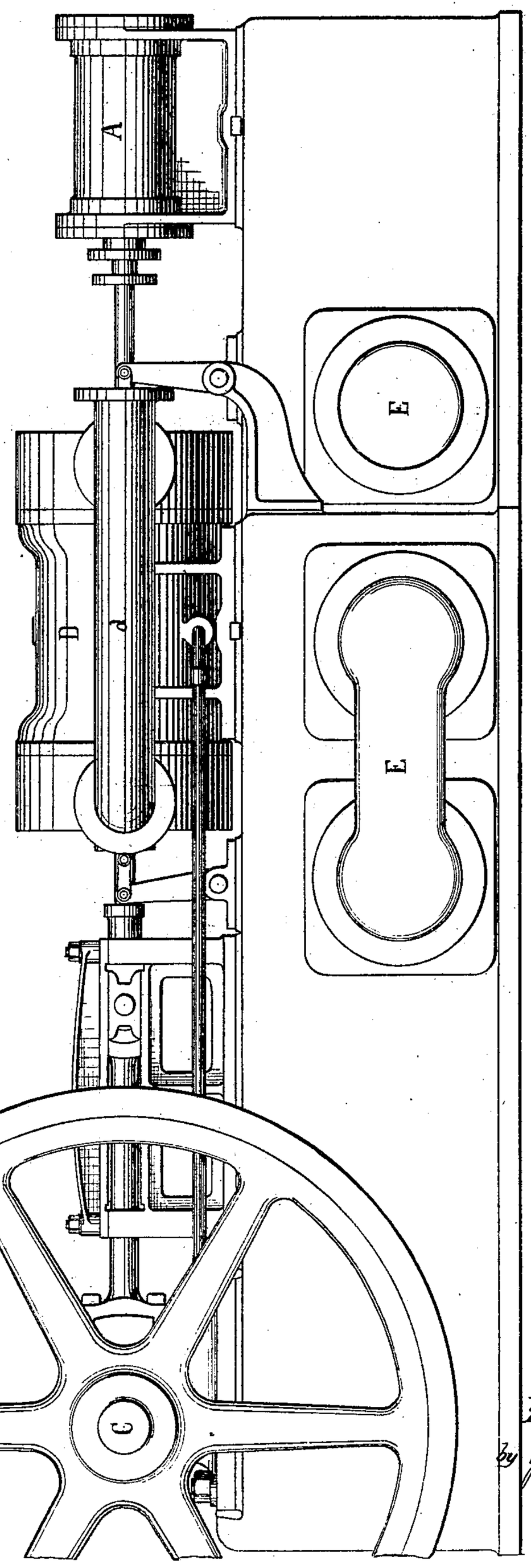

FIG. 1

Witnesses.
Robert Emett.
A. H. Norris.

Inventor
T. B. Lightfoot.
by James L. Norris
Atty.

(No Model.) 3 Sheets—Sheet 2.

J. D. Ellis.

Air Refrigerating Apparatus.

No. 238,408. Patented March 1, 1881.

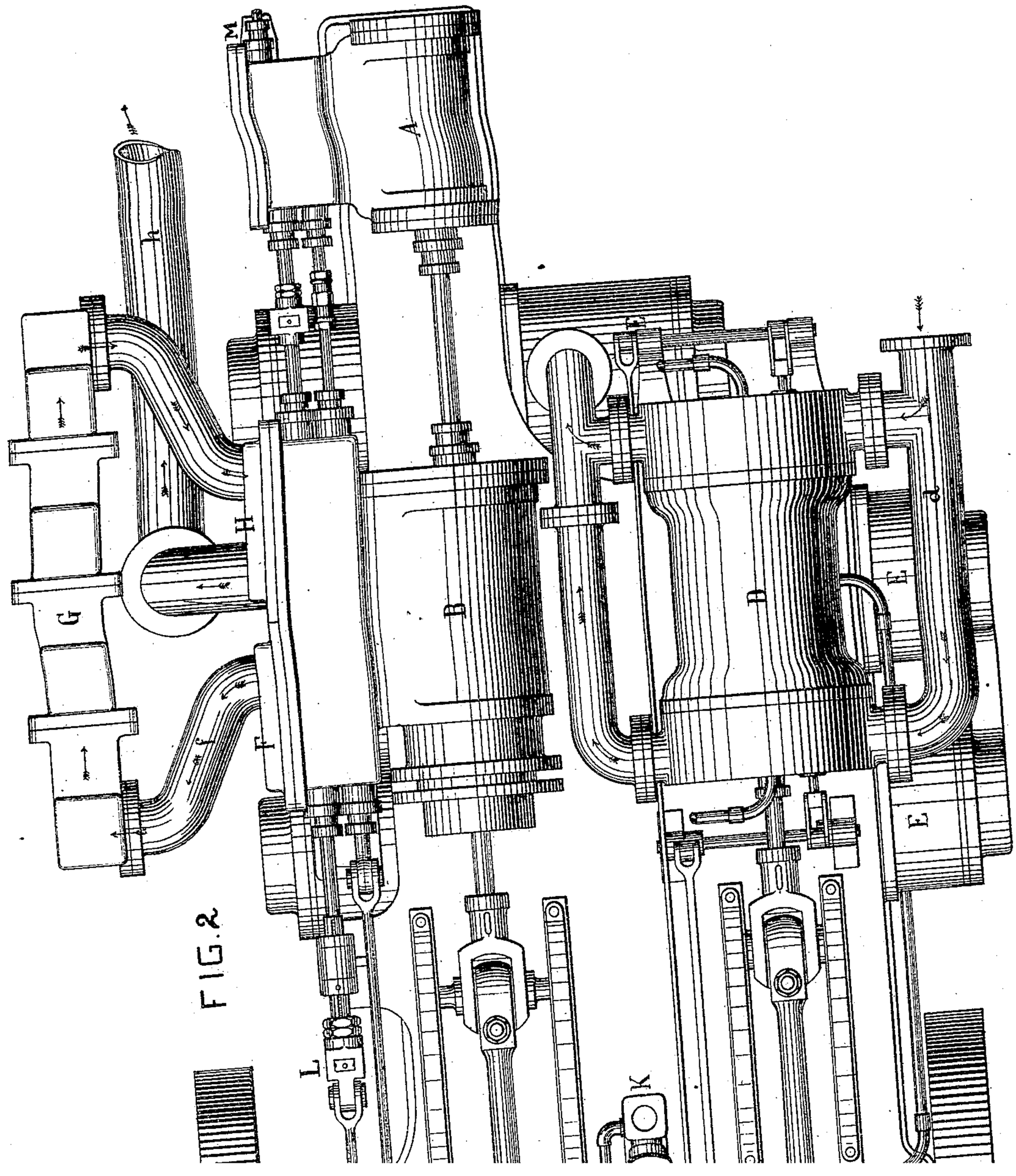

FIG. 2

UNITED STATES PATENT OFFICE.

THOMAS B. LIGHTFOOT, OF DARTFORD, COUNTY OF KENT, ENGLAND.

AIR-REFRIGERATING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 238,408, dated March 1, 1881.

Application filed February 4, 1881. (No model.) Patented in England October 6, 1880.

To all whom it may concern:

Be it known that I, THOMAS BELL LIGHTFOOT, a citizen of England, residing at Dartford, in the county of Kent, England, have invented a new and useful Improvement in Air-Refrigerating Apparatus, (for which I have obtained a patent in Great Britain, No. 4,065, bearing date October 6, 1880,) of which the following is a specification.

In apparatus for effecting refrigeration by compressing, cooling, and afterward expanding air while it is performing work, serious difficulties arise from deposition of moisture in the form of ice and snow, causing obstruction of pipes and passages, and also affecting the chamber in which the cold air is employed.

My invention relates to means of overcoming these difficulties, which I effect in the following manner: Instead of allowing the compressed and cooled air to expand to its full extent in one cylinder, I employ two or more cylinders of different sizes, in which it expands by stages, introducing between the successive cylinders suitable vessels or passages, in which moisture is deposited in liqud form, and from which it can be run or blown off. Thus, by the first stage of its expansion, the temperature of the air may be sufficiently reduced to effect condensation of the greater part of its moisture without freezing it, the more intense cold being produced in the subsequent stages of expansions after the condensed moisture has been removed. In most cases two stages of expansion suffice for the object in view, and in such cases, instead of employing two separate cylinders, one cylinder with a trunk or differential piston may be employed, the first expansion taking place in the annular space of the cylinder and the second expansion in its full capacity.

The accompanying drawings represent a combined steam-engine and refrigerating apparatus arranged according to my invention.

Figure 1 is a side elevation, and Fig. 2 a plan, of the whole apparatus. Fig. 3 is a longitudinal section of the expansion-cylinder, and Fig. 4 is a longitudinal section of the chambers for deposition of moisture.

A is the steam-cylinder, and B the expansion-cylinder, arranged in line with it, their pistons being fixed on one rod, which is connected to a crank on the fly-wheel shaft C. Another crank on the shaft is connected to the piston of a double-acting air-compressing pump, D. This pump is supplied with air by the pipe *d*, compresses it, and discharges it into the coolers E, which are conveniently arranged, as shown, under the engine-bed, and which may be of any known construction—as, for example, a number of tubes, round which water is caused to circulate, so as to abstract from the air a large portion of the heat developed by its compression. From the coolers E the cooled compressed air passes to the front slide-case, F, of the expansion-cylinder B, which has a trunk-piston, as shown in Fig. 3. A certain portion of the air is, at each stroke, admitted to act in the front annular space of the cylinder B and expands therein, performing work, and becoming considerably reduced in temperature. The exhaust-air from this annular space passes, by the pipe *f*, to a set of chambers, G, in which it is caused to travel upward and downward, as indicated by the arrows in Fig. 4, depositing the moisture suspended in it.

For more effectually securing deposit of the moisture a number of inclined screens, *g*, of wire, are placed in the descending channels, so that the air-current is broken up and subdivided, the particles of moisture being more or less retained by the wires and gliding down along them. The moisture that collects at the bottom of the vessels G is from time to time run off or blown off by opening a stop-cock, *g'*, in a pipe communicating with the bottoms of the deposit-vessels. From these vessels the air, which is still under considerable pressure, passes to the hinder-slide case, H, of the expansion-cylinder B, and a portion of it is at each stroke admitted to act in the full capacity of B, expanding and performing work, and thereby having its temperature cooled to a very low degree. The exhaust-air thus refrigerated is conveyed by the pipe *h* to the chamber or chambers where it is employed for refrigerating purposes.

Such being the general construction and action of the apparatus, I will now refer to certain details which I find of advantage.

The suction-valves of the air-compressing pump D, instead of being self-acting, are worked from cams *c* on the fly-wheel shaft. An eccentric, *k*, works a force-pump, K, for causing

(No Model.)

H. G. LOCKE.

Hop Picking Machine.

No. 238,409. **Patented March 1, 1881.**