(No Model.) 2 Sheets—Sheet 1.

J. ERICSSON, Dec'd.

E. SPROUT, G. H. ROBINSON, and C. S. BUSHNELL, Executors.

AIR ENGINE.

No. 431,729. Patented July 8, 1890.

Fig. 1.

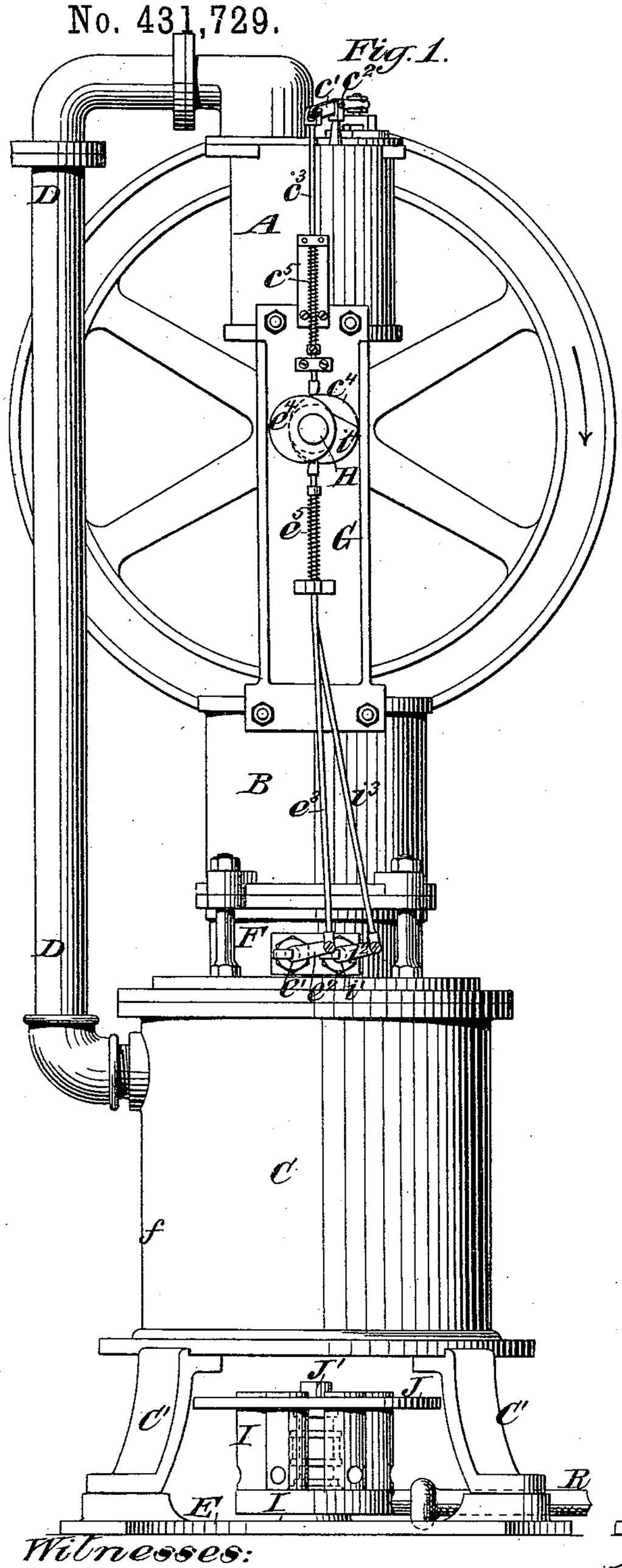

Fig. 2.

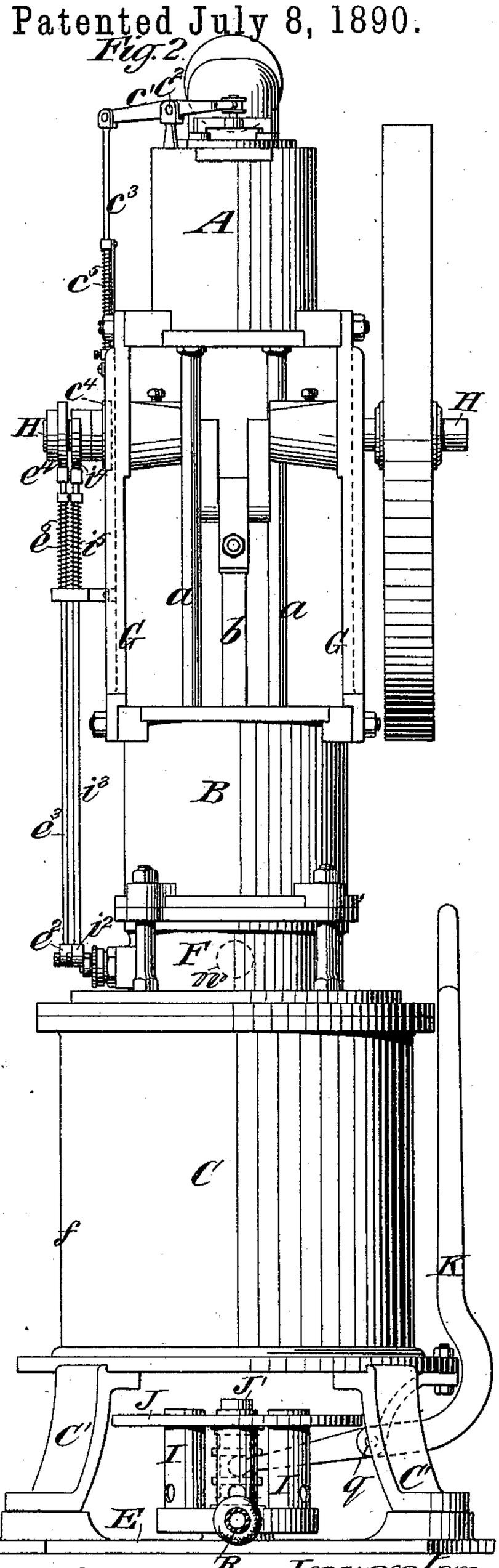

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Fig. 3.

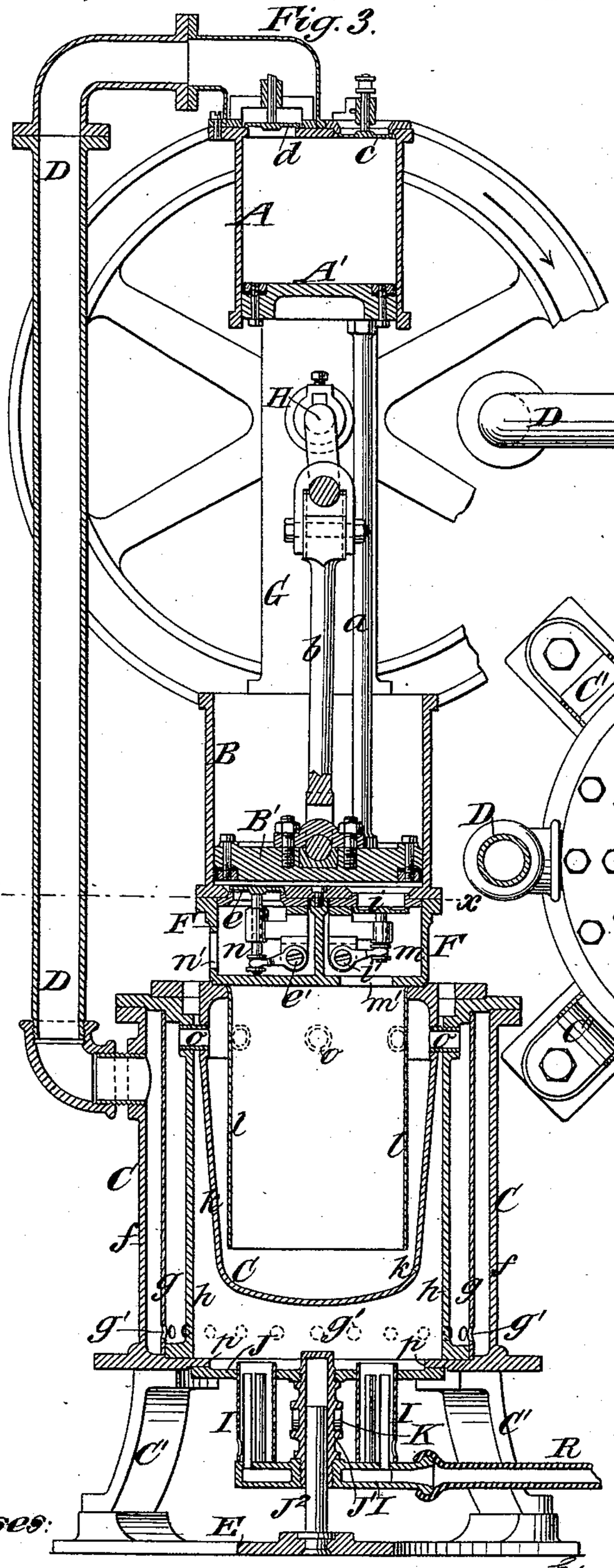


Fig. 5.

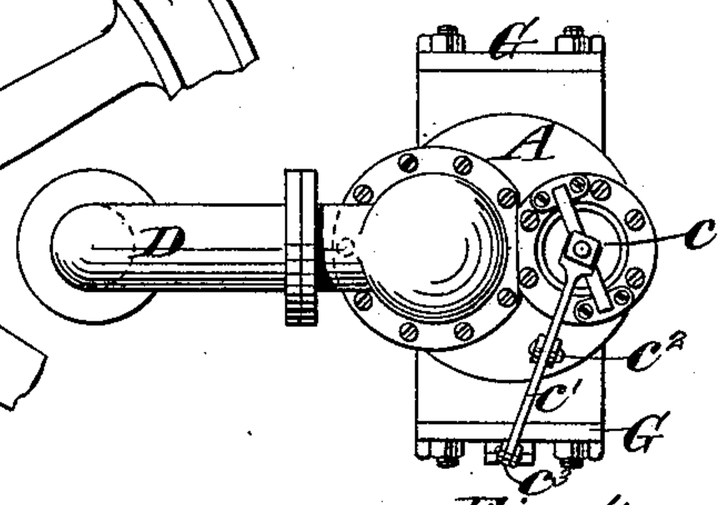
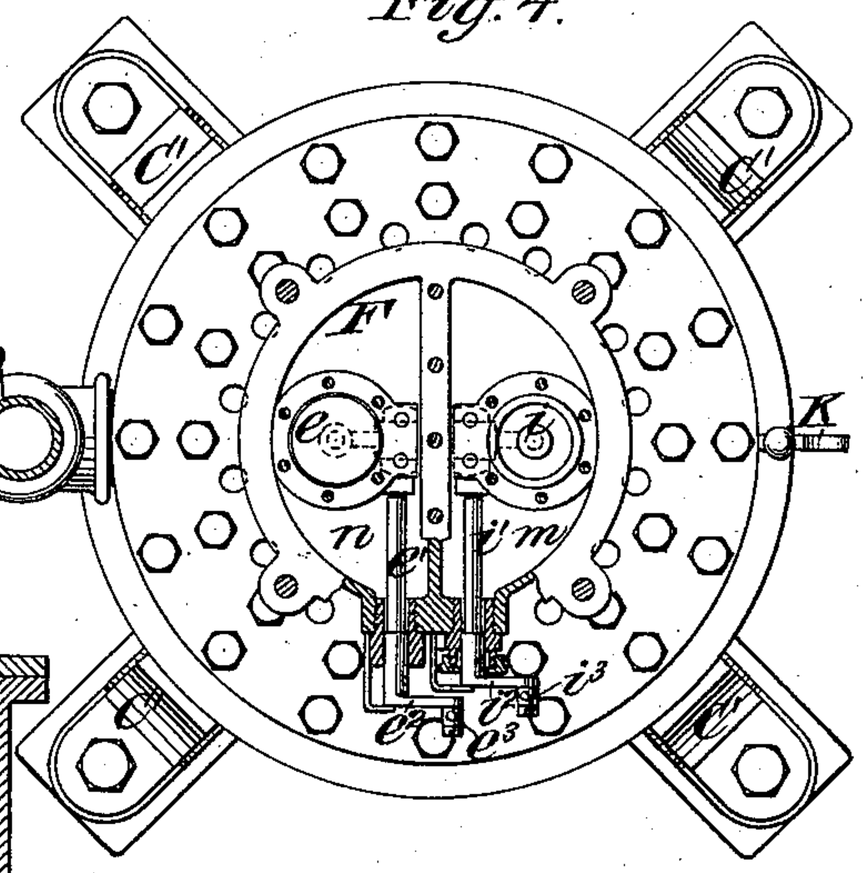


Fig. 4.



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UNITED STATES PATENT OFFICE.

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AIR-ENGINE.

SPECIFICATION forming part of Letters Patent No. 431,729, dated July 8, 1890.

Application filed August 5, 1889. Serial No. 319,804. (No model.)

To all whom it may concern:

Be it known that JOHN ERICSSON, deceased, late of the city, county, and State of New York, did invent a new and useful Improvement in Air-Engines, of which the following is a specification, reference being had to the accompanying drawings.

This invention relates to that class of air-engines in which the air is exhausted from the cylinder after every stroke of the piston.

The improvement will first be described in detail with reference to the accompanying drawings of an engine embodying the improvement, and its novelty will afterward be pointed out in the claims.

Figures 1 and 2 in the drawings represent elevations taken at right angles to each other of the engine. Fig. 3 represents a central vertical section in a plane parallel with Fig. 1. Fig. 4 represents a horizontal section taken nearly in the line $x\,x$, shown in Fig. 3. Fig. 5 is a plan view of the supply-cylinder and its connected parts.

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

A is the supply-cylinder of the engine containing the supply-piston A′.

B is the working-cylinder containing the working-piston B′.

C is a heater which constitutes the principal novel feature of the invention, the said heater being entirely separate from the working-cylinder, and being connected with the supply-cylinder by a pipe D for the purpose of receiving air from the latter cylinder and heating it before its introduction to the working-cylinder.

The heater C is represented as having its outer portion or casing supported by standards C′ on a bed-plate E, and the said casing is represented as supporting a valve-box F, which in turn supports the working-cylinder B. The supply-cylinder A is supported by standards G erected upon the working-cylinder, and these standards contain or support the bearings for the crank-shaft H of the engine. The supply and working pistons A′ and B′ are rigidly connected together by rods a, and the working-piston is connected by a connecting-rod b with the engine-crank.

The valve-box F contains two chambers m n, of which m is always open at the bottom, as shown at m', Fig. 3, to the heater, and the other n is always open, as shown at n', to the atmosphere.

In the bottom of the working-cylinder B there are provided openings fitted with valves i and e, communicating with the chambers m n of the valve-box F. The valve i, which is the induction-valve of the cylinder, opens downward and outward from the cylinder, and the valve e, which is the eduction-valve, opens upward and inward to the cylinder. These valves are connected with rock-shafts i' and e', which work through the side of the valve-box F, as shown in Fig. 4, and which are furnished outside of the said box with arms i^2 e^2, to which are connected rods i^3 e^3, operated upon to open the valves by means of two cams i^4 e^4 on the crank-shaft H, the valves being closed by springs i^5 e^5 applied to the said rods. It will be understood that the cam i^4 is the cam for induction and cut-off, and the cam e^4 is for the eduction.

The supply-cylinder A is furnished with an inlet-valve c, which opens inward to admit air from the surrounding atmosphere. This valve is connected with one end of a lever c', working on a fulcrum c^2 outside of the cylinder, the other end of the said lever having connected with it a rod c^3, which is operated upon to open the said valve at the proper time for the admission of air to the cylinder by means of the cam c^4 on the crank-shaft, the said rod being operated upon by the spring c^5 to close the said valve at the proper time. There is another valve d in the upper end of the supply-cylinder at the place where the pipe D is connected. This valve opens outward and operates automatically, being opened by the compression of the air in the said cylinder by the upward movement of the piston A′ and closing by its weight, aided by any back-pressure in the pipe D.

The heater C, which is here illustrated, and which is the form to be preferably used in

carrying out the invention, is composed, as best shown in Fig. 3, of a pot *k*, placed below the valve-box, three jackets *f g h* surrounding said pot, and a petticoat *l* dependent from the valve-box within the said pot. There is communication between the interior of the jackets *f g* at the bottom by means of openings *g'* in the jacket *g*, and there is also communication with the upper part of the interior of the pot *k* from the space between the jackets *g h* through short nozzles *o o*. The pipe D from the working cylinder communicates with the upper part of the space between the jackets *f g*. In the bottom of the heater there is an opening *p*, under which is placed the heat-generator, which may be of any suitable kind. I have shown as such generator a gas stove or burner I, which is attached to or has attached to it a plate J, which is of a size and construction to adapt it to close the opening *p* in the bottom of the heater. To this plate J is attached a socket J', which is fitted to slide up and down easily on a fixed post J^2, secured in the bed-plate E. The burner or stove applied below the heater is capable of being raised and lowered by means of a hand-lever K, working on a fixed fulcrum *q* below the heater. When in its raised position, it may close the opening *p* in the bottom of the heater, as shown in Fig. 3. When lowered, as shown in Figs. 1 and 2, the top of the burner is way below the bottom of the heater. This provision for lowering the burner is to permit the gas to be lighted without any explosive effect such as is common in the application of gas-stoves to air-engines when the burner is within the heater and only reached by the opening of a door in the side, in which case an explosive mixture of gas and air is likely to be found. When the burner is lowered entirely clear of the heater, as shown in Figs. 1 and 2, there is a free circulation of air around the burner, and no such explosive mixture is likely to be formed. The gas can then be ignited without danger or any unpleasant consequence.

The burner which I propose to employ may be and is represented as of the Bunsen kind and needs no particular description. To provide for the raising and lowering of the burner it is connected with the gas-service pipe by a flexible pipe R.

The operation of this engine is as follows: The gas-burner having been lowered to the position shown in Figs. 1 and 2, and the gas having been lighted, the burner is raised by the hand-lever K to its permanent position. (Shown in Fig. 3.) The gas having burned for some time, the various parts of the heater C, as well as the atmospheric air contained therein, become heated. The shaft H is now turned by hand-power applied to its fly-wheel, or otherwise, in the direction of the arrows shown in Figs. 1 and 3, setting the supply-piston A' and the working-piston B' in motion. Suppose both pistons to be moving upward from their lowest positions. The cold air contained in the supply-cylinder will be compressed, opening the outlet-valve *d*, to pass out through the pipe D into the heater, wherein it will first pass downward through the space between the jackets *f g*, thence through the holes *g'* into the space between the jackets *g h*, wherein it will pass upward to the nozzles *o*, and through the said nozzles into the upper part of the pot *k*, circulating downward between the interior of the said pot and the exterior of the petticoat *l*, and thence upward through the petticoat *l*, making its exit from the heater through the opening *m'* in the valve-box. At the commencement of the upward stroke of the pistons the valve *i* is opened by the cam i^4, and portions of the valve-gear between it and the said valve, and the heated air from the chamber *m* enters the working-cylinder, wherein it exerts its pressure to force the working-piston upward. This valve *i* is closed when the piston has traveled a certain portion of each stroke, as may be determined, say, one-half or two-thirds, to cut off the supply of air to the working-piston. At the commencement of the downward stroke of the two pistons, the inlet-valve *c* of the supply-cylinder is opened by means of the cam c^4, and the valve-gear interposed between the said cam and valve and the eduction-valve *e* in the bottom of the working-cylinder is also opened by the cam e^4, and the valve-gear interposed between it and the said valve *e*, both of these valves *c* and *e* being kept open the full length of the downward stroke and closed at the end of said stroke. After turning the crank-shaft several times by hand the pressure in the air-heater will be increased to a point at which the engine will be self-operating. The larger the air-receiver the more turns of the crank-shaft will be necessary to reach this point of self-operation. The capacity of the air-receiver being several times that of the working-cylinder, it is evident that the time allowed for the air to be heated is just in proportion to their relative volumes, and that the larger the air-receiver is the longer the air will be exposed to the heat from the furnace.

It may be understood that the working-pressure of the engine is determined by three factors: First, the proportion between the diameters of the working and supply cylinders; second, the point of cut-off in the working-cylinder, and, third, the degree of heat to which the air can be raised.

If the area of the supply-cylinder be half that of the working-cylinder and the inlet-valve of the working-cylinder be closed at half-stroke, the amount of air used by the working-cylinder will just equal that furnished by the supply-cylinder and the working pressure would be limited to that due to the confined air of atmospheric pressure heated a certain number of degrees; but if the supply-cylinder be of larger capacity, the working-cylinder and cut-off remaining as before, the engine will work with increased

pressure; or if the cut-off be shortened, the two cylinders being proportioned as at first mentioned, a corresponding increase of pressure will take place. It may be here mentioned that to large engines it may be necessary or desirable to apply a separate pump for compressing the air in the heater before starting the engine, and to compress the air in the receiver by such pump to a point at which the engine will start and be self-operating.

What is claimed as the invention, and desired to have secured by Letters Patent, is—

1. The combination, in an air-engine, of a working-cylinder and piston, a heater separate from the said working-cylinder, a supply-cylinder and piston above said working-cylinder and piston, a supply-pipe and a valve therein between the upper end of the supply-cylinder and the heater, a crank-shaft between said cylinders and connections, substantially as herein described, between said crank-shaft and pistons, a valve-box containing two valve-chambers between the heater and working-cylinder, one of said chambers being open to the heater and the other open to the atmosphere, a valve in each of said chambers for communicating with the working-cylinder, and valve-gear actuated by said crank-shaft for operating the said valves, substantially as herein described,

2. The combination, in an air-engine, of a supply-cylinder and a working-cylinder having an inlet-valve at the bottom, of an air-heater situated below said working-cylinder and valve and consisting of a pot open to said valve, a petticoat within the said pot also open to said valve, and a series of jackets outside of the said valve having inlet and outlet openings at top and bottom alternately, the inner one of said jackets being open to said pot and the outer one having a communication with the supply-cylinder, substantially as and for the purpose herein set forth.

3. The combination, in an air-engine, of a heater having an opening in the bottom and a burner fitted to said opening and capable of being removed downward therefrom for ignition, substantially as herein set forth.

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