(No Model.) 2 Sheets—Sheet 1.

J. ERICSSON.

STEAM ENGINE.

No. 374,354. Patented Dec. 6, 1887.

Fig. 1.

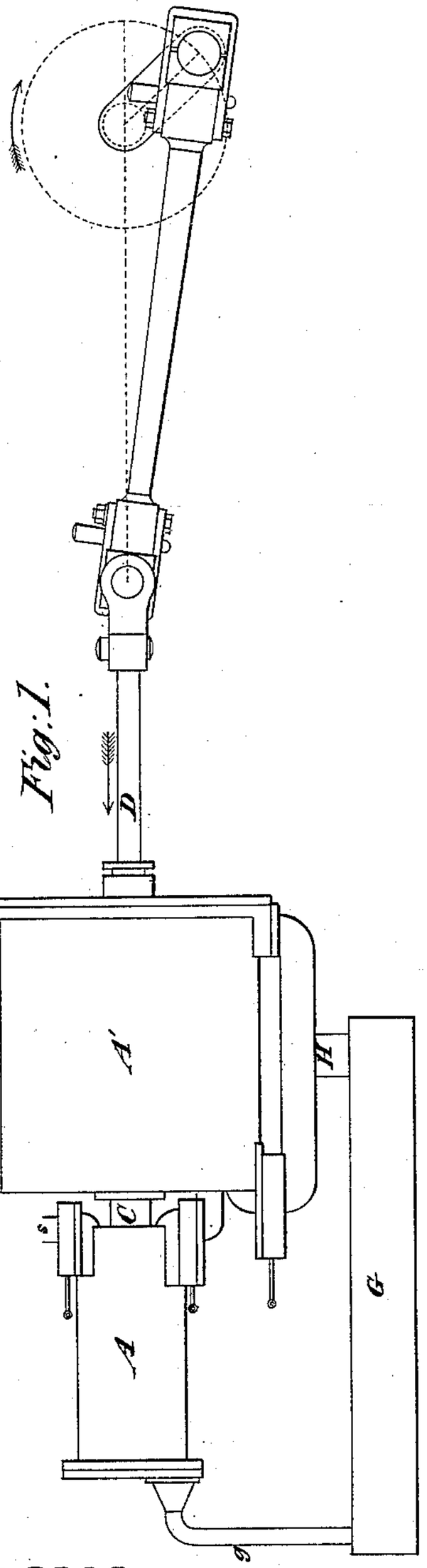
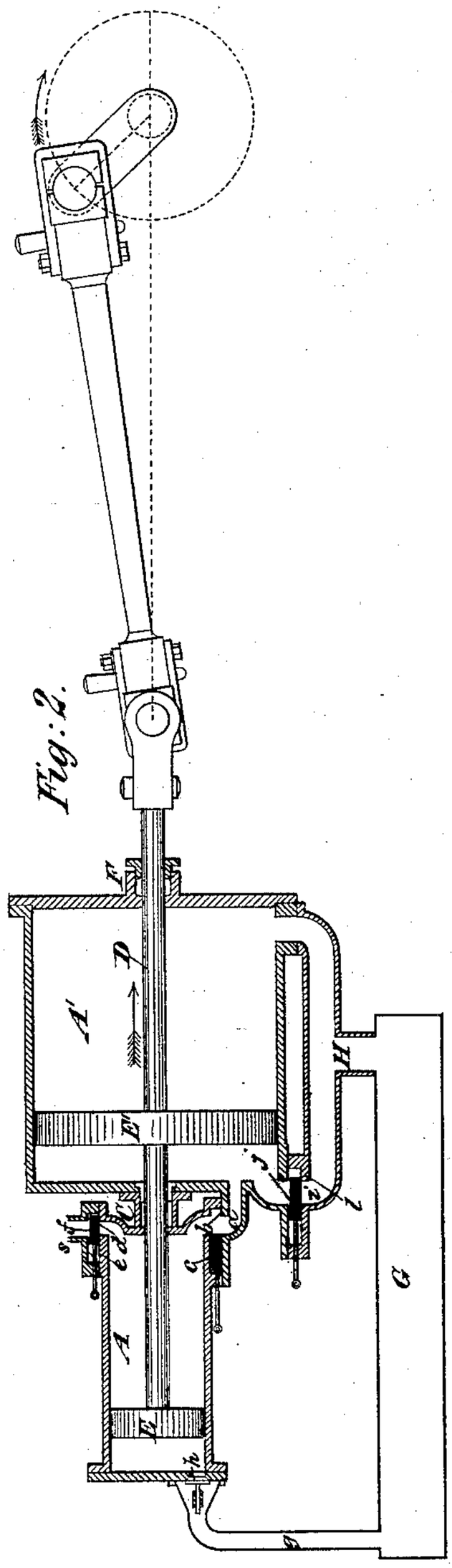


Fig. 2.



Witnesses.
Emil Harter.
C. L. Sundgren.

Inventor:
John Ericsson
by his attorneys
Brown & Hall

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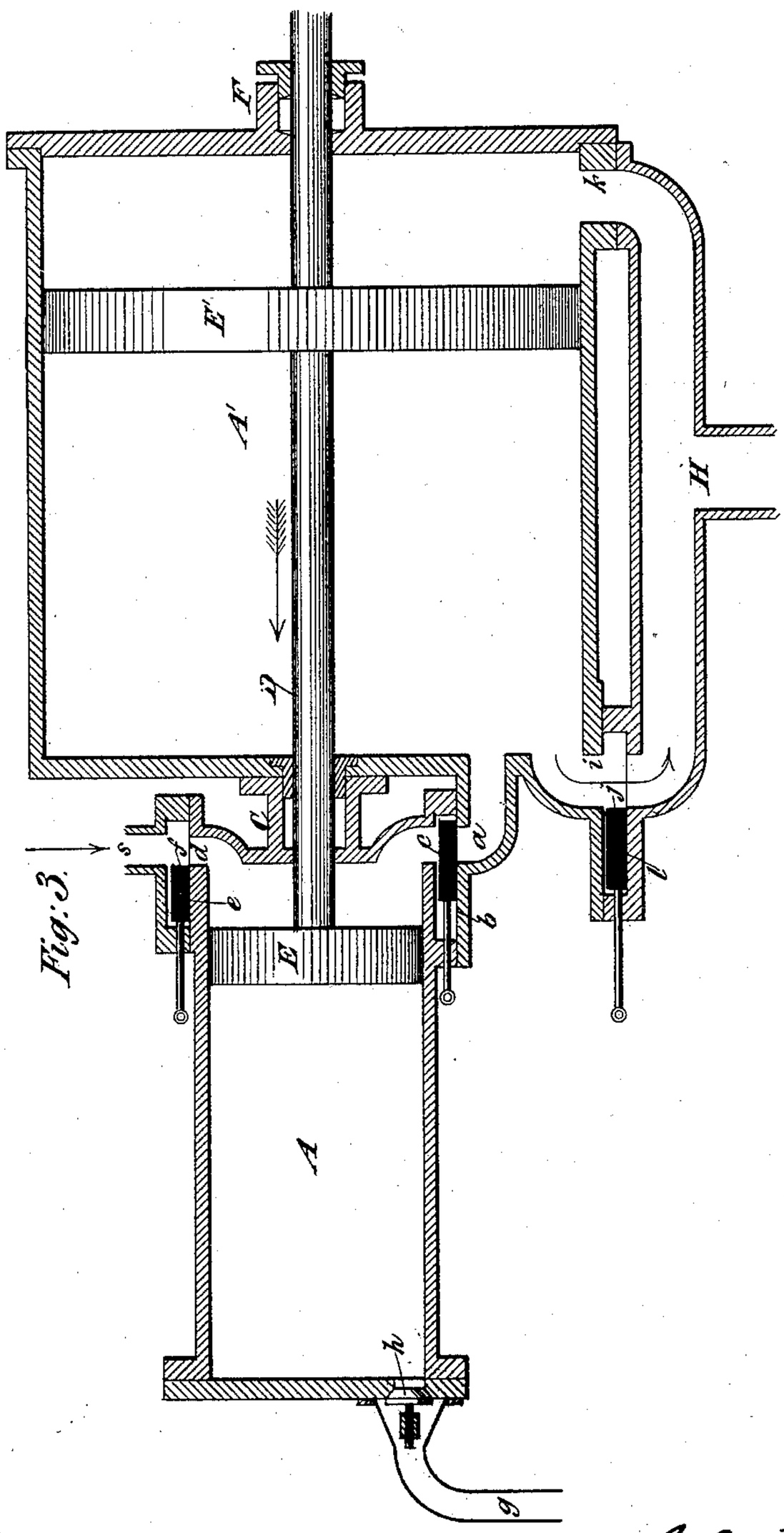

Fig. 3.

Witnesses.
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UNITED STATES PATENT OFFICE.

JOHN ERICSSON, OF NEW YORK, N. Y.

STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 374,354, dated December 6, 1887.

Application filed February 10, 1887. Serial No. 227,099. (No model.)

To all whom it may concern:

Be it known that I, JOHN ERICSSON, a citizen of the United States, residing in the city, county, and State of New York, have invented a new and useful Improvement in Compound Steam-Engines, of which the following is a specification, reference being had to the accompanying drawings.

The object of this invention is to develop and utilize in a compound steam-engine all the mechanical energy contained in a given quantity of steam.

In carrying out my invention I construct the engine with two cylinders only, the said cylinders being arranged so that, their pistons being secured to or connected with the same piston-rod, the pressure and expansive force of the steam may be applied on one side only of each piston, so that each cylinder and its piston are only single-acting.

My invention consists in certain novel combinations, hereinafter described and claimed, of which such two cylinders and pistons constitute essential parts, whereby the small or high-pressure piston is made to work against a perfect vacuum in its cylinder throughout the entire stroke produced by the action of the high-pressure steam upon it, and whereby, also, at the same time the large or low-pressure piston is made to work in equilibrio, the result being that the whole force due to the pressure and expansion of the steam in the small or high-pressure cylinder is directly utilized without any back-pressure or drawback whatever, except, of course, what is unavoidably due to friction.

Figure 1 in the accompanying drawings is a side view of the principal parts of a horizontal compound steam-engine embodying my invention, the parts not necessary to illustrate the invention being omitted. Fig. 2 is a vertical sectional view corresponding with Fig. 1, except that it represents the crank in another position and the pistons moving in the opposite direction. Fig. 3 is a vertical sectional view, on a larger scale, of the cylinders and pistons and the ducts and valves of the said engine, the pistons and valves being in position corresponding with the position of the crank in Fig. 1.

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

A designates the small or high-pressure cylinder of the engine, which receives steam directly from the boiler.

A′ designates the large or low-pressure cylinder, into which steam is pumped from the small cylinder A by the piston of the latter.

The two cylinders are arranged end to end in line centrally with each other, and as close together as is practicable, but entirely separate from each other, except that there is provided between them a steam-duct and a valve, as hereinafter described, and there is provided between them the stuffing-box C with metallic packing for the passage of the piston-rod D, on which are secured the small and large pistons E E′, which are fitted, respectively, to the small and large cylinders. The said cylinders are fitted at their outer ends with tight heads, and in one of the said heads—that of the large cylinder in the example represented—there is a stuffing-box, F, for the passage of the piston-rod D.

Between the adjacent ends of the two cylinders there is a duct, *a*, which, being at the bottom of the small cylinder and communicating with the large cylinder through the end thereof, is very short, and within this duct there is a valve-seat, *b*, for a valve, *c*, (represented as a simple flat sliding plate,) for opening and closing communication between the two cylinders. At the same end of the small cylinder A there is a duct, *d*, with which is connected the steam-pipe *s* from the boiler, and in this duct is the seat *e* for a valve, *f*, which, like *c*, is also represented as a simple flat sliding plate, the said valve *f* serving to admit steam from the boiler to the said cylinder A and cut it off therefrom.

At the outer end of the small cylinder A there is an outlet-pipe, *g*, which may open to the atmosphere, or may communicate with the condenser G, as shown in Fig. 1, and at the connection of this pipe with the cylinder A there is a valve, *h*, which is arranged to close inward, but will be forced open by excess of pressure on its inner side. The large cylinder has at its inner end—that is to say, the end next to the small cylinder—and in valved communication therewith, as described, a second or outlet duct, *i*, for communication with one of the branches of a pipe, H, leading to the condenser G, and in this duct there is a seat,

l, for the valve *j*, which, like *c* and *f*, is represented as a flat plate sliding on its seat. At the outer end of the cylinder there is a duct or port at *k*, which is always open to the condenser through a branch of the pipe H.

The bores of the two cylinders and the surfaces of the pistons will have a relative area according to the intended degree of expansion of the steam, by which, also, the point in the stroke of the small piston, at which the steam from the boiler is to be cut off in the small cylinder by the valve *e*, will be in part determined. For instance, I may expand the steam thirty-six times by giving the larger piston an area nine times that of the smaller one and cutting off the steam from the small cylinder at one-quarter stroke.

The valves may be operated by any known or suitable valve-gear—such as is used for working the valves of steam-engines—and therefore I do not think it necessary to describe it; but I will simply describe the movements of the valves in describing the operation of the engine, which is as follows: Suppose the pistons to be first at the right-hand end of their stroke and close to the corresponding ends of their respective cylinders. The induction-valve *f* is now open or opening to admit steam to the right-hand end of the small cylinder A, to act upon the corresponding face of the piston E and move it and the rod D to the left, the valve *c* between the cylinders being closed and the valve *j* between the left-hand end of the large cylinder and the condenser being open. After the valve *f* has been closed to cut off the supply of steam from the boiler to the small cylinder, the steam remaining in the latter continues by its expansive force to act upon the small piston and move it and the rod D to the left, the valve *c* remaining closed and the valve *j* remaining open. By this its first working-stroke the said piston E expels all air from its cylinder A through the valve *h* and pipe *g*, so that on its return-stroke, during which the valve *h* is closed, the said piston produces a vacuum in its cylinder, and hence on the second and all succeeding working-strokes the said piston works against a vacuum, which, if it should not have been made perfect by the first working-stroke and return, must be perfected by the repeated strokes, and can never be lost. While the small piston is thus working against a vacuum, the large piston, which must move with it, is in equilibrio, for, the valve *j* being open, there is free communication through its duct *i*, and thence through the duct *k*, which is always open, between the two ends of the large cylinder; hence there is no resistance whatever offered to the small piston during its working-stroke, except such as is unavoidably produced by friction.

At the end of the stroke of the two pistons and the piston-rod to the left the valve *c* is opened and that *j* is closed, so that communication is opened between the adjacent ends of the two cylinders, and at the same time the working end of the large cylinder is closed to the condenser, to which the other end of the latter cylinder is always open. The two pistons and their rods are then caused to be moved to the right by the great excess of pressure on the left-hand face of the large piston, due to its vastly-greater area, and the steam is pumped out of the small cylinder by its own piston. In this movement, which is the working movement of the large piston, the latter works against a vacuum as perfect as may be obtained in the condenser. During the first part of the said movement and up to, say, one-tenth of the stroke, the power exerted by the steam on the large piston is comparatively great; but this produces no evil effect, since the power diminishes considerably before the crank has any considerable inclination to the line of motion of the piston, as may be understood by reference to Fig. 3, where the parts are represented in a position near the beginning of the return movement obtained by the pressure on the large piston. Moreover, the great power referred to is exerted by a push; hence it does not strain the parts of the connecting-rod by a pull. Again, it may be mentioned that this excessive power is exerted during so small a portion of the rotation that it cannot cause heated journals. The working-stroke of the large piston having been completed, on the valves *f* and *j* being opened and the valve *c* being closed, steam from the boiler is again admitted to the small cylinder to reproduce the working-stroke of its piston, as before described, while the face or left-hand side of the large piston is completely relieved of pressure through the duct *i*, which is opened by the valve *j*. This perfect relief of pressure on the large piston is not delayed, as in the case of a simple condensing-engine, until the condensation of the steam in the condenser has been completed; but on the instant of the opening of the valve *j* the said relief is effected by the free passage of the steam through the ducts *i* and *k* from the front to the back of the large piston.

In the operation of this engine the small piston, as may be understood from the foregoing description, has three functions, viz., first, that of a working-piston; second, that of an air-pump piston, to produce a vacuum in its own cylinder; and, third, that of a steam-pump piston, to pump out the steam from its own cylinder into the large cylinder, assisted, of course, by the expansive action of the steam.

It has been hereinbefore stated that the pipe *g* may be open to the atmosphere or be in communication with the condenser. It is represented as communicating with the condenser; but so far as the working of the engine is considered that is immaterial, its purpose being to provide for conducting away the air and any steam that might be forced out of the said cylinder, as hereinbefore described, by the air-pump-like action of the piston E through the

valve *h*. The said pipe also serves, by simply feeling its exterior, to ascertain whether or not the packing of the piston E be in good order, for while there is no leakage around the said piston the said pipe will remain cool; but if there be such leakage the said pipe will become hot.

Among the merits of this engine, besides the absence of all back-pressure against the high-pressure piston, and the low-pressure piston being placed in equilibrio during the working-stroke of the high-pressure piston, may be mentioned its freedom from long steam passages and ducts, which involve so much loss in clearance and by radiation, and the simplicity of its construction, and especially the simplicity of the valve system, there being but three valves, and those of the simplest known kind—viz., mere flat plates working over single ports without circuitous ducts or passages.

The cylinders and pistons might be arranged in any position from vertical to horizontal; but the horizontal arrangement which I have represented serves as well as any other for illustration.

What I claim as my invention is—

1. The combination, with the high-pressure cylinder of a compound steam-engine, a steam-actuated piston fitted thereto, and a valve for the induction of the high-pressure steam to the said cylinder at one end only, of a valve at the other end of the said cylinder closing inward, but opening outward by the pressure from within, substantially as herein described, whereby the said piston is made to work as an air-pump piston to expel air and steam from said cylinder on the side of the piston opposite to that on which the high-pressure steam acts, and thereby cause a vacuum on one side of the said piston, while the high-pressure steam acts on the opposite side, as herein set forth.

2. The combination, with the small and large cylinders of a compound engine, arranged end to end and having communication only between one end of the small one and the reverse end of the large one, and two pistons, one for each cylinder, of an outwardly-opening valve at the other end of the small cylinder, whereby the piston of the small cylinder is made to expel any air, water, or steam that may have collected therein, substantially as herein described.

3. The combination, in a compound steam-engine, of a high-pressure steam-cylinder receiving high-pressure steam at one end and having at the other end a valve opening automatically by pressure within the said cylinder, a low-pressure cylinder one end of which is always in communication with the condenser and the other end of which has valved communications with the high-pressure cylinder and the condenser, substantially as herein described, whereby the high-pressure piston during its entire stroke, produced by the direct action of the steam upon it, works against a vacuum, and at the same time the low-pressure piston is in equilibrio, as herein set forth.

4. The combination, in a compound engine, with a small single-acting steam-cylinder and a large single-acting steam-cylinder arranged horizontally end to end and receiving steam only at their adjacent ends, and a condenser below them, of the duct *a*, forming communication from the bottom of the small cylinder through the end of the large one, the ducts *i k*, forming communication between the condenser and both ends of the large cylinder, and the valves *c j* in the ducts *a i*, all substantially as herein described.

JOHN ERICSSON.

Witnesses:
S. W. TAYLOR,
FREDK. HAYNES.