(No Model.) 7 Sheets—Sheet 1.

E. FIELD.

ENGINE.

No. 442,027. Patented Dec. 2, 1890.

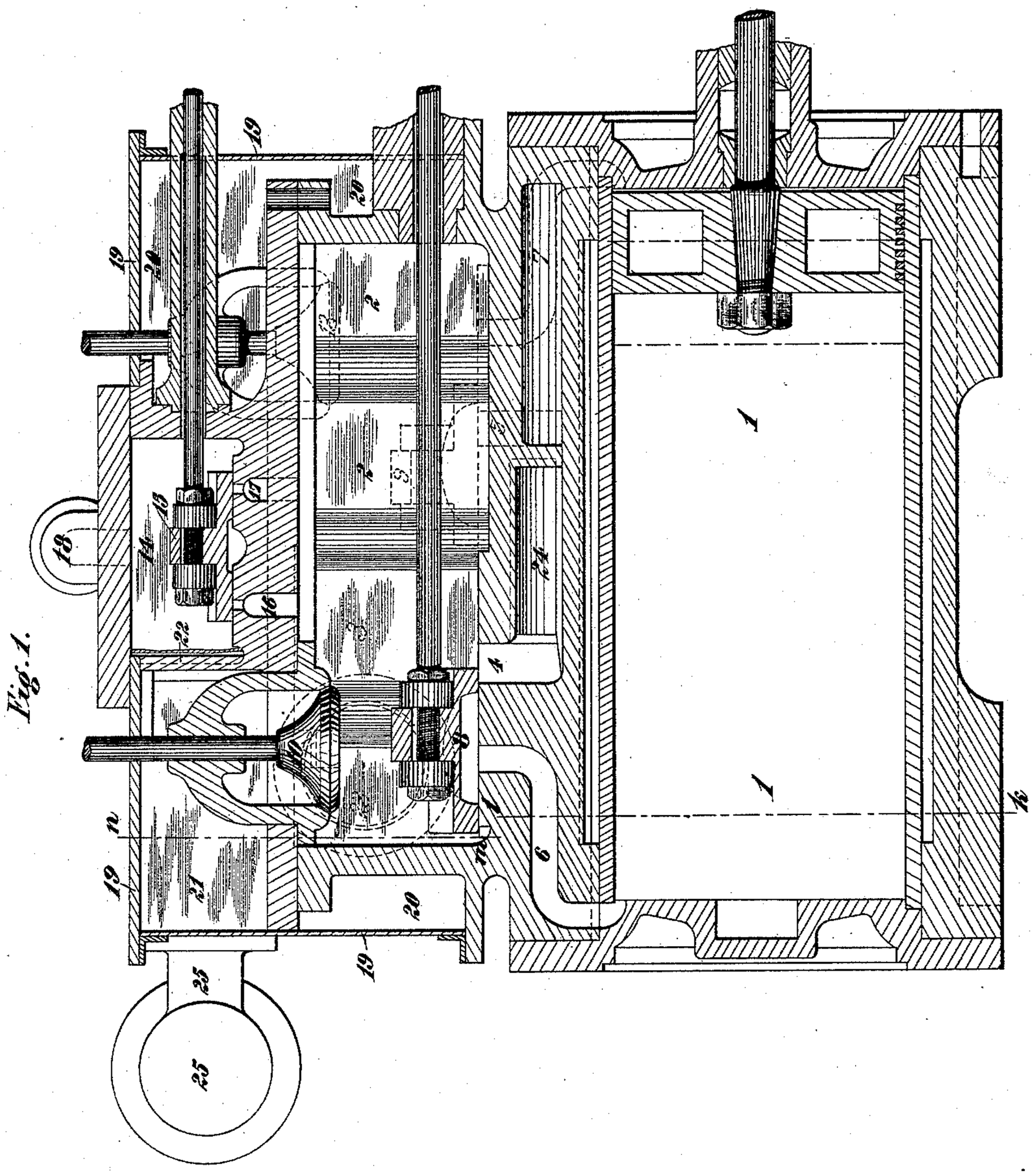

Fig. 1.

Witnesses.
J. Bronshaw
W. Cross.

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E. Field

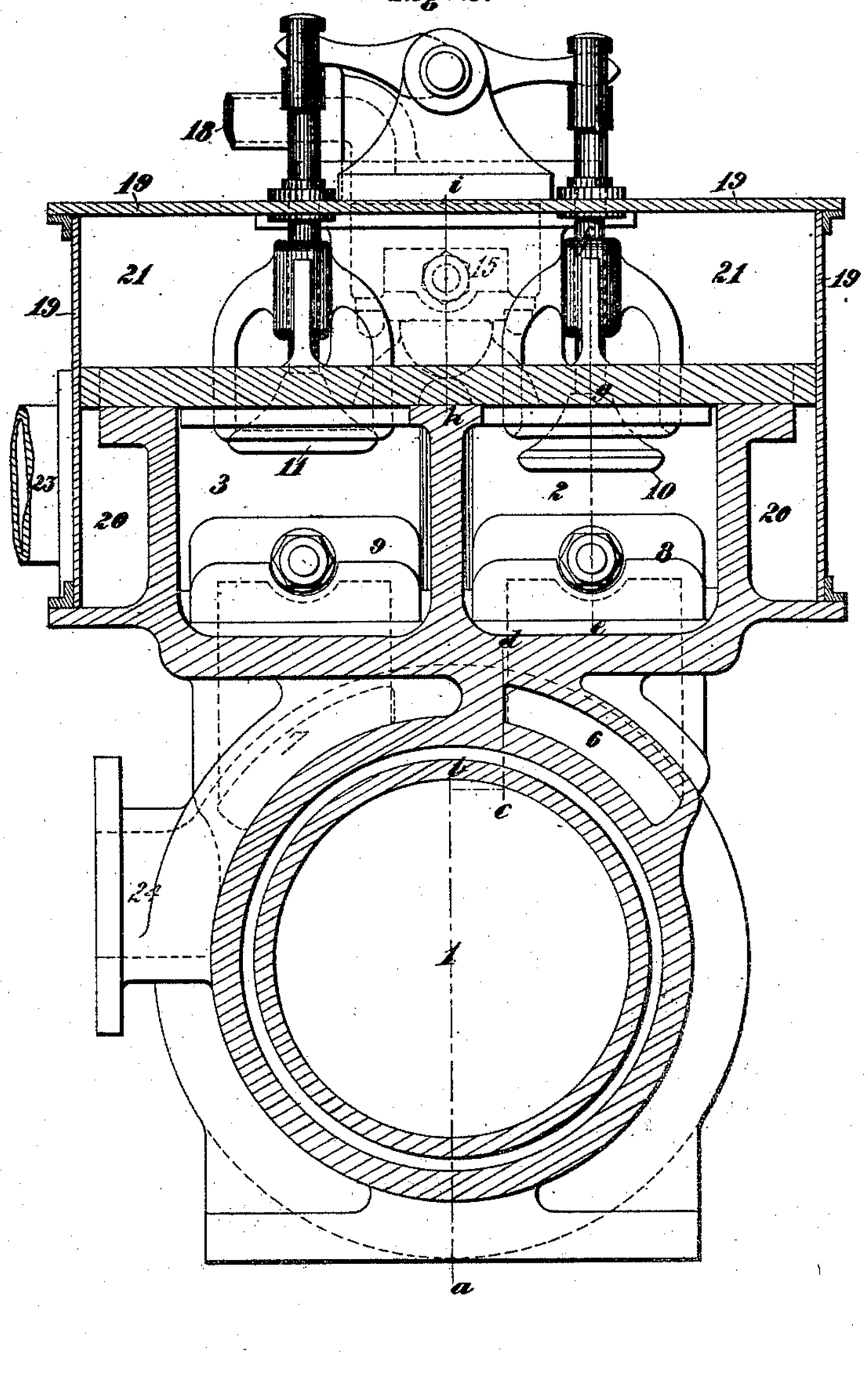
(No Model.) 7 Sheets—Sheet 2.

E. FIELD.

ENGINE.

No. 442,027. Patented Dec. 2, 1890.

Fig. 2.



Witnesses.
H. Bonyhan
W. Cross

Inventor:
E. Field

(No Model.) 7 Sheets—Sheet 3.

E. FIELD.

ENGINE.

No. 442,027. Patented Dec. 2, 1890.

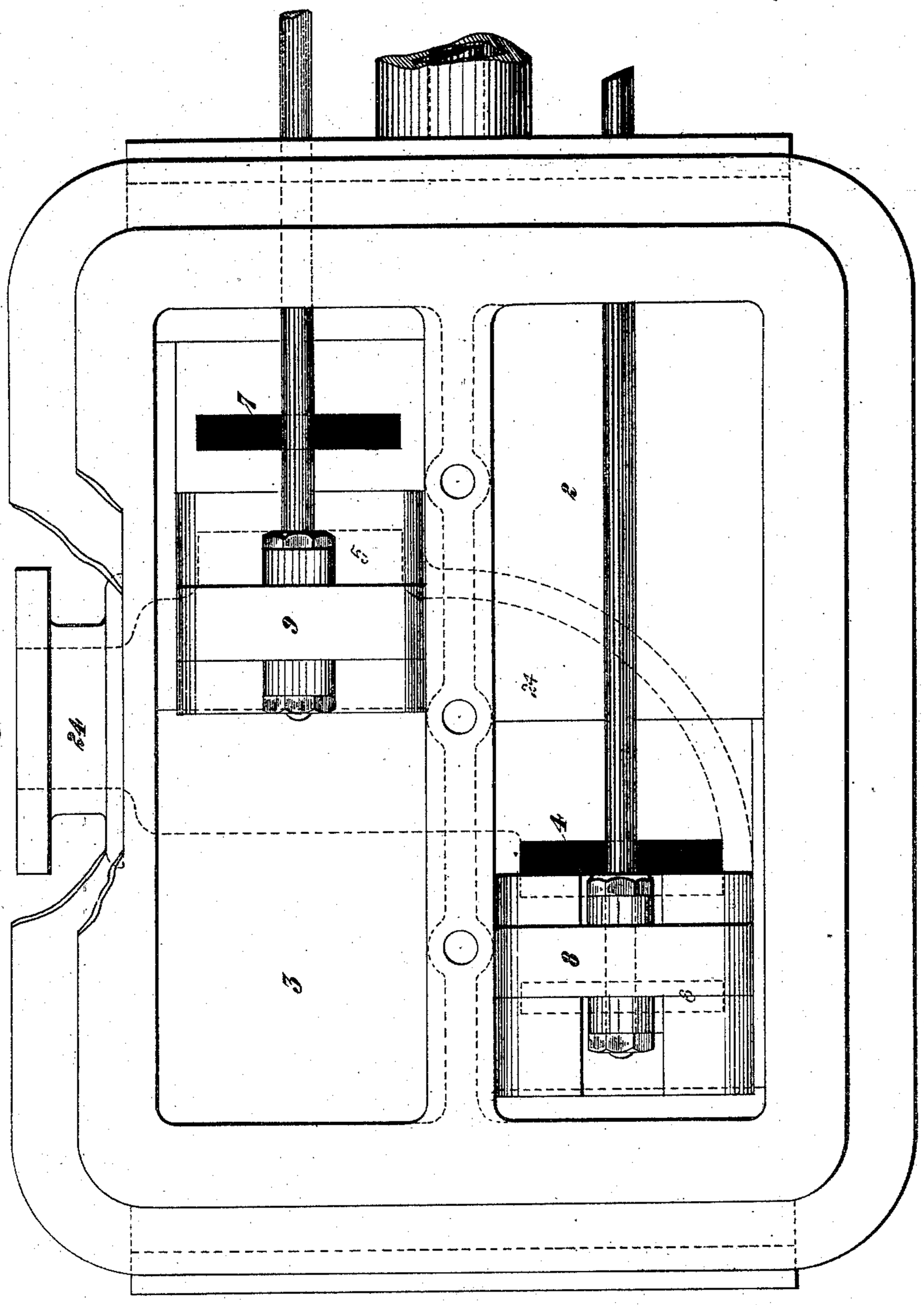


Fig. 3.

Witnesses.
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W. Cross

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(No Model.) 7 Sheets—Sheet 4.

E. FIELD.

ENGINE.

No. 442,027. Patented Dec. 2, 1890.

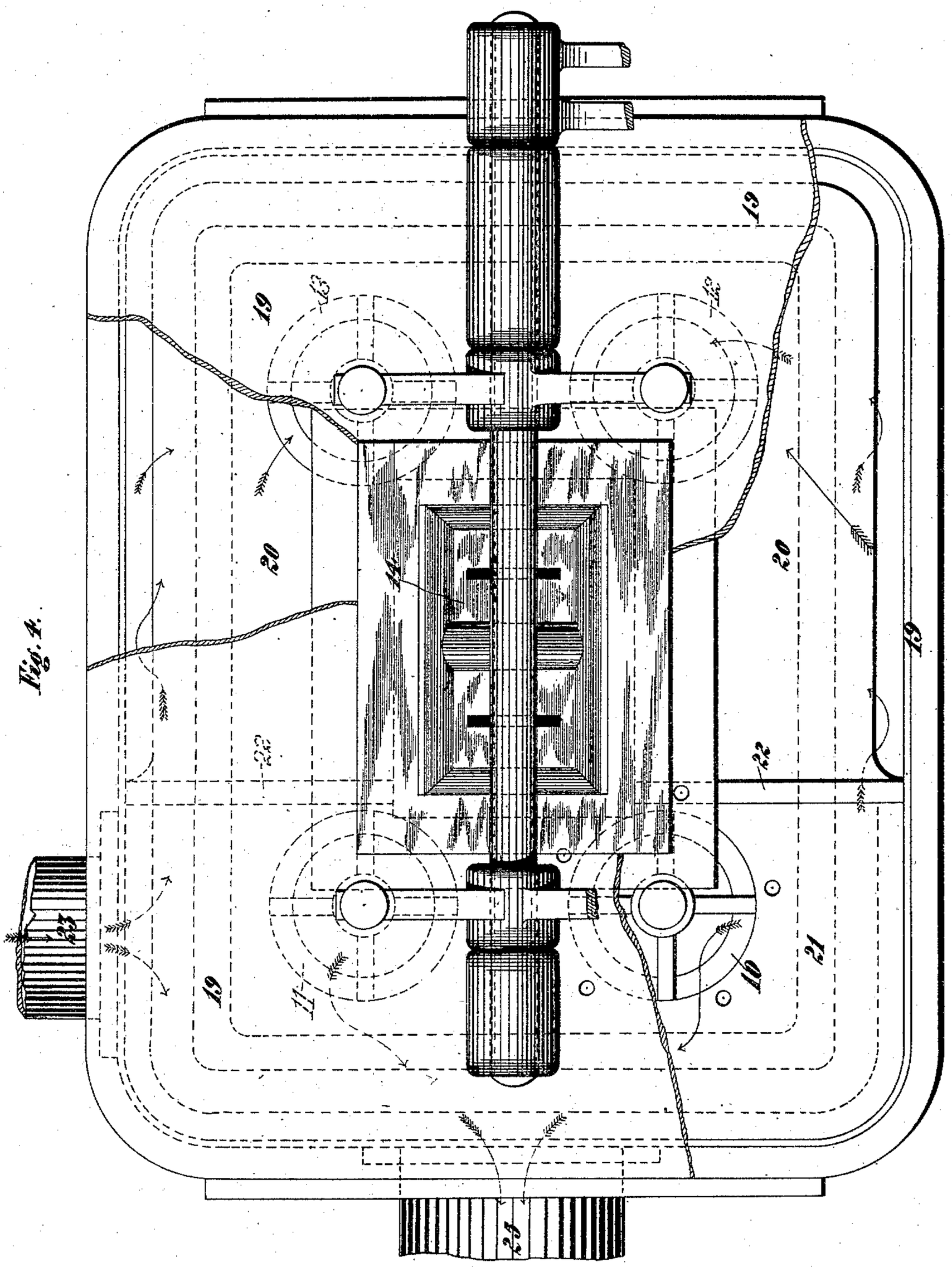

Fig. 4.

Witnesses.
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(No Model.) 7 Sheets—Sheet 5.

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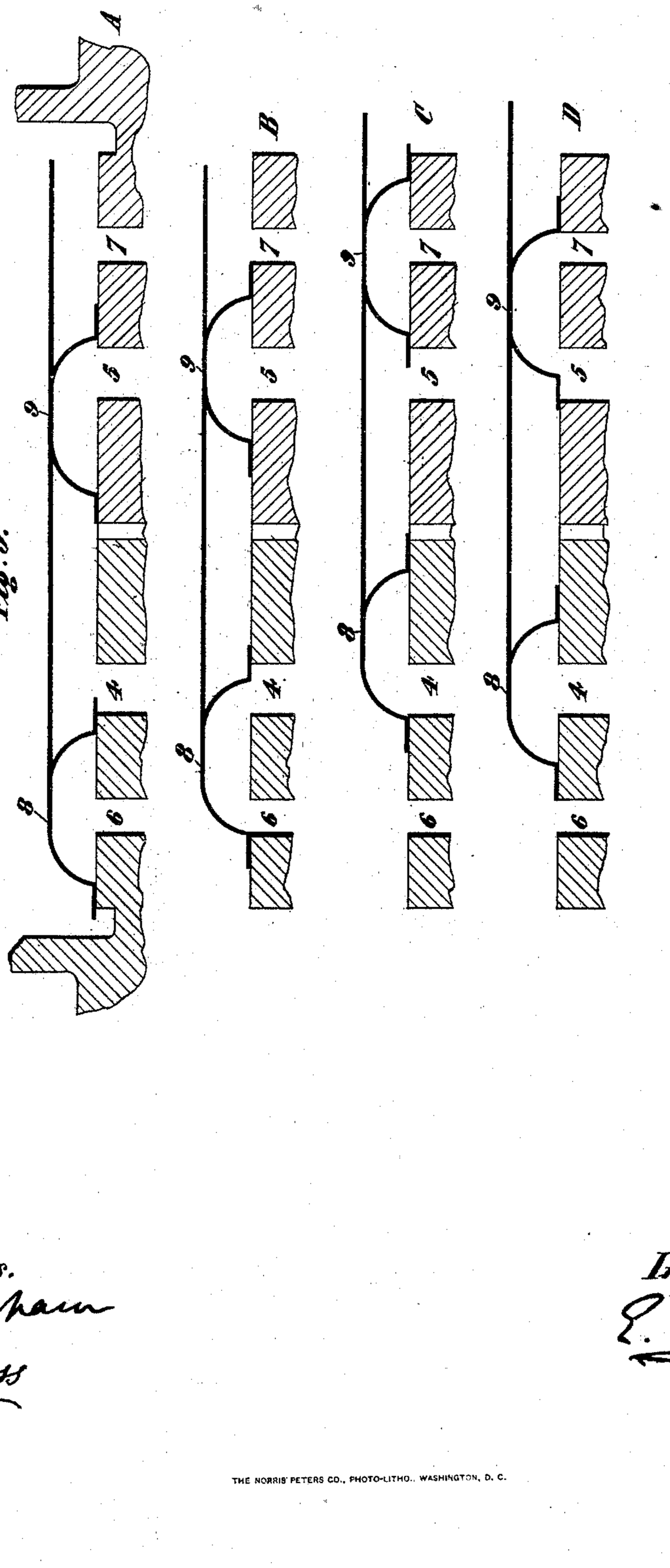
ENGINE.

No. 442,027. Patented Dec. 2, 1890.

Fig. 5.



Witnesses.
J. J. Bumgarner
W. Cross

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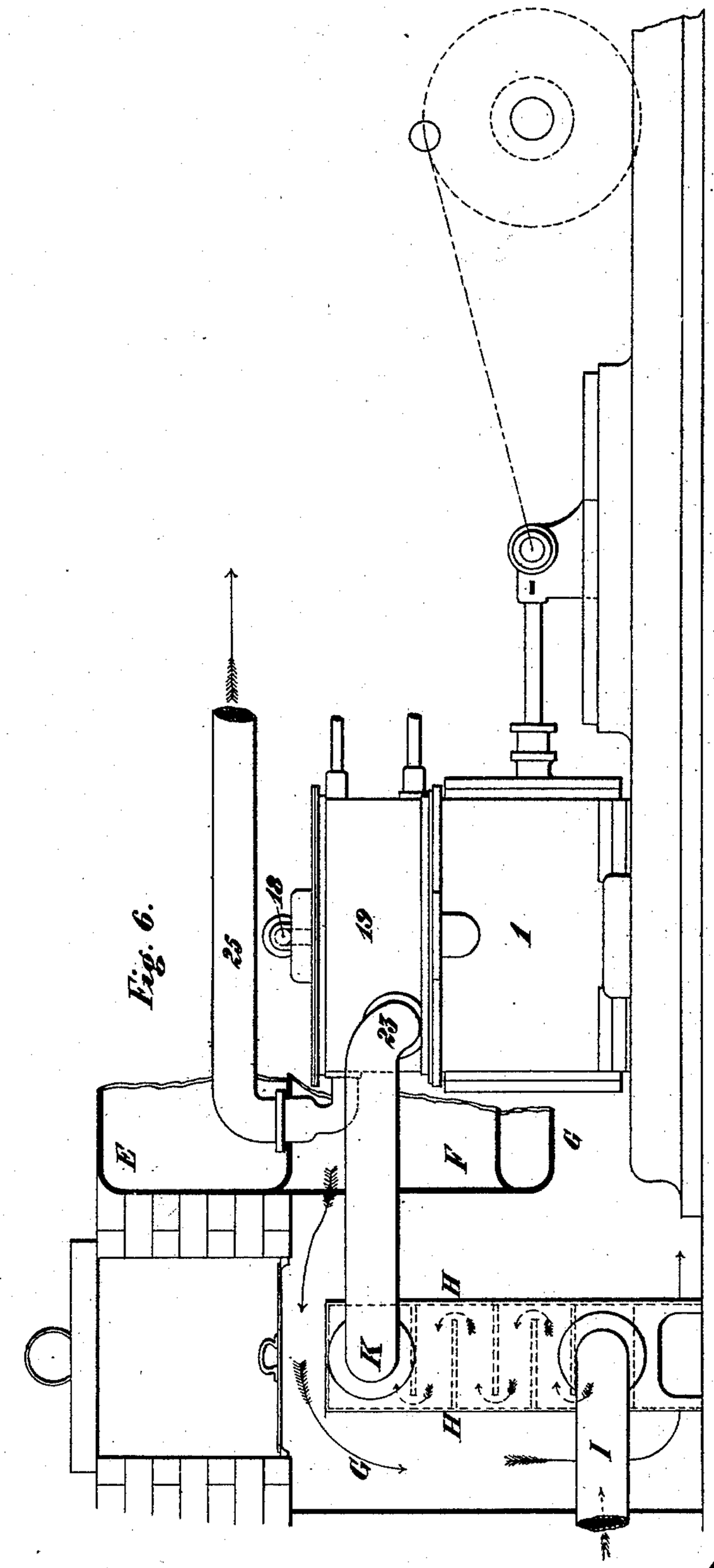
(No Model.) 7 Sheets—Sheet 6.

E. FIELD.

ENGINE.

No. 442,027. Patented Dec. 2, 1890.



Witnesses.
F. F. Dromgoole
W. Cross

Inventor.
E. Field

(No Model.)

7 Sheets—Sheet 7.

E. FIELD.

ENGINE.

No. 442,027.

Patented Dec. 2, 1890.

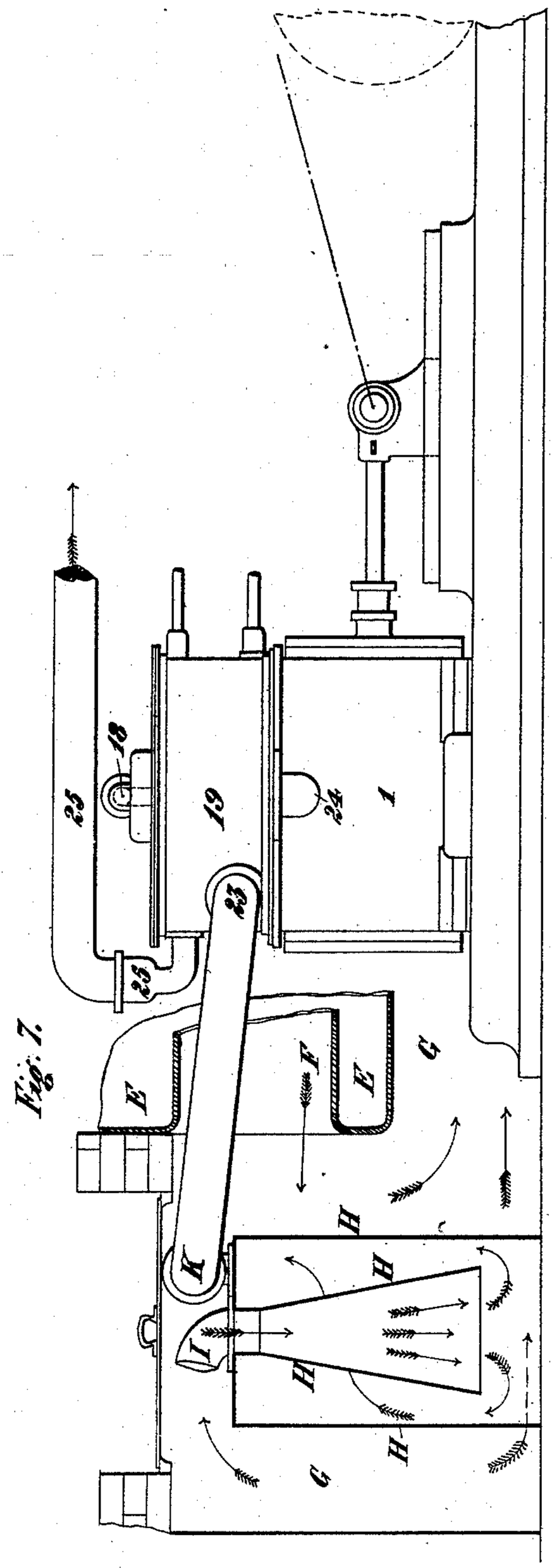


Fig: 7.

Witnesses.
J. Thompshaw
W. Cross

Inventor.
E. Field

UNITED STATES PATENT OFFICE.

EDWARD FIELD, OF LONDON, ENGLAND.

ENGINE.

SPECIFICATION forming part of Letters Patent No. 442,027, dated December 2, 1890.

Original application filed January 3, 1890, Serial No. 338,729. Divided and this application filed May 28, 1890. Serial No. 353,505. (No model.) Patented in France January 6, 1890, No. 202,990; in Belgium January 8, 1890, No. 89,106; in Luxemburg January 22, 1890, No. 1,241, and in Italy March 31, 1890, LIII, 93.

To all whom it may concern:

Be it known that I, EDWARD FIELD, a subject of the Queen of Great Britain and Ireland, residing at Buckingham Street, Adelphi, London, England, have invented improvements in engines to be worked by hot gases—such as air or products of combustion—with steam, (for which I have obtained Letters Patent in France by patent dated January 6, 1890, No. 202,990; in Belgium by patent dated January 8, 1890, No. 89,106; in Luxemburg by Patent No. 1,241, dated January 22, 1890, and in Italy by Patent Reg. Att. Vol. LIII, No. 93, dated March 31, 1890,) of which the following is a specification.

This invention relates to improvements in engines designed to be worked with hot gases—such as air or products of combustion—with addition of steam for the purpose of developing motive power.

This application is filed as a division of my pending application for United States patent, filed January 31, 1890, Serial No. 338,729.

In such an engine the mixture of the steam with the hot gases to form a charge for doing duty in the working-cylinder (or in one of the working-cylinders) of the engine is effected in a chamber in the following way: First, said chamber having supplied a charge of mixture to the working-cylinder and been thereafter opened to an exhaust, hot gases are passed through said chamber to clear and dry it. Then while said chamber is yet full of hot dry gases it is closed. Then steam at a suitable pressure is admitted into said chamber and mixed with the hot gases therein, thus forming the working-mixture for use in the cylinder. This mixture, being at a high pressure, then expands into said cylinder, and after it has done duty in effecting a stroke of the piston said cylinder is opened to the exhaust and the spent mixture is allowed to escape from it. For a single-acting engine one mixing-chamber will usually suffice. A double-acting engine, however, requires at least two such mixing-chambers, in each of which the above-described process will take place; but the chamber or chambers to supply actuating-fluid to one end of the cylinder (or of each cylinder) must be separate from the chamber or chambers that supply the other end, in order to allow ample time for the above-described process of clearing out, drying, filling with hot gases, and admitting steam thereto to take place in an efficient manner in each of said chambers in the required order.

By "hot dry gases," which expression I use primarily to distinguish hot air or products of combustion without addition of steam, I mean as respects temperature, say, about 400° Fahrenheit, and as respects dryness as dry as I can practically obtain such gases, taking care that the clearing out of the mixing-chamber (by which I mean substitution for gases with steam of hot gases, such as air or products of combustion alone) shall be as complete as possible. In such an engine whereof the cylinder (or each cylinder if there be more than one) is provided with two mixing-chambers. Each of these chambers is in connection with one end only of the cylinder and with the exhaust, and each mixing-chamber is provided with a slide or valve adapted to control ports leading, respectively, to the one end of the cylinder and to the exhaust, also with an inlet and an exit for hot gases—such as products of combustion or heated air, also suitably controlled—and likewise with an inlet for steam controlled by a suitable slide or valve adapted to admit steam and close the inlet while all other openings to the mixing-chamber are closed. The arrangement and operation of the various parts are such that while motive fluid—*i. e.*, hot gases having some steam mixed therewith—is passing from one of the said mixing-chambers into one end of the cylinder and is doing duty in propelling the piston one way, the fluid that previously entered the other end of the cylinder and has done duty in it will be escaping to the exhaust, past the slide or valve of the other mixing-chamber, and this last-mentioned mixing-chamber will be opened to an exhaust, so as to allow a part of its contents to escape, thus reducing the pressure in such chamber to atmospheric pressure. Then this chamber will be cleared out, dried, closed, and left full of hot gases at a suitable pressure. Steam

will be admitted to such gases, the mixture will be admitted to the corresponding end of the cylinder to do duty in the cylinder during the return-stroke of the piston, and during this stroke exhaustion of the contents from the other end of the cylinder and the exhaustion, clearing out, drying, filling, closing, and admission of steam to the proper mixing-chamber for effecting the succeeding stroke of the piston will be effected.

According to a modification the cylinder (or each cylinder if more than one) might have four mixing-chambers, two in connection with one end of the cylinder, the other two in connection with the other end of the cylinder, and all in connection with the exhaust, each mixing-chamber being provided with a slide or valve and with an inlet and exit for hot gases and an inlet for steam, with a slide or valve for controlling the same. The arrangement would in this case be such that the strokes of the piston in each direction—that is to say, what I will call for distinction, respectively, the "instrokes" and the "outstrokes"—would be effected by mixture of hot gases and steam supplied alternately, respectively, from the two mixing-chambers in connection with the one end of the cylinder and from the two mixing-chambers in connection with the other end of the cylinder, so that, for example, one outstroke having been effected by mixture of hot gases and steam from the one mixing-chamber in connection with the inner end of the cylinder the succeeding outstroke would be effected by mixture of hot gases and steam from the other mixing-chamber in connection with the same end of the cylinder, and so with regard to the instrokes.

It will be advantageous that all the cylinders and chambers, as far as practicable, should be jacketed with high-pressure steam or equivalent for maintaining heat.

Referring now to the accompanying drawings, Figure 1 is a longitudinal sectional view showing a cylinder with mixing-chambers and valves according to my invention, being taken partly on the line *a b c d e f* of Fig. 2 and partly on the line *a b c d e g h i* of the same figure. Fig. 2 is an end view, partly in transverse section, on the line *k l m n* of Fig. 1. Fig. 3 is a plan of cylinder and mixing-chambers with the covers of both chambers and the casing removed, and showing the two distributing-valves in the positions they respectively occupy at the commencement of the backstroke. Fig. 4 is a plan with the cover of the steam-slide jacket and part of the casing cover removed to show the course of the hot gases before entering and after leaving the chambers. Figs. 5 show four longitudinal diagrammatic sections A B C D of the distributing valves and ports. Each of these sections shows to the right a position of rest of the slide-valve located in the mixing-chamber that communicates with the front end of the cylinder, while to the left each section shows a position of the slide-valve at rest in the other mixing-chamber—namely, that which communicates with the back end of the cylinder. It is to be noted that the two slides have an equal and simultaneous intermittent travel imparted to them by any well-known or suitable means, such as a cam actuated by the motion of the crank-shaft. Fig. 6 shows, partly in elevation and partly in section, an engine according to this invention with apparatus for heating the air or gases for use therein. Fig. 7 is a similar view to Fig. 6, illustrating a modified construction.

In Figs. 1 to 5, inclusive, 1 is the cylinder. It is externally heated or steam-jacketed. 2 is a mixing-chamber that communicates through suitable ports with the back end of the cylinder and with the exhaust. 3 is another mixing-chamber. It communicates through suitable ports with the front end of the cylinder and with the exhaust. 4 is the exhaust port or passage from mixing-chamber 2. 5 is the exhaust port or passage from mixing-chamber 3. 6 is the port through which hot gases with added steam (hereinafter called "mixture") passes from mixing-chamber 2 to the back end of the cylinder. 7 is the port through which mixture passes from mixing-chamber 3 to the front end of the cylder. 8 is the slide-valve for controlling the admission and emission of the mixture to and from the back end of the cylinder. 9 is the slide-valve for serving the front end of the cylinder, but operating inversely to the valve 8, though having the same travel and the same times of travel as valve 8. It is to be noted that this simultaneous travel is adopted to simplify construction, and that these valves can be actuated by separate motions, if desired. 10 and 11 are valves that serve for the exit of mixture alternately from the mixing-chambers 2 and 3. 12 and 13 are two similar valves serving alternately for the admission of hot gases into the mixing-chambers 2 and 3. The pairs of valves 10 12 and 11 13 are opened and closed alternately by suitable mechanism, such as two rocking shafts having slightly different times of travel, as hereinafter explained, these rocking shafts being actuated by any well-known device from the crank-shaft. In the drawings the rocking shafts are arranged one within the other; but they may be otherwise constructed. 14 is the steam-slide jacket; 15, the steam-valve, having two short reciprocating motions, first in one direction and then in the other—that is to say, for example, first to the left and back, then to the right and back. It opens and closes the steam-ports 16 and 17 alternately and momentarily, always coming to rest in a position which will insure the closing of both ports effectively. The rod of this slide is fitted with disconnecting gear, so that the slide can be worked by hand when necessary. The port 16 serves the mixing-chamber 2, and the port 17 serves the mixing-chamber 3 with steam from the steam-

slide jacket 14. 18 is the inlet for steam from any convenient source, governed by a suitable throttle-valve. 19 is an external casing enveloping the mixing-chambers 2 and 3 and the jacket 14. 20 is a chamber formed between the casing 10 and its inclosure. Into this chamber the hot gases are forced or drawn previous to entering the chambers 2 and 3. 21 is a similarly-constructed chamber, but smaller and separated by the walls 22 and the covers of the chambers 2 and 3 from the chamber 20. This chamber 21 serves to receive spent mixture and convey it to the exit 25. 23 is the inlet for hot gases into chamber 20. (See Figs. 1, 2, and 4.) 24 is the exhaust from cylinder and chambers 2 and 3. 25 is the outlet for mixture after use in the cylinder 1.

In explaining the operation of the above-described engine I will assume steam at the desired pressure to be available. For the purpose of heating the cylinder 1 and other parts, steam is admitted in the usual way from the boiler to the jacket of the cylinder and to the steam-valve jacket 14, and is allowed to escape through petcocks, (not shown,) as well understood, care being taken to clear the engine of water as completely as practicable before commencing to work. Assuming the valves 8 and 9 to occupy the positions indicated at A, Figs. 5, and that the piston is in a position shown by full lines in Fig. 1, to now start the engine, the gear of the steam-valve 15 having been previously disconnected to admit of being worked by hand, the crank is put a little past the dead-center, thus bringing the piston to, say, the position indicated by the dotted lines in Fig. 1, in readiness to be acted on by fluid-pressure admitted at the front end of the cylinder. In starting from the position shown the steam-valve 15 is moved first to the left, thereby opening port 17 and admitting steam to the mixing-chamber 3. This steam will pass directly through the mixing-chamber 3 by port 7 into the outer end of the cylinder, causing the piston to complete its inward stroke—namely, from right to left, Fig. 1. The steam-valve 15 is then to be moved by hand from left to right, and thus the port 17 will be closed and port 16 will be opened, thereby admitting steam to the mixing-chamber 2, and as by the working of the engine the valve 8 will have been caused to open port 6 steam will pass from the mixing-chamber 2 into the back end of the cylinder. At the same time the valve 9 will have been caused to assume a position in which the front end of the cylinder will be open to the exhaust. On now reversing the slide 15 by hand at the end of each stroke of the piston the engine will be driven by steam alone. This should be continued until a moderate speed has been attained, whereupon the valve 15 is to be thrown into gear and the engine will then run with mixture instead of with steam alone. For the purpose of now describing the cycle of operations when running the engine with mixture, I will assume the parts of the engine to be in the same positions as at starting—namely, with the valves 8 and 9 in the positions indicated at A, Figs. 5, and the piston as shown by full lines in Fig. 1. The slide-valves 8 and 9 will move to the right-hand position, (indicated at B, Figs. 5,) and thus the back end of the cylinder will be opened to the exhaust through the ports 6 and 4. At this moment, the valves 11 and 13 having been just previously closed, the valves 10 and 12 will be opened. The valves 11 and 13 will remain closed and the valves 10 and 12 will remain open until just before the completion of the inward or right to left stroke of the piston, whereupon the valves 10 and 12 will be closed and immediately afterward the valves 11 and 13 will be opened, and steam will be admitted momentarily through the port 16 into the mixing-chamber 2, which will thereby be charged in readiness for the return or outward stroke. The slides 8 and 9 will complete their stroke from left to right, assuming the position C, Figs. 5, and while they do so the slide 9 will connect the ports 5 and 7, momentarily putting the front end of the cylinder in communication with the exhaust through the port 5. In completing its travel to the right the slide 9 will open the mixing-chamber 3 through the port 5 to the exhaust 24, at the same time opening the charged mixing-chamber 2 to the back end of the cylinder. The slides will now move from right to left to the position D, Figs. 5, shutting off the mixing-chamber 3 from the exhaust through the port 5 and opening the front end of the cylinder to the exhaust. At this instant the valves 10 and 12, having just previously been closed, the valves 11 and 13 will be opened, steam will be admitted momentarily through the port 17, and the mixing-chamber 3 will be charged for the next inward or right-to-left stroke. The slides will now revert to the original position A, Figs. 5, and in so doing will momentarily connect the back end of the cylinder with the exhaust 24 through the ports 6 and 4, also opening mixing-chamber 2 to the exhaust and the charged mixing-chamber 3 to the front end of the cylinder through the port 7 and completing the revolution of the engine.

In Fig. 6 I have illustrated an engine such as hereinbefore described with apparatus for heating the air or gases for use therein. The air or gases is or are drawn or forced from some convenient source and heated by the hot products of combustion from a boiler-flue, although hot products of combustion from another source might be employed for the purpose. 1 is the engine-cylinder; 18, the steam-inlet; 19, the chamber-casing; 23, the inlet for hot gases, and 25 the exit for spent mixture. E is a part of a Cornish boiler, whereof F is the fire-tube and G is the flue. H is the heater located in the flue G, wherein it will be surrounded by hot products of combustion. This heater is composed of a chamber with shelves so disposed that the gases

shall be compelled to take a zigzag upward course in order to insure their being heated by contact with the heated metal, or a large coil of thin metal might be substituted, or any suitable arrangement adapted to impart heat and at the same time prevent the mixture of the products of combustion with the gases to be heated. With such an arrangement as referred to air or gases is or are forced by a blower or other suitable means through the pipe I into the heater H, and being heated therein then passes or pass through the pipe K into the engine at 23 and for use, as before explained.

Fig. 7 is a similar arrangement to that shown in Fig. 6, with this difference, that products of combustion from the flues are used in the place of air or gases. 1 is the engine-cylinder; 18, the inlet for steam; 19, the chamber-casing; 23, the inlet for products of combustion; 24, the engine-exhaust; 25, the exit for spent mixture; E, part of any suitable boiler, (Cornish;) F, the fire-tube, and G the flues. H is a dust-depositing-vessel. I is the inlet for products of combustion, and K is the exit from the depositing vessel for the hot products of combustion to the engine. The depositing vessel H may be of the form shown, or of any other suitable form; or in some cases, where the products of combustion are free from dust, as in the case where gaseous fuel is used, the depositing vessel may be dispensed with. The action is as follows: The products of combustion pass from the tube F around the depositing vessel H, depositing the greater part of the solid matter. They then rise to the top part of the flue G, and entering the inlet I pass down the cone in the direction of the arrows to the bottom of the depositing vessel, where the remainder of solid particles are deposited, and rising quietly to the exit K, from whence they pass into the chambers 2 or 3, Fig. 3, as required, and hereinbefore explained. An exhauster of any suitable description is connected with the pipe 25, so as to draw the products of combustion rapidly through the chambers 2 and 3 alternately, as hereinbefore described.

Although I have described my invention as applied in the construction of double-acting engines, yet it will be evident a mixing-chamber (or more than one) with distributing-valve, steam-supply valve, and exhausting and clearing valves arranged to operate as I have above explained, could be advantageously used in a single-acting engine—that is to say, an engine wherein the piston would be propelled by mixture in one direction only, the return-stroke being effected by the momentum of a fly-wheel or otherwise, as well understood.

It is to be understood that by "clearing out" a mixing-chamber I mean practically removing from it the mixture it contains, the same being replaced by gases alone as distinguished from gases with steam; also, that an important feature in carrying out this present invention is the provision whereby I insure the practical drying of the mixing-chamber by hot gases caused to flow through it in advance of the charge of hot gases, to which steam is admitted to form each charge of mixture to be supplied to the engine-cylinder.

What I claim is—

1. In an engine to be worked with hot gases, such as air or products of combustion, with addition of steam, the combination, with a cylinder, or with each cylinder if more than one, of two mixing-chambers, each in connection with one end only of the cylinder, for the purpose set forth.

2. In an engine to be worked with hot gases, such as air or products of combustion, with addition of steam, the combination, with the working-cylinder, of a mixing-chamber arranged to be placed in communication with one end only of the cylinder and with an exhaust-passage and provided with inlet and outlet openings for hot gases, valves for controlling said inlet and outlet openings, and means for operating said valves, a pipe or conduit for hot gases in communication with said inlet-opening, a distributing-valve for placing one end of said cylinder in communication alternately with said mixing-chamber and with said exhaust-passage, a steam-chamber with port for placing same in communication with said mixing-chamber, a valve for controlling said port, and means for operating said valve, all substantially as herein described, for the purposes mentioned.

3. In an engine to be worked with hot gases, such as air or products of combustion, with addition of steam, the combination with a working-cylinder, of two mixing-chambers, each arranged to be placed in communication with one end only of said cylinder and with an exhaust-passage and each provided with inlet and outlet openings, a pipe or conduit for hot gases in communication with each of said inlet-openings, valves for controlling each of said inlet and outlet openings, and means for operating said valves, distributing-valves, each adapted to place one end of said cylinder alternately in communication with one of said mixing-chambers and with an exhaust-passage, means for operating said distributing-valves, a steam-chamber with inlet for steam and with an outlet-opening to each of said mixing-chambers, a valve for controlling said ports, and means for operating said valves, all substantially as herein described, for the purposes set forth.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

EDWARD FIELD.

Witnesses:
F. J. BROUGHAM,
W. CROSS,
Both of 46 *Lincoln's Inn Fields, London, W. C.*