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C. C. WORTHINGTON.

DIRECT ACTING DUPLEX ENGINE.

No. 401,401. Patented Apr. 16, 1889.

Fig. 1.

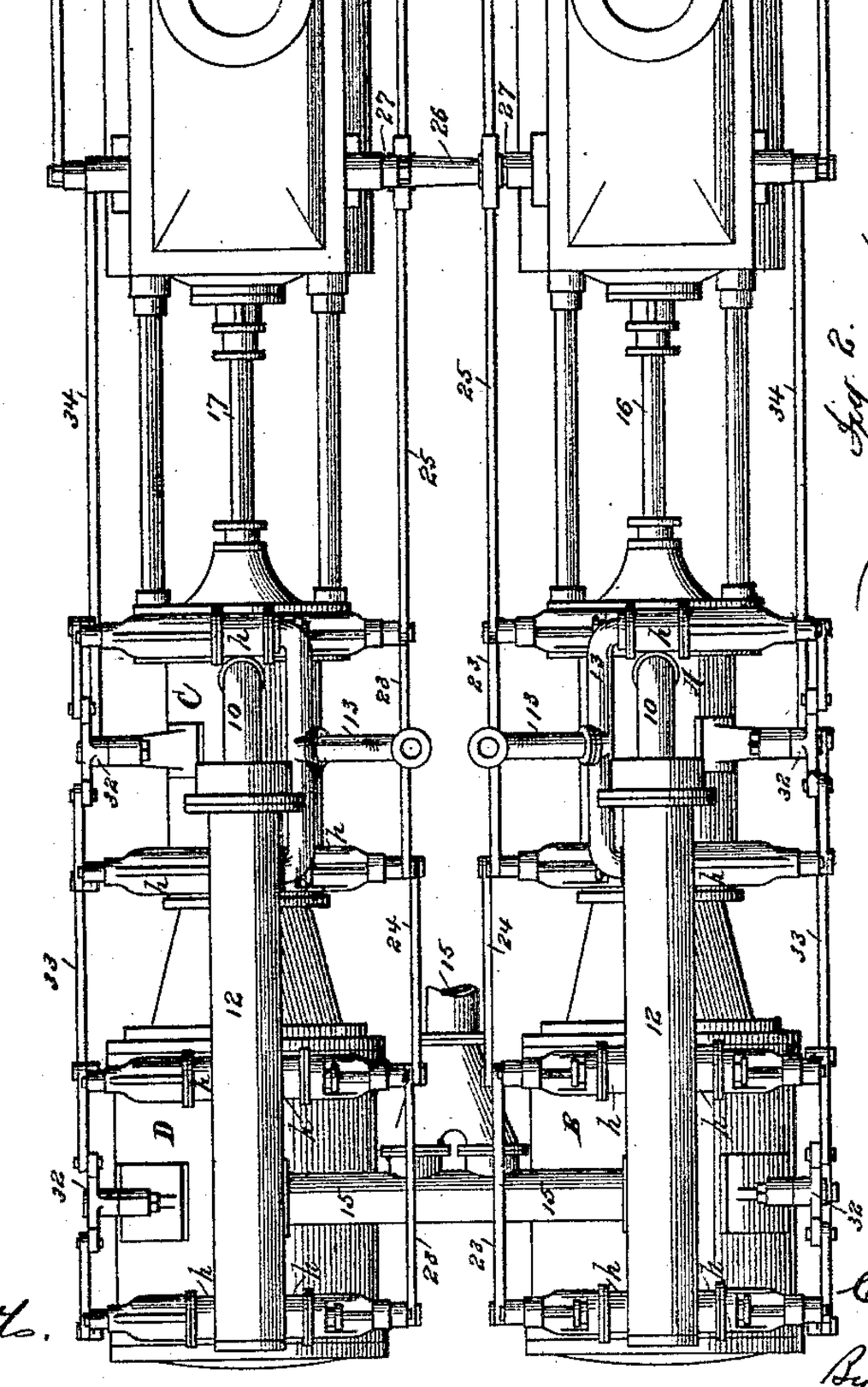
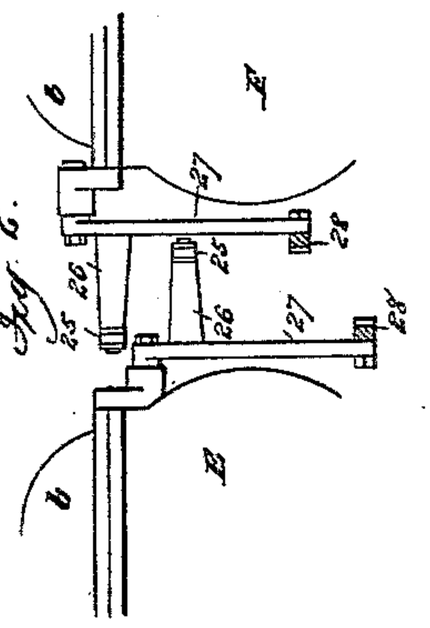


Fig. 2.



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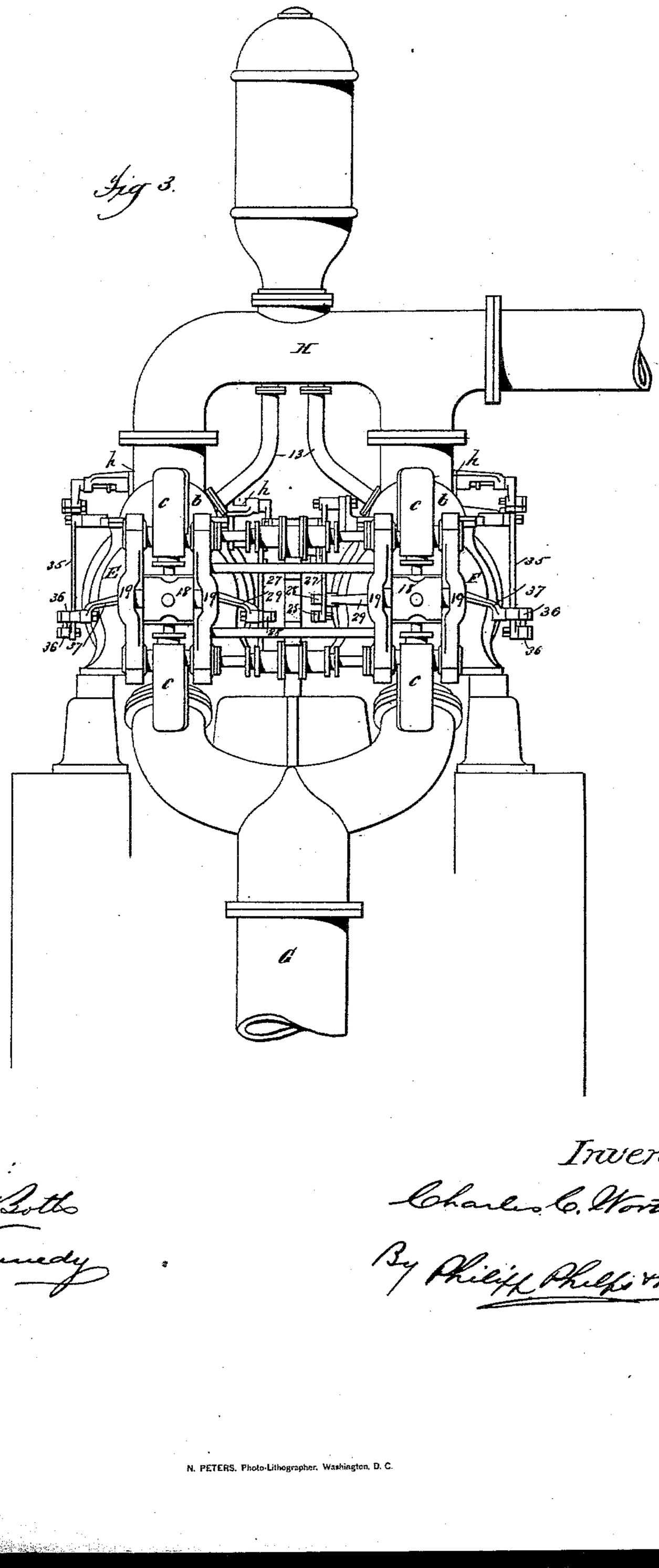
DIRECT ACTING DUPLEX ENGINE.

No. 401,401. Patented Apr. 16, 1889.

Fig 3.



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C. C. WORTHINGTON.

DIRECT ACTING DUPLEX ENGINE.

No. 401,401. Patented Apr. 16, 1889.

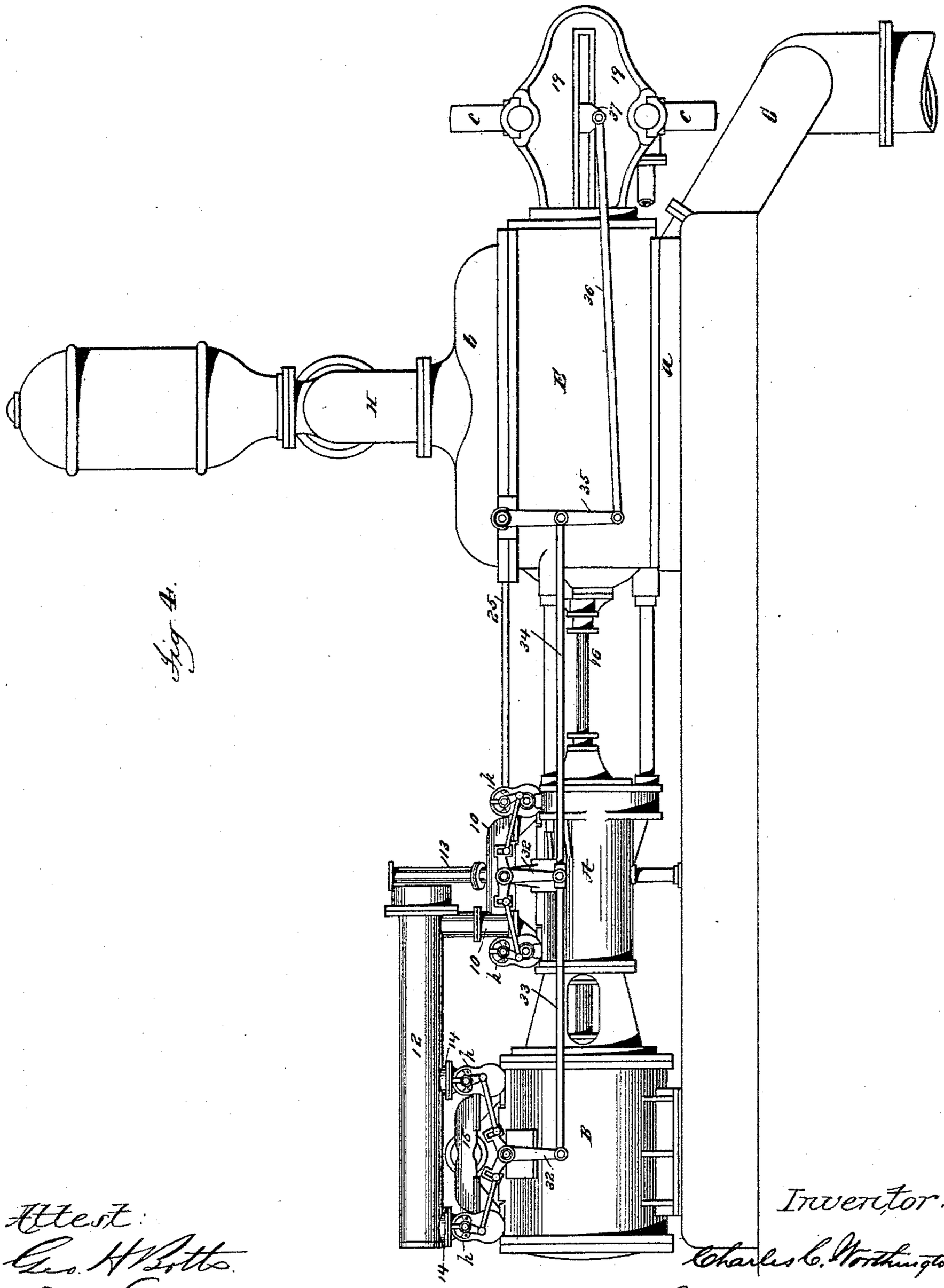

Fig. 4.

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DIRECT ACTING DUPLEX ENGINE.

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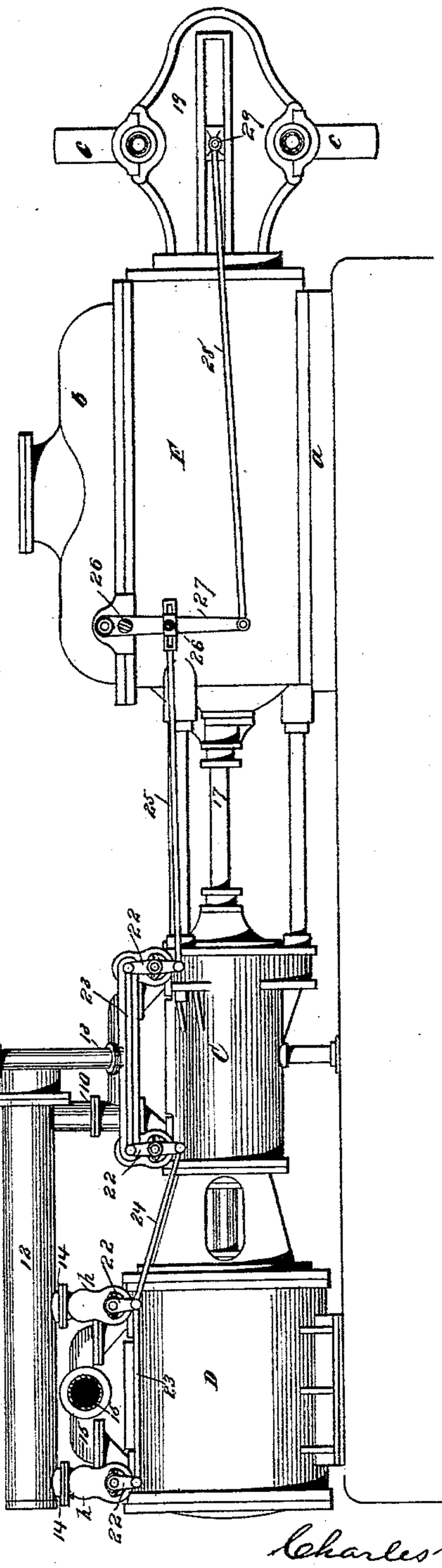
Fig. 5.



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DIRECT ACTING DUPLEX ENGINE.

No. 401,401. Patented Apr. 16, 1889.

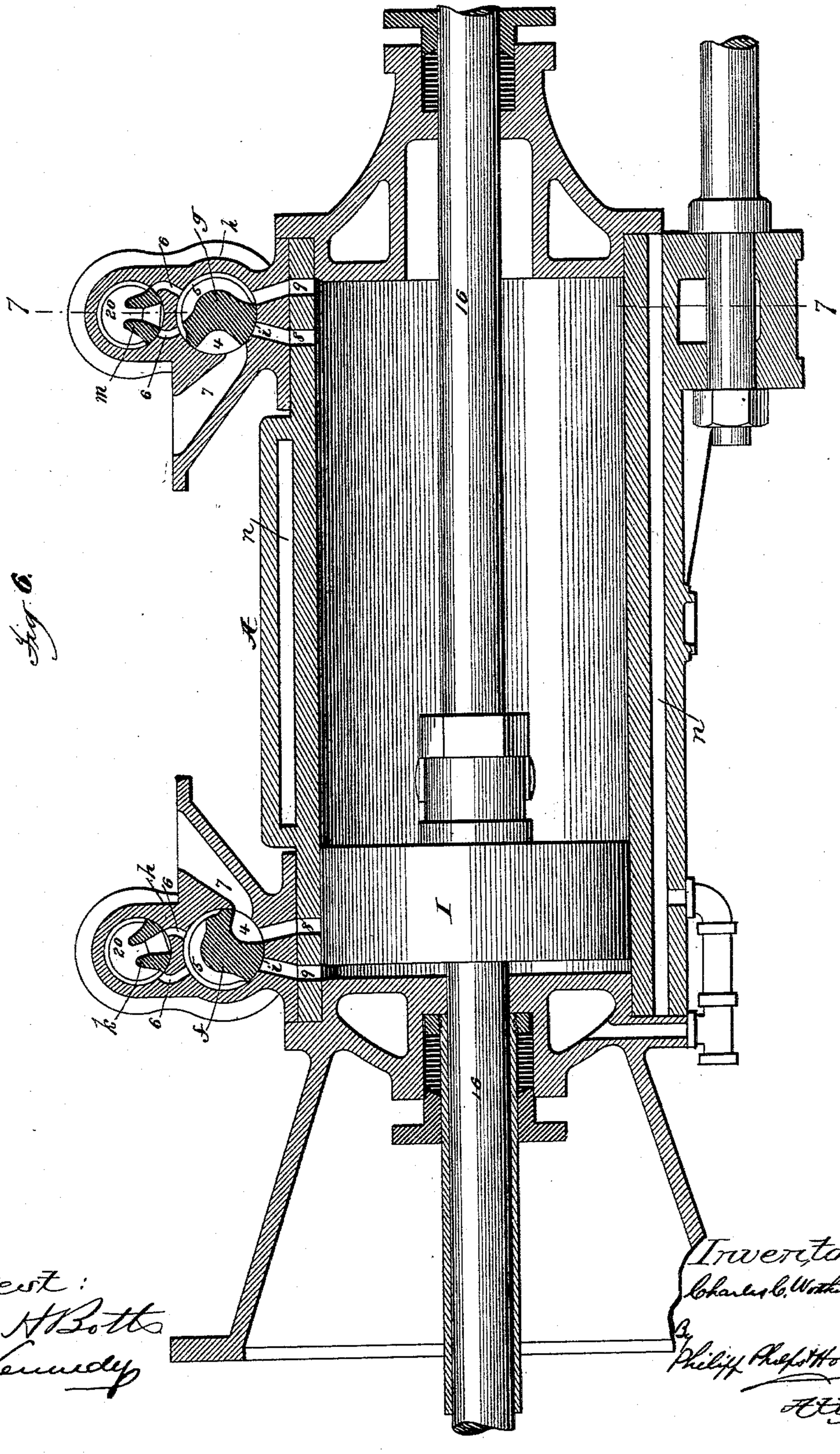

Fig. 6.

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DIRECT ACTING DUPLEX ENGINE.

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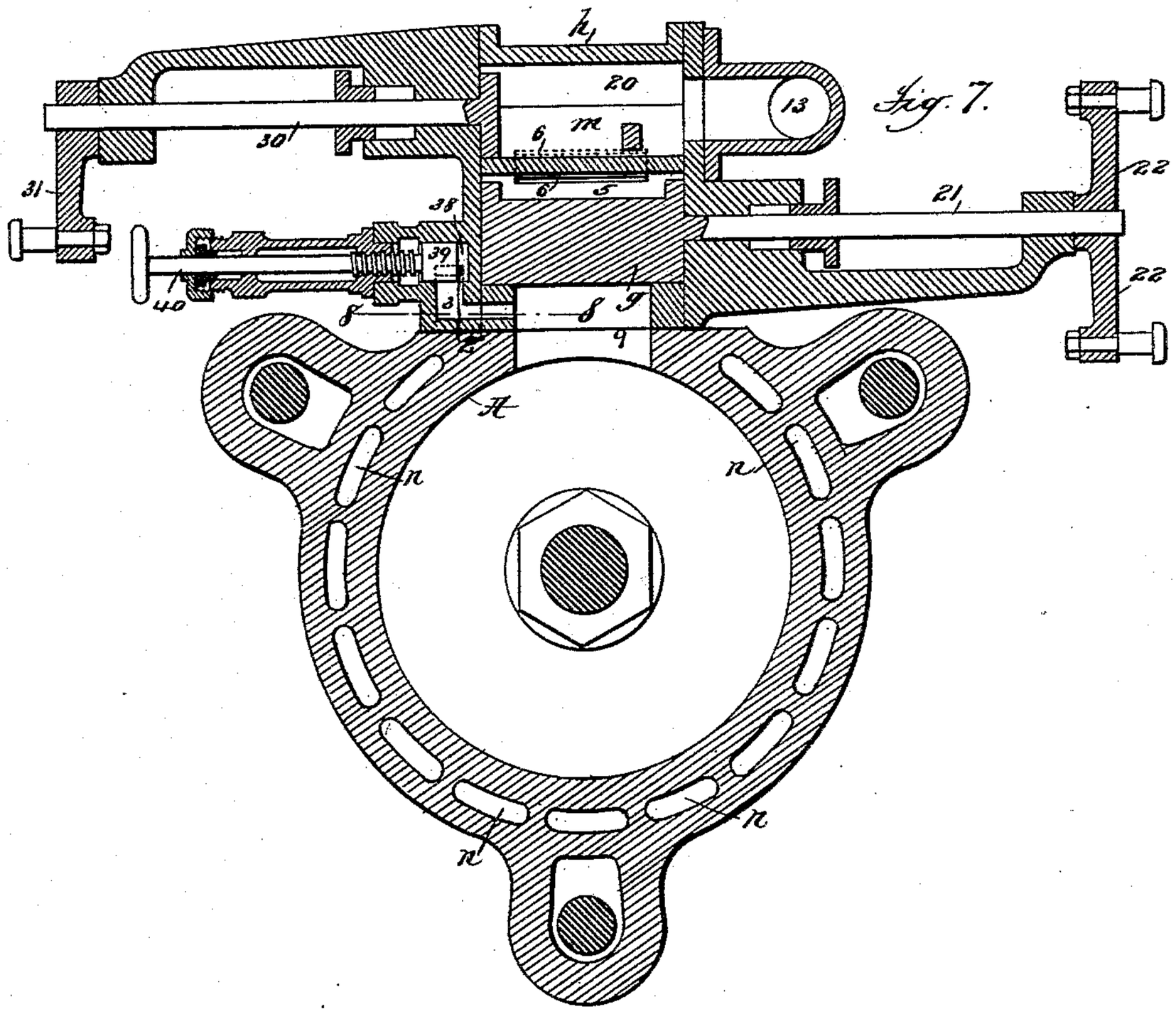
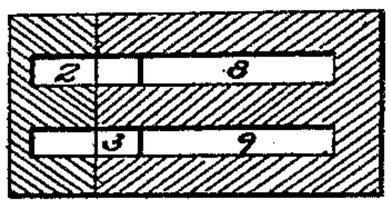


Fig. 7.

Fig. 8.



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C. C. WORTHINGTON.

DIRECT ACTING DUPLEX ENGINE.

No. 401,401. Patented Apr. 16, 1889.

Fig. 9.

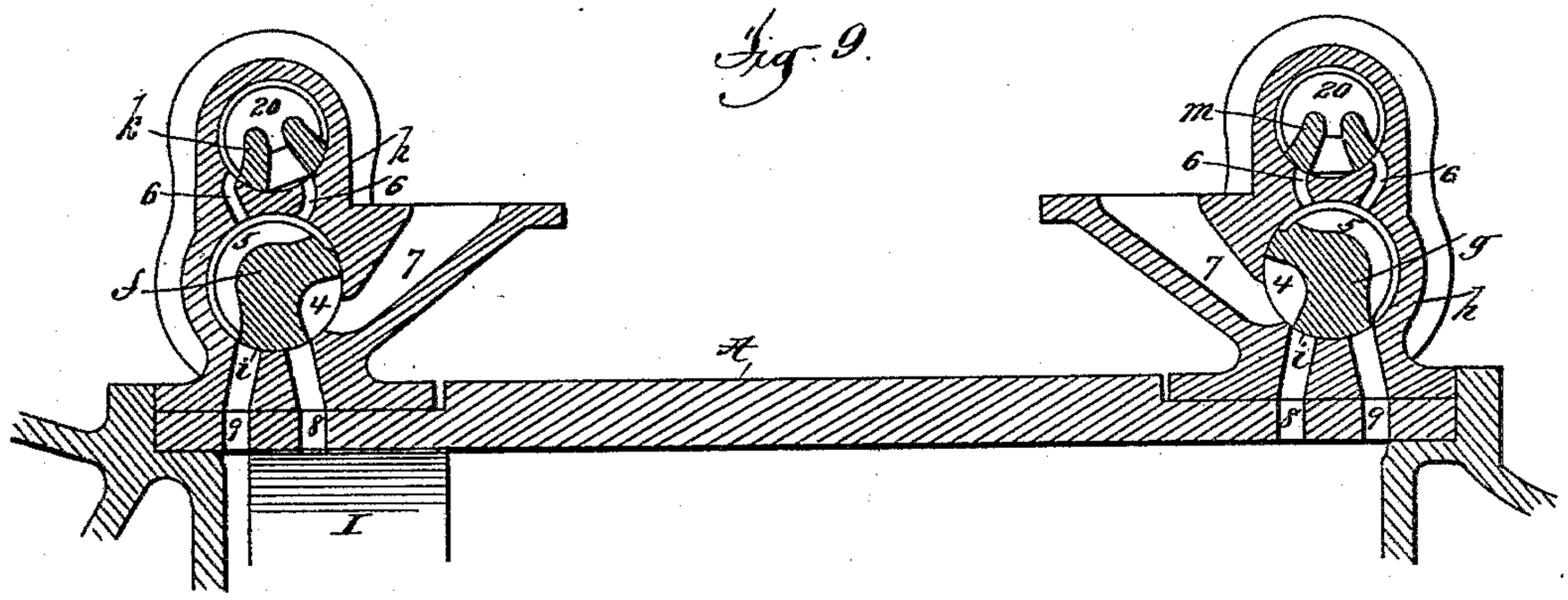


Fig 10.

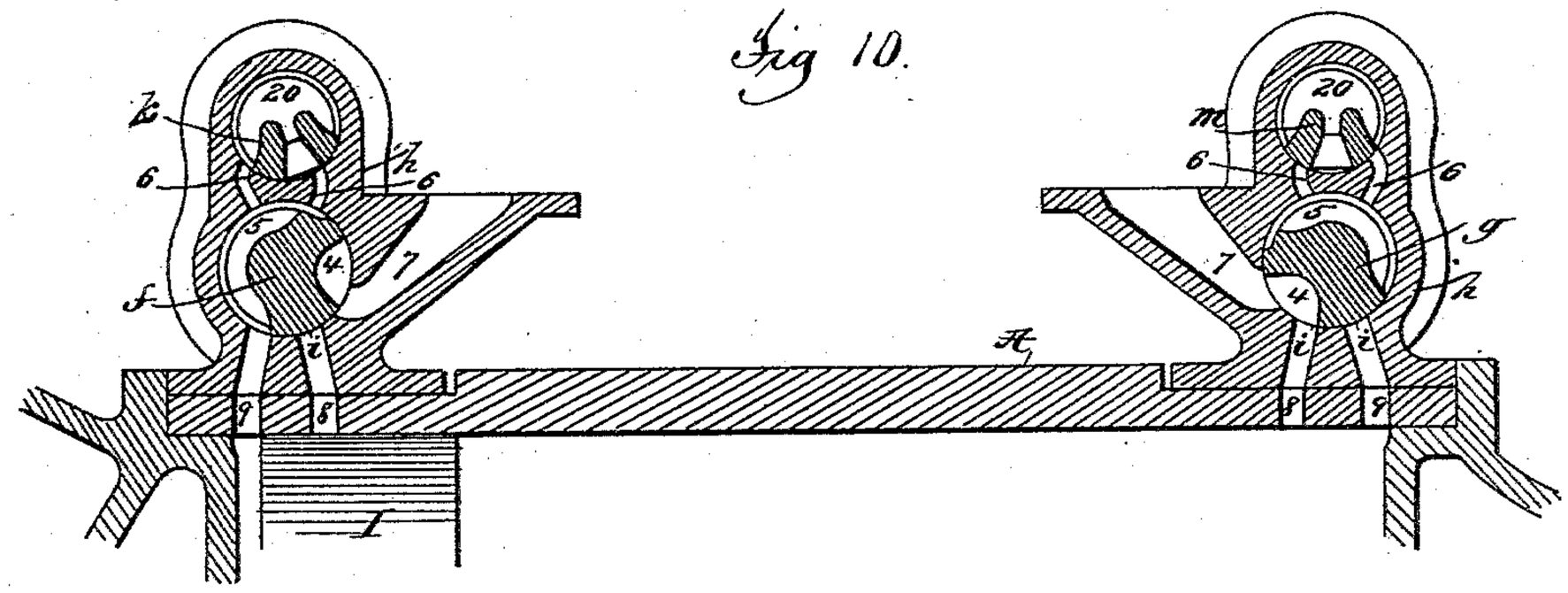
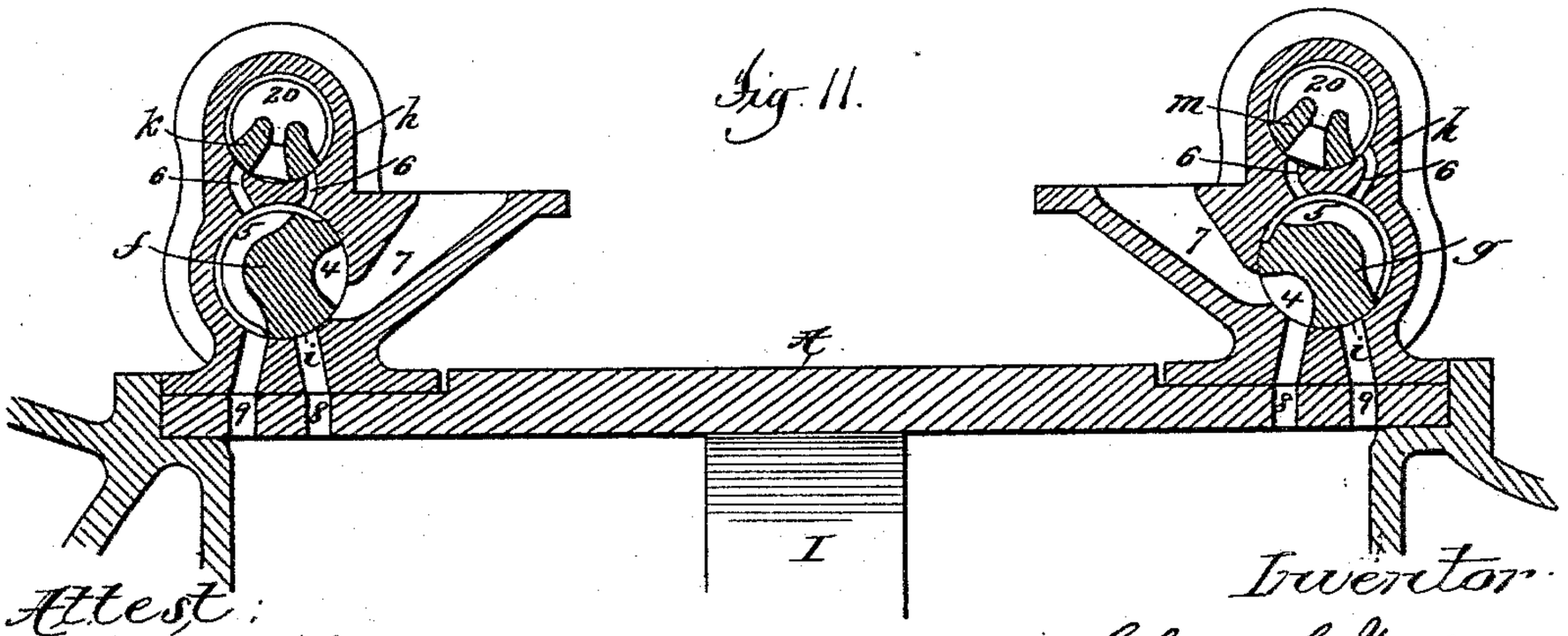


Fig. 11.



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UNITED STATES PATENT OFFICE.

CHARLES C. WORTHINGTON, OF IRVINGTON, NEW YORK.

DIRECT-ACTING DUPLEX ENGINE.

SPECIFICATION forming part of Letters Patent No. 401,401, dated April 16, 1889.

Application filed September 24, 1888. Serial No. 286,168. (No model.)

To all whom it may concern:

Be it known that I, CHARLES C. WORTHINGTON, a citizen of the United States, residing at Irvington, county of Westchester, and State of New York, have invented certain new and useful Improvements in Direct-Acting Duplex Engines, fully described and represented in the following specification and the accompanying drawings, forming a part of the same.

This invention relates to that class of engines known as "direct-acting duplex engines," certain features of the invention being especially applicable to those engines of this class having one or more compensating cylinders and pistons for each side of the engine, which act in opposition to the main piston or pistons during the first part of the stroke and in conjunction therewith during the last part of the stroke, thus permitting the steam to the main cylinder or cylinders to be cut off after the engine has made part of its stroke. Examples of engines of this class are shown in United States Letters Patent Nos. 292,525, 309,676, 332,857, and 341,534, heretofore granted to me.

The present invention includes certain improvements in the valve apparatus by which the steam is admitted to and exhausted from the main cylinder or cylinders; also certain improvements in the cut-off apparatus; also certain improvements in the valve-gear by which the cut-off and the induction and exhaust valves are operated, and also in certain combinations of parts, all of which will be hereinafter explained, and particularly pointed out in the claims.

As a full understanding of the improvements constituting the invention can best be given by an illustration and a somewhat detailed description of an engine embodying the same, all further preliminary description will be omitted and a full description given, reference being had to the accompanying drawings, in which—

Figure 1 is a plan view of a compound direct-acting duplex pumping-engine embodying the invention. Fig. 2 illustrates a detail which will be hereinafter referred to. Fig. 3 is an end elevation of the engine, looking from the right of Fig. 1. Fig. 4 is a side elevation of the engine. Fig. 5 is a side elevation of one side of the duplex engine, looking from between the two engines, and showing particularly the valve-gear for operating the induction and exhaust valves. In these figures the two engines forming the duplex engine are both shown as at the middle of their strokes, which position has been selected for the purpose of illustration, although the engines will not assume this position in actual operation. Fig. 6 is an enlarged vertical section of one of the main steam-cylinders and its cut-off and induction and exhaust valves. Fig. 7 is a cross-section taken on the line 7 of Fig. 6. Fig. 8 is an enlarged section taken on the line 8 of Fig. 7. Figs. 9, 10, and 11 are diagrams showing the valves in different positions.

Referring to said drawings, it is to be understood that the steam end of this form of compound duplex engine consists of four steam-cylinders, A B and C D, which are arranged in pairs, the cylinders A C being the high-pressure and the cylinders B D being the low-pressure cylinders of the respective sides of the engine.

The steam is admitted to the cylinders A C through induction-pipes 13, and after performing its work in these cylinders is exhausted through exhaust-pipes 10 and passes into tanks 12, from which it passes through induction-pipes 14 to the cylinders B D, and after acting at a reduced pressure in these cylinders it is exhausted through exhaust-pipes 15 and passes to a condenser or to the open air.

The water end of the engine or pump proper is composed of two water-cylinders, E F, having plungers which are connected directly with the piston-rods 16 17 of the two sides of the engine. The two water-cylinders are provided with the usual suction-chambers, *a*, which communicate with the suction-main G and with force-chambers *b*, which communicate with the force-main H in the usual manner. The piston-rods 16 17 of the two sides of the engine are extended through and beyond the water-cylinders and are connected to cross-heads 18, (see Fig. 3,) which slide in guides 19, and are acted upon by the piston-rods of two pairs of oscillating compensating cylinders, *c*, having pistons which act in op-

position to the main piston-rods 16 17 during the first part of the stroke of the engines and in conjunction therewith during the last part of the stroke. The arrangement of the compensating cylinders is substantially the same as shown in my prior Letters Patent before referred to, and need not therefore be herein further described. The compensating cylinders are supplied with a suitable motor-fluid in any of the ways described in the Letters Patent before referred to.

The induction and exhaust and cut-off valve apparatuses for each of the four steam-cylinders A B C D are, as shown in the present case, exact duplicates, and a description of the apparatus of one cylinder will therefore apply to all. It is to be remarked, however, that in some cases the double ports, by means of which the steam is confined so as to cushion the piston, may be omitted from two of the cylinders—either the high or low pressure, as may be preferred. Each of the cylinders is provided at its opposite ends with induction-ports 9 and exhaust-ports 8. The exhaust-ports are located somewhat nearer the middle of the cylinder than the induction-ports, as is common in this class of engines, in order to allow them to be covered by the piston as it approaches the end of its stroke in each direction, and thus confine a quantity of steam in the end of the cylinder to act as a cushion or dash for the piston. The induction and exhaust ports at the opposite ends of the cylinder are controlled by a pair of oscillating induction and exhaust valves, *f g*, which are located in cavities formed in valve-chests *h*, located at the opposite ends of the cylinder. The cavities in the valve-chests in which the induction and exhaust valves are located are provided with exhaust-ports 7, which communicate with the exhaust-pipes 10 or 15, as the case may be.

Located in the valve-chests *h*, above the induction and exhaust valves *g f*, are cavities 20, which communicate with the induction-pipes 13 or 14, as the case may be, and also with the cavities in which the induction and exhaust valves are located by means of one or more ports, 6. The port or ports 6 are controlled by oscillating cut-off valves *k m*, located in the cavities 20 of the valve-chests at the opposite ends of the cylinder.

In order to secure the quick opening and closing of the port or ports 6, which is desirable to effect a quick cut-off, there will preferably be provided a plurality of these ports, and the valves *k m* will preferably be made of gridiron form, as shown in the present case.

The induction and exhaust valves *f g* are provided with cavities 4, which are of such extent that when the respective valves have reached the limit of their movement in one direction the ports 7 8 will be brought into communication and the exhaust be fully open. The valves are also provided with cavities 5, which are of such extent that when the respective valves have reached the extent of their movement in the reverse direction the ports 6 9 will be brought into communication and the induction be fully opened.

The working-faces *i* of the induction and exhaust valves are of such extent, and the induction and exhaust ports 8 9 are so positioned, and the valves *f* and *g* are so connected, that they have no lap or lead—that is to say, the faces *i* are of such extent that when the valves are in their central position they no more than cover both the induction and exhaust ports 8 9 at either end of the cylinder, so that any movement in either direction from this position will at once commence to open one or the other of the ports, depending upon the direction in which the valves are moved. This is an important feature in this class of engines, as by reason of this construction it becomes impossible to stop the engine in such position that both the induction and exhaust ports will be absolutely closed, and thus the valves are always in position to admit steam to one end or the other of the cylinder and exhaust it from the opposite end, so as to start the engine whenever steam is admitted to the valve-chests. If it were otherwise—that is to say, if the valves were constructed or connected so as to have either lap or lead—the engine might be stopped in such position that it would require some appreciable movement of the valves to open one or the other of the ports, and if this were the case and the engine were stopped with the valves in such position it would be impossible in this class of engines to start the engine without bringing into play some outside force or readjusting the parts.

The valve-chests *h* are cast separate from each other and from the cylinder, so as to be readily and separately removable, and the chests and valves for the opposite ends of the cylinder are exact duplicates, which is a feature of importance, as it secures economy in the manufacture of the engine and facilitates the renewal of worn-out or damaged parts. These valves and chests are, however, as will be observed, reversely arranged, so that the two valves oscillate in the same direction at the same time. The making of the valve-chests in this manner and the locating of them at the ends of the cylinder also secures another important advantage, in that it permits the steam-jackets *n* (see Fig. 6) to extend entirely around the cylinders between the valve-chests, and thus secures more effective jacketing and reduces condensation.

For the purpose of operating the valves *f g* each of the valves is provided with a stem, 21, (see Fig. 7,) which passes through a stuffing-box in the side of the valve-chest and extends inward toward the opposite side of the duplex engine. Each of the stems 21 is provided with a crank-arm, 22. The crank-arms of the valves of each cylinder are connected by a link, 23, and the crank-arms of the adjacent valves of the two cylinders are con-

nected by a similar link, 24, these links being so arranged that all of the valves oscillate in the same direction at the same time, as shown in Fig. 5.

The valves of each side of the engine are operated from the opposite side of the engine the same as is usual in duplex engines, and for this purpose the connections are arranged as follows: The crank-arm 22 of the valve of each side of the engine which is nearest the water-cylinders is connected by a rod, 25, with a stud, 26, (see Fig. 2,) projecting from a rock-arm, 27, which is connected by a rod, 28, with an arm, 29, extending from the cross-head 18 of the opposite side of the engine.

The cut-off valves *k m* are provided with stems 30, which project outward and are provided with crank-arms 31, which are connected to a pair of T-shaped levers, 32, which are connected to each other by a link, 33, and operate the cut-off valves in substantially the same manner as described in my prior Letters Patent, Nos. 332,857 and 342,669.

The cut-off valves for each side of the engine, instead of being operated directly from the piston-rod of that side of the engine, as shown in the Letters Patent before referred to, are preferably operated through a rod, 34, which is connected to a rock-arm, 35, which in turn is connected by a rod, 36, to an arm, 37, extending outward from the cross-head 18 of that side of the engine. By reason of this form of valve-gear the strain upon one side of the cross-head 18 of each side of the engine produced in operating the induction and exhaust valves of the opposite side of the engine is nearly or quite balanced by the strain upon its opposite side produced in operating the cut-off valves, and thus all tendency to skew the cross-heads out of proper position by reason of unequal strain is obviated.

In engines of this class it frequently happens, owing to changes in speed or in the effectiveness of the condenser, that the cushioning effect of the steam confined in the end of the cylinder by the covering of the exhaust-port by the piston is not as uniform as is desirable—that is to say, if the steam confined in the end of the cylinder when the exhaust is covered by the piston is sufficient to produce the necessary dash when the condenser is working at its maximum effectiveness or the engine is running at quick speed, the dash produced when the condenser is less effective or the engine running at slower speed will be too great, and the stroke of the engine will consequently be shortened. To obviate this it is desirable to provide means by which under such conditions a portion of the steam confined in the end of the cylinder can be allowed to escape to compensate for these variations in the condenser or speed of the engine and to properly regulate the stroke. For this purpose the induction and exhaust ports 8 9 are provided with branch ports 2 3, which communicate with a small chamber, 38, located at the side of the valve-chest. The chamber 38 is provided with a valve, 39, having a threaded stem, 40, by which it can be adjusted so as to entirely close the ports 2 3 and thus cut off communication between the ports 7 8, or can be adjusted to open the ports 2 3 to any desired extent, and thus allow any desired portion of the steam confined in the end of the cylinder after the exhaust-port is closed by the piston to pass through the induction-port 9 and ports 2 3 to the exhaust-port 8, and thus reduce the cushioning effect of the confined steam to any desired extent.

The operation of the engine thus organized is as follows: In describing the operation of the engine it will be assumed that the pistons I of the cylinders A B have just completed their stroke away from the water-cylinders and have come to rest at the end of their stroke, as shown in Figs. 6, 9, and 10. When the pistons I arrive in this position, the valves *f g* will be in the position shown in Fig. 6. As the pistons of these cylinders arrive in this position they will, through the piston-rod 16 and the connections which have been described, complete the movement of the induction and exhaust valves of the cylinders C D to the same position, so as to start the pistons of those cylinders and cause them to make a stroke in the same direction, and as the pistons of the cylinders C D make their stroke in this direction they will, through the piston-rod 17 and the connections which have been described, oscillate the valves *f g* of the cylinders A B, and as they arrive at or near the middle of their stroke the valves *f g* of the cylinders A B will arrive in their mid-position, as shown in Fig. 9, in which position they will close, but not more than close, the induction and exhaust ports 8 9; but the valves *f g*, being so constructed and connected as to have no lap or lead, will, as soon as they close the exhaust-port at one end of the cylinder and the induction-port at the other end of the cylinder, commence to open the induction-port at the first end of the cylinder and the exhaust-port at the other end, and as the pistons of the cylinders C D complete their stroke the valves *f g* will arrive in the position shown in Fig. 10, so as to completely open the induction-ports 9 in front of the pistons I and the exhaust-ports 8 behind them. The pistons I of the cylinders A B will then commence and make their return-stroke, and as they arrive at the middle or about the middle of their stroke they will, through the connections which have been described, operate the cut-off valves *k m*, so as to close the ports 6, as shown in Fig. 11, and cut off the further admission of live steam in front of the piston, and at the same time open the ports 6 at the opposite end of the cylinder to permit the admission of live steam for the next stroke, and so the operation will be repeated.

If at any time it is not desired to use the steam expansively, all that is necessary is to disconnect the rod 34 or 36 or disconnect the levers 32 from the cut-off valves and turn the

cut-off valves to such position as to leave the ports 6 permanently open. The steam will then be admitted to the main steam-cylinders during the entire stroke of the pistons. From this it will be seen that the construction which has been described is one by which steam can be used expansively or not, at pleasure, without any material change in the organization of the engine.

The improvements constituting the present invention are herein shown as applied to a compound engine; but it is to be understood that such an engine has been selected merely for the purpose of illustration, as the improvements are equally applicable to those engines which do not employ compound cylinders.

What I claim is—

1. The combination, with a steam-cylinder and piston, of separate induction and exhaust ports for each end of the cylinder and two oscillating valves, one for controlling the induction and exhaust of the steam to and from each end of the cylinder, said valves moving synchronously and being so timed and connected that the opening of the exhaust-port at one end of the cylinder commences immediately upon the closing of the exhaust-port at the other end of the cylinder, substantially as described.

2. The combination, with a steam-cylinder and piston, of separate induction and exhaust ports for each end of the cylinder and two oscillating valves, one for controlling the induction and exhaust of the steam to and from each end of the cylinder, said valves moving synchronously and being so timed and connected that the opening of the induction-port at one end of the cylinder commences immediately upon the closing of the induction-port at the other end of the cylinder, substantially as described.

3. The combination, with a steam-cylinder and piston, of separate induction and exhaust ports for each end of the cylinder and two oscillating valves, one for controlling the induction and exhaust of steam to and from each end of the cylinder, said valves moving synchronously and being so timed and connected that the exhaust-port for one end of the cylinder and the induction-port for the other end of the cylinder are opened simultaneously, substantially as described.

4. The combination, with the steam-cylinders and pistons of a duplex engine, of an oscillating valve for controlling the induction and exhaust of the steam to and from each end of the cylinders of the two sides of the engine, rods 23, connecting with two valves of each cylinder, so as to cause them to move synchronously and in the same direction and without lost motion, and connections between one of the valves of each side of the engine and the piston-rod of the other side of the engine, substantially as described.

5. The combination, with a steam-cylinder and piston, of separate induction and exhaust ports for each end of the cylinder, two oscillating valves, one for controlling the induction and exhaust port for each end of the cylinder, ports 2 3, located in the valve-chests and connecting the induction and exhaust ports, and adjustable valves 39, controlling said ports, substantially as described.

6. The combination, with the main steam-cylinders, pistons, and piston-rods of a duplex engine, of induction and exhaust valves and cut-off valves, a cross-head carried by the piston-rod of each engine, a rod, 36, connected to one end of the cross-head of each engine to operate the cut-off of that engine, and a rod, 28, connected to the other end of the cross-head to operate the induction and exhaust of the other engine, substantially as described.

7. The combination, with a steam-cylinder and piston, of an induction and exhaust valve and a cut-off valve for each end of the cylinder, and connections for operating the cut-off valves from one side of the cylinder and for operating the induction and exhaust valves from the other side of the cylinder, substantially as described.

8. The combination, with a steam-cylinder and piston, the cylinder being provided with separate induction and exhaust ports at each end, of two independent valve-chests, *h*, located at the ends of the cylinder and detachably connected thereto, each chest containing an oscillating valve for controlling the induction and exhaust of the steam to and from that end of the cylinder, substantially as described.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

CHAS. C. WORTHINGTON.

Witnesses:

STILLMAN H. STORY,

T. H. PALMER.