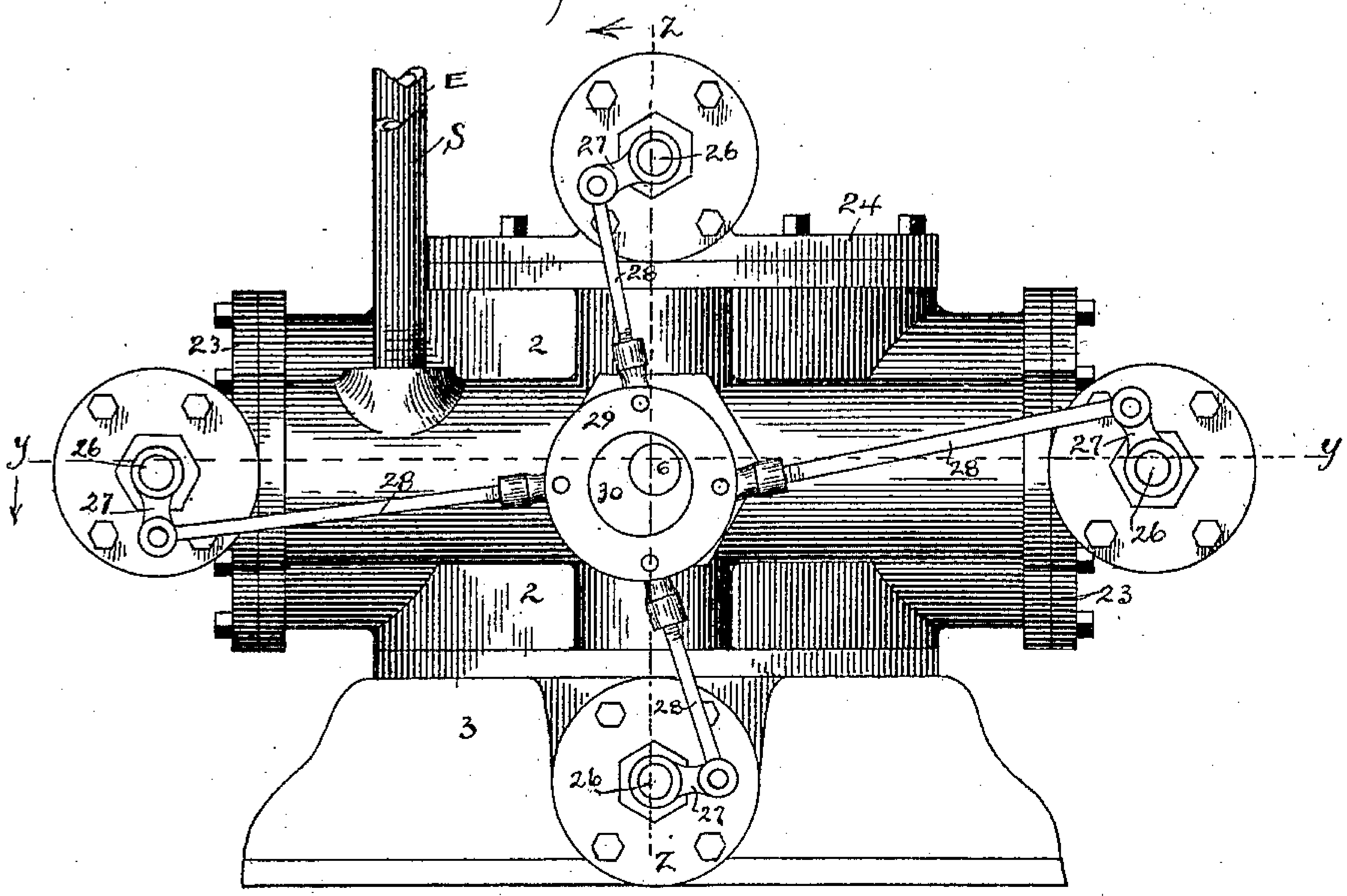
(No Model.) 3 Sheets—Sheet 1.

C. A. TOWER.

DOUBLE ACTING ENGINE.

No. 444,259. Patented Jan. 6, 1891.

Fig. 1



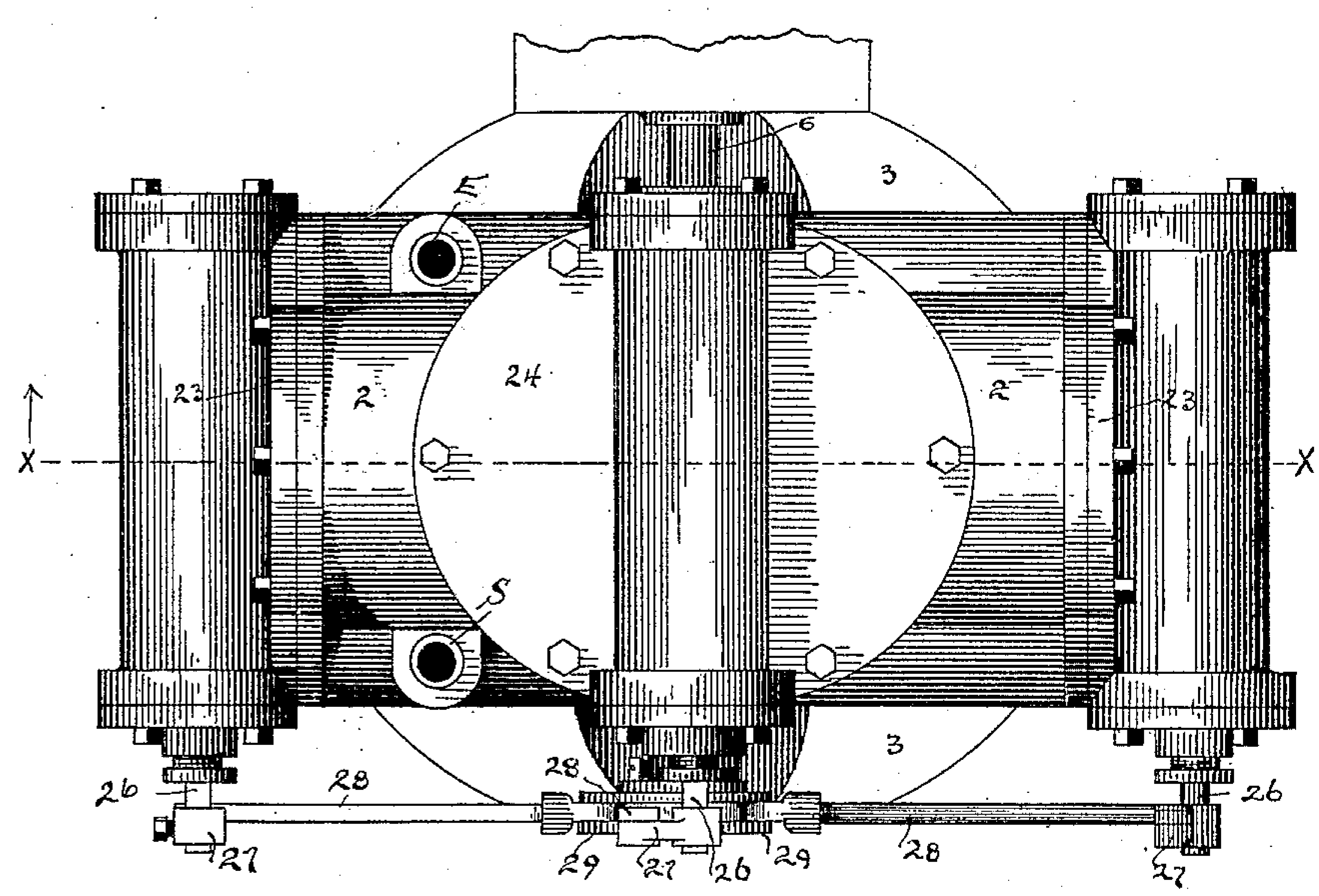


Fig. 2

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Fig. 3.

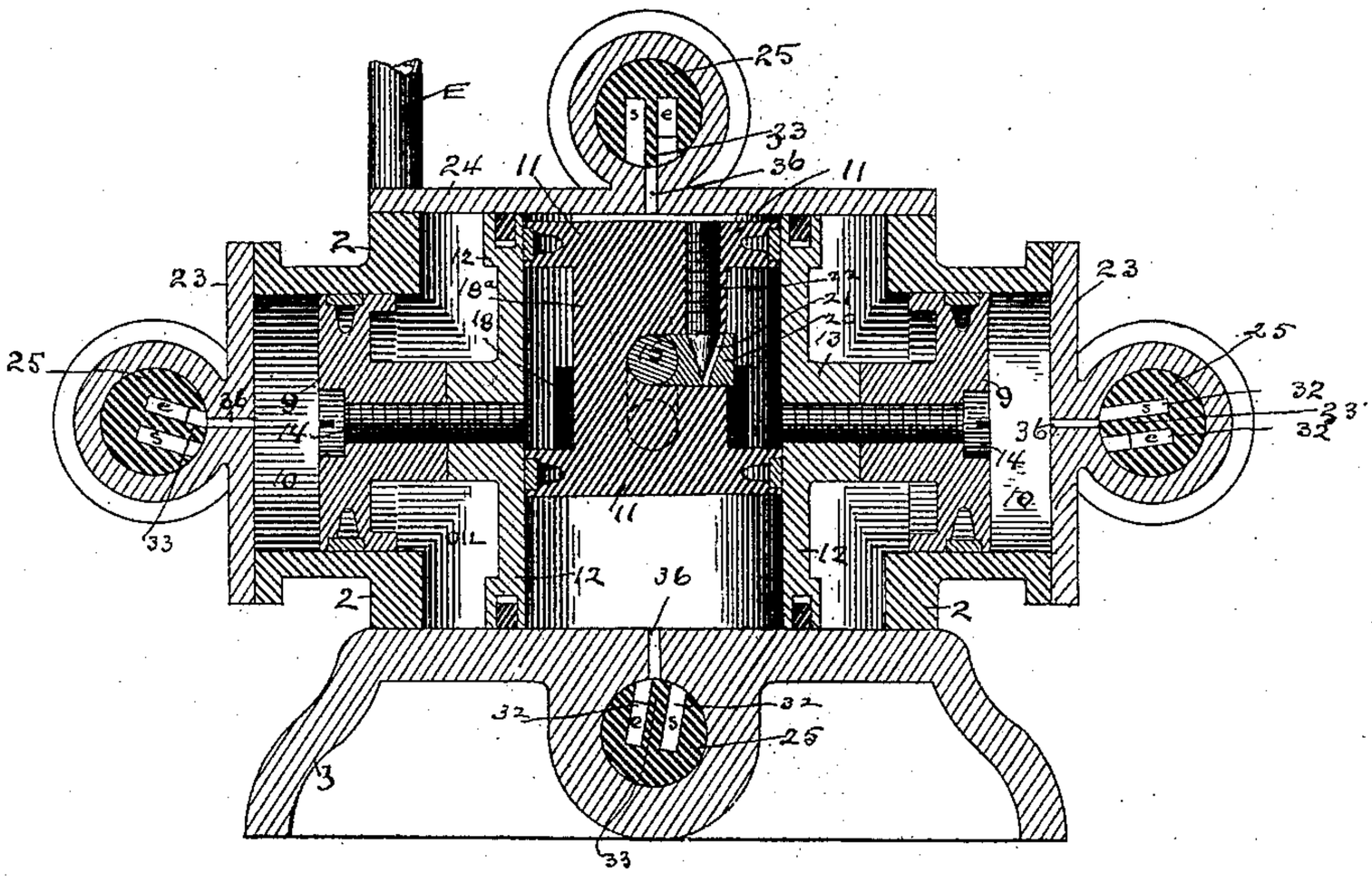

Fig. 4.

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(No Model.) 3 Sheets—Sheet 3.

C. A. TOWER.

DOUBLE ACTING ENGINE.

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Fig. 5.

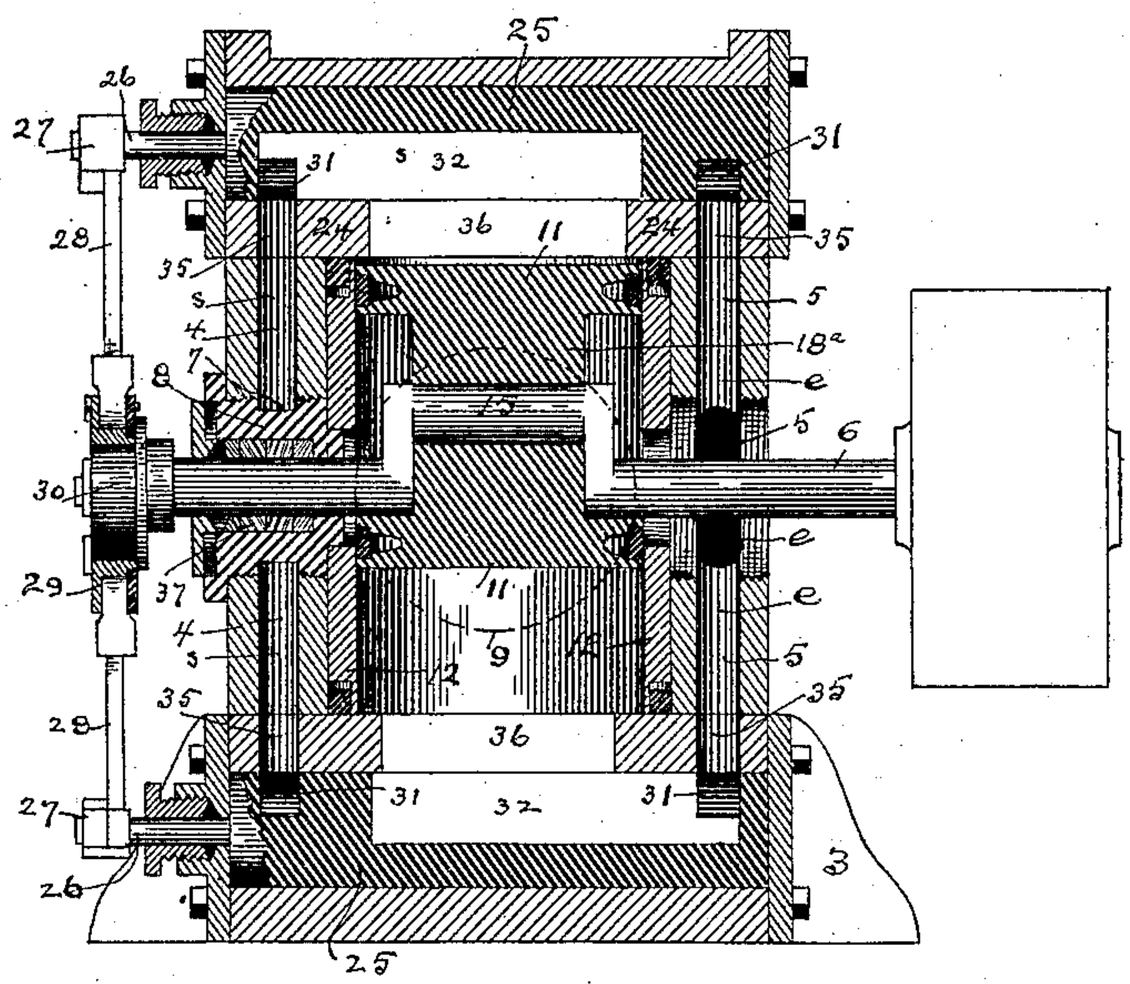

Fig. 6.

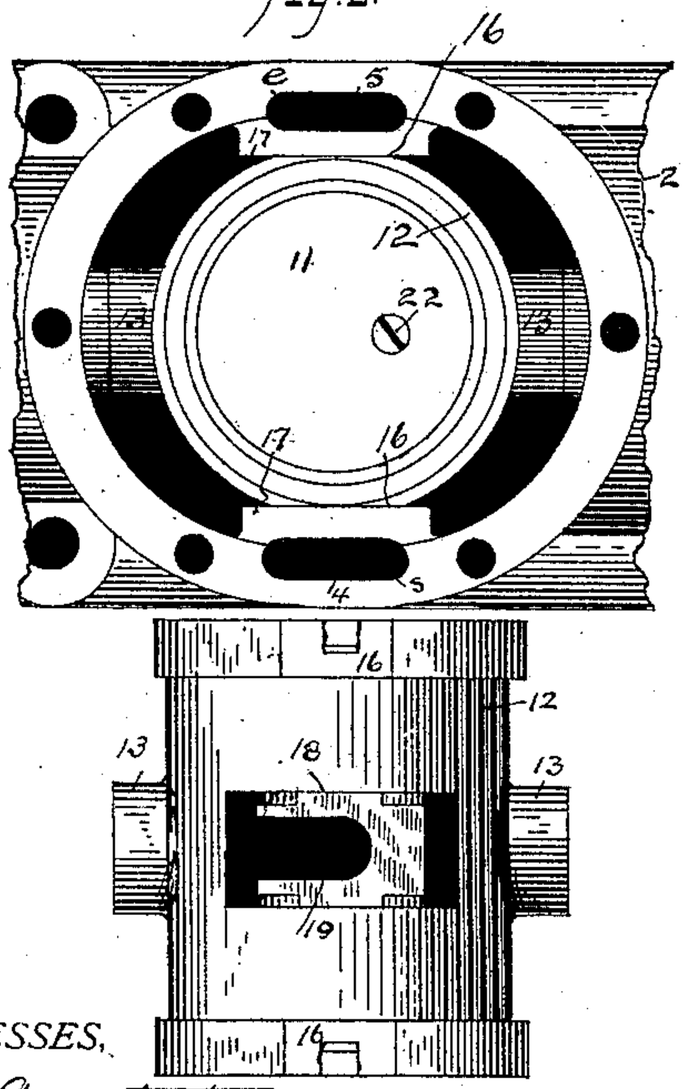

Fig. 7.

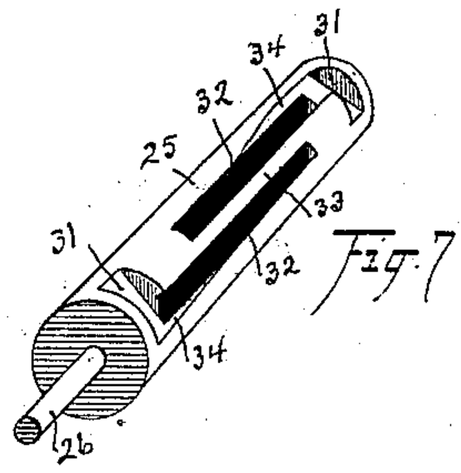

Fig. 8.

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UNITED STATES PATENT OFFICE.

CLINTON A. TOWER, OF CLEVELAND, OHIO.

DOUBLE-ACTING ENGINE.

SPECIFICATION forming part of Letters Patent No. 444,259, dated January 6, 1891.

Application filed July 27, 1889. Serial No. 318,832. (No model.)

To all whom it may concern:

Be it known that I, CLINTON A. TOWER, a citizen of the United States, residing at Cleveland, in the county of Cuyahoga and State of Ohio, have invented certain new and useful Improvements in Double-Acting Engines; and I do hereby declare that the following is a full, clear, and exact description of the invention, which will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to improvements in steam-engines of the class known as "double-acting engines," having pistons at right angles to each other and a crank-shaft in the pistons, whereby dead-centers are overcome and a high-speed engine of uniform and easy movement is obtained.

To this end the invention consists, broadly, in an engine having four circular pistons working in circular chambers, two of which chambers are stationary and two movable, all as shown and described, and particularly pointed out in the claims.

In the accompanying drawings, Figure 1 is a side elevation of an engine which embodies my invention, the view showing particularly the valve-operating mechanism. Fig. 2 is a plan view thereof. Fig. 3 is a central sectional elevation on line *x x*, Fig. 2. Fig. 4 is a horizontal sectional view on line *y y*, Fig. 1. Fig. 5 is a central sectional elevation on line *z z*, Fig. 1. Fig. 6 is a view of the central portion of the casing with, say, the top valve-cap shown in Fig. 1 removed and disclosing the shape of the chamber in the casing and the relation of the top piston and its case to said chamber. Fig. 7 is a perspective view of one of the four valves. Fig. 8 is a side elevation of the inner piston-cylinder with the pistons at the sides detached, and showing the bearing for the crank-shaft in the connection between the inner pistons.

The original drawings show an engine of one-half-horse-power capacity at a speed of three thousand revolutions per minute, and the engine is designed especially for running dynamos in the generation of electricity, although it is equally well adapted for other work where speed and regularity of movement are needed.

In the drawings, 2 represents the casing, and 3 the base upon which the casing rests. It will be understood, however, that while a certain position of the engine is shown here the position is not material, as the engine will work equally well in different positions—that is, it might be set on either of what appear here as its ends or turned upside down. It is obvious, also, that the respective ends and sides of the entire structure are duplicates of one another, the two opposite pistons and the portions of the casing in which they work being identically the same. Hence the pistons at the ends are interchangeable with one another, as also are those at the side. The same is true of the valves, all four of which are alike. The two sides of the casing likewise are the same in construction, and are each provided with steam-passages running at right angles to one another to communicate with the chambers at the heads of the respective pistons through the valves. Hence either side may be used as the supply side for steam, and either as the exhaust; but when one is used for the supply the other necessarily becomes the exhaust side. Thus for this description I have marked the front as the supply side, with supply-pipe S and distributing channels or passages 4. (Seen longitudinally at the center of the casing in Fig. 4 and vertically in Fig. 5.) On the reverse side is the exhaust pipe or opening E, having exhaust-passages 5 (shown in Figs. 4 and 5) leading thereto from the respective steam-chambers before the pistons through the several valves to the exhaust.

The respective steam-passages 4 and 5 angle at the drive-shaft, and an enlarged annular opening is made in the casing at this point, and a corresponding annular groove 7 is formed in each bearing-nut 8 to enable the steam to pass around the nut and have free flow through the passages. The casing is threaded on either side of the steam-passages, as is also the nut 8, which is threaded on both sides of the groove 7 to engage the casing and form a firm support for the shaft, as well as to confine the steam. The casing thus formed is adapted to the use of four pistons, two of which work, say, horizontally and two vertically. The horizontal pistons 9 work in close-fitting chambers 10, formed in the main casing, and the pistons 11 work in a cylinder 12, set into the main casing at right angles to

chambers 10. The main casing has an oval-shaped chamber, as plainly seen in Fig. 7, in which the cylinder 12 is adapted to reciprocate laterally, and has short arms 13 at either side of its center, upon which the pistons 9 are fixed by long bolts 14, as plainly seen in Fig. 3 If it were not for the fact of placing the pistons in the casing, the pistons 9 might be cast integral with the cylinder 12. As it is, the pistons 9 are bolted to the cylinder after each has been placed separately in its chamber. It will thus be observed that the cylinder 12 and its attached pistons 9 have a right and left hand movement together within their respective chambers, and this movement in either direction is limited by the throw of the crank 15 on the drive-shaft, the relative length of which is shown in Fig. 5. Both ends of the cylinder 12. are confined by the cap and base, respectively, and its sides are here shown as flattened slightly, as seen at 16, Fig. 6, to work against the flat faces 17 on the sides of the casing and keep the cylinder in perfect alignment. Centrally through the sides of the cylinder 12 are slots 18, which afford room for the lateral movement of the cylinder on said shaft, and the crank 15 works inside the cylinder between these slots.

Within the cylinder 12 are the pistons 11, connected by a neck 18^a, which, in this instance is cast solid with the pistons, but may be made separate, if preferred. This neck has a transverse open slot 19 at its center, which forms part of a bearing for the crank 15, and the bearing is completed by a block 20, fitting in said slot and provided with a conical hole 21, Fig. 3, which is entered by a screw bolt or plug 22, having a tapering end to enter said hole and tighten the block in proportion as said plug is turned home. The plug 22 passes through the upper or exposed piston, and the shaft and block are not placed in position until after the cylinder 12 has been placed in the casing. Now, having the several pistons arranged as shown and described, the steam chests or chambers are closed by caps 23 at the end of the casing and cap 24 at the top. In the present construction the base 3 closes the lower portion of cylinder 12 and forms a chamber for the lower valve. For the other valves the caps 23 and 24 are provided with valve-chambers. Each of the valves 25 has a stem 26 projecting from one end through the cap, which confines the valve in its place, and on these stems are fixed short arms 27, provided with set-nuts for convenience of adjustment. Each arm has a rod 28, connected with a common ring 29, which works on an eccentric 30 on the main shaft, and through which the movements of the valves are effected. By this mechanism, after the requisite adjustment of the several valves has been made so that each will open and reverse at the proper time, the flow of the steam is automatically controlled, as in other engines. To establish the necessary circulation of the steam through the valves, each valve has a transverse cut or groove 31 near its ends and two parallel slots or grooves 32, separated by a narrow partition 33, and each terminating at its outer end in the transverse cut. The outer edges of each slot are cut down toward one end, as at 34, Fig. 7, so as to facilitate the flow of the steam. The respective caps which close the steam-cylinders have openings 35, which communicate between the regular steam-ducts 4 and 5 in the main casing and the valve-chambers, or, to be more explicit, with the slots and grooves 31 and 32 in the valve 25. Then to complete the steam-circulation each head or cap 23 24 has a narrow longitudinal slot 36, which opens a passage between the space in the steam-chest before each piston and the valve and valve-chamber, and the steam enters and exhausts through this slot, according as one or the other of the grooves 32 registers therewith—that is, if the valve be rotated to a certain position steam will be admitted through ports or ducts 4 35 31 32 36 to the steam chest or chamber, and when said valve is slightly turned to exhaust the steam will flow out through 36, 32, 31, 35, and 5 to the exhaust-pipe E, and these channels are the same for the several valves. The ducts, channels, or chambers for the live steam are further indicated by *s*, and the ducts, channels, or chambers for the dead or exhaust steam by *e*. As before stated, however, these respective channels may be reversed, if desired, as the engine will work equally well either way.

Thus constructed the operation of the machine is as follows: Steam being admitted at the right of the engine and exhausted at the left—say as shown in Fig. 3—the operating parts will be in the positions as seen in the respective figures 1, 2, 3, 4, and 5. Thus positioned the two pistons 9 and the cylinder 12, by which they are connected, move to the left under pressure of steam on the right-hand piston. This movement will continue carrying the pistons 11 along with cylinder 12 till the crank 15 reaches the dead-center with respect to the upper piston, when the upper valve 25 will begin to open and admit pressure against the upper piston. Meantime the left-hand steam-chamber has exhausted and said chamber and its valve prepared to admit steam in turn as the crank 15 is carried down past the dead-center with respect to said piston and chamber. When this occurs, the right-hand valve has rotated sufficiently to open the exhaust, and in all cases the opposed chambers have their supply and exhaust channels open at the same time—that is, when one valve takes steam the other exhausts steam. The crank 15 having passed the dead-center at the left, the cylinder 12, with its attached pistons, will return toward the right with the crank 15 on the downstroke and under pressure of the expanding steam in the upper cylinder and steam now appearing in the left-hand cylinder. Movement down on the left and around below past the

dead-center follows, when steam in turn enters the lower chamber and carries the crank 15 past the dead-center on the right and opposite the respective pistons 9. Thus steam enters each of the piston-chambers in succession at each quarter-revolution of the shaft, and the exhaust is opened in like manner. The full head of steam is on each piston in turn as the crank of the drive-shaft reaches the dead-center of the next preceding piston. This gives a sweeping movement to the steam as it follows the crank round and round and keeps the crank under a substantially constant and regular pressure, which is the object of the invention. One of the rods 28 is rigid with the ring 29 to prevent it from turning on the eccentric, while the other rods are pivoted thereon, and the eccentric itself is fixed on the shaft by a set-screw, so that the necessary movement of the valves is imparted by the eccentric turning in the ring.

The idle-chamber, in which the cylinder 12 moves back and forth, furnishes room and opportunity to oil the interior of the engine.

Suitable packing for the bearing-screws 8 around the drive-shaft is shown at 37 in Figs. 4 and 5.

In operation the side ports in the casing are constantly filled with live steam; but this steam is never lost till used.

The valves 25 might be made slightly tapering, if desired; but this is not deemed necessary, as what little steam gets back of them only helps to keep them down to place. At most their movement is slight, and the direction of the steam is governed by the position of the partition 33 with respect to slot 36.

Compactness in construction, a continuous movement under constant and even pressure, and possibility of very high speed are among the advantages of this invention.

It will be seen that no packing is required between the inner cylinder 12 and the casing, as no steam can enter the chamber on which said cylinder works unless it creeps through the packing of the pistons or at other points; but of this there is no danger when suitable packing is made. Thus said cylinder is as free to work in its bearing as if its chamber were open to the outer air.

The slot 36 in the cap 24 on the top of the engine is in line with the axis of the drive-shaft, so that it will be open to the corresponding piston at all times when the valve that controls said slot is in position to admit or exhaust steam, and the same is true of the slot at the base.

A peculiar and novel feature of this invention is the enlarged interior chamber and the cylinder therein carrying two pistons and forming the chambers therefor. These piston-chambers are inclosed around the side by the cylinder and are open at the end to the steam, so that the piston is exposed to the steam only at its front and nowhere else. The same is true of the side pistons, which are only exposed to the steam on their front and work closely in chambers at their sides.

It should be understood that, though the word "steam" is here used as the means by which the engine is driven, any other means, as gas, compressed air, or other similar agency which exerts pressure by expansion, may be employed.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In a double-acting engine, the casing having opposite circular piston-chambers, a cylinder set in said casing at right angles to said chambers and carrying a pair of pistons working in said piston-chambers, and a pair of pistons working in said cylinder at right angles to the aforesaid pistons, all four of said pistons having equal surfaces exposed to pressure, substantially as set forth.

2. In a double-acting engine, the casing having a hollow interior chamber and circular piston-chambers opposite to one another and of less diameter than said interior chamber, in combination with a plain cylinder set at right angles to the axis of the said piston-chambers and carrying pistons working in said chambers, and a pair of connected pistons in the said cylinder, all of said pistons having an equal area subject to pressure, substantially as set forth.

3. In a double-acting engine, a casing provided with an interior chamber and cylindrical piston-chambers of less diameter than said interior chamber at right angles to the axis of the drive-shaft, in combination with a cylinder set in the casing intermediate of said piston-chambers and with its axis at right angles thereto, a pair of connected pistons in said cylinder, and a pair of pistons on the sides thereof and working in said cylindrical chambers, substantially as set forth.

4. In a double-acting engine, the outer cylindrical casing having a chamber in the center with flat sides at right angles to the axis of the main shaft, and a cylinder in said casing having its sides flattened to match the flat sides of the casing, in combination with pistons upon the outside of said cylinder and inside thereof, substantially as described.

5. In a double-acting engine, a cylinder containing two united pistons free to reciprocate therein and having two other pistons on its sides connected to said cylinder by arms, in combination with a casing having an interior chamber in which said cylinder works, and two piston-chambers on its sides for the pistons on the outside of the said cylinder, all said pistons having equal pressure area, substantially as set forth.

6. In a double-acting engine, a main casing provided with a hollow interior, a cylinder in said casing carrying two pistons on its inside and two pistons supported on arms at its outside and removed from the side of the cylinder by said arms, each set of pistons being

at right angles to the other set and all of equal area, in combination with a separate valve for each piston, inlet and outlet ducts common to the several valves, and mechanism operating said valves, having a common center of movement, substantially as set forth.

7. In a double-acting engine, a casing having steam ducts centering at the bearing of the drive-shaft, in combination with said shaft and a bearing for the shaft around which the steam passes from one side of the shaft to the other, substantially as set forth.

8. In a double-acting engine, a casing having an interior chamber and two piston-chambers outside the limits of said chamber and opening into the same, in combination with a cylinder having arms at its sides, carrying pistons working in said piston-chambers, the opening through said cylinder being at right angles to said piston-chambers, and a pair of connected pistons working in said cylinder, substantially as set forth.

9. In a double-acting engine, a main casing having an interior chamber and opposite piston-chambers distinct and separate from said chamber, but opening therein, in combination with a cylinder in the interior chamber, carrying two pistons at its sides working in said piston-chambers and two pistons inside at right angles to the other pistons, and a separate valve on the main casing opposite the face of each piston to control the flow of steam, substantially as set forth.

In testimony whereof I hereunto set my hand this 20th day of July, 1889.

CLINTON A. TOWER.

Witnesses:
IRENE L. COREY,
H. T. FISHER.