(No Model.) 4 Sheets—Sheet 1.

J. A. ARTHUR.

STEAM ENGINE.

No. 375,689. Patented Dec. 27, 1887.

Fig. 1

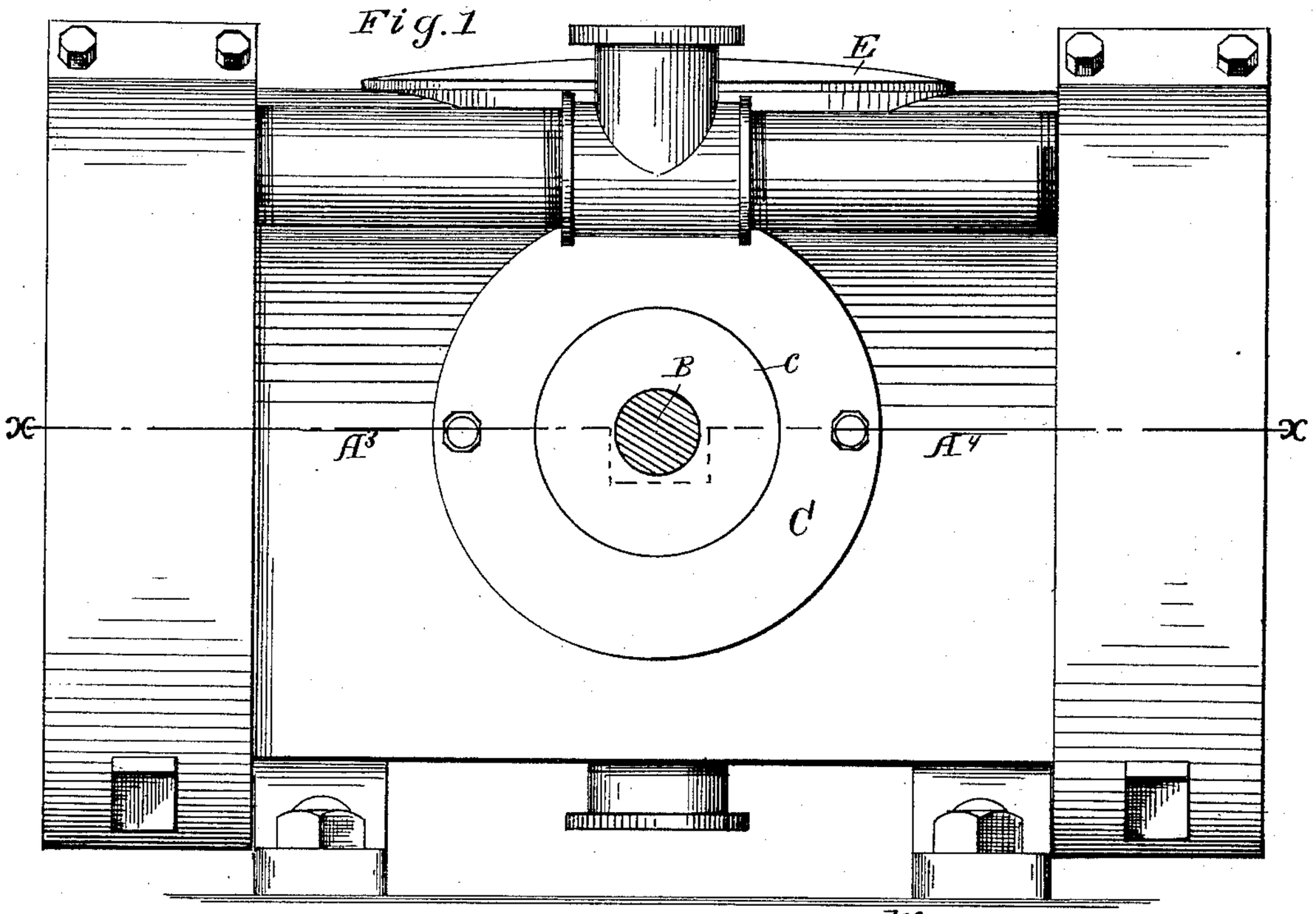
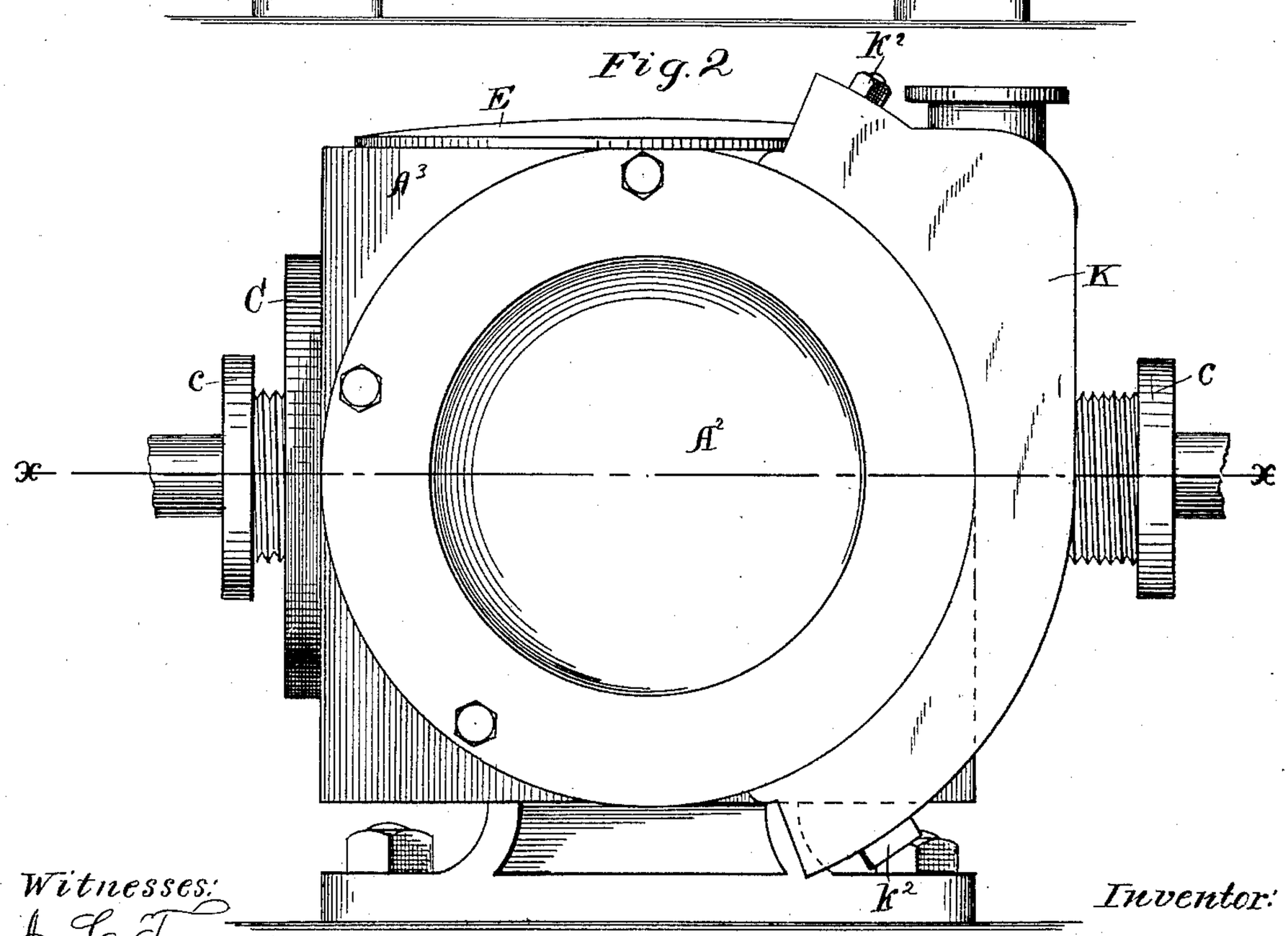


Fig. 2



Witnesses:
J. C. Turner
J. L. Doubleday

Inventor:
Joseph A. Arthur
by Doubleday & Bliss atty

(No Model.) 4 Sheets—Sheet 2.

J. A. ARTHUR.

STEAM ENGINE.

No. 375,689. Patented Dec. 27, 1887.

Fig 3

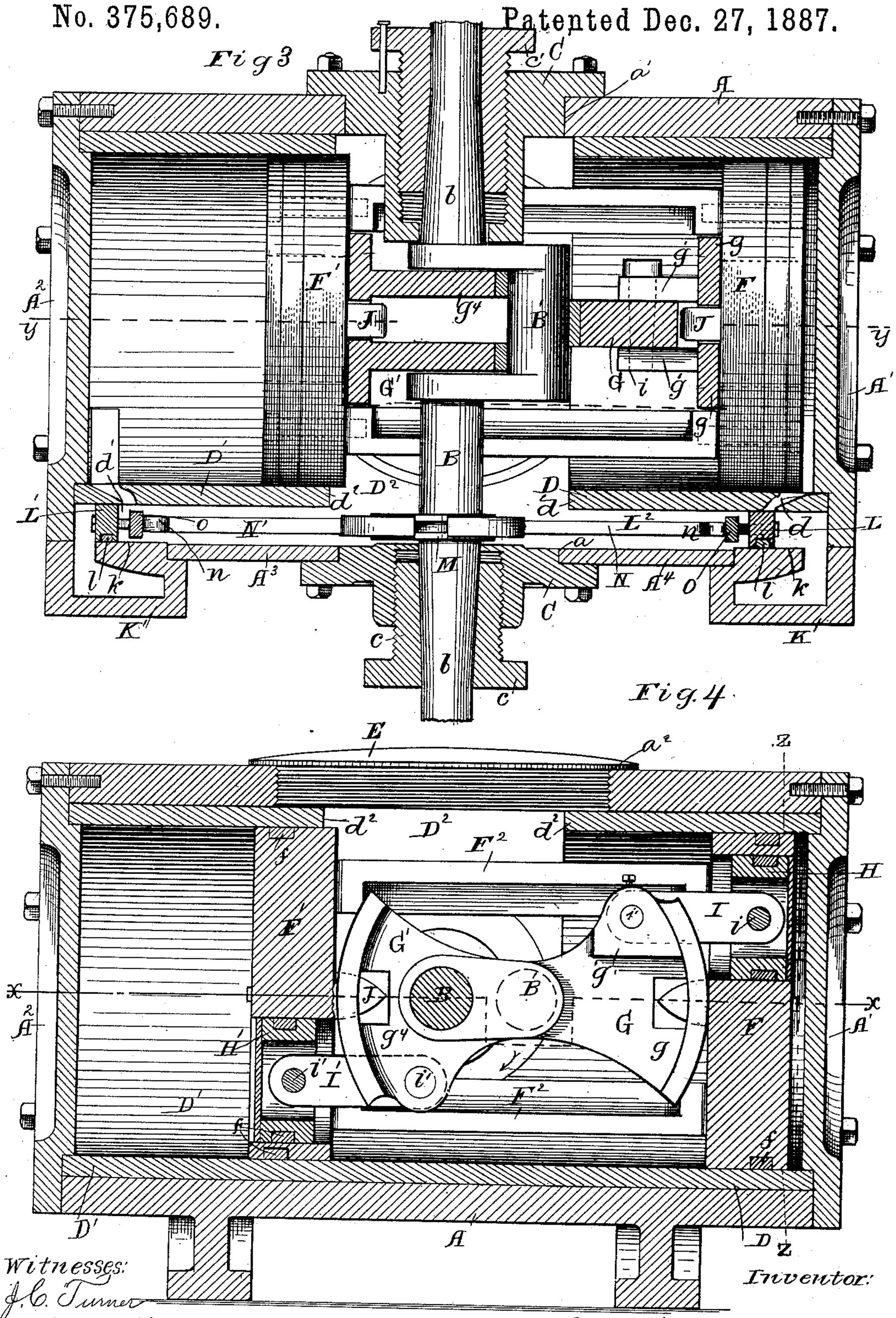


Fig. 4.

Witnesses:
J. C. Turner
J. L. Doubleday

Inventor:
Joseph A. Arthur
by Doubleday & Bliss atty.

(No Model.)

4 Sheets—Sheet 3.

J. A. ARTHUR.

STEAM ENGINE.

No. 375,689. Patented Dec. 27, 1887.

Fig. 5

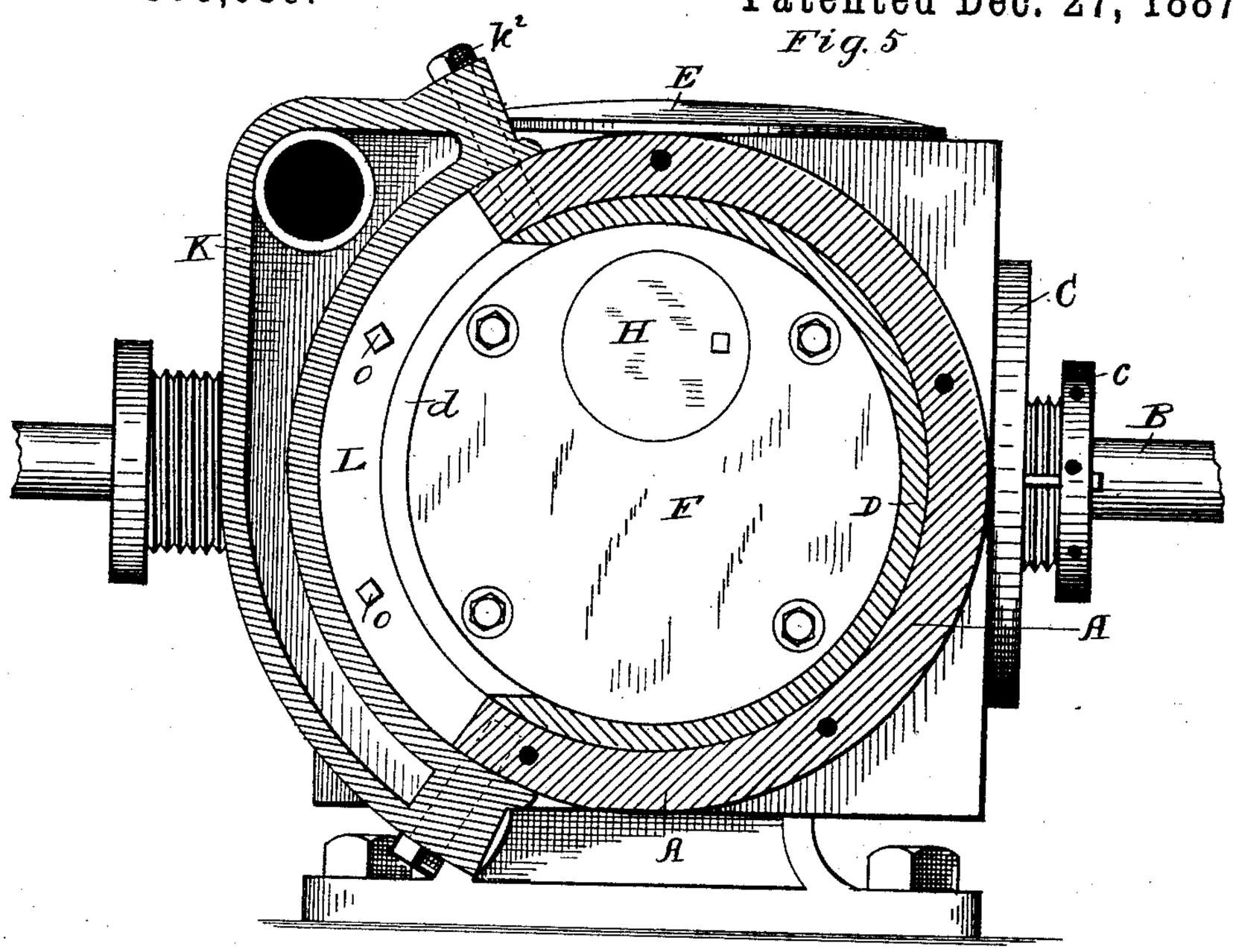
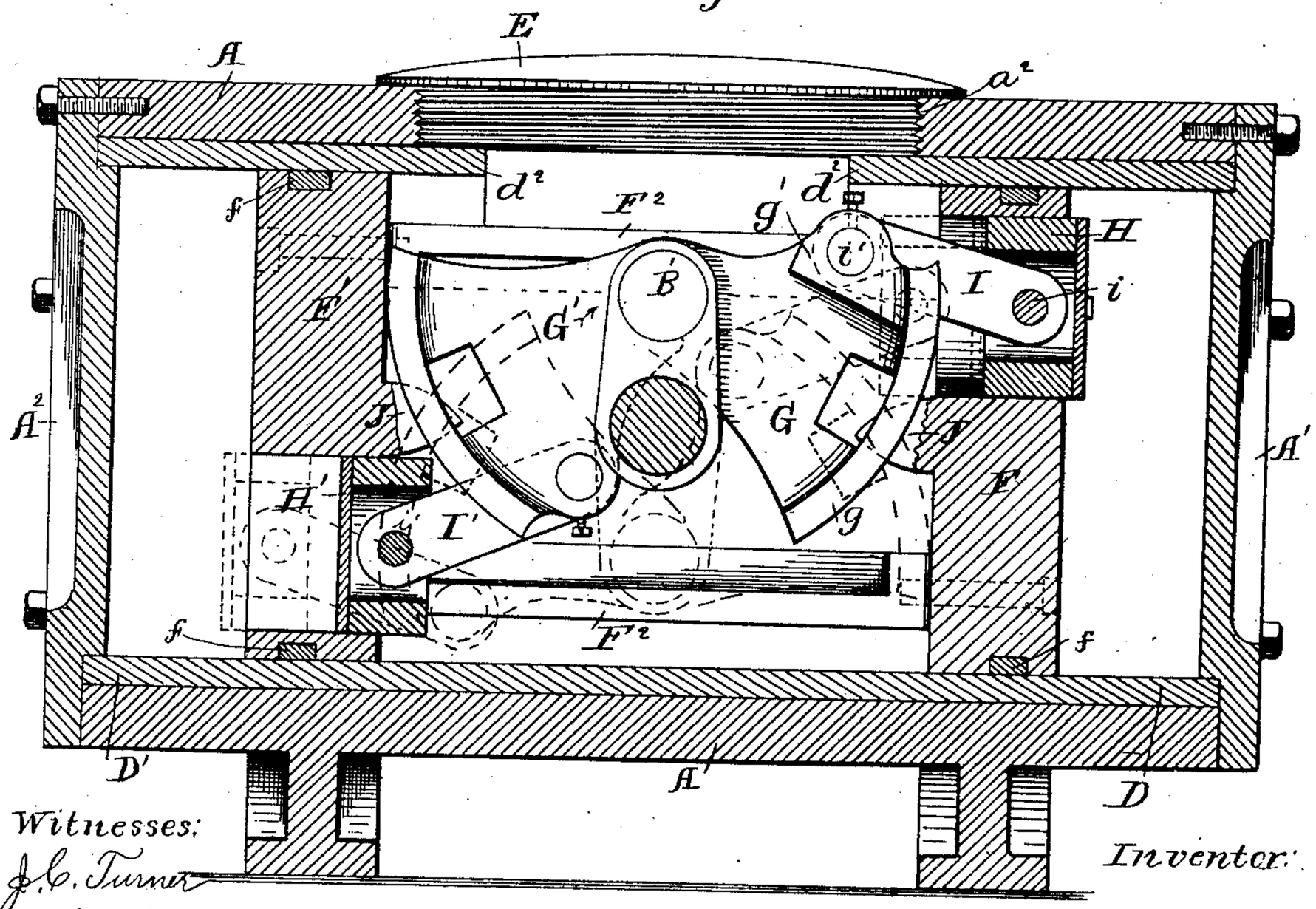


Fig. 6



Witnesses:
J. C. Turner
J. L. Doubleday

Inventor:
Joseph A Arthur
by Doubleday & Bliss attys.

(No Model.)

4 Sheets—Sheet 4.

J. A. ARTHUR.

STEAM ENGINE.

No. 375,689. Patented Dec. 27, 1887.

Fig. 7

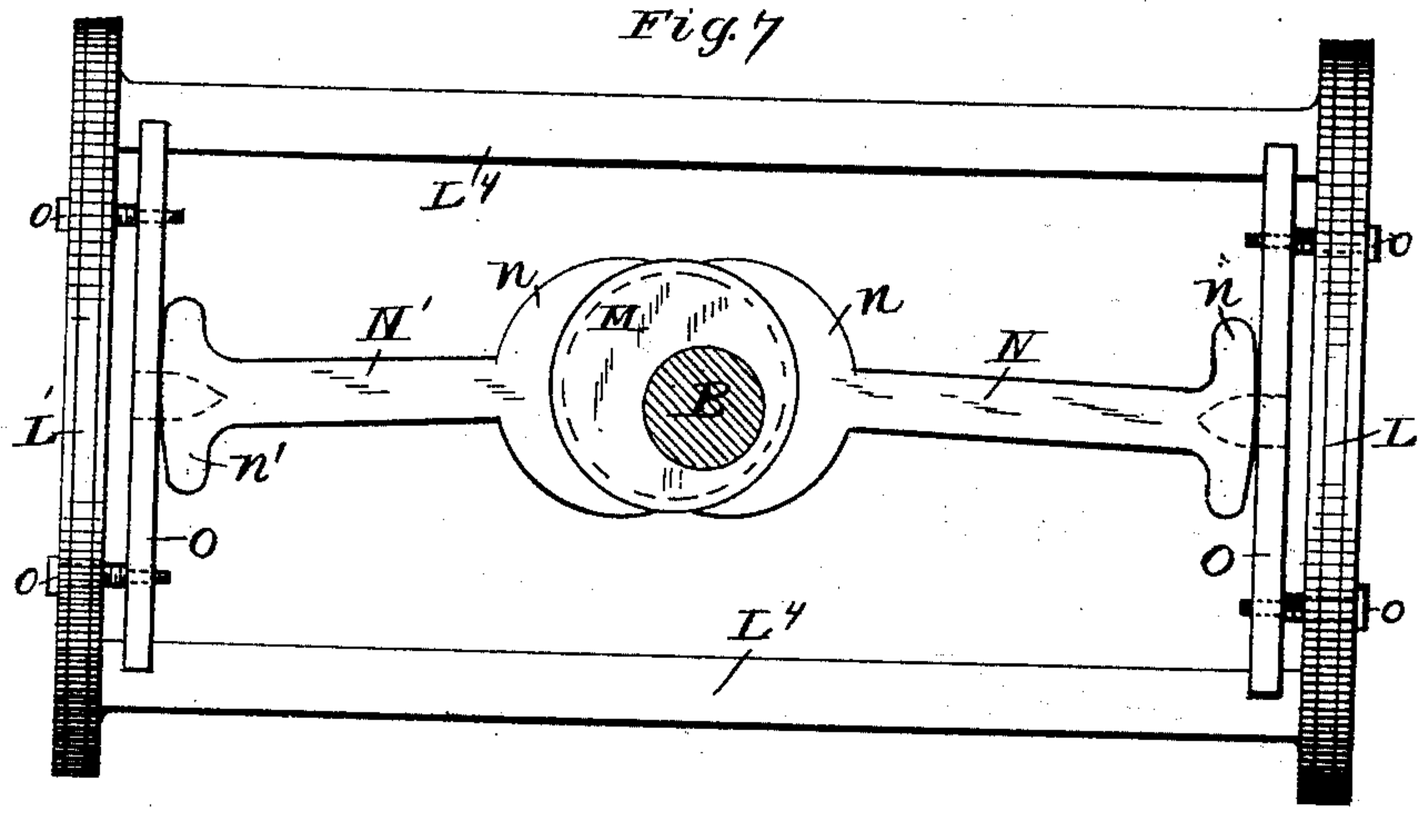


Fig. 8

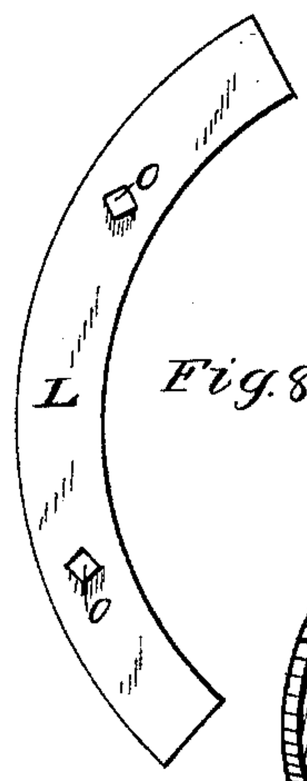


Fig. 11

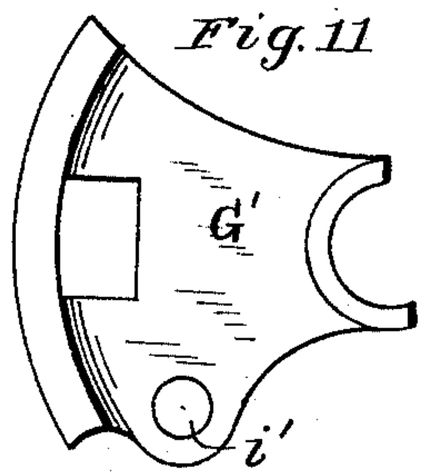


Fig. 9

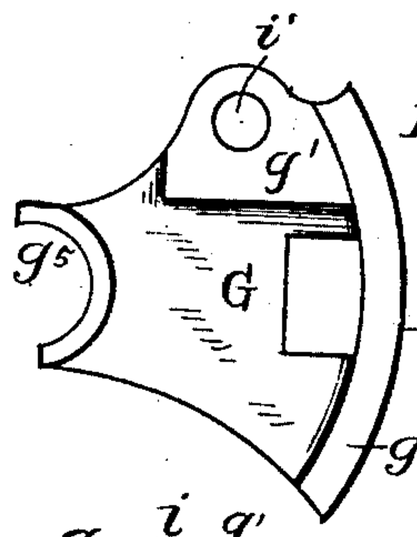


Fig. 12

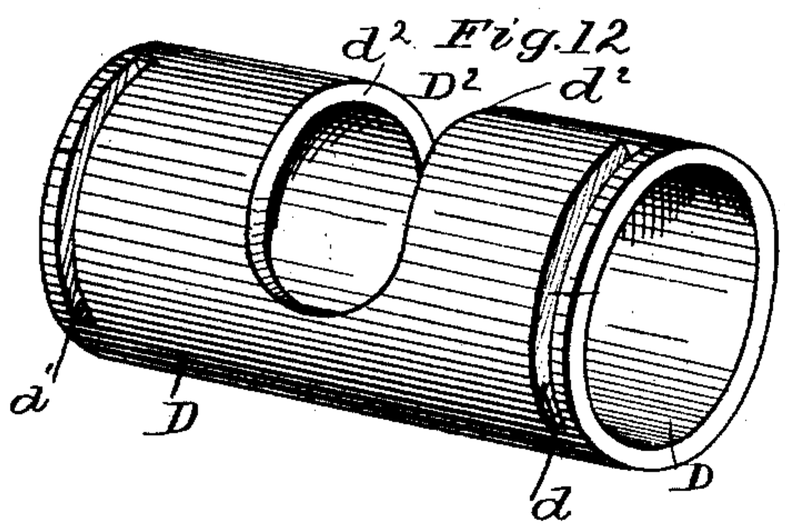
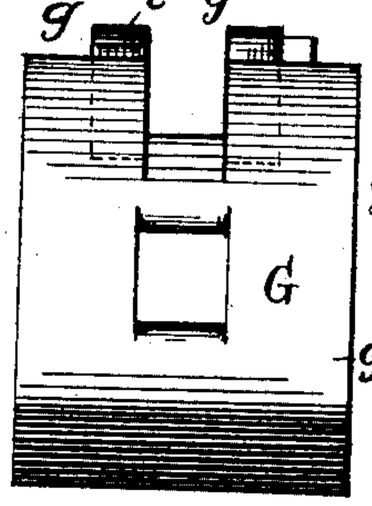


Fig. 10



Witnesses:

J. C. Turner

J. L. Doubleday.

Inventor

Joseph A Arthur

by Donkeday & Bliss attys

UNITED STATES PATENT OFFICE.

JOSEPH A. ARTHUR, OF COLUMBUS, ASSIGNOR, BY DIRECT AND MESNE ASSIGNMENTS, TO MICHAEL J. ENRIGHT AND GEORGE G. HADLEY, OF TOLEDO, OHIO.

STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 375,689, dated December 27, 1887.

Application filed March 30, 1887. Serial No. 233,004. (No model.)

To all whom it may concern:

Be it known that I, JOSEPH A. ARTHUR, a citizen of the United States, residing at Columbus, in the county of Franklin and State of Ohio, have invented certain new and useful Improvements in Steam-Engines, of which the following is a specification, reference being had therein to the accompanying drawings.

Figure 1 is a side view of an engine embodying my improvements. Fig. 2 is an end view. Fig. 3 is a longitudinal section on the lines *x x*, Figs. 1, 2, and 4. Fig. 4 is a longitudinal section on the line *y y*, Fig. 3. Fig. 5 is a section on the line *z z*, Fig. 4. Fig. 6 is a longitudinal section similar to Fig. 4, but with the piston and its adjuncts in different positions. Fig. 7 is a view of the valve and valve-gear. Fig. 8 is an end view of the valve. Figs. 9, 10, and 11 are views of the rockers G and G′. Fig. 12 is a view of the cylinder-lining.

In the drawings I have shown an engine of one of the numerous forms which can be constructed to embody my improvements, and wish it understood that I do not limit myself to all of the details which are shown, because of the fact that there can be modifications made without departing from the spirit of the invention.

In the drawings, A represents a cylinder which may be cast and planed, though I prefer that the wall should not be continuously circular in cross section, for reasons which will appear from what is said below. The part which is circular in section is represented by A, and this letter will be herein used to indicate the cylinder as a whole. At A^3 a wall is cast with the cylinder, it lying outside of the circle of the cylinder and serving the purpose to be hereinafter described. The cylinder is provided with heads $A' A^2$, bolted to it in the usual manner. In the wall A there is formed an aperture, *a′*, and in the wall A^3 there is formed an aperture, *a*. In the top of the cylinder there is formed an aperture, a^2, adapted to be closed by a circular threaded cap, E. The apertures *a* and *a′* are closed by caps C C′, which provide a support for the crank-shaft B, there being hollow bearing-nuts *c c′* adapted to be inserted into the cap-pieces C C′. The shaft is tapered at *b b* and the apertures in the bearing parts *c c′* are correspondingly tapered, so that the wear on the shaft can be readily taken up.

It will be seen that the shaft B passes transversely through the center of the cylinder, it being formed with a crank and wrist at B′ of any suitable character.

F F′ represent the piston-heads. These are not shown as being fitted to the cylinder A; but they are fitted to a tube or tubes, D D′, inserted into the cylinder A, being turned so as to fit the cylinder tightly and having true cylindrical surfaces both inside and out. I prefer to form the parts D D′ in one and the same tube, so that the turning and fitting can be accomplished properly, and so that the parts at both ends of the cylinder shall be held uniformly. As shown, the part D′ of the interior cylinder-tube is partially separated from the part D, the tube being cut away at D^2, the edges being shown at d^2. Through the tube or tubes D D′ are formed the ports *d d′*, which in the construction shown are on one of the sides vertically of the cylinder. By having the operative part of the cylinder made of a tube or tubes of this character it can be comparatively thin, so that the steam-ports are shortened and can be readily turned, as above set forth, whereas much difficulty is experienced in thus manipulating, turning, and fitting the ordinary cast portion of the cylinder.

The piston-heads F F′ may, so far as their general construction is concerned, be of the ordinary or of any suitable forms, and can be packed in any preferred way, a packing being indicated at *f*. The pistons are arranged one upon one side of the shaft and the other upon the other side. Heretofore in making engines at all resembling mine it has been customary to connect the piston-heads with the crank of the shaft either by means of a pitman, a sliding box, or a rack. I have found objections incident to each and all of the forms which have thus been in use. I aim to always maintain a constant driving-connection between the pistons and the cranks, as constant, in fact, as is the case when connecting-rods are used, and at the same time overcome the serious difficulties met with in using the engines with connecting-rods, which difficulties are

mainly due to the fact that the application of the power to the shaft varies greatly in respect to the different parts of the path taken by the crank—that is to say, are due to what is commonly called the "dead-center" met with in using such devices.

I employ means for connecting the piston-heads to the crank which are adapted to vary the points of bearing of the piston-heads and vary the lines of thrust along which the pistons exert their force upon the crank. I prefer to employ (for accomplishing this purpose) what I term a "rocker" connection. Such a connection is shown in the drawings at G and at G'. The part G consists of a plate or bar of sufficient strength to attain its end, it being loosely interposed between the piston-head F and the wrist B'. It is formed with a cavity or socket, g^5, at the inner end, which surrounds a part of the wrist, and at the outer end it has a curved bearing-surface, g^6, in contact with the inner surface of the piston F, this bearing-surface being preferably provided by means of laterally-extending flanges $g\,g$, which are on curved lines struck from the center of the wrist B'. As the crank revolves the connecting part or rocker G follows it, always maintaining a position such that it is in contact both with the wrist and with the piston. The part G' corresponds substantially to the part G, though I prefer to have two inwardly-projecting bearing-pieces, as shown at g^4, Fig. 3, these also having sockets at their inner ends fitting part way around the wrist and having flanges g, with curved bearing-surfaces. In order to provide a bearing or support and a guide for the rockers G and G', I provide inwardly-extending studs J J, preferably cast integral with the piston-heads and having rounded or beveled top and bottom surfaces, which permit the parts G and G' to rock freely up and down.

By examining and comparing Figs. 4 and 6 it will be seen that the rockers G and G' follow the wrist-pin in all positions, one rocker applying a pushing force upon it during one half of the revolution and the other rocker applying such force during the other half. The piston-heads are held rigidly together by means of connecting-bars F^2, which may be of any suitable shape and size. Still referring to and comparing the last said figures, it will be also seen that when the rocker-connection G is pressing against the wrist-pin (the revolution being in the direction of the arrow) the wrist is moving through the lower half of the revolution, during which movement the part G turns first so as to carry the points of bearing downward along its bearing-surface, and then turns so as to carry B', the said points of bearing, upward. Inasmuch as the piston brings the line of thrust farther down as the wrist-pin comes down, power is applied to the latter from the piston in a right line. When the wrist is moving through the second quarter, the part G rocks back into the position shown in Fig. 4, the wrist-pin being, however, on the opposite side of the shaft B. When the end of the third quarter of a revolution is reached, the parts are in the position shown in Fig. 6, full lines, the rocker-connection G' being that which is now pushing the wrist. In order to insure that the crank shall pass the lines of dead-center and overcome its tendency to stop, I combine with the parts above described the following:

H H' represent supplemental pistons respectively mounted in apertures in the piston-heads F F'. There may be variations in this respect as to the size of these pistons H H', as to the depth of aperture in which they work, as to the distance from the center of the main cylinder, &c.

I I' are links respectively connecting the supplemental pistons H H' with the rocker-connecting pieces G G', these links being pivoted to the pistons at i and to the rockers at i'.

$g'\,g'$ represent ears or lugs formed with or secured to the rocker G and adapted to receive the pivot i', the latter being preferably threaded at the end and tapered at the bearing part, so that the wear in the aperture in the link can be taken up. The link I' is secured in a similar manner by a pivot between the inwardly projecting bearing parts g^4 of the rocker G'.

When the wrist is in the position shown in Fig. 4—that is to say, on the axial line—the parts are in such relation that steam is beginning to enter behind the piston F and its supplemental piston H, the pressure of which results in an advance of the piston H, which in turn, through link I and the rocker G, effects a downward movement of the wrist B', so that, although the wrist is in the line of center from the piston F, a downward movement of the wrist is caused independently of the momentum of the driven parts. The supplemental piston H continues its advance relatively to the main piston F until the wrist B has reached the end of the first half of the stroke, although the piston F also moves forward immediately after the wrist has passed the position shown in Fig. 4, the supplemental piston moving thus with the main piston and also independently of it.

The position of the piston H' and link I' in the main piston F' at the end of the first half of their stroke is illustrated in Fig. 6.

It will be seen that the parts are so related that the supplemental pistons H H' are efficient not only in throwing the shaft off from the dead-centers, but also in assisting the main pistons F F' in driving the shaft. The links I I', the pivots $i\,i'$, the supplemental pistons H H', and the rocker-connections G G' are all so placed and proportioned that even though there is at times a backward motion of the supplemental piston relatively to the main pistons, yet this is merely relative, and occurs at such times in respect to the feed and exhaust that the supplemental pistons are nevertheless assisting in the driving of the shaft.

There may be variation in the relations of the several devices forming this part of the mechism without departing from the essential principles of the construction and operation. The supplemental pistons H H′ may be put at greater distances from the axis of the main cylinder, and the parts G G′ can be elongated accordingly for providing a greater leverage for throwing off from the dead-center, and when so placed the area of the supplemental pistons can be decreased.

One of the objects of the present invention is to provide, where required, engines of high speed and short stroke, which have heretofore been found difficult to construct and operate, but in which a throw-off mechanism of the character I have indicated can be used with a powerful leverage.

I prefer for most purposes about the relative positions, dimensions, &c., of the essential parts, the main pistons, the supplemental pistons, the rocker-connections, the links, and their pivots, finding that I can thereby utilize the power for the two purposes of throwing off from the dead-center and driving in the ratio of about one to two.

Of course that part of my invention which relates to the supplemental piston as a device for throwing off from the dead-center can be applied in constructions more or less of the ordinary character, wherein use is made of connecting-rods and the like, and I do not wish this part of the invention to be limited to the rocker-connection shown. As to the matters of the amount of steam supplied for each stroke, the point of cut off, the degree of expansion, &c., it will be understood that these may be regulated as may be dictated by preference or the character of the work to be performed by the engine. The steam is guided to the aforesaid ports *d d′* and its passage through them regulated by the following devices:

L L′ are the valves, mounted in chambers adjacent to the said ports *d d′*.

K K′ represent the steam-chests, they being in cross-section, and having a chamber of the shape shown in Figs. 5 and 3. These chests are cast and shaped separately from the cylinder parts, and are secured in place after the proper surfaces have been turned and fitted by bolts at k^2. By examining Fig. 3 it will be seen that these steam-chests are formed with bearing-surfaces at *k*, to which are fitted the valves L L′, the opposite bearing-surfaces being the exterior surfaces of the tubes D D′ adjacent to the ports *d d′*.

The shape and constructions of the valves will be readily understood by examining Figs. 3, 5, 7, and 8. They are curved to conform to the surface of the tubes D D′ and to the inner surfaces of the valve-chamber at *k*—that is to say, the inner and outer faces of the valves are on arcs of circles, the depths of the posts *d d′* being the same throughout their length. The valves and the ports are thus readily distinguishable from those heretofore commonly in use in engines wherein the ports vary in depth, from their centers becoming deeper gradually toward the ends, and the bearing-faces of the valves and the valve-seats being planes and not curved, as is herein shown—that is to say, in those constructions in which the valves reciprocated rectilinearly in paths parallel to the axis of the cylinder. By having the ports constructed as shown, and having the curved valves, I can insure that the steam shall be supplied to and exhausted from the cylinder instantly—that is to say, in such way that all of the steam admitted shall be immediately efficient in the cylinder and as immediately exhausted after its work is done. A packing is provided for the valve at *l*, it being of any suitable material and held in place in any preferred way. It can be forced automatically against the opposing bearing surface by means of the steam through suitable ducts, or by any of the ordinary springs, or even by devices to be adjusted by hand. As wear occurs on the inner surfaces of the valves, it is constantly taken up by reason of the fact that the valve is forced inward automatically, as just described, the ends of the valve being shaped in relation to the valve-seats, as is clearly shown in Fig. 5, in such way as to insure the tight fitting under all circumstances. In this respect, however, there may of course be variation in ways readily suggesting themselves to those acquainted with such devices.

The valves L and L′ may be made and fitted separately from each other, so far as concerns some of the features of the present invention; but I prefer to cast them integral, providing connecting-bars L^4, one or more, inasmuch as I can then turn up and true both of the valves together, thereby insuring a perfect uniformity in their sizes and fitting and making them more easily and cheaply than when they are made and shaped separately. I prefer to have the arc of each valve somewhat less than the one-third of a circle, so that I can cast three sets of valves and their connecting-rods integrally in one piece, which can be manipulated and turned in the lathe as readily as a complete cylinder; but the devices and method of turning and shaping the different parts need not be here described in detail, the present case relating to the finished engine.

Much trouble has been heretofore experienced in engines of all kinds wherein use was made of reciprocating oppositely-acting valves by reason of the fact that the means for moving the valves have been of such character as to cause one of them to move in relation to its port differently, in the matter of speed of travel, from the other, and this lack of similarity of the movements of the valves relative to their ports has made it impossible to accurately regulate the feed, exhaust, and cut-off for one valve exactly the same as for the other. I obviate this by constructing and arranging the valve mechanism as follows: M represents an eccentric secured to the shaft B in the plane of the valves. N N′ are arms or rods interposed between the valves and the eccentric,

these being adapted to rock or oscillate in a way similar to that in which the parts at G G′ operate. At their inner ends there are curved arms or socket-pieces *n*, which are fitted to the eccentric by means of tongues fitting in a groove in the latter. At their outer ends they are formed with somewhat elongated curvilinear bearing-faces, which bear against the valve. To provide for taking up wear, I interpose adjustable bearing-bars O, which, by means of set-screws *o*, can be adjusted toward and from the eccentric, and against these bars the curved bearing parts at *n*′ rest.

The mode of operation of these devices in moving the valves to and fro will be readily understood. As the connection between the eccentric and the valves is a broken one, in contradistinction to such a connection as the ordinary pitman, the eccentric always operates by a pushing thrust first upon one of the rocker-bars and then upon the other. Therefore in relation to the rotation of the shaft and eccentric it will be seen that the valve L always moves in respect to its port with the same speed as does the valve L′ in relation to its port, and these movements occur at corresponding times in relation to the rotation of the shaft.

What I claim is—

1. The combination, with the cylinder, the piston, and the shaft, of the two opposing rocker-connecting devices, the two supplemental pistons within the cylinder on opposite sides of the shaft, and means for connecting each of the said supplemental pistons with the shaft, substantially as set forth.

2. The combination, with the shaft and the piston, of the rocker-connecting device and means, substantially as described, for throwing the shaft from the dead-centers, as set forth.

3. The combination, with the cylinder of the rectilinearly-reciprocating valves having curvilinear inner and outer edges and converging end surfaces, of the packing at the outer edge and means for adjusting said packing, substantially as described.

4. The combination, with the sliding valves and the eccentric, of the rocking connecting devices and means for adjusting the valves relatively to the operating devices, substantially as described.

5. The combination, with a cylinder, two pistons in the cylinder connected together, as described, a crank between said pistons, a rocker having rolling bearing against one of the pistons, and having arm G bearing centrally on the crank-pin, and a rocker having rolling bearing against the other piston, and having two arms which bear on the crank-pin, one at each side of arm G, substantially as shown.

6. A steam cylinder, a piston, and a crank-shaft and a connecting-piece between said piston and shaft, in combination with a supplementary piston in the main piston and a link joining the same with the connecting-piece between the piston and crank.

7. The combination of a cylinder, piston, and crank, a bearing-piece interposed between said piston and crank and a supplementary piston in the main piston connected to said bearing-piece at one side of its center.

8. The combination, with a steam-cylinder having a steam-chest at the side thereof, of a cylindrical lining forming a casing for the piston and forming a bearing against which the valve in the steam-chest works, substantially as described.

9. The combination, with a steam-cylinder having a steam-chest, as described, of a cylindrical lining in which the piston works and a valve having a curved inner surface which works against said lining.

10. The combination, with the cylinder having that part which contains the piston made with curved outer surface, of a valve having a curved inner surface of less than a half-circle and mechanism for reciprocating said valve lengthwise of the cylinder.

11. The combination of the cylinder-lining of hollow cylindrical form, the cylinder proper of similar form, an arc-shaped valve extending less than half-way round the lining and bearing on the cylinder and lining, and mechanism for reciprocating said valve, substantially as described.

12. The combination, with the two arc-shaped valves connected together, as described, of an eccentric between the valves and a rod at each side of the eccentric bearing on the same, said rod having a rocking bearing against the edge of the valve.

In testimony whereof I affix my signature in presence of two witnesses.

JOSEPH A. ARTHUR.

Witnesses:
M. P. CALLAN,
H. H. BLISS.