(Nc Model.) 3 Sheets—Sheet 1.

J. A. ARTHUR.

STEAM ENGINE.

No. 548,769. Patented Oct. 29, 1895.

Fig. 1

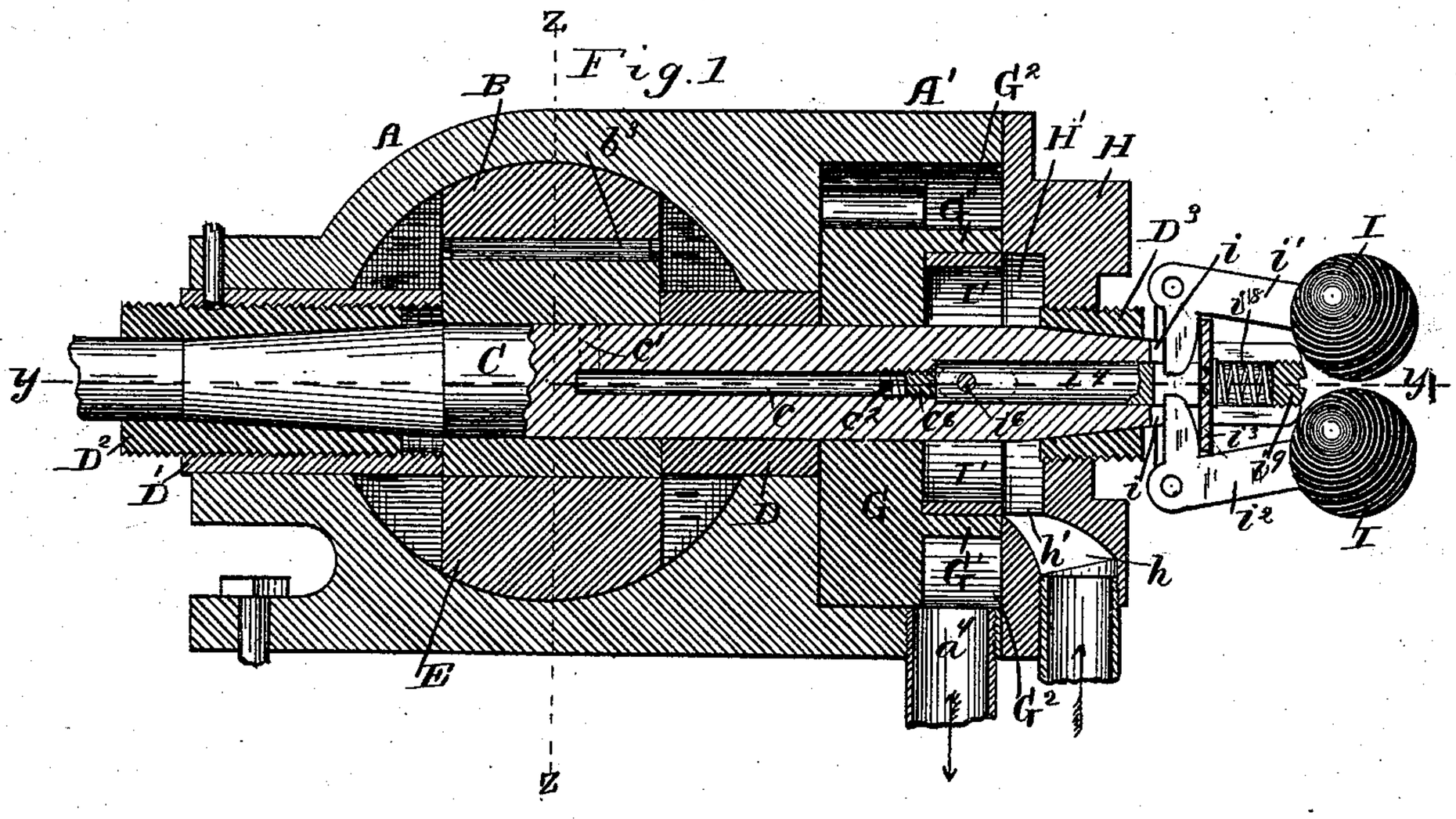


Fig. 6

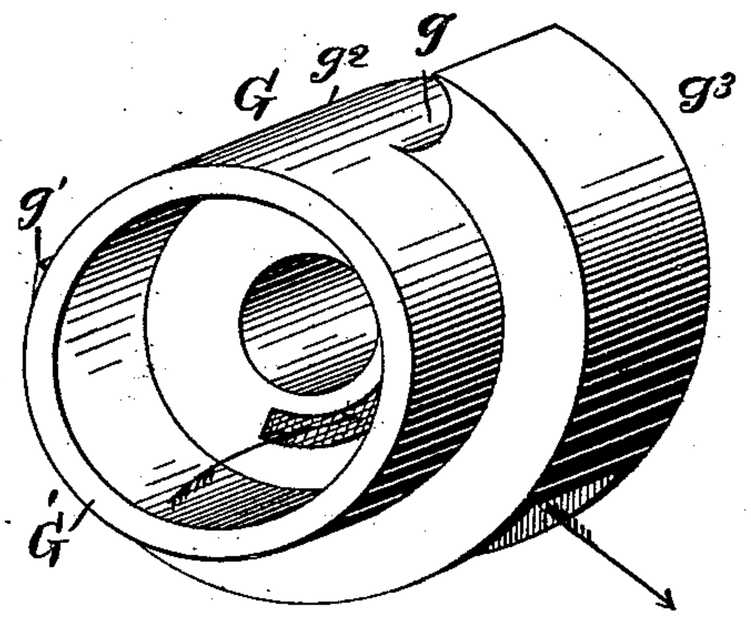
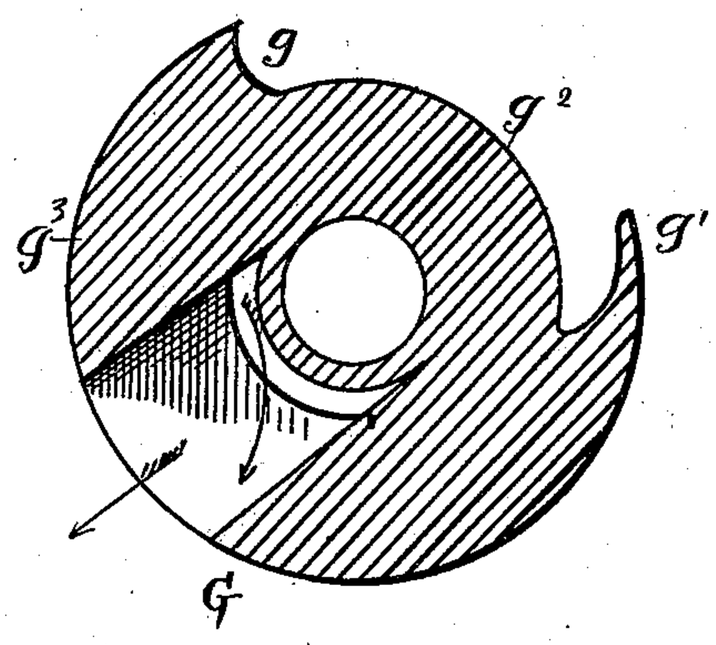


Fig. 5



Witnesses:
E. D. Smith
F. C. Turner

Inventor:
Joseph A. Arthur
by Doubleday & Bliss
Attys

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Fig. 2

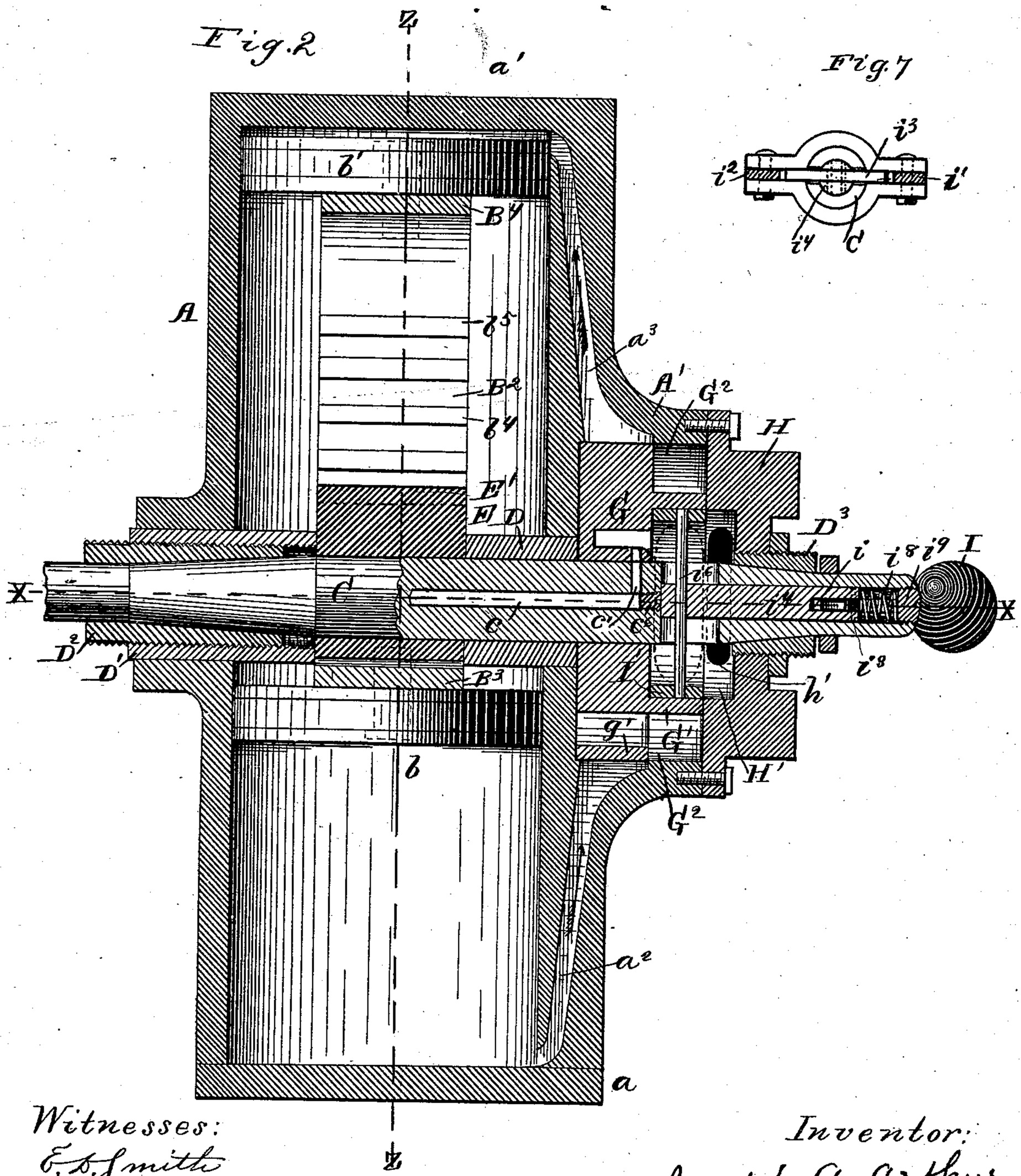

Fig. 7

Witnesses:
E. S. Smith
J. C. Turner

Inventor:
Joseph A. Arthur
by Doubleday & Bliss
Attys

(No Model.)

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J. A. ARTHUR.

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Fig. 4

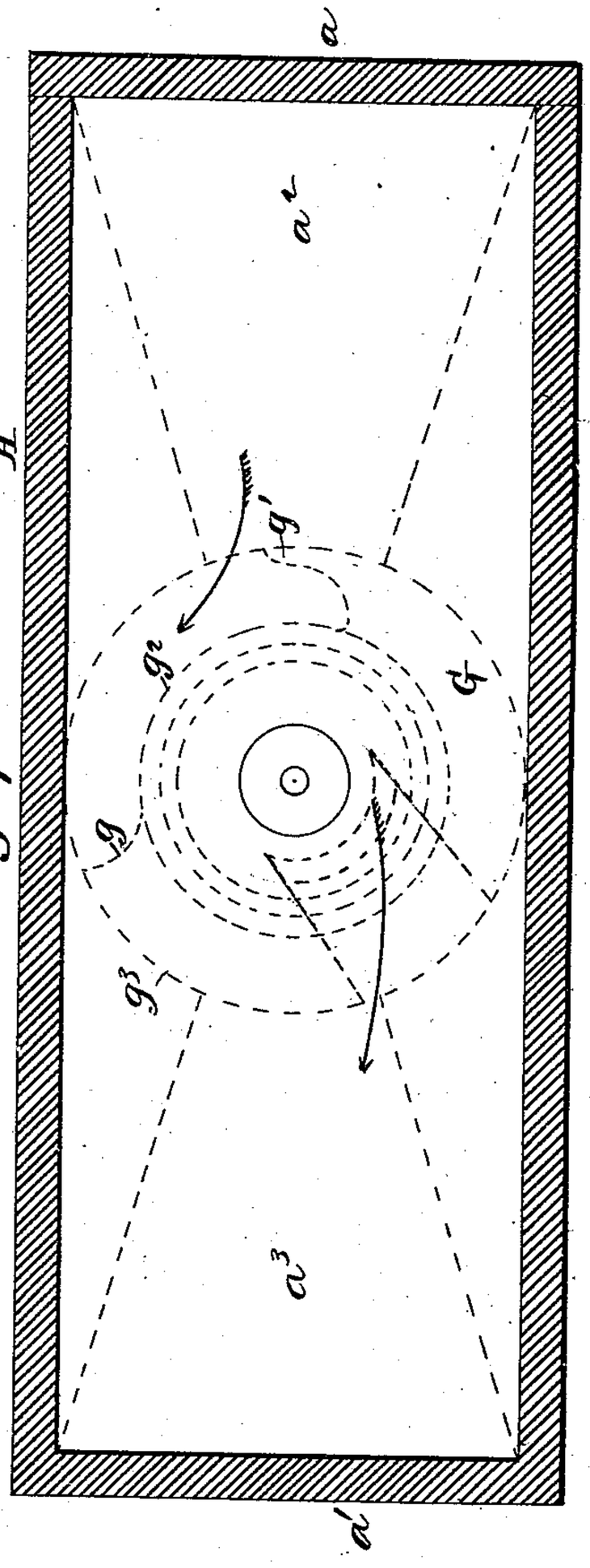
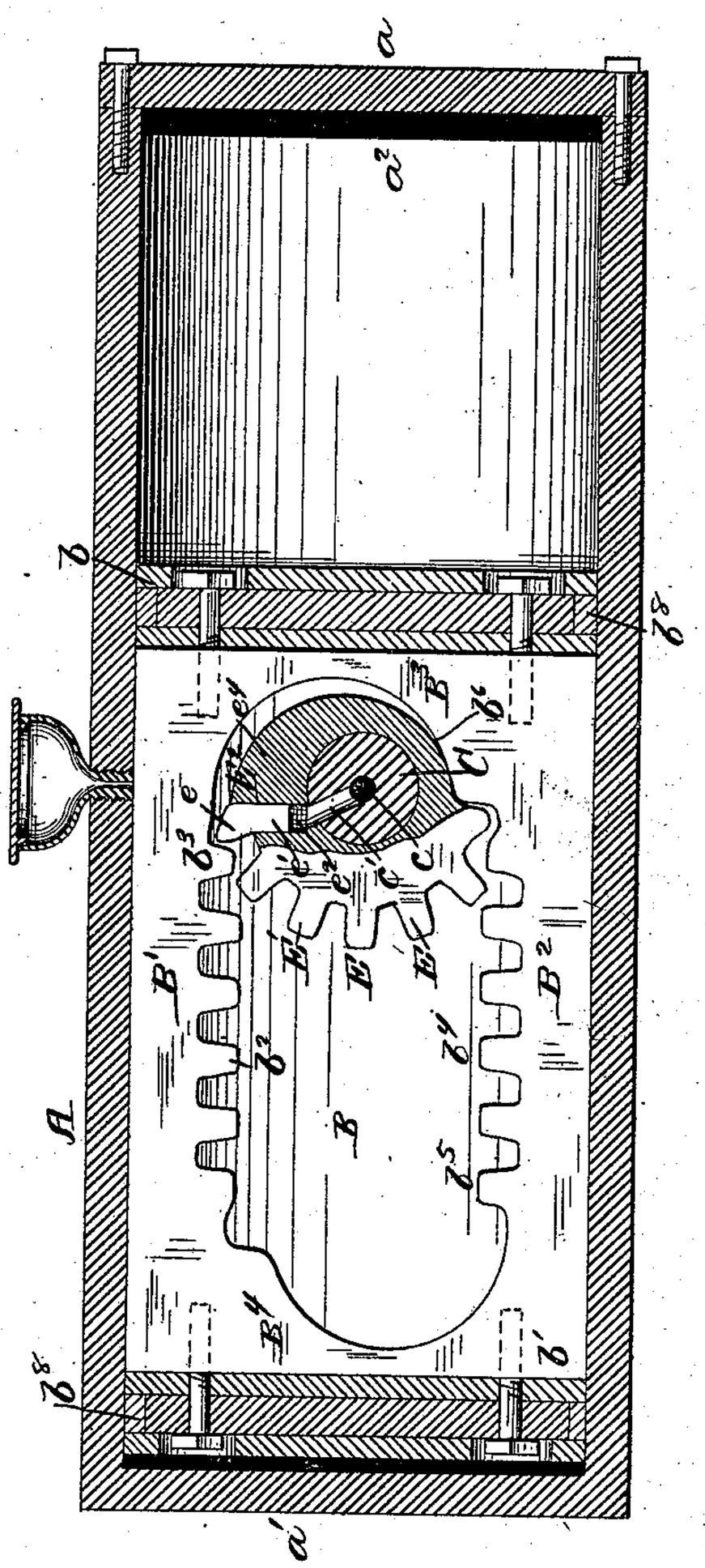


Fig. 3



Witnesses:
E. S. Smith
P. C. Turner

Inventor
Joseph A. Arthur
by Doubleday & Bliss
Attys

UNITED STATES PATENT OFFICE.

JOSEPH A. ARTHUR, OF PITTSBURG, PENNSYLVANIA, ASSIGNOR TO THE LECHNER MANUFACTURING COMPANY, OF COLUMBUS, OHIO.

STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 548,769, dated October 29, 1895.

Application filed August 11, 1886. Serial No. 210,637. (No model.)

To all whom it may concern:

Be it known that I, JOSEPH A. ARTHUR, a citizen of the United States, residing at Pittsburg, in the county of Allegheny and State of Pennsylvania, 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 vertical central transverse section of an engine embodying my invention on line *x x*, Fig. 2. Fig. 2 is a horizontal central section on the line *y y*, Fig. 1. Fig. 3 is a section taken centrally and longitudinally of the cylinder on the line *z z*, Figs. 1 and 2. Fig. 4 is a side elevation from the steam-chest side. Figs. 5 and 6 are respectively a transverse section and a perspective view of the valve. Fig. 7 is a sectional view taken through the levers which carry the governor-balls.

In the drawings the main portion of the cylinder proper is represented by A. The heads *a a'* may be made separately and bolted in place, though I prefer that one should be integrally cast with the cylinder. Upon one side of the cylinder there is a projection, as shown at A', comprising a cylindrical chamber adapted to serve as a steam and valve chest and for other purposes to be described.

a^2 a^3 are the passages or ports through which the steam alternately passes to and exhausts from the ends of the cylinder.

The piston B reciprocates within the cylinder A and is generally represented by B' B^2 B^3 B^4 and the circular heads *b* and *b'*. The heads may be made separately from the intermediate connecting part, as shown, or circular plates may be cast integrally with the said intermediate part and adapted to serve as the ordinary piston-heads. In either case provision should be made for packing, as at b^8. The intermediate part which connects the two piston-heads *b b'* consists of a top bar B', a bottom bar B^2, and end pieces B^3 and B^4, all of which are preferably cast in one piece, though they may be made separately or in any preferred way, as circumstances or the objects aimed at may dictate. The upper and lower parts B' B^2 are formed with inwardly-projecting teeth b^2 b^3 and b^4 b^5, these being so arranged as to form two racks adapted to engage with a segment or mutilated wheel, to be described. The end parts B^3 and B^4 are concave on the inner sides, the curvature of the cavities, in section, being preferably about that shown in Fig. 3, for a purpose to be described.

C represents the shaft to which motion is to be imparted from the piston. This shaft passes directly through the cylinder transversely, it lying between the cylinder-heads *b b'* and between the upper and lower bars B' B^2 of the intermediate connecting part. It is mounted and supported in steel hubs D D', which are inserted into apertures in the walls of the cylinder, and in tubular journal-pieces D^2 and D^3, the former being inserted into the hub-piece D' and secured by thread connection and the latter D^3 being inserted into the cap-piece H, to be described. The tubular parts D^2 and D^3 are flared internally, and the parts of the shaft which are journaled therein are beveled or cone-like, and when the parts are thus constructed provision is made for readily taking up any wear that may occur from the rotation of the shaft in its bearings.

I employ connecting devices between the pistons and the shaft, comprising a crank secured to the shaft and means for imparting power to said crank from the piston-heads. The crank is indicated by E E' E^2, it being of the form of a segment of a toothed wheel, the leverage being applied through the teeth. The teeth E' on this segment are adapted to engage alternately with the racks b^2 b^3 and b^4 b^5, the three sets of teeth being so related that when the piston moves in one direction it imparts a half-revolution to shaft C and while moving in the opposite direction it imparts the remainder of the revolution.

In order to insure the immediate engagement with the crank-segment E of the piston at each stroke of the latter, I combine with the segment a supplemental movable tooth adapted to move into and recede from the path of the rack-teeth. It is represented at E^2, it having the projecting tooth part proper *e* and the shank part *e'*, which is seated in a

recess e^2, formed in the segment, and this recess being somewhat deeper than the said shank part the tooth can play in and out sufficiently to attain the desired purpose. It does not move radially relatively to the center of the shaft C, but moves on a line tangential to a circle around said center. By having it arranged in this way it can be automatically caused to move inward by means of one of the teeth on each rack. The toothless portion of the segment has a periphery which is not concentric with the teeth E′, but which is so shaped as to be cam-like, that portion adjacent to the movable tooth E^2 being of greater radius than the portion which is diametrically opposite, and this is related to the aforesaid cavities in the end pieces B^3 and B^4, as shown in the drawings. As a result of this construction and arrangement the shaft compels the piston at the end of each of the strokes of the latter to move through the full normal throw, for when the piston is thus nearing the end of a stroke the part e^4 of the cam is bearing against the part b^6 of the end piece B^3 (or B^4) and the forward motion of the shaft compels the piston to travel positively to the limit of its throw. Thus, although cushioning can be provided for to a sufficient extent, the exhaust-steam can be thoroughly forced out.

The shaft C is provided with a steam-duct $c\ c'\ c^2$, the part c being preferably on the longitudinal central line of the shaft, the part c' lying radially and communicating with the above-described chamber or recess e^2, wherein plays the movable tooth E^2, and the part c^2 communicating with the live-steam chamber. In this way means are provided for having tooth E^2 forced out by a yielding pressure, so that it shall be ready at the proper times for engaging with the rack-tooth and yet can be pushed in when it is necessary to attain the purposes aimed at.

G represents the valve. It is secured to and rotates with the shaft C. The inner face of the valve is plane and fits against the bottom of the wall of the above-mentioned cylindrical steam or valve chamber. The shape of the valve in face view will be clearly understood by examining Figs. 5 and 6. It is cut away in such manner as to provide a curved shoulder at g and a tongue or projection g', there being between these a peripheral wall g^2, concentric with the outer periphery g^3.

G′ is a flange projecting outwardly from the outer face of the valve.

H represents the cap-piece which closes the outer end of the steam and valve chamber, it being bolted to the outer surface of the part A′. It is formed with the chamber H′ on its inner face, which communicates with the chamber surrounded by the aforesaid flange G′ on the valve G. In the lower side of this cap-piece H is formed the passage h and a port h' for the supply of live steam. Outside of the flange G′ there is a chamber at G^2, into which the exhaust-steam escapes from the cylinder and from which it passes out through the exhaust-port at a^4. The passages $a^2\ a^3$ (communicating with the cylinder) are at their outer ends of such width that they can be closed by the body portion of the valve G; but inasmuch as this portion of the valve is cut away or mutilated in the manner before described it will be seen that these passages or ports $a^2\ a^3$ are alternately opened and closed in such way that the steam is admitted to one while it is being exhausted from the other. By having the tongue-piece g' properly related in length it can be used to cut off the exhaust at such time as to allow the cushioning which is necessary. It can be made of the proper size when the valve is being constructed, or it can be formed of adjustable parts, so that after the engine is put in use any required adjustment can be attained. The paths traveled by the live steam and by the exhaust-steam, respectively, will be understood by examining the drawings, reference being made to the arrows in Figs. 2 and 4.

The cap H fits sufficiently close to the flange G′ to effectually separate the live-steam chamber from that which receives the exhaust.

With the mechanism above described a governor can be combined or not, as is desired. I, however, prefer to employ a governor to regulate the supply of steam, and have shown that form which I at present adopt.

The shaft C projects a short distance through the steam or valve chamber and is provided with a central longitudinal aperture extending from the end of the shaft to a point within the steam-chest. Preferably this aperture extends into the above duct c, and the outer end of the latter is closed by a threaded plug c^6. This latter can be used to regulate the amount of steam admitted behind the tooth E^2, for it (the part c^6) can be screwed in far enough to close more or less of the inlet-duct c^2.

I I represent governor-balls adapted to operate in substantially the ordinary way so far as concerns a tendency to move centrifugally under an increase in velocity. They are carried by pivoted arms or levers $i'\ i^2$. These latter have their inner ends situated in slots i in the shaft. They act to draw out longitudinally a bar i^4. They bear against a cross-bar i^3, situated in the side slots i and secured to said bar i^4. At the inner end the bar i^4 carries a cross-bar i^6, and the latter is secured to an annular valve I′, which is fitted against the inner surface of the flange G′. When the balls I separate, they operate to draw the valve I′ outward, so as to close more or less of the port h', through which the live steam enters. When a decrease of velocity occurs, the rod i^4 is forced inward by means of a coiled spring i^8, bearing against the plug i^9 and against the aforesaid cross-bar i^3. By means of the plug i^9 the pressure of the spring i^8 can be so regulated as to have the motions of the valve properly adjusted, the plug be-

ing screw-threaded, so that it can be forced more or less against the spring.

Governors of modified forms can be used, and their constituent parts can be so constructed and arranged that the shaft C shall be permitted to extend outward on the side on which lies the governor to a point beyond the same, for the purpose of transmitting power at such more distant point on that side. In the construction shown the intention is to take the power from the shaft on that side of the engine which is opposite to the governor.

I am aware of the fact that direct-acting engines have been heretofore known in which the driven shafts pass directly through the cylinder and directly through the piston or through the intermediate connecting part which unites the piston-heads in the cylinder.

The power is applied to the shaft on a longitudinal line (relative to the cylinder) away from but parallel to the axis of the cylinder. In the construction shown the lines at which the power is applied are constantly at the farthest point from the axis; but it will be understood that if the power be applied parallel to this axis on other lines some of the advantages can be attained, even though the said lines should be nearer the axis than are the lines of application shown. Again, it will be seen that one of the racks is during the first half of a revolution of the shaft engaging with it and exerting a pushing action thereon and that the other rack is during the other or second half of each revolution engaging with and pushing upon the shaft, each rack being practically disengaged from the shaft during one half of each revolution, the engine in this respect differing radically from those in which the connecting device which unites the shaft to the two piston-heads pushes upon the shaft during one half of a revolution and pulls upon it during the other half. Then, in respect to those earlier constructions, in which use has been made of a crank, my engine is much superior, as I avoid entirely what is known as "dead-center," as will be fully understood by those skilled in the matters to which my invention pertains, I applying the power at all times at ninety degrees, substantially as above described. However, I do not wish all parts of the present invention to be limited to the matter of applying the power at all times at ninety degrees, as engines having some of the said features can be employed, even if there be modification as concerns the line on which the power is applied.

In several other features my construction is superior to those heretofore known, which matters will be understood from the foregoing description and the following claims.

I am aware of the fact that mechanical movements of numerous sorts have been used for converting reciprocating rectilineal motion into rotary motion, including toothed racks and toothed cranks or wheels of various sorts, and I do not claim such devices as my invention; but so far as I know I am the first to have arranged translating devices of any of these sorts in such way that an engine could be greatly simplified, piston-rods, stuffing-boxes, guides, and cross-heads could be dispensed with, and all of the mechanism be arranged between the piston-heads, within the cylinder, and in such way that the power should always be transferred from the piston to the shaft on lines substantially parallel to the axis of the cylinder.

What I claim is—

1. The combination of the cylinder, the two piston-heads both in said cylinder, the connecting bars B, B^2, fitted to the top and bottom cylinder walls, the end parts B^3 B^4, having cam-shaped recesses, a shaft passing through the cylinder, between the piston-heads, fixed in transverse lines relatively to cylinder and rack and having a cam which intermittingly engages with the said recessed parts alternately, and the connecting devices one of which exerts a pushing action on the shaft during the first half of a revolution and is disengaged during the second half, and the other which exerts a pushing action during the second half of the revolution and is disengaged during the first, substantially as set forth.

2. The combination with the cylinder, of the two piston-heads in said cylinder, the connecting bars B B^2 fitted to the top and bottom cylinder walls and having teeth projecting inwardly therefrom, the shaft passing through the said cylinder between the connecting bars B B^2 and mounted in bearings in the walls of the cylinder, and also stationary in transverse lines relatively to the rack and the cylinder a cam on said shaft having teeth which intermittingly engage with the teeth on said connecting bars, whereby the said shaft is continuously rotated, substantially as set forth.

3. In an engine, the combination of a cylinder, a rectilineally reciprocating piston, a shaft passing through the cylinder, and means for converting the rectilineal motion of the piston into the rotation of the shaft, said means comprising interlocking teeth of which one is movable by steam pressure relatively to the part which carries said tooth, substantially as set forth.

4. In an engine, the combination of the cylinder, a rectilineally reciprocating piston, a shaft passing through the cylinder, a rack carried by the piston, and a toothed crank carried by the shaft, one tooth of said crank being movable on non-radial lines relatively to the other parts of the crank, substantially as set forth.

5. The combination with the cylinder, the piston, and the shaft, of the rotating valve G, having the flange G′ and the tongue g', substantially as set forth.

6. The combination of the cylinder, the piston, the engine shaft passing through the cylinder, the steam chest, the governor valve, the governor, the reciprocating bar i^4, sliding longitudinally in the engine shaft, cross-bar i^6, and the cross-bar i^3, substantially as set forth.

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

JOSEPH A. ARTHUR.

Witnesses:
KATE E. WILLIAMS,
ROBERT H. EVANS.