No. 867,394. PATENTED OCT. 1, 1907.

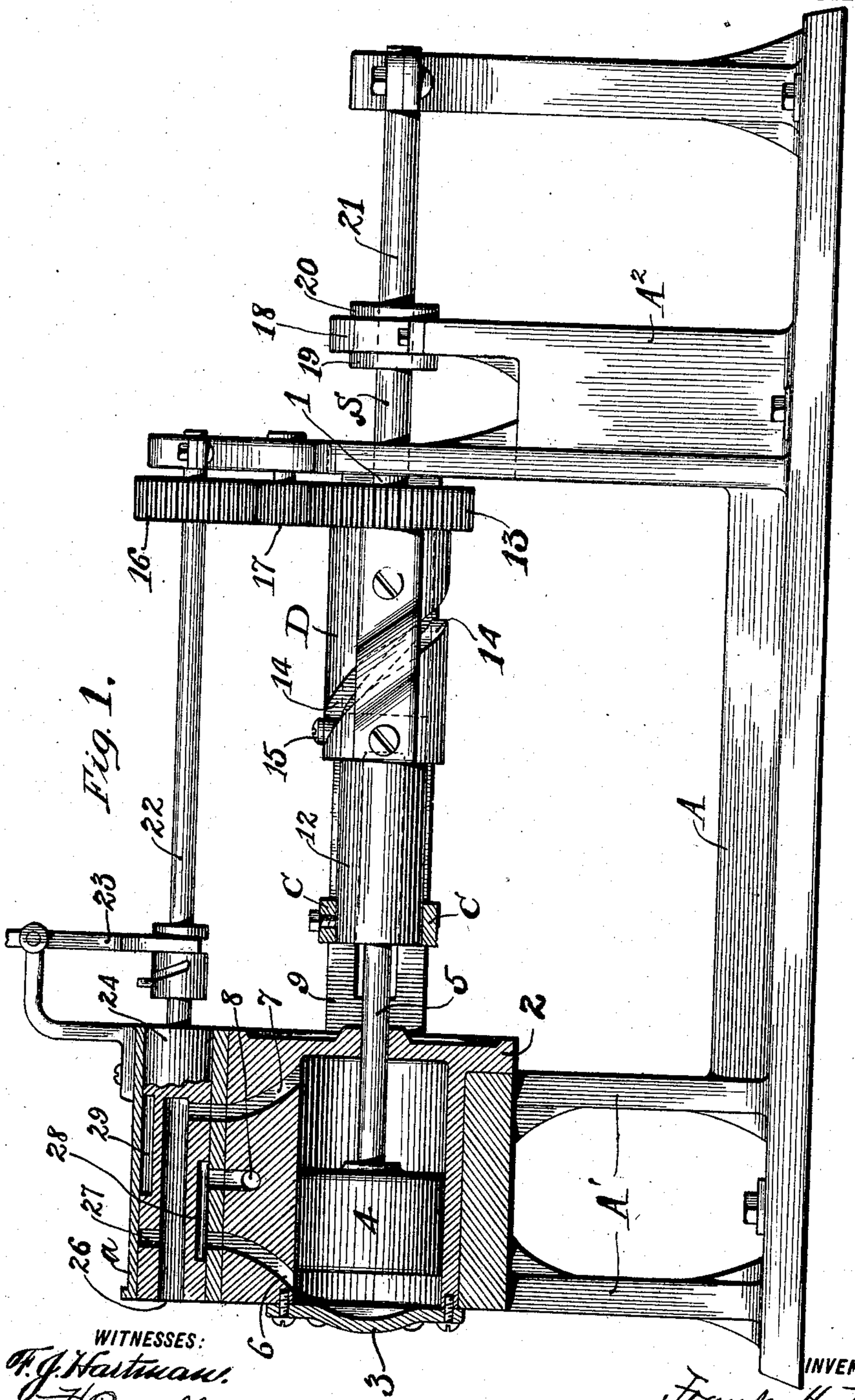
F. H. MILLS.

STEAM ENGINE.

APPLICATION FILED DEC. 23, 1903.

4 SHEETS—SHEET 1.

Fig. 1.



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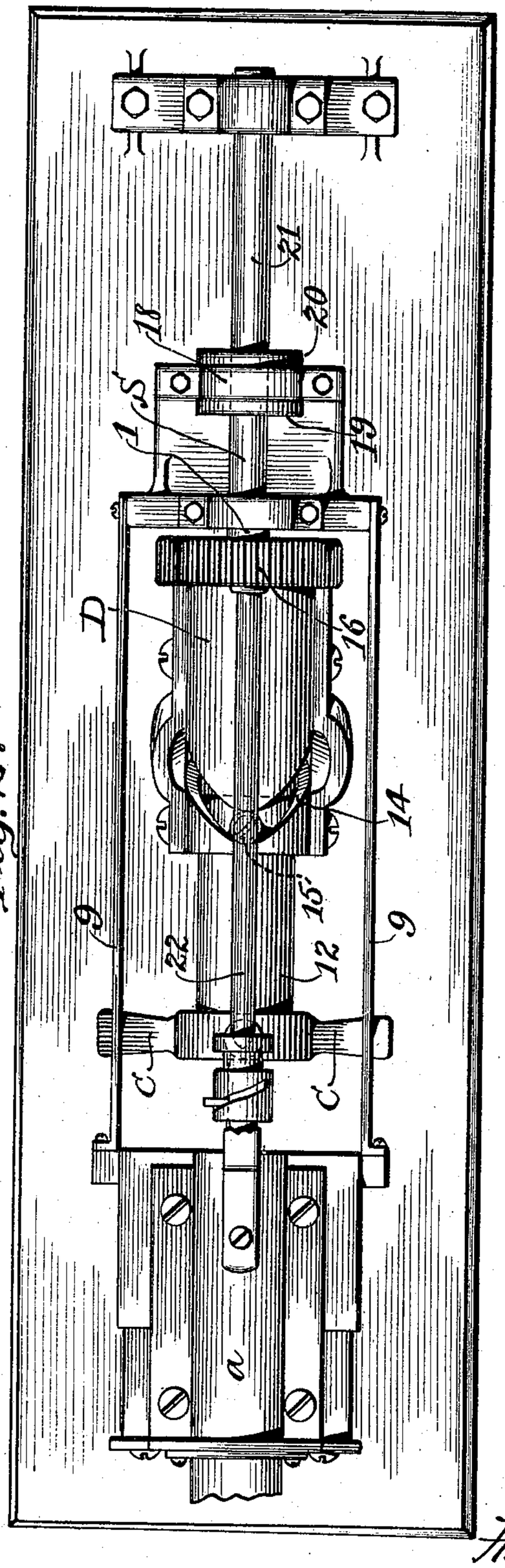
4 SHEETS—SHEET 2.

Fig. 2.



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4 SHEETS—SHEET 3.

Fig. 4.

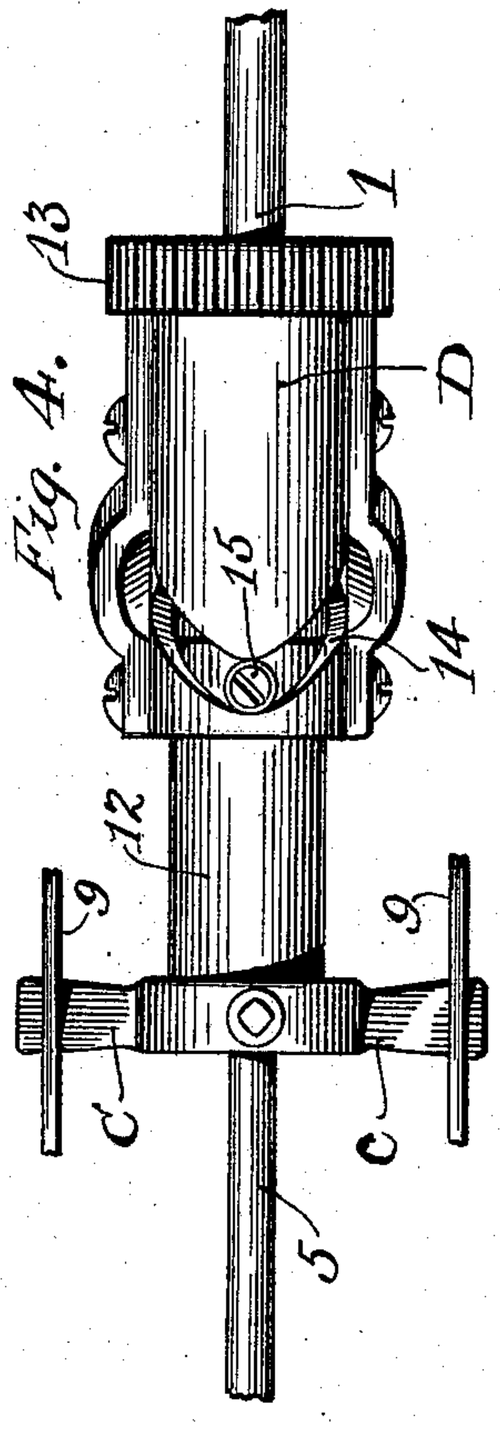


Fig. 5.

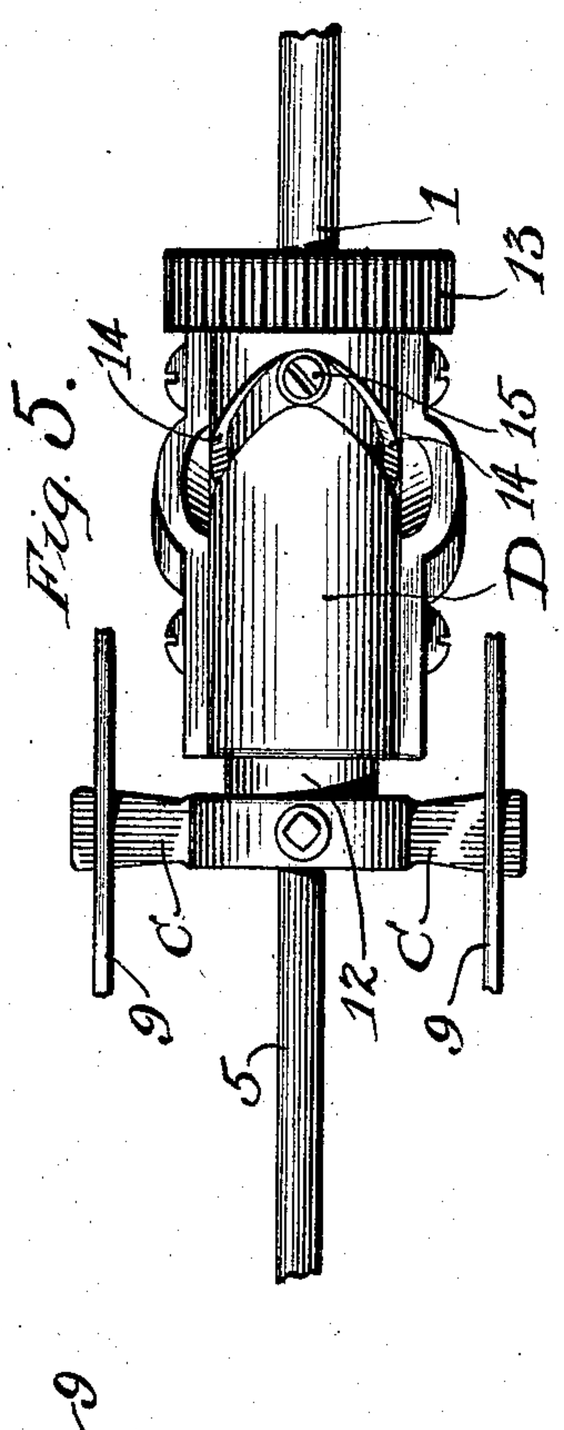


Fig. 6.

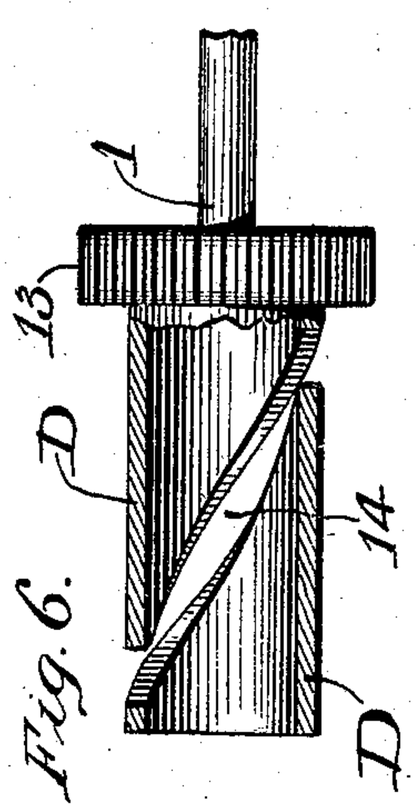
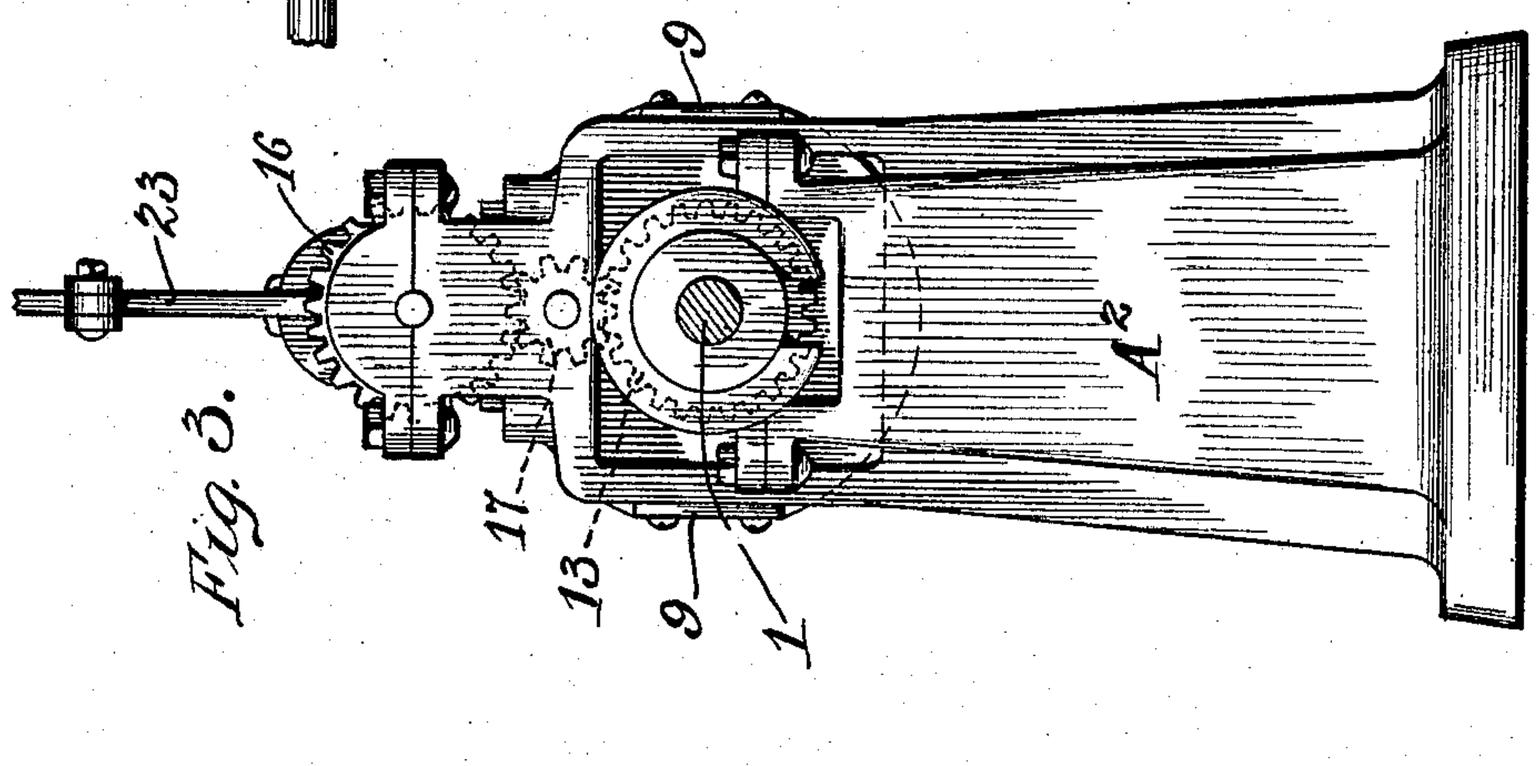


Fig. 3.



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STEAM ENGINE.

APPLICATION FILED DEC. 23, 1903.

4 SHEETS—SHEET 4.

Fig. 7.

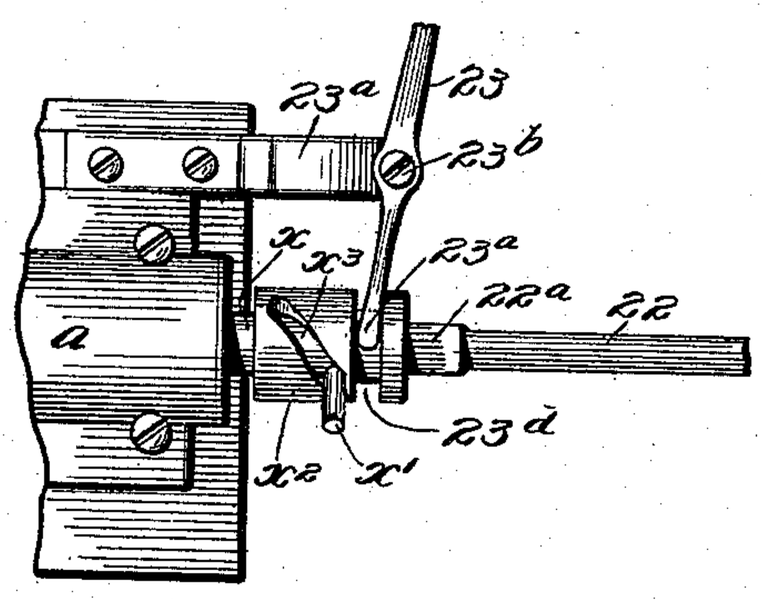


Fig. 8.

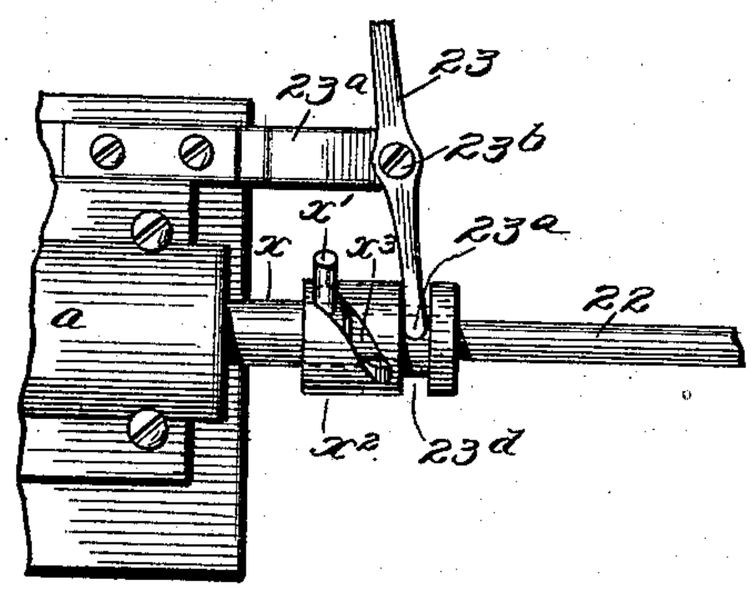


Fig. 9.

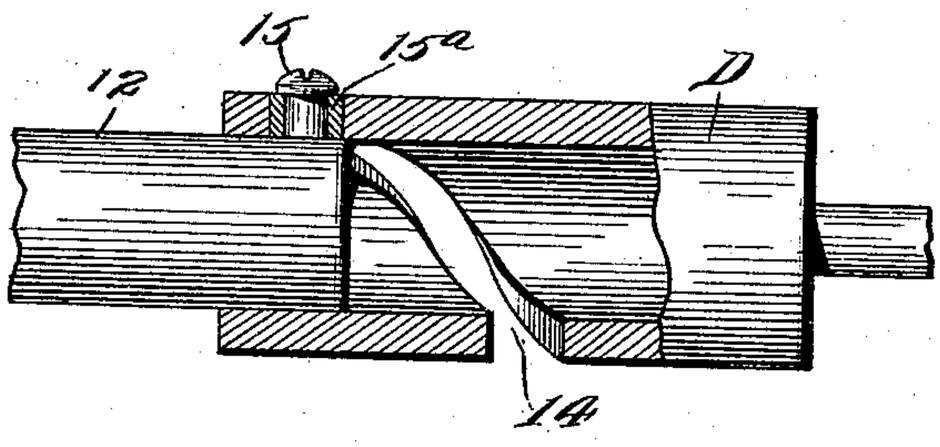
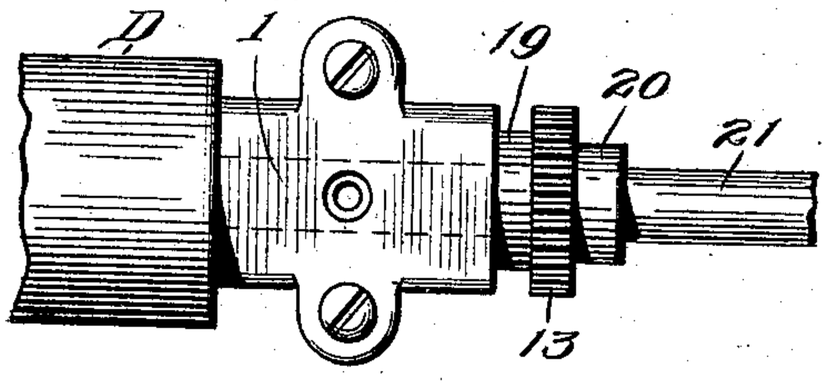


Fig. 10.



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UNITED STATES PATENT OFFICE.

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STEAM-ENGINE.

No. 867,394. Specification of Letters Patent. Patented Oct. 1, 1907.

Application filed December 23, 1903. Serial No. 186,287.

To all whom it may concern:

Be it known that I, FRANK H. MILLS, a citizen of the United States, residing at Camden, in the State of New Jersey, have invented certain new and useful Improvements in Steam-Engines, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

My invention relates to engines operated by steam or other motive fluid, and has for its object to improve that class of engines in which means are employed for directly transmitting and converting the power developed by a reciprocating piston into rotary motion, without the necessity for interposed crank mechanism; and to improve the means constituting the valve mechanism and its actuating devices, governing the inlet and exhaust ports of the engine, whereby it may be actuated by the directly-rotated power shaft and in unison of time therewith.

To these ends my invention consists of the novel means hereinafter described, comprising in combination with the cylinder and piston of a reciprocating engine, of a rotatable power shaft in alinement therewith, means between the same to rotate the power shaft directly from the reciprocating piston, a steam chest on the cylinder, a hollow valve therein, inlet and exhaust ports common to the valve and steam chest, a valve stem, a shaft therefor, power transmitting devices between the power shaft and valve shaft, and connecting mechanism between the valve stem and valve shaft operating to normally actuate the valve, and also to reverse the valve motion at pleasure.

In the accompanying drawings illustrating my invention: Figure 1 is a side elevation, partly in section, of an engine comprising the novel features of construction stated; Fig. 2 is a plan view thereof; Fig. 3 is an end rear view. Figs. 4 and 5 are detached views of the end of the piston rod, the cross-head and its extension end, the power shaft, the cam-grooved sleeve and actuating cam-pin; these views showing the position of the parts when the piston is at full inward stroke (Fig. 4) and full outward stroke, respectively; and Fig. 6 is a detached sectional view of one-half side or round, of the spiral cam-grooved sleeves mounted on the power shaft. Figs. 7 and 8 are plan views of the valve actuating and reversing mechanism and adjunctive parts, showing the reversing sleeve in its two different positions. Fig. 9 is an elevation, partly in section, to illustrate the compensating device to take up wear between the actuating pin and the cam-grooved sleeve between piston connection and power shaft; and Fig. 10 is a plan view showing the thrust-bearing for the main power shaft.

Referring now to said drawings, A indicates a supporting-frame with standards A', A^2. The standard A' fixedly supports the engine cylinder 2, the open bored end of which is closed by cylinder-head 3. Steam ports 6 and 7 and exhaust passage 8, are provided as usual. The engine is provided with the usual reciprocating piston 4 and piston rod 5, with cross-head guide-plate 9. A cross-head C is shown, to which the end of the piston rod is secured (see Fig. 2) said cross-head having rigidly connected to it a projecting cylindrical piston shaft 12. A power shaft 1 is rotatably supported upon the frame of the engine, in alinement with said shaft 12, and directly rotated thereby, the two being operatively connected by and through a cam-grooved sleeve D which is fixedly mounted on the inner end of the rotatable power shaft. And a cam-pin 15 on the periphery of the reciprocating piston shaft 12 plays in the double spiral cam-groove 14 of the sleeve D on the end of the rotatable power shaft. As the cam-pin travels back and forth in the double spiral cam groove of the sleeve, on the reciprocation of the piston shaft 12, the sleeve is rotated and with it the alining power shaft on which it is fixedly mounted.

Near the rearward end of the rotatable power shaft 1 is mounted fast thereon a gear wheel 13, and it drives a gear wheel 16, in the same direction, through an interposed pinion 17, these gears being mounted on the standard A^2 (see Fig. 1) for the purpose of actuating the valve mechanism hereinafter described. An extension S of the rotatable power shaft 1 abuts against a thrust-bearing 18 shown formed of two collars 19 and 20 (see Figs. 1 and 2) and a further extension 21 of said shaft will supply means for any usual device for transmitting rotary power, as a source of supply, to a belting or other means, or to drive a marine screw. Instead of the end thrust-bearing for the power shaft being constructed as described, the collars 19 and 20 may be arranged as shown in Fig. 10 wherein the gear 13 on the power shaft is arranged between the two bearing collars; but any other arrangement of said elements which will give a bearing to sustain the end thrust of the shaft will operate in the same way.

As a leading feature in my new engine and characteristic of it, is the mechanism for transmitting and directly converting the reciprocating motion of the piston and its adjunctive parts into rotary motion, as a functional substitute for the ordinary crank shaft, it is to be noted, as essentials, that the cross-head *c* working in guides, is provided, to prevent rotation of the piston shaft 12 carried by said cross-head, and that said shaft carries the cam-pin 15. Also that the power shaft 1 is mounted in alinement with the piston and piston shaft, and that the sleeve D which is fixedly mounted on the inner end of the latter is cam grooved with a double spiral groove 14, one side of which is shown in detached view in Figs. 6 and 9, with top and bottom side views thereof in Figs. 4 and 5. As the groove extends throughout the complete periphery of the sleeve, severing it in two parts, these are secured together by oppositely disposed connections as shown in Figs. 4 and 5. By ref-

erence to Fig. 4, showing a full inward stroke of the piston (which is also that represented in Figs. 1 and 2) it will be seen that the cam pin has caused the cam-grooved sleeve to make exactly a half revolution, which in turn has rotated the power shaft and the gearing and connected valve shaft, rotating the valve and bringing it into position to open the steam ports in the cylinder to cause an outward stroke of the piston, which, on its full outward stroke (shown in Fig. 5) has caused another half revolution of the sleeve and power shaft; so that each full reciprocation of the piston causes a full revolution of the sleeve and power shaft. Means are provided to compensate for wear in the cam-grooved sleeve, which may be made of hardened tool steel, these means consisting (see Fig. 9) of a ring 15^a mounted loosely sleeve-like on the cam-pin 15 and rotatable thereon and therefore interposed and rotatable between the cam-pin 13 and the walls of the spiral groove 14 in the sleeve D. This rotatable ring reduces friction and at same time compensates for wear, as the walls of the spiral groove in the sleeve are preferably made with a slight incline towards the base in order that any wear may be taken up by screwing down the cam-pin 15, carrying its rotatable friction ring 15^a lower into the cam-groove and into closer relation thereto.

I will now describe the valve mechanism and its actuating devices: The steam-chest *a* is a hollow cylinder within which is contained a valve 24, shown as a rotary valve, and actuated directly by the valve stem. This valve is a cylindrical plug, practically hollow, because it has a centrally bored steam inlet passage 26 and steam passages 27, 28 & 29 (see Fig. 1) which, on the rotation of the valve, open communication between the steam inlet 26 and the inlet ports 6 and 7 of the engine cylinder, and with the exhaust 8 thereof. It is actuated by the following means: A valve-operating shaft 22 carries the gearing 16 and rotates the valve stem x directly, through the interposed connecting sleeve x^2 which is cam-grooved at x^3 for the purpose of receiving an actuating pin x' on the valve stem x, and is slotted annularly at 23^d to receive the forked end of a reversing lever 23 which is pivotally hung at 23^b on a bracket 23^a mounted, for convenience, on the valve-chest; see Fig. 1. These parts are shown detached, and more in detail in Figs. 7 and 8.

By reference to Fig. 8 it will be observed that the ends of the valve stem x and of the valve shaft 22 meet in and are operatively connected by the sleeve x^2, so that they will rotate together. The shaft 22 is squared at the coincident end to fit a like-shaped opening in that end of the sleeve, or otherwise keyed therein, such as by a feather on the shaft, in order that the shaft 22 will rotate the sleeve and the valve stem. The end of the valve stem x is operatively held, for rotation, by the sleeve x^2, by means of the pin x' on the valve stem, which always bear against one or the other terminus of the groove x^3. For the purpose merely of operatively connecting said elements this groove could be straight, but for the additional purpose of longitudinally sliding the connecting sleeve on the valve stem and valve shaft, the groove is spiraled and thus made a cam-groove, and a shallow annular recess 23^d is cut in the periphery of the sleeve. The forked end of the lever 23 rests in said annular recess. The lever is pivotally mounted, as at 23^b, on the end of a bracket, such as 23^a, supported from the valve chest. A sliding movement of the sleeve, from the position shown in Fig. 7 to that shown in Fig. 8, and vice versa, will make a quarter turn of the valve stem, and bring the steam inlet and exhaust ports into changed relation, thereby reversing the engine.

While I have shown and described what I consider to be the best embodiment of the constructive principles in the invention as a whole and in its several features, it is to be noted that the engine is not confined to the use of steam as a motive fluid, nor is it dependent on the use of a rotary valve. I prefer the rotary valve and particularly my form of it described, for its simplicity and efficiency and for the consequent rapidity with which it supplies and exhausts the motive fluid to and from the engine cylinder, and for its capability of being rotated, through gearing, by and in unison of time with, the rotatable power shaft in alinement with the reciprocating piston and its shaft.

The constructive principles of my invention can be embodied in an engine, such as illustrated, for either stationary or marine purposes, or for light work such as in automobiles. It is compact and will develop greater power as compared with an engine of the same size of cylinder the power from which is transmitted by crank mechanism; there is practically no limit to the speed which may be developed; there is substantially no dead center to be compensated for, the power developed is the same at either end as in the middle of the stroke; it can be reversed quickly and operate precisely the same in either direction; and it will give greater leverage of the piston shaft as compared with a crank-shaft engine, without any lengthening of the piston stroke.

While I have shown in the drawings the details of construction of the mechanism between the piston shaft and the rotatable power shaft in alinement therewith, for directly converting the power developed as reciprocatory in the former into rotary in the latter, it is to be noted that I have filed a separate application for patent for the same, as a new mechanical movement for such purpose, and hence I make no claim herein to that feature, as a separate and distinct element of the combinations of mechanisms described, forming an engine as shown.

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

1. In an engine of the class recited, a cylinder, a piston and piston rod therefor, a rotatable power shaft in alinement therewith, an end-thrust bearing therefor, a cam-grooved sleeve and actuating pin therefor operatively mounted between the piston rod and power shaft, a steam chest cylindrically bored, with inlet and exhaust passages leading therefrom to the engine cylinder, a hollow cylindrical valve having ports and passages adapted to be brought into register with the ports and passages of the steam chest, a valve-actuating shaft parallel with the rotatable power shaft of the engine, with power transmitting devices intermediate said power shaft and valve actuating shaft.

2. In an engine of the class recited, a cylinder and piston rod, a rotatable power shaft operatively supported in alinement therewith, means to directly rotate said power shaft by the reciprocatory movement of the piston rod, said means comprising a hollow sleeve the peripheral wall of which is provided with a reversely-set spiral cam-groove having inwardly inclined walls, and an actuating cam pin provided with a rotatable collar in operative engagement with said cam groove, power transmitting gear-

ing carried by said power shaft, valve-actuating mechanism in substantial parallelism with said power shaft, and a hollow valve actuated thereby and having inlet and exhaust ports governing the steam ports and passages of the piston cylinder.

3. In combination with the engine cylinder, piston, piston rod, a rotatable power shaft, a thrust-bearing therefor, means to effect alinement of said elements, a cam-grooved sleeve and actuating cam pin therefor between the power shaft and the piston rod, gearing upon the power shaft communicating through a pinion with other gearing, a rotating valve stem driven by the latter, a steam chest cylindrically bored, with inlet and exhaust passages leading therefrom to the engine cylinder, and a cylindrical hollow plug-valve rotating therein and having inlet and exhaust ports and passages adapted to register with the ports and passages in the steam chest.

4. In combination with the engine cylinder, a piston movable therein, a piston rod, a sleeve adapted to receive said piston rod, connections between said sleeve and piston-rod whereby said sleeve is rotated through the reciprocation of said piston rod, a power shaft in alinement with said sleeve; connections between said sleeve and shaft for driving the latter from the former, valve-actuating mechanism for controlling the supply of steam to the cylinder and connections between the aforesaid sleeve and said valve actuating mechanism for operating the latter.

5. In combination with the engine cylinder, a piston therein, a piston rod, a sleeve adapted to receive said piston rod, connections between said piston rod and sleeve, whereby said sleeve is rotated through the reciprocation of the piston rod, said connections comprising a cam groove in said sleeve and a coöperating pin on said piston rod, valve actuating mechanism for controlling the supply of steam to the cylinder and suitable connections between said sleeve and said valve actuating mechanism whereby the latter is operated.

In testimony whereof, I have hereunto affixed my signature this 14th day of December, A. D. 1903.

FRANK H. MILLS.

Witnesses:
WM. A. HUSTED,
SAML. R. LODGE.