No. 753,527. PATENTED MAR. 1, 1904.

J. M. STADEL.

GAS ENGINE.

APPLICATION FILED JUNE 23, 1902.

NO MODEL. 8 SHEETS—SHEET 1.

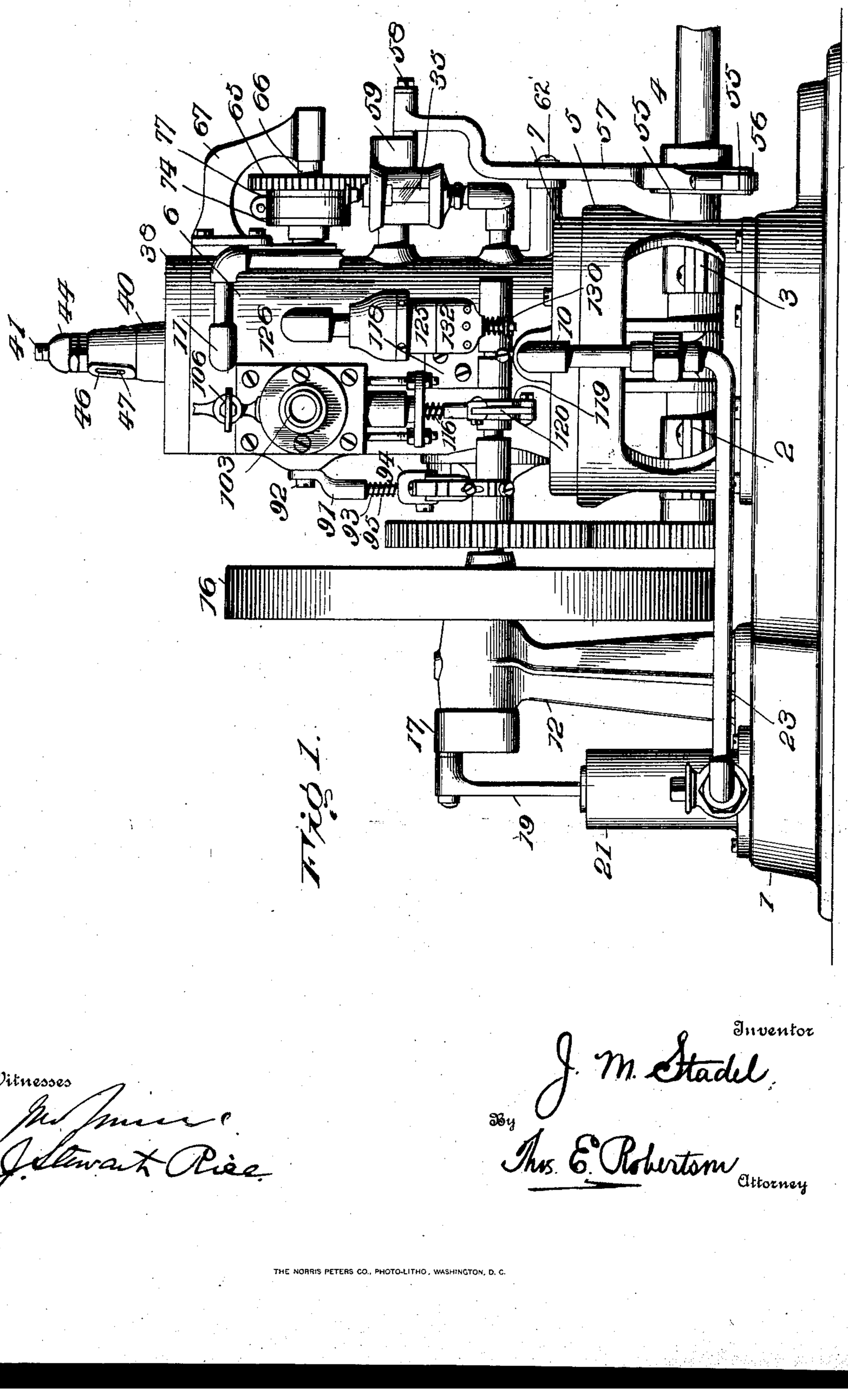

Fig. 1.

Witnesses

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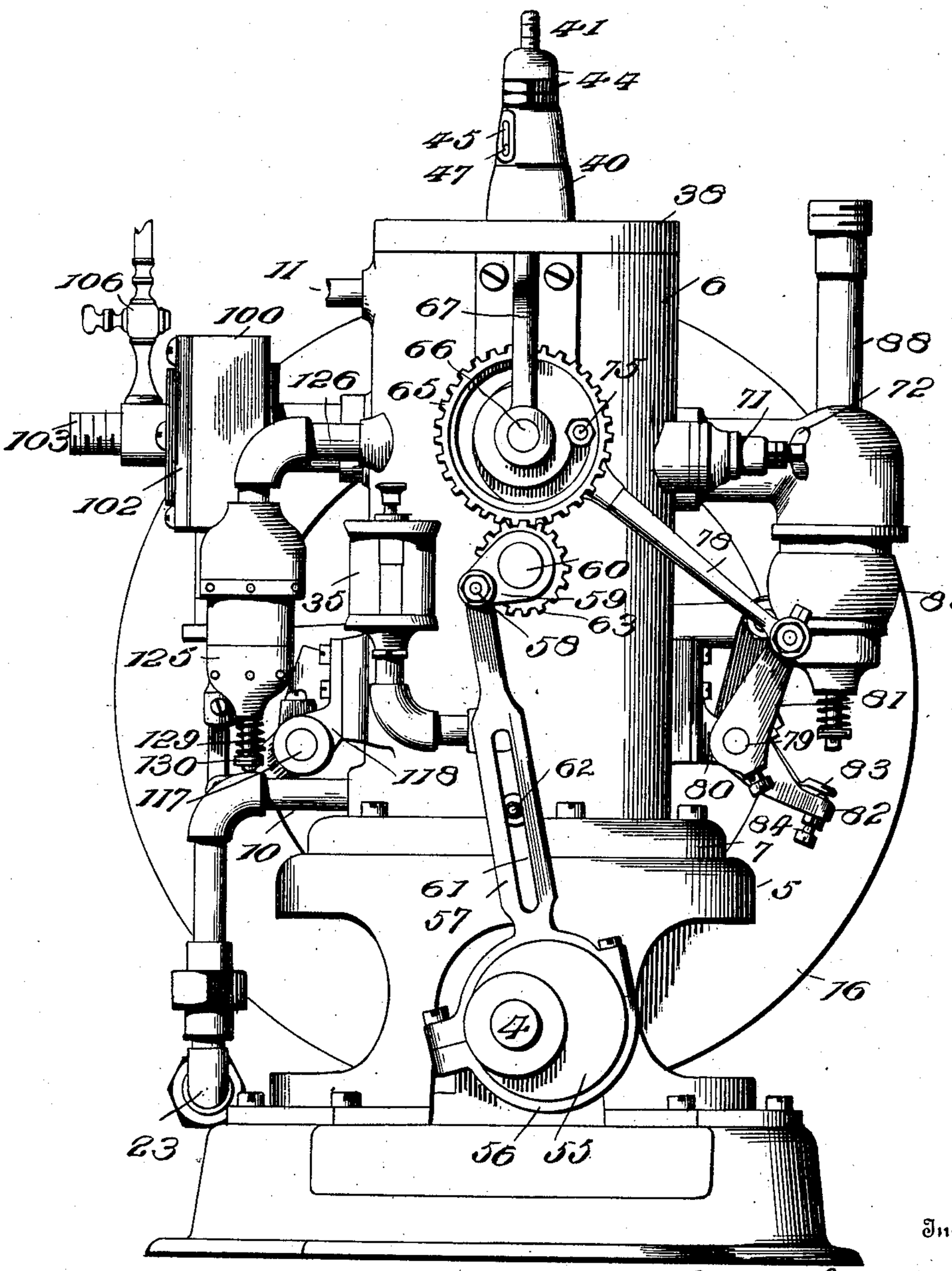
NO MODEL. 8 SHEETS—SHEET 2.

Fig. 2.



Witnesses

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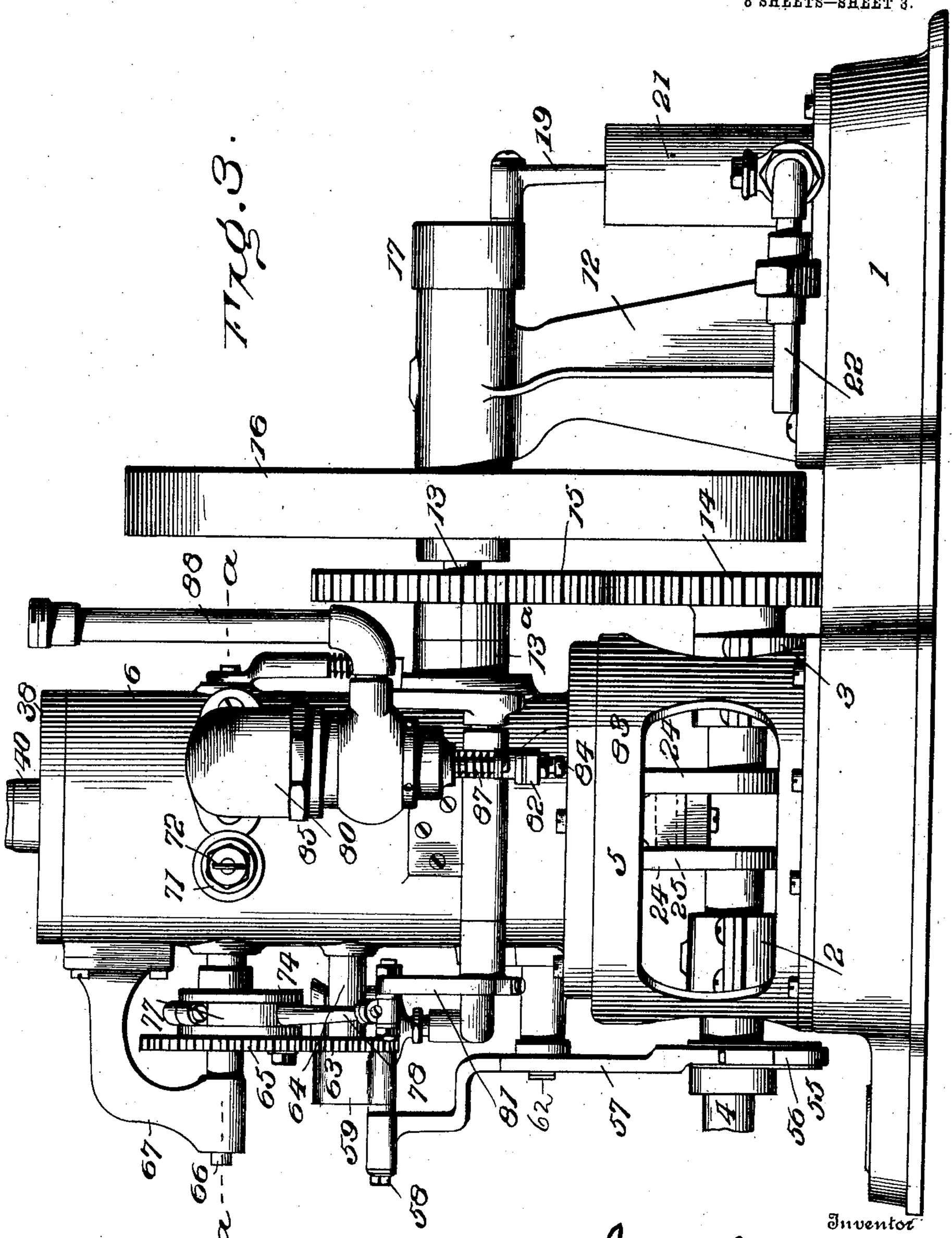
NO MODEL. 8 SHEETS—SHEET 3.

FIG. 3.



Witnesses

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NO MODEL. 8 SHEETS—SHEET 4.

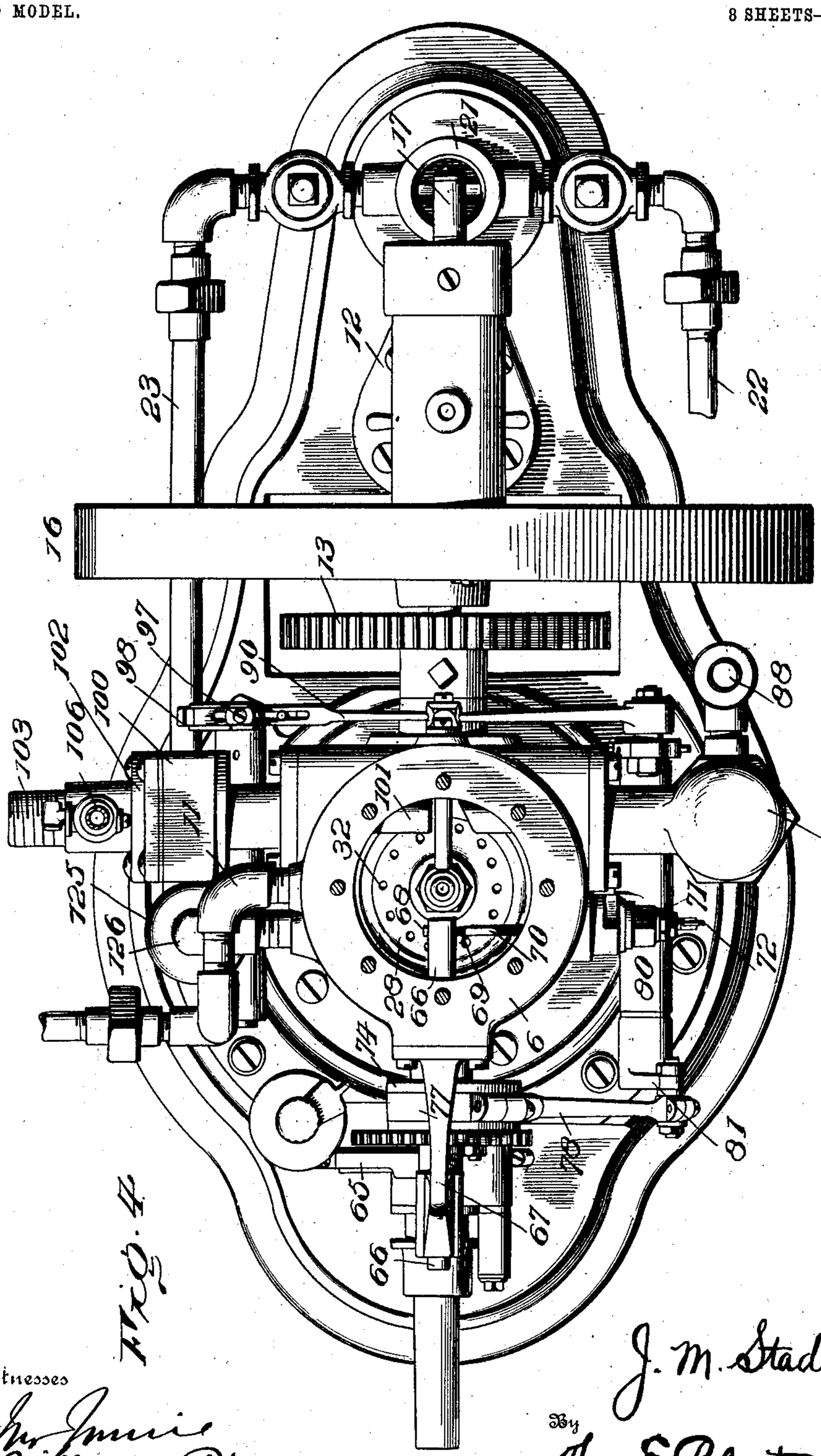

Fig. 4.

Witnesses

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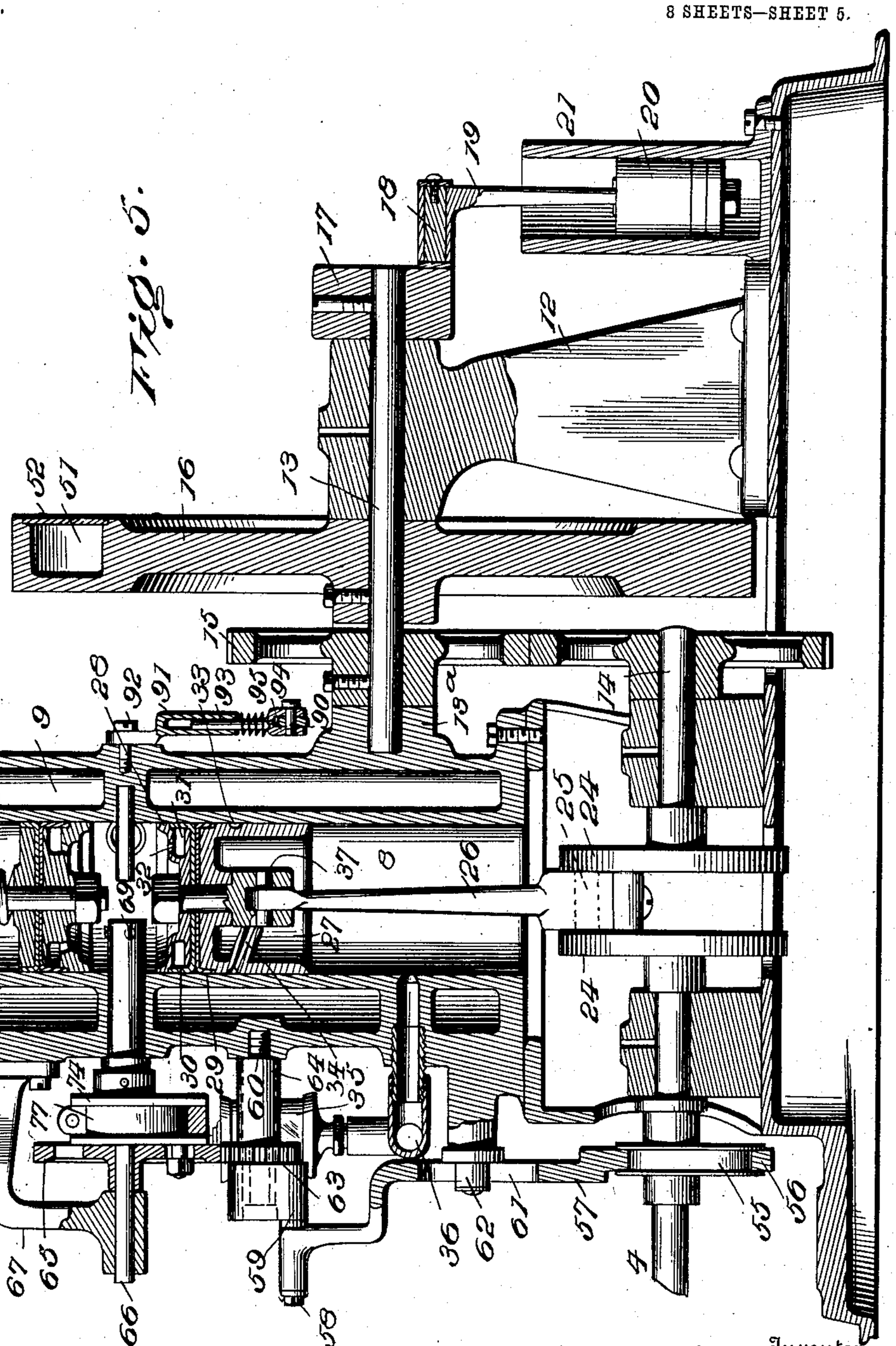
NO MODEL. 8 SHEETS—SHEET 5.

Fig. 5.



Witnesses

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NO MODEL. 6 SHEETS—SHEET 6.

Fig. 6.

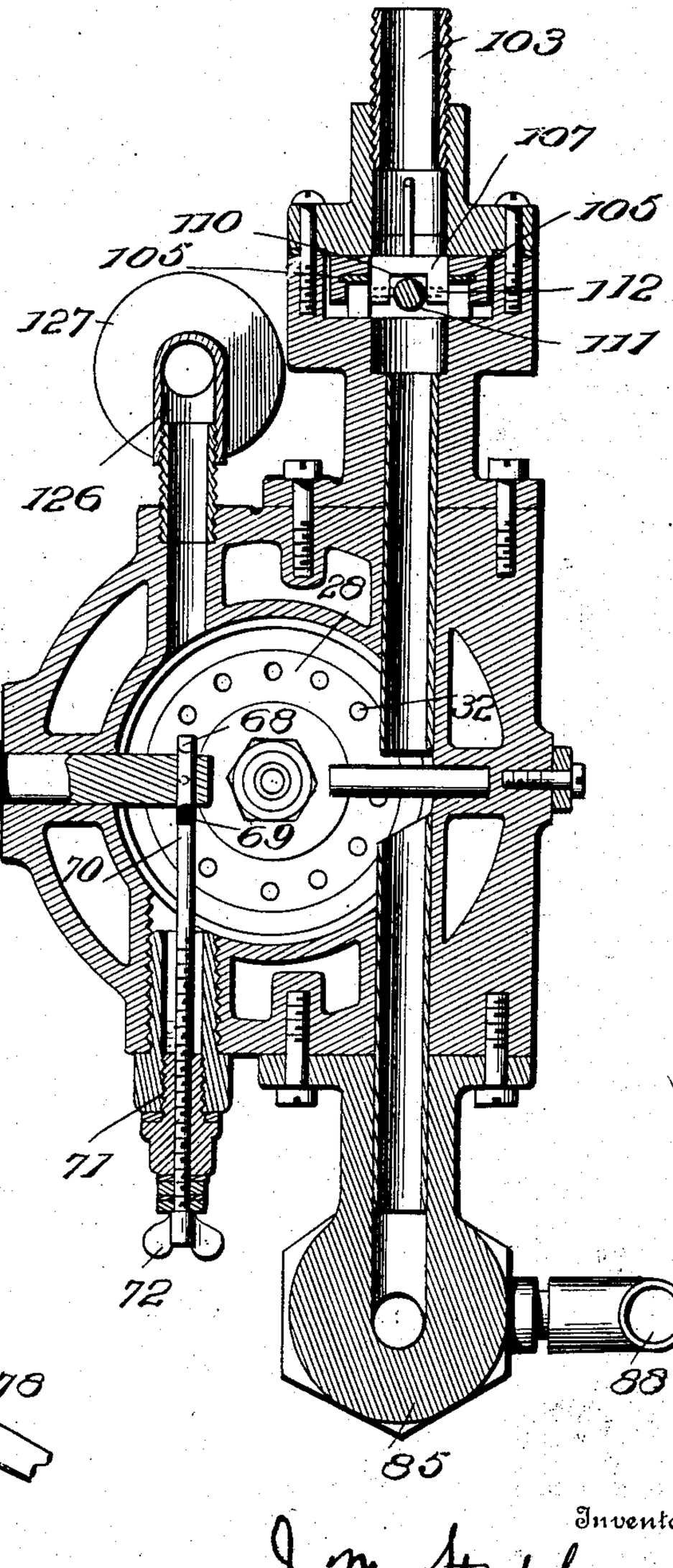


Fig. 7.

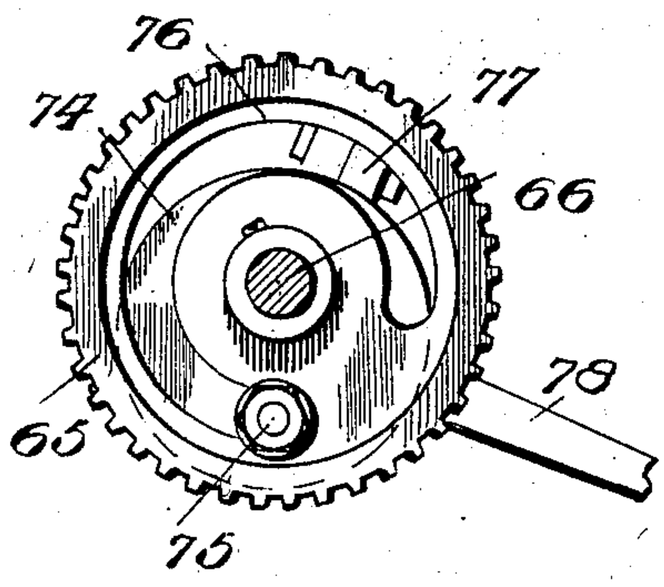
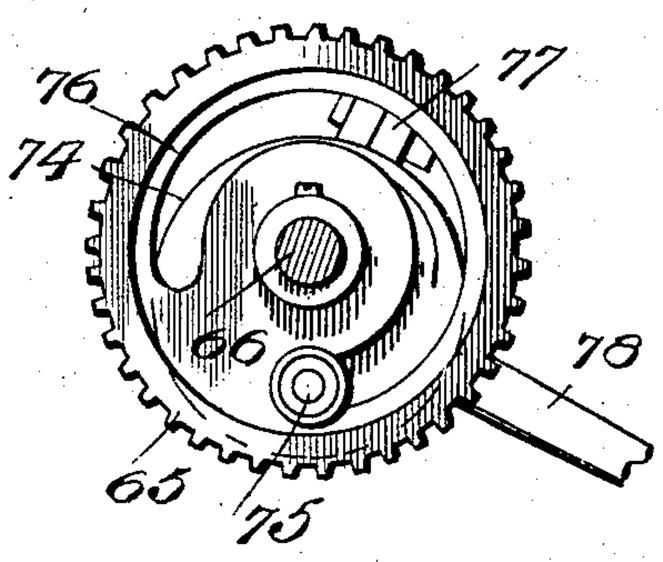


Fig. 8.



Witnesses

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No. 753,527. PATENTED MAR. 1, 1904.

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GAS ENGINE.

APPLICATION FILED JUNE 23, 1902

NO MODEL. 8 SHEETS—SHEET 7.

Fig. 9.

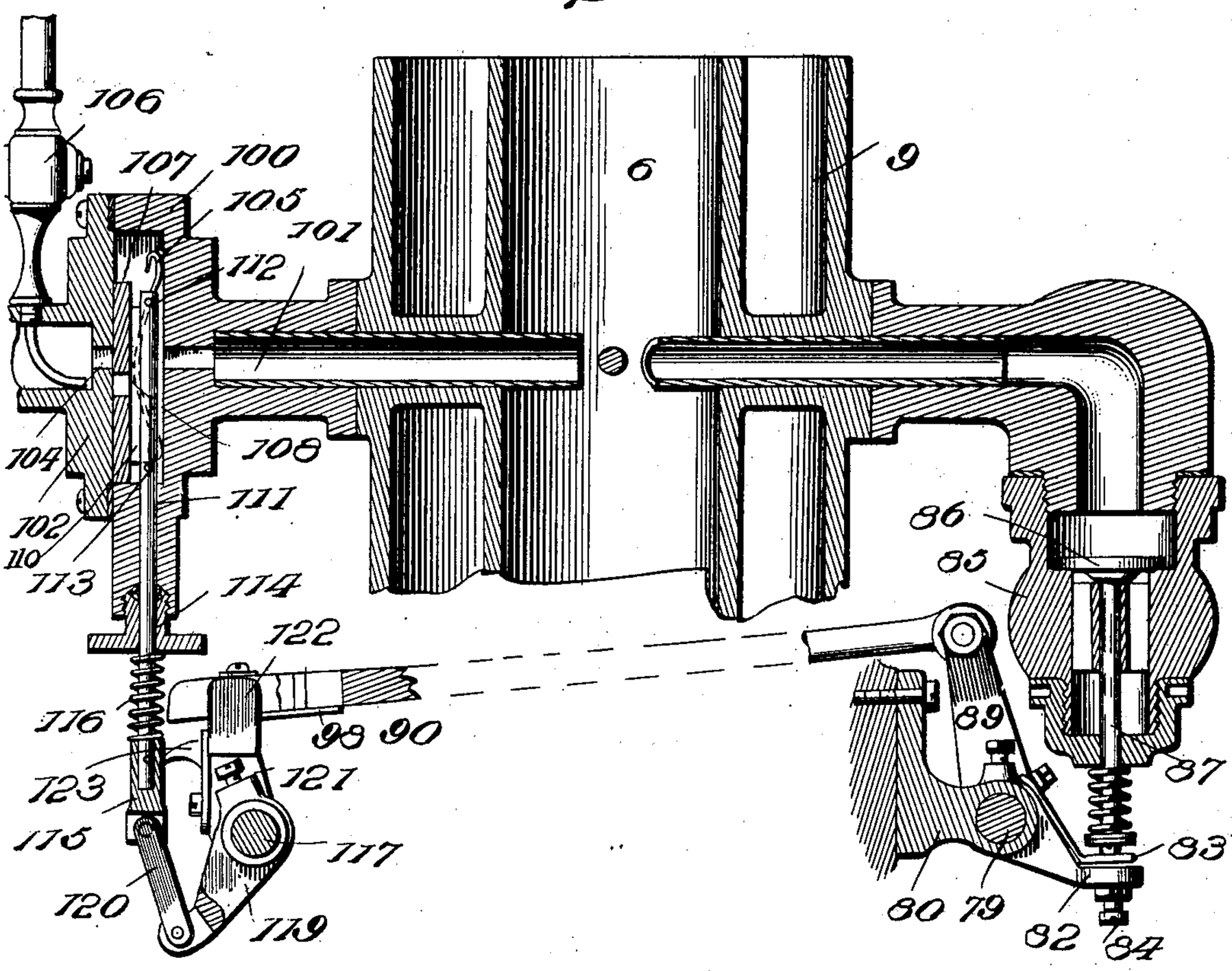
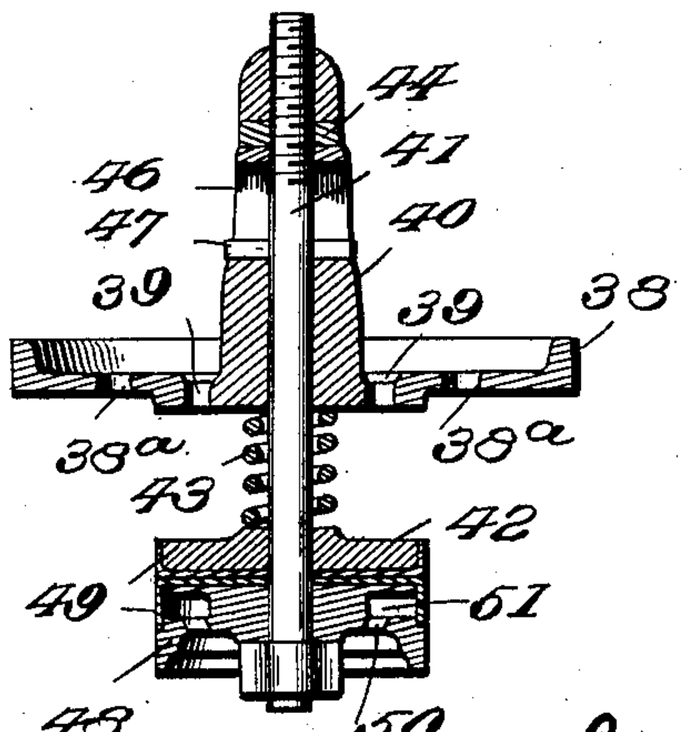


Fig. 11.



Witnesses

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No. 753,527. PATENTED MAR. 1, 1904.

J. M. STADEL.

GAS ENGINE.

APPLICATION FILED JUNE 23, 1902.

NO MODEL. 8 SHEETS—SHEET 8.

Fig. 10.

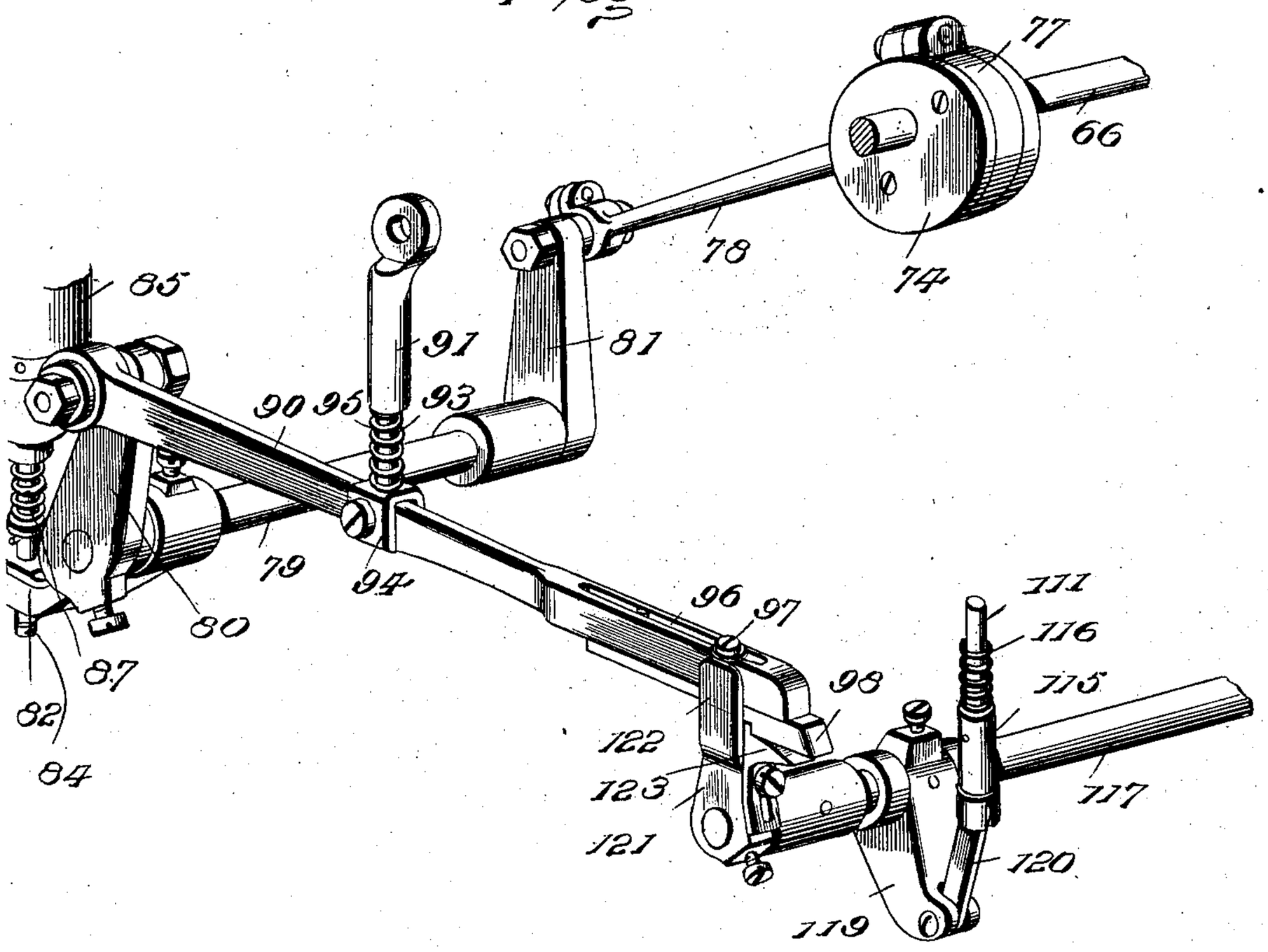
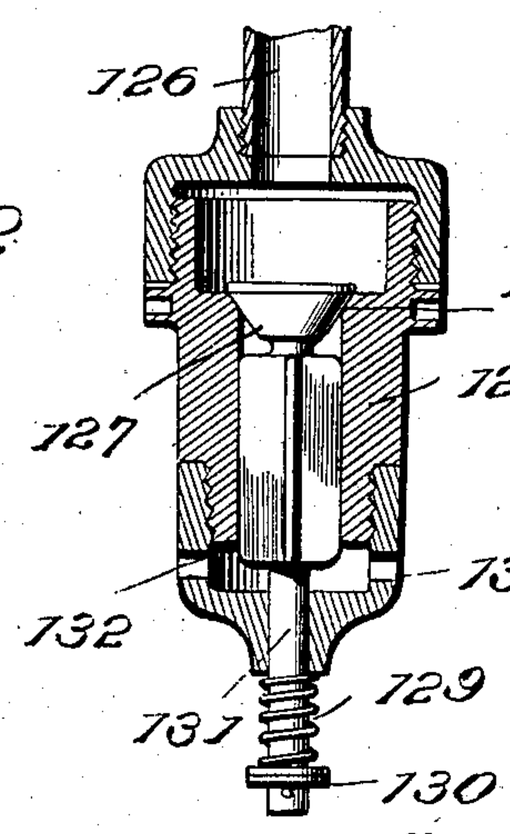


Fig. 12.



Witnesses

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J. Stewart Rice.

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Thr. E. Robertson

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No. 753,527. Patented March 1, 1904.

UNITED STATES PATENT OFFICE.

JOHN MARTIN STADEL, OF WILMINGTON, DELAWARE, ASSIGNOR OF ONE-HALF TO WILLIAM A. McCOWEN, OF WILMINGTON, DELAWARE.

GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 753,527, dated March 1, 1904

Application filed June 23, 1902. Serial No. 112,928. (No model.)

To all whom it may concern:

Be it known that I, JOHN MARTIN STADEL, a citizen of the United States of America, and a resident of Wilmington, in the county of Newcastle and State of Delaware, have invented certain new and useful Improvements in Gas-Engines, of which the following is a specification.

This invention relates to improvements in gas-engines, and especially to those engines which are adapted for use on launches, ships, &c., although, of course, it is readily adapted to other purposes.

It is my object to construct an engine which is extremely compact, very powerful for its size, and one that can be easily kept from undue heating.

A further object is to invent an engine in which the driving-shaft is at the very bottom or base of the engine notwithstanding the fact that the fly-wheel and its shaft are located rather high relatively. This location of the shaft not only makes it possible to run the driving-shaft itself directly into the water and overcomes loss of power and obviates other objectionable features common to engines with which I am familiar, but enables me to place a pump under the fly-wheel shaft and yet have the main shaft placed extremely low.

With these main objects in view my invention consists in the engine as shown in its preferable embodiment in the accompanying drawings and as will be hereinafter more particularly described and then definitely claimed at the end hereof.

In the drawings accompanying and forming a part of this application, Figure 1 is a side elevation of an engine constructed in accordance with my improvement, the main shaft being shown as broken away. Fig. 2 is an end elevation taken from the right-hand end as shown in Fig. 1. Fig. 3 is a side elevation taken from the opposite side from that shown in Fig. 1. Fig. 4 is a top plan with the cylinder-head removed. Fig. 5 is a vertical central longitudinal section. Fig. 6 is a horizontal section through the line *a a* of Fig. 3. Figs. 7 and 8 are details of one of the driving-gears and its connnected parts. Fig. 9 is a vertical section of part of the cylinder, showing the inlet and exhaust valves in section and with other features omitted. Fig. 10 is a perspective view of the mechanism for opening the inlet and exhaust valves entirely detached from the engine to avoid confusion. Fig. 11 is an enlarged detail of the cushioned head of the main cylinder. Fig. 12 is a detail sectional view of an air-valve.

Referring now to the details of the drawings by numerals, 1 represents the base-casting, to which are bolted the bearing-boxes 2 and 3 for the main shaft 4, and the latter is thus supported as near as possible to the base-casting or the foundation on which it rests in order to specially adapt the engine for use in launches, &c. Bolted to the base-casting 1 and extending up and over the main shaft 4 and its bearings is a shell or housing 5, to which is bolted, on the top thereof, the main cylinder 6, the latter being provided with a flanged part 7 at its base affording sufficient strength for bolting. This main cylinder 6 is best shown in Fig. 5, where it will be seen that it has a central passage 8 extending entirely through it and of uniform bore. Around this cylinder is formed a water-jacket 9, which is provided with an inlet 10, (see Figs. 1 and 2,) near the bottom thereof, and an outlet 11, near the top thereof, and water is pumped through this jacket, as will be hereinafter described.

Referring again to the base-casting 1, there will be found a standard 12, bolted to said casting and on which is supported the fly-wheel shaft 13, whose inner end passes into and is journaled in a boss 13^a on the main cylinder 6. (See Fig. 5.) Motion is transmitted to this shaft by means of two gears 14 and 15, the first of which is on the main shaft 4 and the other on the fly-wheel shaft 13. Intermediate of its two bearings the shaft 13 has rigidly secured to it the fly-wheel 16, and on the outer end of said shaft is secured a collar 17, having a wrist-pin 18 to which is connected the piston-rod 19 of a trunk-piston 20, which latter works in a pump-cylinder 21, bolted to the main casting 1. (See Fig. 5.) Motion is thus transmitted from the main

shaft 4 to the shaft 13 and from thence to the piston 20, by which water may be pumped from a suitable source of supply (see the inlet-pipe 22 in Fig. 3) through the outlet-pipe 23 (see Fig. 1) into the water-jacket 9, heretofore referred to, the water leaving the jacket through the pipe 11, where it may be conducted to any suitable place. When my engine is used in a vessel, (for which it is specially arranged,) the inlet and outlet pipes may be connected through the bottom or sides of the boat into the water, and this of course provides a never-ending supply of cool water.

On reference to Fig. 5 it will be seen that the main shaft 4 is divided, and each half has a crank-disk 24 secured to it. These disks are connected by a wrist-pin 25, (shown in dotted lines,) to which is connected a piston-rod 26, which is pivotally attached to the main piston 27, which works in the main cylinder 6. This piston is of novel construction and consists of the usual trunk-piston proper, (marked 27,) and bolted thereto is a head 28, and between the piston 27 and this head 28 are two thicknesses of packing, which are turned in opposite directions, so that one, 29, projects downward and the other, 30, projects upward. The head 28 is formed with an annular opening 31, and passages 32 lead into the annular opening, so that when the expanding gases are driving the piston downward part of the gas enters the passages 32 and acting against the packing 30 forces it outward against the bore of the cylinder, and thus insures the utmost efficiency in practical operation. The piston is also formed with an annular groove 33, from one side of which leads an oil-duct 34, leading downward to the pivotal pin 37, connecting the piston with its piston-rod. The result of this is that as the piston passes upward the oil from an oil-cup 35 passes through a pipe 36 and is scraped into the aforesaid groove 33 and passes from thence to the pivotal pin 37, and any surplus oil may pass from the pin 37 down the piston-rod and lubricate the lower swelled portion of the piston-rod as it turns between the crank-disks 24. The head of the main cylinder 6 is also formed in a novel manner and comprises the head proper, 38, which is also provided with the usual bolt-holes 38ª, by which it is secured in position, and escape-openings 39. (See Figs. 5 and 11.) In addition the head has an upwardly-extending boss 40, through which passes a spindle 41, on the lower end of which is rigidly secured what may be termed a "piston" 42, (although it normally receives no motion,) and between this piston and the bottom of the head 38 is a stiff spring 43, the tension of which may be changed by adjusting-nuts 44. I prefer to have just sufficient tension to equal the force of the expanding charge, as when so adjusted it best breaks the heavy shock and absorbs the vibration. In order to prevent the spindle 41 from turning when the nuts are turned, I insert a pin 47 through it, which passes through a slot 46 in the boss 40. It will be obvious from an inspection of my drawings that if too great an explosion occurs the upper piston will be driven slightly upward against the tension of the spring 43, and thus prevent any damage. It will likewise be evident that this spring-piston absorbs a great deal of the vibration. The spring besides absorbing vibration may also be adjusted by the adjusting-nuts 44, so that the spring-piston has some of the characteristics of a "safety-valve." The piston proper, 42, is formed very much like the main piston 27, as it has a head 48, with two rings of packing 49 and the perforations 50, leading into the annular passage 51, so that the expanding gases may enter and spread the packing, and thus insure a perfect fitting.

The cushioned head just described and illustrated in my drawings is not claimed herein, but forms the subject-matter of a divisional application filed February 5, 1904.

Before passing from the description of the piston I would state that the piston 27 is balanced with the fly-wheel 16 by forming an opening 51 in the latter, which is covered by a name-plate 52. The amount of metal taken from this fly-wheel at this point is about sufficient to counterbalance the weight of the piston, and as the piston and the light side of the fly-wheel are always on the same side of their respective shafts one is counterbalanced by the other.

The inlet and exhaust valves and the igniter are all operated from the main shaft 4 by means of the following-described mechanisms: Rotating with the main shaft 4 is an eccentric 55, and motion is transmitted therefrom by means of the eccentric-strap 56 and connecting-rod 57 to a crank-pin 58, secured to a crank 59, revolving on a shaft 60, screwed into the side of the cylinder 6. (See particularly Fig. 5.) To insure proper working of the parts, the connecting-rod 57 is slotted, as shown at 61, so as to permit it to slide on and be guided by a stud 62, projecting from the main cylinder 6, as seen best in Figs. 2 and 5. The crank 59 is formed integral with a pinion 63 and a sleeve 64, all of which parts rotate on the aforesaid shaft 60, as motion is transmitted to them by means of the eccentric connections 55, 56, and 57. The pinion 63 meshes with a gear 65, containing just twice the number of teeth on the pinion 63, and this gear is fixedly secured to the igniting-shaft 66, journaled in one of the walls of the main cylinder 6 and in a downwardly-hanging arm 67, bolted to the main cylinder 6. The inner end of this shaft 66 has secured to it one of the igniting-contacts 68 and a non-conducting wiper 69, which as the shaft 66 rotates are caused to alternately make contact with and wipe the contact 70, (seen in Fig. 6,) which latter forms part of a spindle or wire which is screw-threaded into a bushing 71 and provided with the usual

binding-screw 72, by which the electric wire may be secured. It will be evident that as the igniting-shaft rotates only once to two rotations of the main shaft 4 the igniting-contact 68 only contacts with the companion contact 70 once in two revolutions of the main shaft 4 or at every other stroke of the piston 27.

Loosely journaled on the igniter-shaft 66 is an eccentric 74, which is given its rotary movement through a stud or pin 75, which projects therefrom and passes through a circular slot 76, formed in the gear 65, and when this stud is at either end of the slot it of course is moved with the gear, and thus transmits its motion to the eccentric 74. An eccentric-strap 77 and connecting-rod 78 are provided to transmit the movement of the eccentric to rock a rock-shaft 79, journaled in a bearing 80, bolted to the main cylinder 6, a crank 81 being interposed between the connecting-rod 78 and the rock-shaft 79. Near the opposite end of the rock-shaft 79 is secured a tappet 82, provided with an adjustable face 83, which may be changed as necessary by moving the adjusting-screw 84. (See Figs. 2 and 9.) Situated immediately over this tappet 82 is the exhaust-valve casing 85, which contains the exhaust-valve 86, fixed to a spring-actuated spindle or stem 87, the valve-casing being provided with an outlet-pipe 88, by which the exhaust-gases may be led or fed into a suitable muffler. (Not shown.) At the upper end of the valve-casing is connected a tube or port leading into the main cylinder 6, as shown in Fig. 9. It will be evident from this construction that as the rock-shaft 79 is rocked it moves toward and away from the spring-actuated valve-stem 87, and when it moves against it, as seen in Fig. 9, at every second revolution of the main shaft 4 the exhaust-valve is opened, and as the shaft is rocked in the reverse direction the spring-actuated stem 87 is released and the valve automatically closes and remains closed until the tappet is again brought upward at the next second revolution of the main shaft.

On the extreme outer end of the rock-shaft 79 I fixedly secure a crank 89, to which is connected a valve-actuating rod 90, which latter is partially supported at about its central portion by means of a suspending-hanger 91, pivotally secured to the main cylinder 6, as seen at 92 in Figs. 1 and 5. This pivoted hanger 91 is hollow and has a spindle 93 of a yoke 94 working therein, which is pressed downward by a spring 95, placed around said spindle. The forward end of this valve-actuating rod 90 is slotted in a vertical plane, as seen at 96 in Fig. 10, and a screw 97 passes through this slot and adjustably secures a hook 98 to the rod 90. This hook opens the inlet-valve, as will be hereinafter described.

The inlet-valve is connected to the main cylinder 6 at the opposite side to which the exhaust-valve is connected, as clearly shown in Fig. 9, and this valve comprises a casing 100, having a port 101, leading into the cylinder, and a cover 102, provided with a connection 103, by which the engine may be connected with any suitable supply, and with a cock 106, by which lubricant may be supplied to the valve. A suitable port 104 leads from this cover into the valve-chamber, and a slide-valve 107 is held against the inside of the cover, so as to open and close the port 104, by springs 105, which bear against the valve and the rear wall of the valve-casing 100. This is clearly shown in vertical section in Fig. 9 and in horizontal section in Fig. 6. The slide-valve 107 has an inlet-opening 108 through it and a vertical channel 110 in its rear side, and fitting within this channel is a valve-stem 111, which is provided with two pins 112 and 113, bearing, respectively, on the top and bottom of the slide-valve 107 and causing the valve and its stem to move together. The valve-stem 111 passes downward and through the stuffing-box 114 into a socket 115, a coiled spring 116 being employed between the head of the stuffing-box 114 and the socket 115, which normally holds the valve-stem 111 and its valve 107 in its extreme lower position when the supply is cut off, as seen in Fig. 9.

At the rear of the valve-casing 102 is a rock-shaft 117, which is suitably supported in a bearing-box 118, bolted to the main cylinder 6, and to this rock-shaft is secured a crank 119, which is connected to the socket 115 of the valve-stem 111 by means of a pivoted link 120. The rocking of the shaft 117 of course opens the valve 107 through the intermediate connections just described. To cause this shaft to rock, and thus open the valve 107, I secure a crank-arm 121 to the end of the rock-shaft 117, which arm projects upward under the hook 98 of the valve-actuating rod 90, hereinbefore described. In order to properly guide the parts, the crank 121 is provided with two upwardly-projecting guides 122, between which the rod 90 and its hook 98 slide back and forth. To the front face of the crank 121 is adjustably secured a cam 123, as seen in Fig. 10. This cam is situated immediately under the hook 98, and it of course follows that when the hook 98 and its rod 90 are moved forward by the rocking of the shaft 79 the hook 98 drops over the point of the cam 123, and as said hook and its rod 90 move back again the hook 98 moves the cam, and thereby rocks the shaft 117, which in turn opens the valve 107 through the intermediate connections. As the rod 90 and its hook draw the cam 123 slightly to the rear of its normal position the cam is turning with its shaft 117, and the cam thus causes the hook to rise until it disengages the cam, when the latter is free to be forced to its normal position through the agency of the spring 116, and this movement of course closes the valve.

From the construction so far described it

will be seen that the igniting-shaft, the exhaust-valve, and the inlet-valve are all operated from the same eccentric—namely, the eccentric 55 on the main shaft 4.

I have hereinbefore described the igniting-shaft 66 as having an eccentric 74 loosely journaled thereon and that said eccentric has a pin or stud passing into a slot, and thus deriving its movement from the gear-wheel 65. (See Figs. 7 and 8.) The object of this construction is to enable an attendant to stop the engine and turn the fly-wheel in the opposite direction to that in which it was moving and in doing this change the relative location of the parts, so that the engine will run in the opposite direction when the gas is again turned on. The circular slot 76 in the gear-wheel 65 permits this movement of the parts with relation to each other, so that when the fly-wheel is moved in the reverse direction it changes the location of the main crank, the piston, and the igniting devices without changing the relative location of the valves, and yet in doing this the crank, piston, and igniter are all brought to the proper position to run the engine in the reverse direction. It will be understood, of course, from reference to Figs. 7 and 8 that while the crank, piston, and igniting devices are reversed by the movement of the fly-wheel the eccentric 74, which controls the movement of the valves, does not move until the gear-wheel 65 moves around the shaft 66 until the opposite end of the slot engages the pin or stud 75, projecting from the eccentric 74, and thus begins to move the latter and their connected parts.

In order to provide for the admission of air to mix with the gas entering through the slide-valve 107, I provide an automatic air-valve, which is shown in Figs. 1 and 2 and in detail in Fig. 12. This valve is provided with a casing 125, which has an air-pipe 126 leading into the main cylinder 6 alongside of the gas-inlet 101. Working within the valve-casing 125 is a valve 127, kept on its seat 128 by means of a spring 129, working between the bottom of the valve-casing 125 and a collar 130 on the valve-stem 131, and at the lower end of the casing are a number of perforations 132 for the admission of air. The operation of this valve is automatic, and when the main piston descends it causes the usual vacuum and lifts the valve 127, admitting sufficient gas to pass into the cylinder and mix with the gas which has been entering through the inlet 101. Of course as soon as sufficient air has entered the valve will be automatically closed by its spring 129.

The operation of most of the parts has been briefly described in describing their construction, and hence I will give only a brief description of the operation, which is as follows: When the parts are in the positions indicated in Fig. 5, the charge is just being ignited, which drives the piston 27 downward, motion being thus transmitted through the main eccentric 55 and its connected parts to the inlet and exhaust valves, and the parts are timed so that when the piston reaches the end of its downward stroke the tappet at the rear of the engine is moved upward into the position shown in Fig. 9 and then opens the valve 86, so that as the piston moves upward the charge will be pumped out of the open exhaust-valve. By the time the piston is at the end of its upward stroke the rock-shaft 79 has been moved again to permit the exhaust-valve to close. The continued movement of the piston (which is of course now caused by the momentum of the fly-wheel) causes the piston to descend, and at this time the hook (see Fig. 10) has drawn onto crank 121 to open the inlet and admit the charge. Further movement of the parts causes the valve-actuating rod 90 to move in the opposite direction, and when it moves sufficiently far the cam 123 trips the hook 98 and permits the inlet-valve to close. The main piston is now making its upward stroke to compress the charge, and just as it starts its downward movement the movable igniting contact 68 breaks contact with its companion contact and ignites charge to repeat the movements, as just described.

From the foregoing description and the accompanying drawings it will be seen that I have invented a most compact engine of great power compared with its size and one withal that is especially adapted to its use on vessels, owing to the fact that its main shaft is very near the base, notwithstanding the relatively high location of the fly-wheel and its shaft. It will also be seen that I have produced an engine in which the igniting-shaft, the inlet-valve, and the exhaust-valve all operate from one eccentric secured to the main shaft. In addition to these features I have an engine in which the water-jacket is kept cool with practically no expense by utilizing a crank connected with one of the shafts for operating a pump to keep a constant supply of cool water in the water-jacket.

It is obvious that changes may be made without departing from the spirit of my invention, and I therefore wish it understood that I have illustrated what I now consider the preferable embodiment of my invention and that the following claims are intended to cover all such variations and modifications as would naturally suggest themselves.

What I claim as new is—

1. In an engine, a base, a propeller-shaft suitably supported in close proximity to said base, an engine-cylinder arranged over the aforesaid shaft and having its piston-rod driving the latter, a fly-wheel shaft arranged above the aforesaid shaft and receiving motion therefrom, and a pump situated under said fly-wheel shaft and driven thereby; the arrangement of the parts being such as to permit the first-mentioned shaft to be at the lowest point, and

the pump to be driven from and situated underneath the fly-wheel shaft; substantially as described.

2. In an engine, a base, a main shaft suitably supported in close proximity to said base, a main cylinder arranged over said main driving-shaft and having its piston-rod driving the latter, said main cylinder having a water-jacket, a fly-wheel shaft arranged above said main shaft and receiving motion therefrom and a pump situated under said fly-wheel shaft and driven thereby and arranged to pump water into the jacket around said cylinder; the arrangement of the parts being such as to permit the main driving-shaft to be at the lowest point, and the pump to be driven from and situated underneath the fly-wheel shaft; substantially as described.

3. In an engine, a substantially vertically arranged cylinder, a piston working therein and having a downwardly-working piston or connecting-rod, a main shaft under said cylinder connected with said piston-rod, a fly-wheel, an inlet-valve, an exhaust-valve, and a rotatable igniter and a single connection with said main shaft for operating the valves and rotating the igniter, substantially as described.

4. In an engine, a substantially vertically arranged cylinder, a piston working therein and having a downwardly-working piston or connecting-rod, a main shaft under said cylinder connected with said piston-rod, a rotatable igniter, inlet and exhaust valves, and an eccentric on the main shaft for operating said valves and rotating said igniter, substantially as described.

5. In an engine, and in combination with the piston and shafts thereof, a rotatable igniter and igniter-shaft, inlet and exhaust valves operative from said shaft and an operating connection between said igniter-shaft for rotating said igniter-shaft and said main shaft, substantially as described.

6. In an engine, and in combination with the piston and main shaft thereof, a rotatable igniter and igniter-shaft, inlet and exhaust valves operated from said igniter-shaft, and an eccentric connected with said main shaft for rotating said igniter-shaft, substantially as described.

7. In an engine, and in combination with the valves, the piston and main shaft thereof, a rotating igniter and an igniting-shaft, operating connections between said igniting-shaft and said main shaft, and an eccentric on said igniter-shaft for operating said valves, substantially as described.

8. In an engine, in combination with the valves, the piston and main shaft thereof, a rotating igniter and an igniter-shaft, a gear thereon, a pinion meshing with said gear, and having an operative connection with said main shaft, and an eccentric on the igniter-shaft for operating said valves, substantially as described.

9. In an engine, and in combination with the valves, the piston and main shaft thereof, an igniting-shaft, an operating connection between said igniter and main shafts, mechanism interposed between said igniter-shaft and said valves, said mechanism comprising an eccentric loosely connected with said igniter-shaft, substantially as described.

10. In an engine, and in combination with the valves, the piston and main shaft thereof, an igniter-shaft operated from said main shaft, an eccentric on said igniter-shaft, intermediate connections between said eccentric and said valves, and a loose connection between said eccentric and the igniter-shaft, substantially as described.

11. In an engine, and in combination with the valves, the piston and main shaft thereof, an igniter-shaft having a gear thereon for receiving motion from said main shaft, an eccentric on said igniter-shaft having a loose connection with said gear, and intermediate connections between said eccentric and said valves, substantially as described.

12. In an engine, and in combination with the valves and the main shaft thereof, an igniter-shaft having a gear thereon, intermediate connections between said gear and the main shaft, an eccentric loosely connected with the igniter-shaft, a loose connection between said eccentric and said gear, and intermediate connections between said eccentric and valves for operating said valves, substantially as described.

13. In an engine, and in combination with the main shaft thereof, a second rotatable shaft carrying a rotatable igniter, intermediate connections between said shafts, inlet and exhaust valves, a rock-shaft for operating said valves, and an operative connection between said rock-shaft and the shaft for rotating the igniter, substantially as described.

14. In an engine, and in combination with the main shaft thereof, a rotatable igniter-shaft receiving motion from said main shaft, a rock-shaft rocked through a connection with said igniter-shaft, an exhaust-valve and a connection between said rock-shaft and said exhaust-valve for operating the latter, substantially as described.

15. In an engine, and in combination with the main shaft thereof, a rotatable igniter-shaft operative from said main shaft, a rock shaft operated from said igniter-shaft, exhaust and inlet valves, and connections operated by said rock-shaft for opening said valves, substantially as described.

16. In an engine, and in combination with the main shaft thereof, an igniter-shaft operated from said main shaft, a rock-shaft rocked through said igniter-shaft, inlet and exhaust valves, a tappet operated by said rock-shaft for opening said exhaust-valve, and intermediate connections between said rock-shaft and the inlet-valve for operating the same, substantially as described.

17. In an engine, and in combination with the main shaft thereof, an igniter-shaft, operated from said main shaft, a rock-shaft rocked through said igniter-shaft, exhaust and inlet valves, a tappet on said rock-shaft for operating said exhaust-valve, a crank on said rock-shaft, and a connection between said crank and the inlet-valve for operating the latter, substantially as described.

18. In an engine, and in combination with the main shaft thereof, an igniter-shaft rotated through said main shaft, a rock-shaft rocked by said igniter-shaft, exhaust and inlet valves, a tappet on said rock-shaft for operating said exhaust-valve, a crank on said rock-shaft, a supplemental shaft connected with the inlet-valve, and a hook and cam interposed between said crank and said last-named shaft, for operating the inlet-valve, substantially as described.

19. In an engine, and in combination with the main shaft thereof, a rock-shaft, exhaust and inlet valves, a tappet on said rock-shaft for operating said exhaust-valve, a crank on said rock-shaft, a supplemental shaft having a connection with the inlet-valve, and a hook and cam interposed between said crank and said supplemental shaft for operating the inlet-valve, substantially as described.

20. In an engine, and in combination the cylinder and main shaft thereof, an inlet-valve arranged on one side of the cylinder, and an exhaust-valve arranged on the opposite side thereof, a rock-shaft operated from the main shaft, and connections between said rock-shaft extending from one valve to the other, for operating said valves, substantially as described.

21. In an engine, a base, a main shaft suitably supported in close proximity to said base, a main cylinder arranged over said main shaft and having its piston-rod driving the same; and a fly-wheel shaft arranged above said main shaft and driven therefrom at substantially the same speed; substantially as described.

Signed by me at Wilmington this 2d day of June, 1902.

JOHN MARTIN STADEL.

Witnesses:

AMOS COLE,

J. W. COOKE.