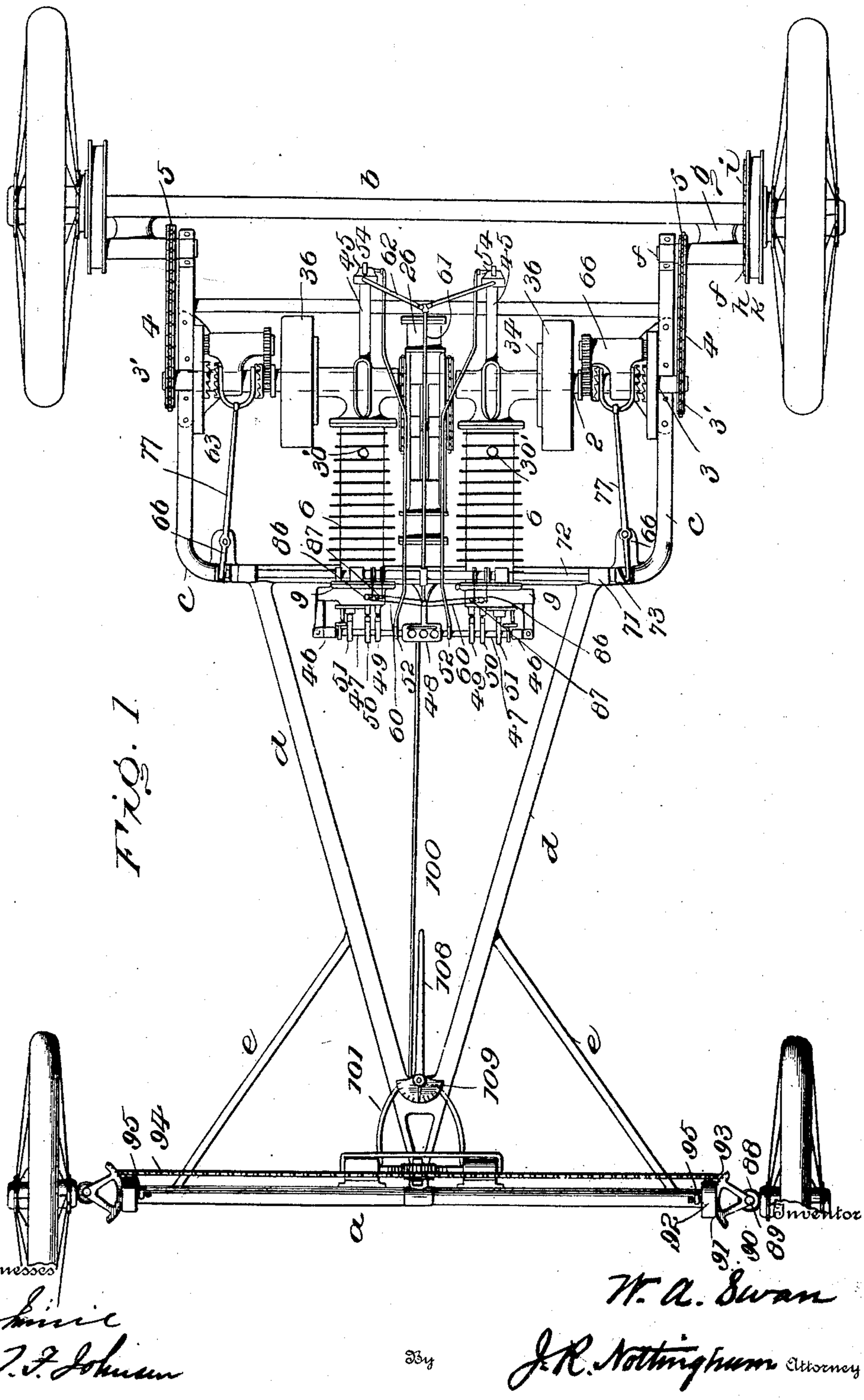
No. 692,218. Patented Jan. 28, 1902.

W. A. SWAN.

FREE PISTON EXPLOSIVE ENGINE.

(Application filed Aug. 31, 1900.)

(No Model.) 6 Sheets—Sheet 1.



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(No Model.)

6 Sheets—Sheet 2.

Fig. 3.

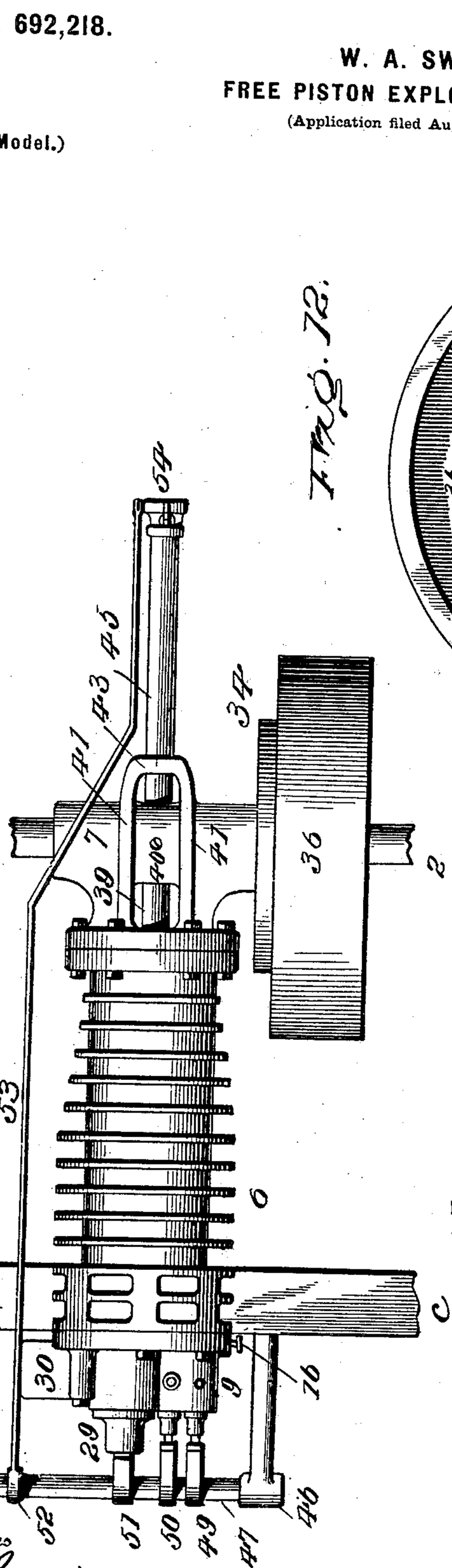


Fig. 1.

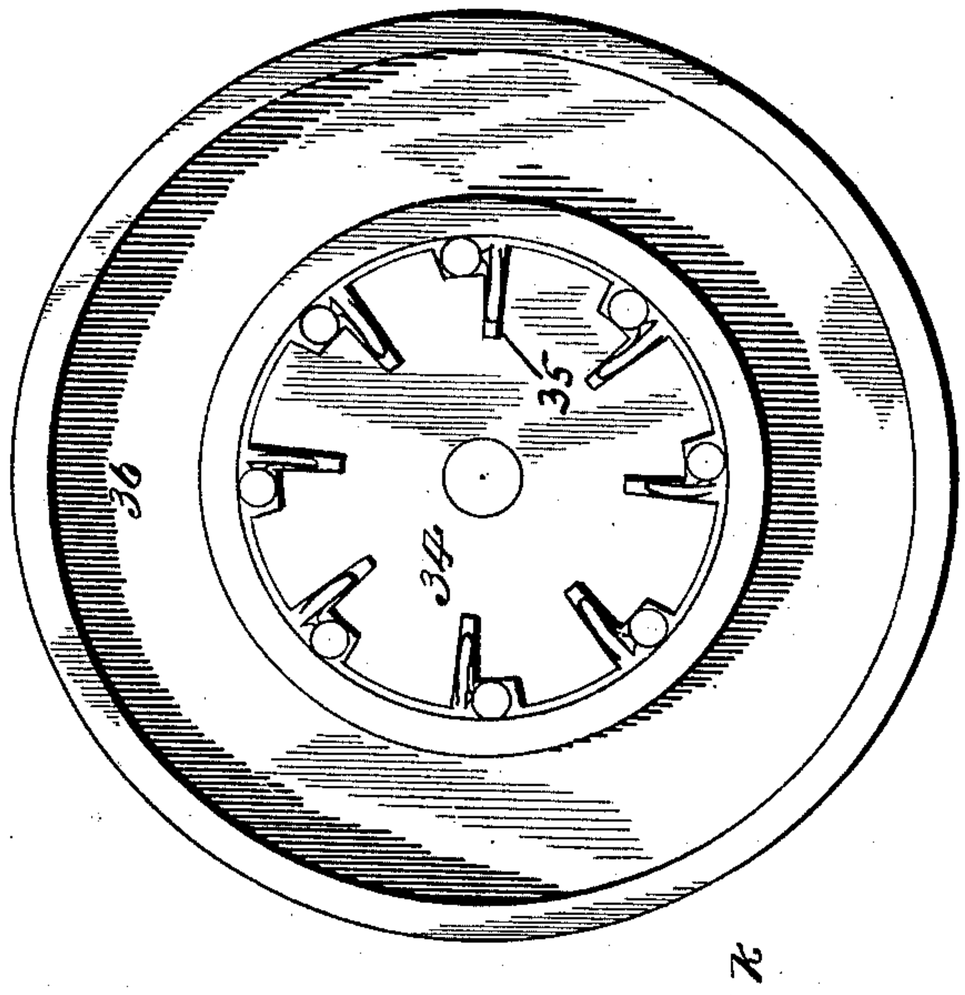
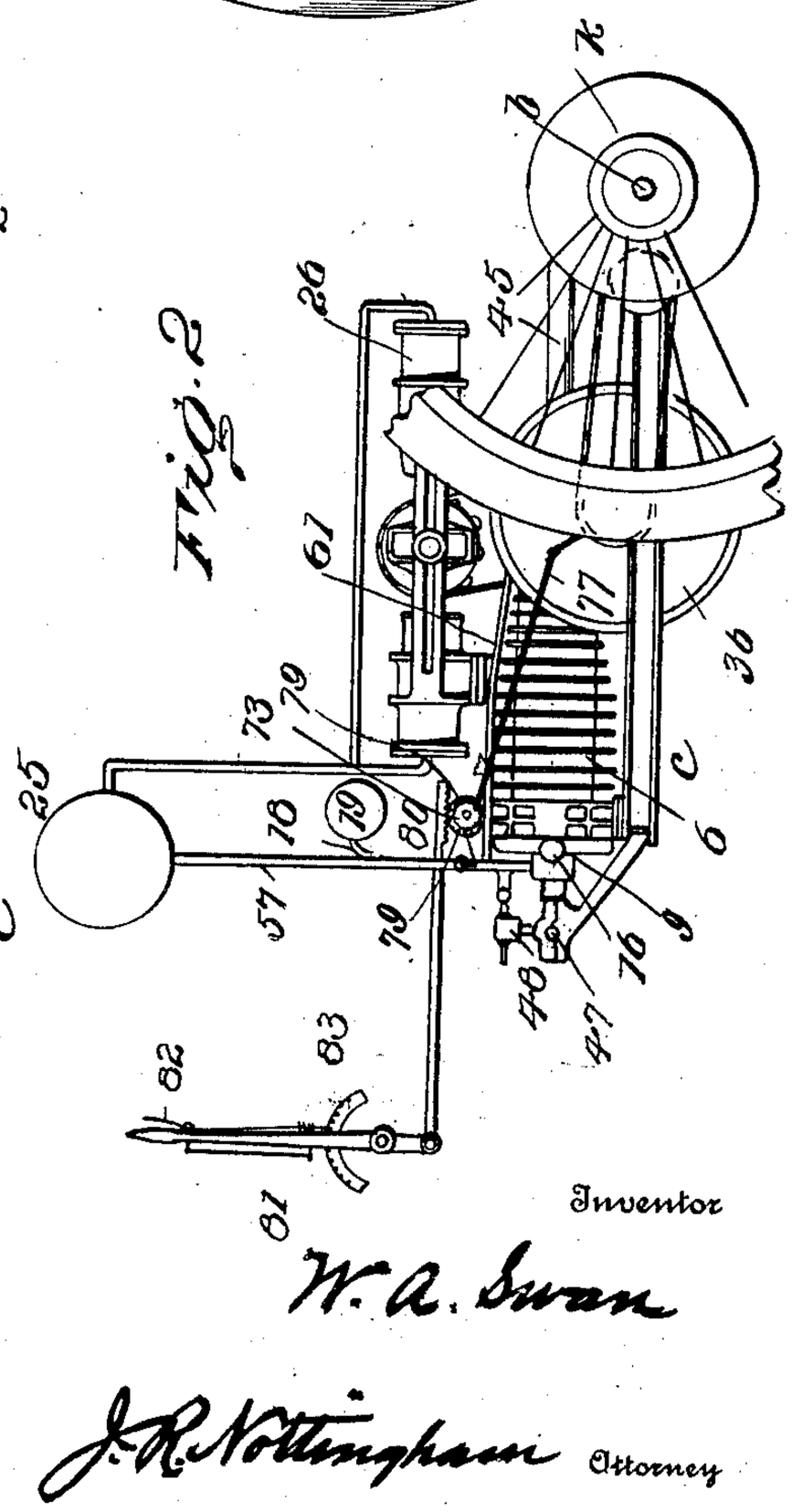


Fig. 2.



Witnesses

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No. 692,218. Patented Jan. 28, 1902.

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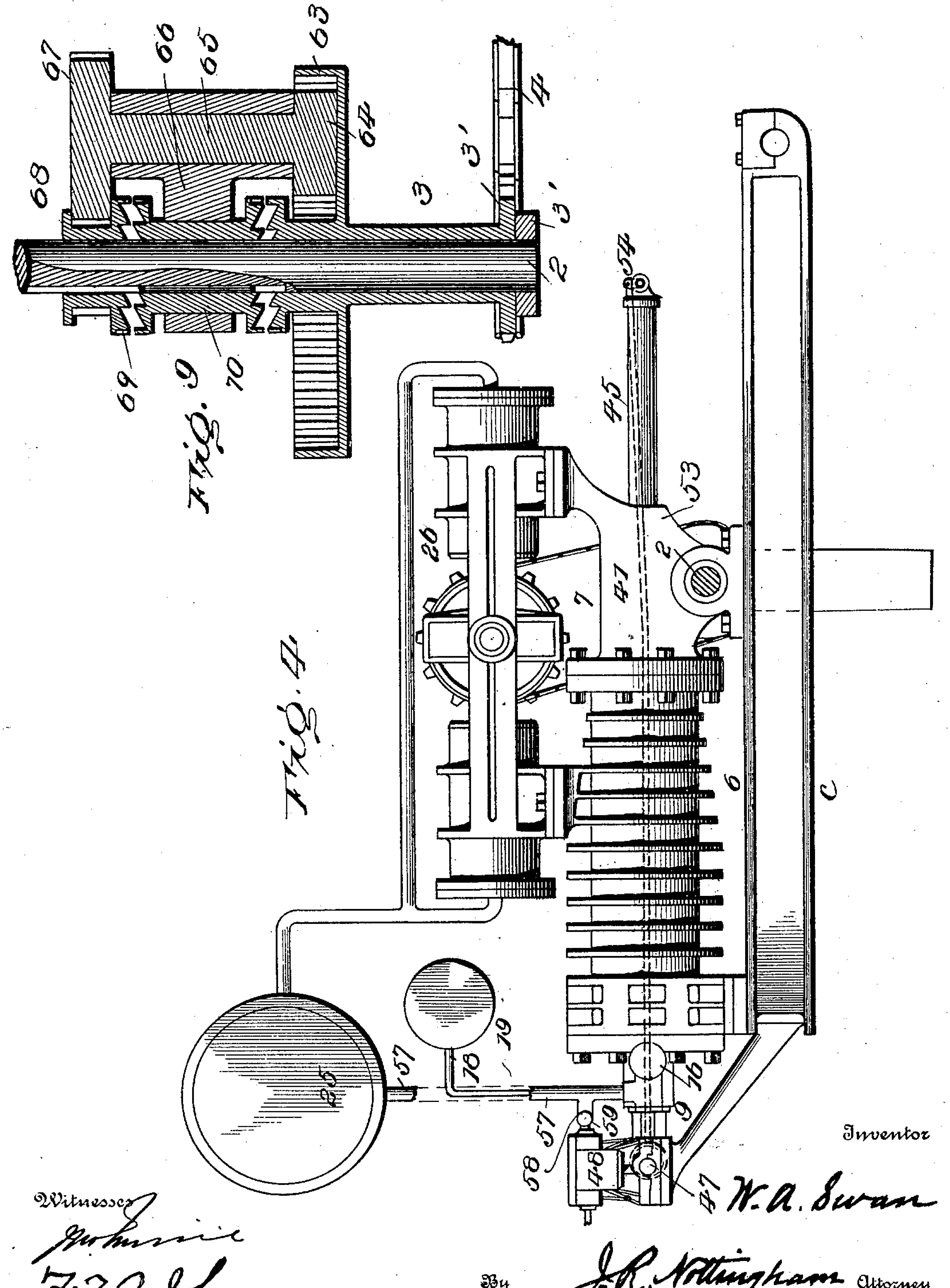
FREE PISTON EXPLOSIVE ENGINE.

(Application filed Aug. 31, 1900.)

(No Model.) 6 Sheets—Sheet 3.



Witnesses
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No. 692,218. Patented Jan. 28, 1902.

W. A. SWAN.

FREE PISTON EXPLOSIVE ENGINE.

(Application filed Aug. 31, 1900.)

(No Model.) 6 Sheets—Sheet 4.

Fig. 5.

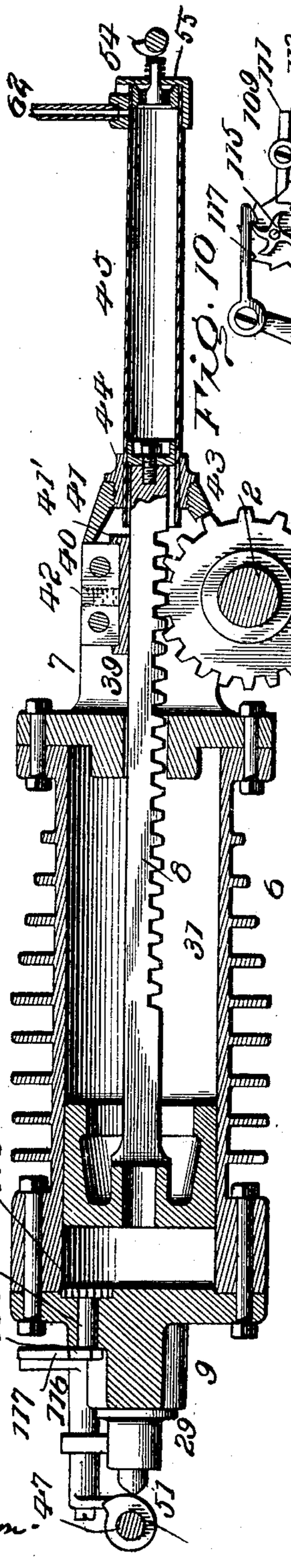
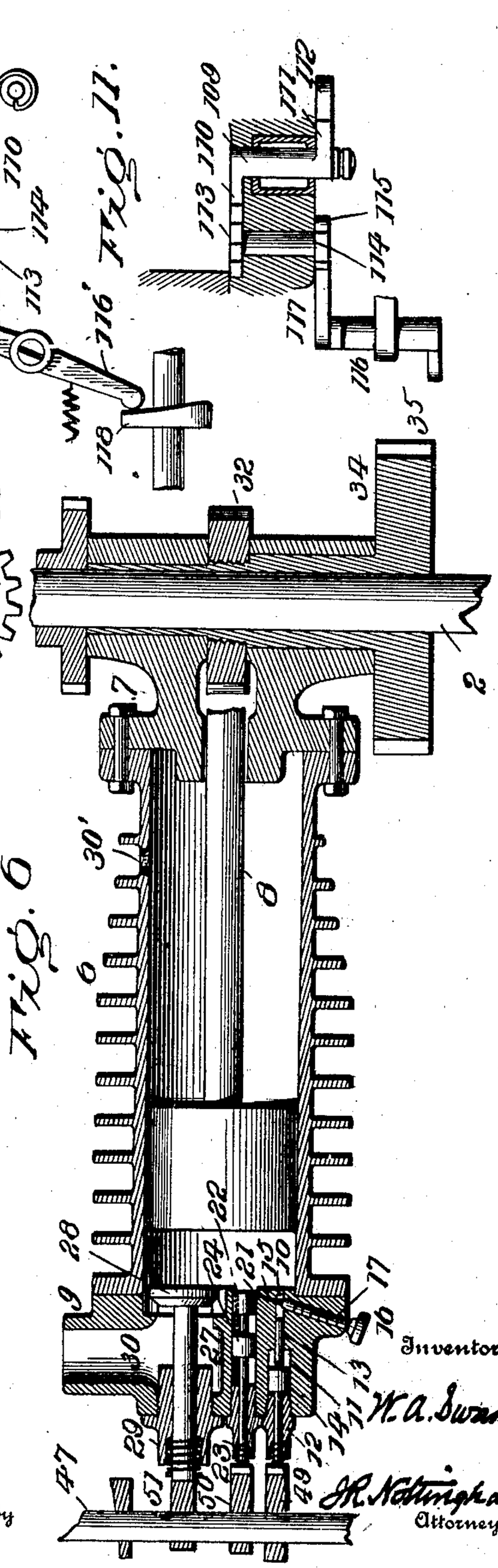


Fig. 6.



Witnesses

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No. 692,218. Patented Jan. 28, 1902.

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FREE PISTON EXPLOSIVE ENGINE.

(Application filed Aug. 31, 1900.)

(No Model.) 6 Sheets—Sheet 5.

FIG. 7.

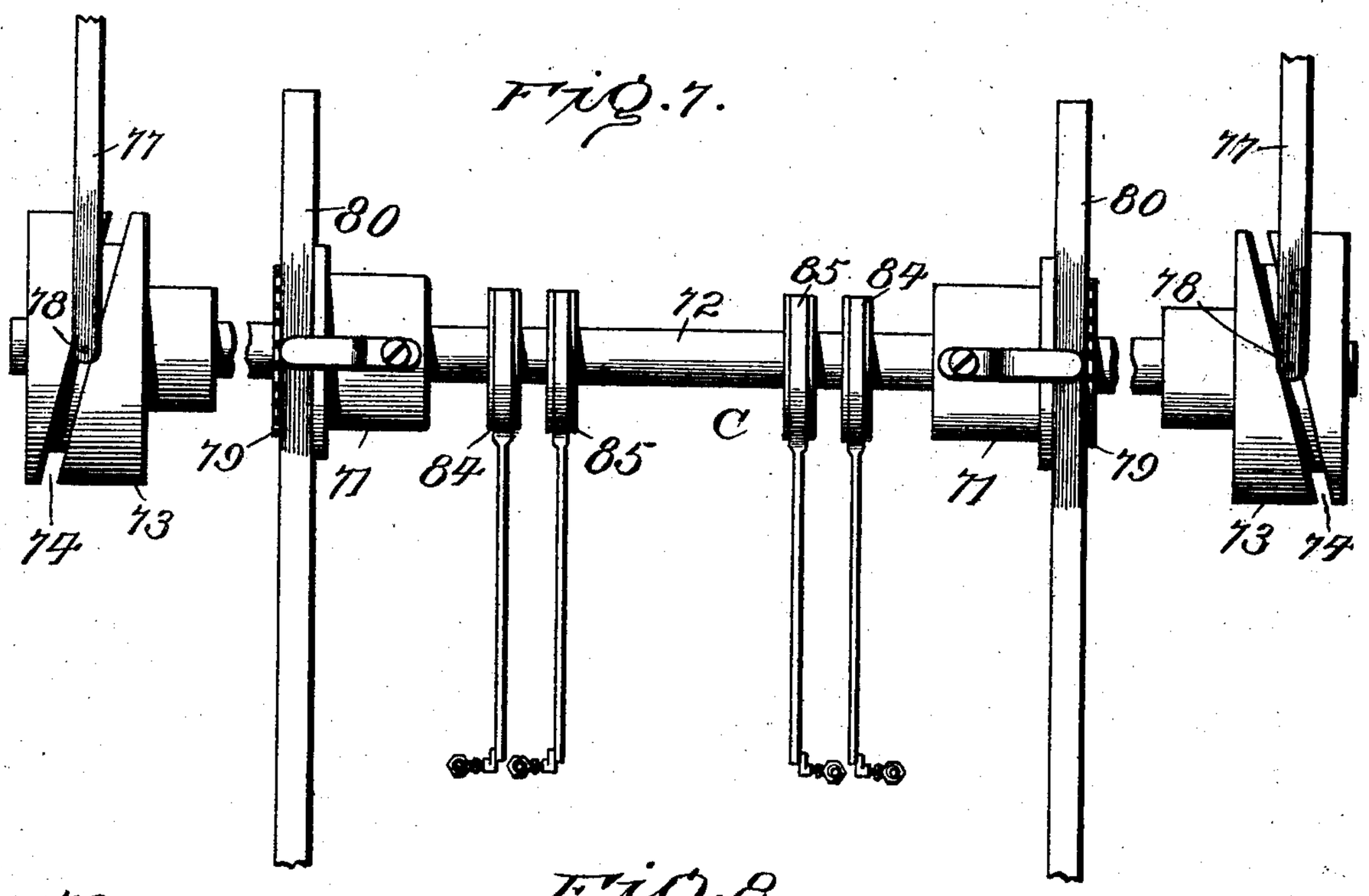
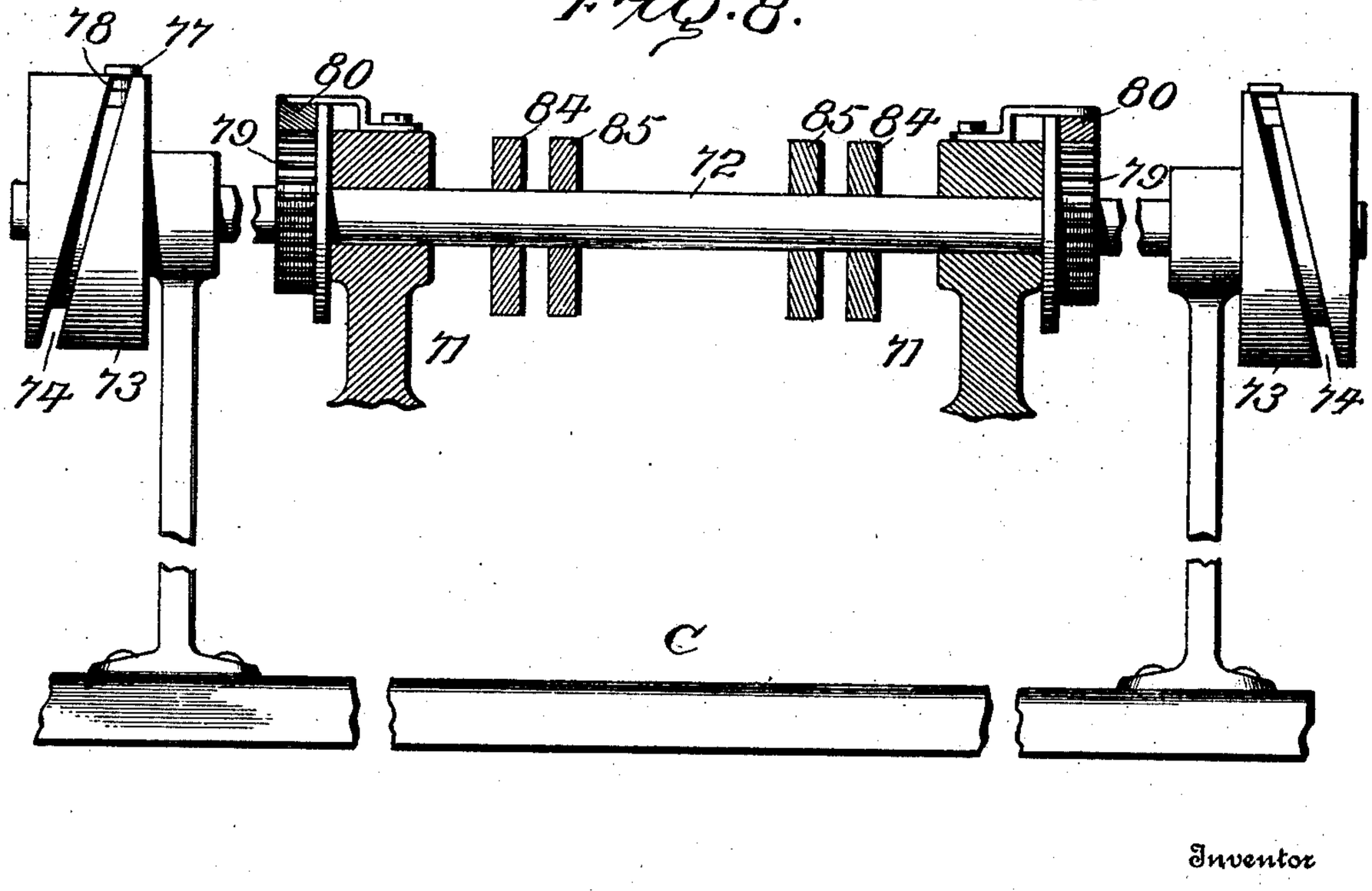


FIG. 8.



Witnesses
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No. 692,218. Patented Jan. 28, 1902.

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FREE PISTON EXPLOSIVE ENGINE.

(Application filed Aug. 31, 1900.)

(No Model.) 6 Sheets—Sheet 6.

Fig. 13.

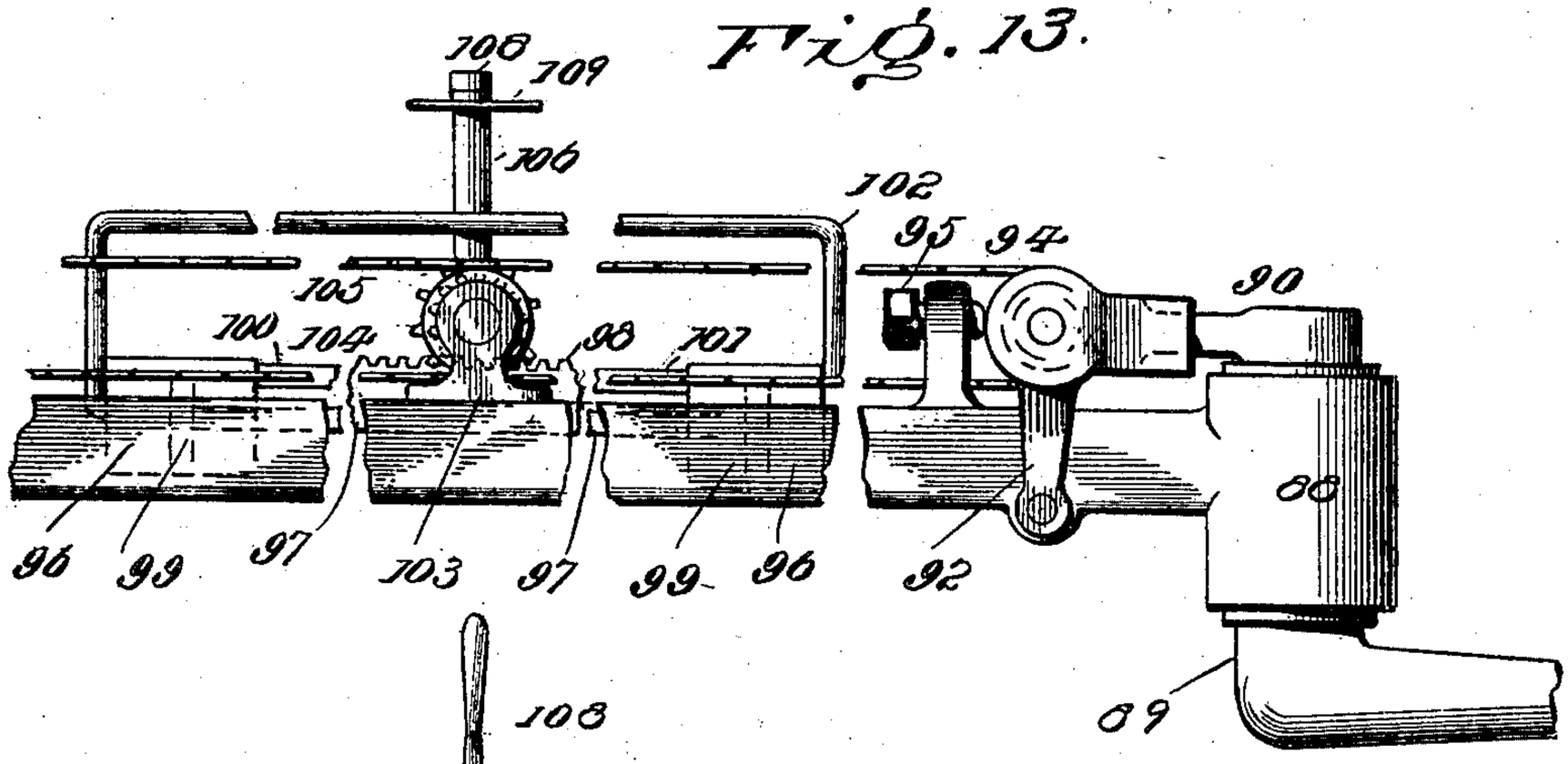


Fig. 14.

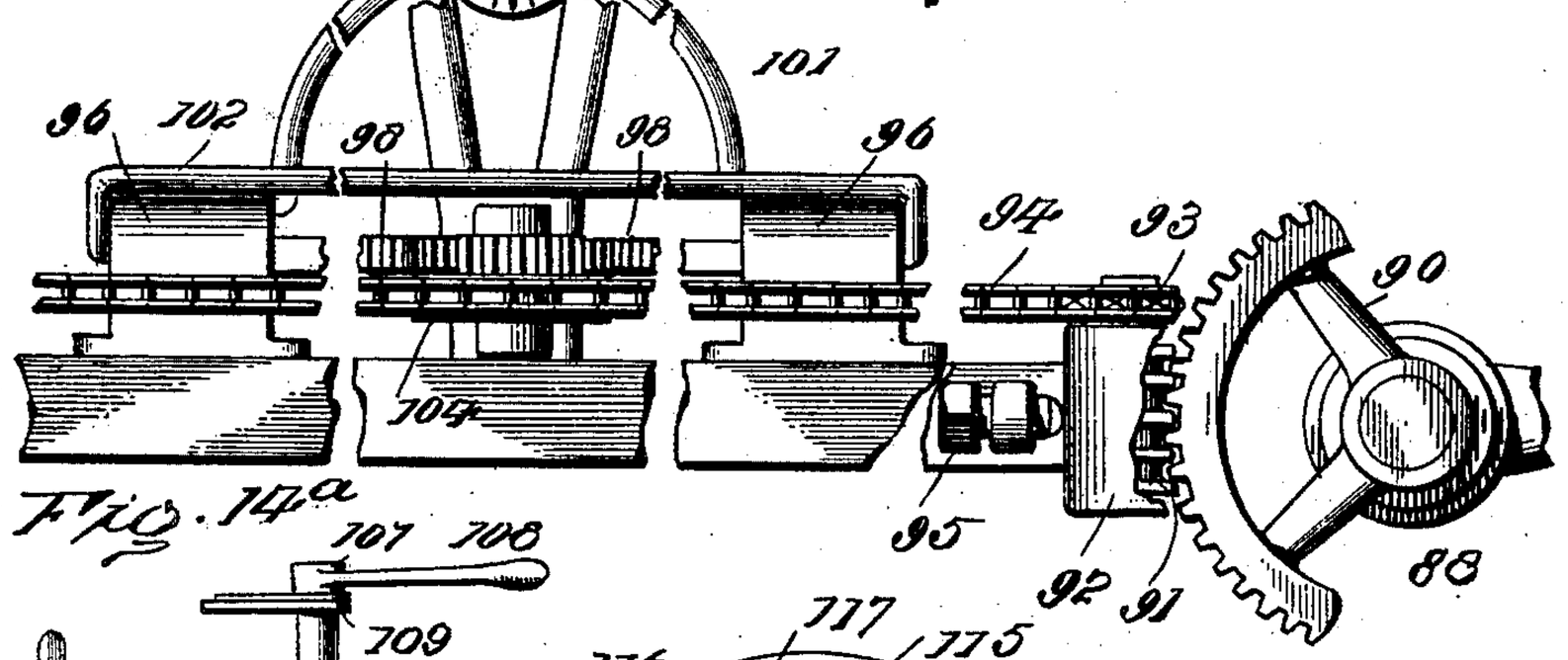


Fig. 14a

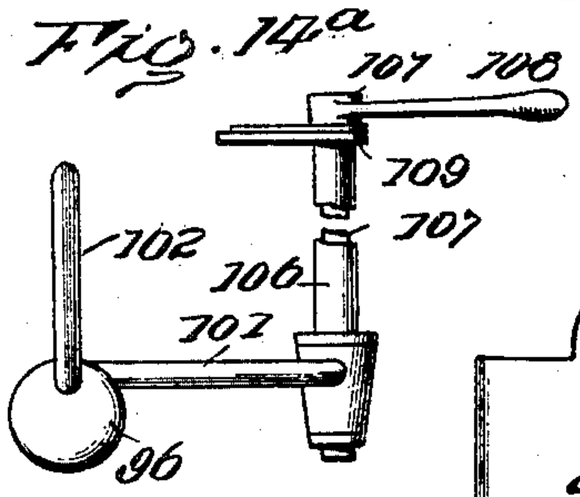
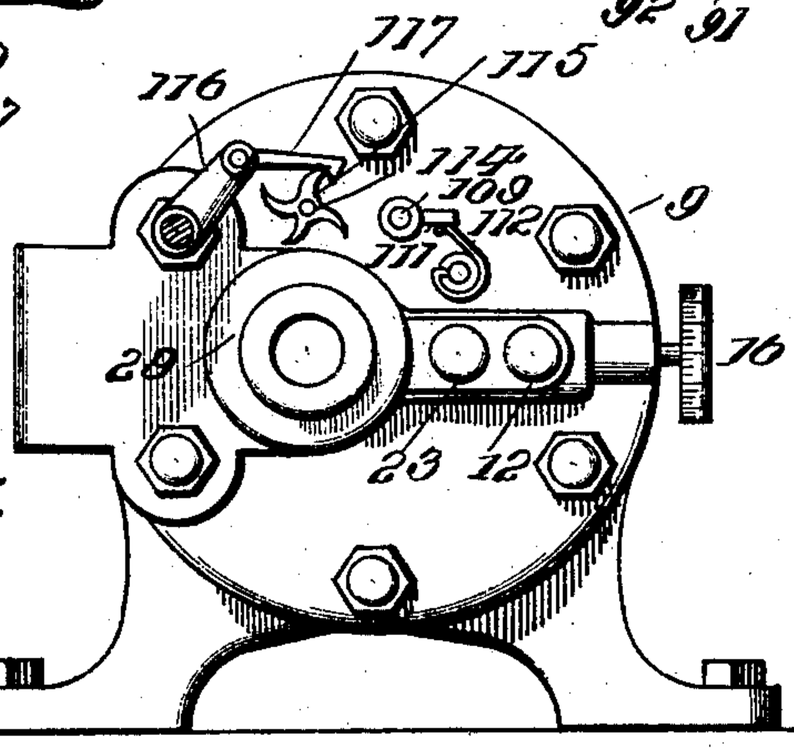


Fig. 15.



Witnesses

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UNITED STATES PATENT OFFICE.

WILLIS A. SWAN, OF PROVIDENCE, RHODE ISLAND.

FREE-PISTON EXPLOSIVE-ENGINE.

SPECIFICATION forming part of Letters Patent No. 692,218, dated January 28, 1902.

Application filed August 31, 1900. Serial No. 28,681. (No model.)

To all whom it may concern:

Be it known that I, WILLIS A. SWAN, a citizen of the United States, residing at Providence, in the county of Providence and State of Rhode Island, have invented certain new and useful Improvements in Gas-Engines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to gas-engines of the type known as "free-piston" engines; and it consists principally in providing certain novelly constructed and arranged valve mechanism for controlling and governing the speed of the engine and for regulating the supply of oil and air to the cylinder.

The invention still further consists in providing a simple and effective means for the return stroke of the piston; and the invention still further consists of the general construction, arrangement, and combination of the various parts, as will be hereinafter more fully described, and particularly pointed out in the claims.

One of the principal objects of the invention is to provide a simple and effective means for moving the piston on its back stroke with a gradual and uniform movement, so as to render the operation practically noiseless.

Another object of the invention is to obtain the greatest of expansive force from the expenditure of a minimum quantity of oil.

Still another object of the invention is to provide an independent or auxiliary power and novel mechanism to make the engine self-starting.

A still further object of the invention is to provide a means for regulating the speed of the engine without the use of speed-changing gear.

Other objects, such as dispensing with the usual compensation-gearing used in vehicle propulsion, will become apparent upon further description of the invention.

These objects are attained by means of the various mechanism illustrated in the accompanying drawings, in which—

Figure 1 is a top plan view of two gas-engines constructed after my improved plan applied to a wheeled vehicle; Fig. 2, a side elevation of the same with the body of the vehicle and a portion of the running-gear removed; Fig. 3, an enlarged top plan view of one of the gas-engines; Fig. 4, an enlarged side elevation of the same and air-pump connected thereto; Fig. 5, a vertical longitudinal section of engine and valve mechanism; Fig. 6, a horizontal longitudinal section of the same; Fig. 7, an enlarged top plan of the mechanism for controlling the supply of oil and air and for operating the reversing-clutches; Fig. 8, a front elevation thereof; Fig. 9, a horizontal section of the reversing-clutch mechanism; Fig. 10, a front elevation of the igniting device detached; Fig. 11, a top plan of the same, showing the position of the parts in relation to the cylinder-head; Fig. 12, a plan view of the inner face of one of the fly-wheels, showing the clutch-disk seated therein; Fig. 13, a front elevation of a portion of the front axle and steering mechanism; Fig. 14, a top plan view of the same; Fig. 14^a, a detail of the operating-lever and connections, and Fig. 15 a front elevation of one of the cylinder-heads with the valve mechanism removed.

As my invention is especially applicable to the propulsion of wheeled vehicles, although equally well adapted for driving machinery, I have shown it applied to a four-wheel vehicle, and in order to facilitate its description I will proceed to describe it under the following heads, viz: first, the supporting-frame and connections; second, the main driving-shaft; third, the engine; fourth, mechanism for operating the valves; fifth, driving and reversing gear; sixth, mechanism for operating the clutch mechanism and for controlling the supply of oil and air; seventh, steering mechanism, and, eighth the igniting device.

While I show and describe my invention applied to a wheeled vehicle, I do not seek to claim herein those parts or devices which relate to the particular mechanism for operating the valves, the driving-clutch mechanism, and the sparking igniter, as these will form the subject-matter of future separate applications.

The supporting-frame and connections.—Referring to the several views, the letter *a* indicates the front axle, *b* the rear axle, and *c* the frame supporting the engines. The

front of the engine-supporting frame is supported from the front axle by two converging bars *d d*, suitably braced by bars *e e*, and its rear by the arms of two short shafts *f f*, supported in bearings *g g*, attached to the rear axle. The connection between the converging bars and the front axle is preferably by means of a ball and socket, although any well-known and suitable coupling may be employed. The outer end of each shaft *f* carries a gear-wheel, which meshes with an internal gear (not shown, being of the usual form) provided on the inner face of a brake-wheel *k*, rigidly secured to the hub of the vehicle-wheel. By means of the mechanism to be hereinafter described motion is imparted to the brake-wheel to revolve the rear vehicle-wheels. Any suitable brake mechanism may be employed. The engine-supporting frame may be of any suitable or desired construction and is flexibly supported from the front and rear axles of the vehicle.

The main driving-shaft.—Journaled in suitable bearing secured upon the side pieces of the engine-supporting frame is the main driving-shaft 2, which has mounted on each end thereof a sleeve 3, carrying a sprocket-wheel 3′, which is connected by a sprocket-chain 4 with a sprocket-wheel 5 on the shaft *f*, the purpose of which will be hereinafter explained.

The main shaft carries the mechanism for driving the vehicle in a forward direction and for reversing the direction of movement, as will be hereinafter described.

The engine.—In applying my invention to a wheeled vehicle I employ two engines identical in structure, but independent of each other, so that the description of one will apply to the other.

Each engine 6 is supported upon the front and central transverse bars of the frame *c*. The head 7 of the cylinder or shell is bored transversely for the reception of the main shaft and is provided with a longitudinal passage for the reception of the piston-rod 8. The head 9 of the cylinder is provided with a chamber 10, communicating with a chamber 11 of increased diameter. The outer end of the chamber 11 is provided with a screw-threaded plug 12, bored to receive the stem of a valve 13. The valve-stem is provided with an enlargement 14, which serves to accurately guide the valve in its operation. The chamber 10, which may properly be termed the "oil-chamber," is provided with an oil-passage 15, which is controlled by a needle-valve 16, adjustable in a screw-threaded opening 17 in the aforesaid head. This valve regulates and controls the supply of oil to the cylinder, the supply being received through a pipe 18, leading from a suitable supply-tank 19 to the chamber 10. The head 9 is also provided with an air-chamber 20, controlled by a valve 21, provided with air-passages 22. The valve-stem operates through a plug 23, screwed into the outer end of the air-chamber, and it is provided with an enlargement 24, which serves to cut off the supply of air and to assist in guiding the movement of the valve. The air-chamber receives its supply of air from a tank 25, in which the air is compressed by means of an air-pump 26 of any suitable type, the pump being run by sprocket wheels and chains driven from the main shaft 2, as shown in Fig. 4.

The head 9 is formed with an exhaust-chamber 27, controlled by a valve 28, the stem of which works through a plug 29, screwed into the outer end of said chamber. An exhaust-passage 30 leads from the chamber 27 to the open air. Additional exhaust-ports 30′ may be made in the wall of the cylinder at a point just in front of the position of the piston-head when the piston has reached its full outward stroke.

The lower or under side of the piston-rod for a portion of its length is provided with a rack 31, which meshes with a gear-wheel 32, screwed on a sleeve 33, loosely mounted on the main shaft 2. The outer end of the sleeve carries a clutch-disk 34, which is provided with right-angle openings 35 in its outer periphery, and rigidly mounted on the shaft 2 is a fly-wheel 36, in the face of which the clutch-disk is loosely seated. In that part of the openings 35 lying parallel with the periphery of the clutch-disk are placed rollers 37, so that as the fly-wheel is caused to revolve the rollers impinge between the wall of the flange 38, forming the seat for the clutch-disk, and the wall of said part of the openings and cause the clutch-disk to revolve with the fly-wheel during the forward movement of the vehicle. On the reverse movement of the vehicle the clutch-disk will become disengaged from the fly-wheel, as the rollers will fall back to the opposite part of the openings, which is slightly greater in width than the closed end, springs 38′, seated in the inwardly-extending portion of the openings, serving to limit their movement.

In the top central portion of the head 7 is an opening 39, which is partially closed by a cap 40, bolted between the ribs 41, formed on said head. On the under face of the cap 40 is fitted a metal bearing-plate 41′, vertically adjustable by a screw 42, for guiding the rear end of the piston-rod in its travel. The ribs 41 extend beyond the rear end of the head 7 and are joined together by a ring 43, internally screw-threaded to receive an externally-screw-threaded sleeve 44. Secured within this sleeve is one end of a tube 45 of sufficient length to accommodate the full outward stroke of the piston.

Mechanism for operating the valves.—Journaled in suitable bearings 46, supported from the frame *c*, is a shaft 47, which is rotated by an independent motor 48. This motor may be of any suitable type or style. Rigidly secured on the shaft 47 are two sets of cams, one

set for each engine, and as they are of similar construction it will only be necessary to describe one set.

The numeral 49 indicates the cam for operating the oil-valve, 50 the cam operating the air-valve, and 51 the cam operating the exhaust-valve. A cam 52, also rigidly secured on the shaft 47, operates a valve-connecting rod 53, which may be suitably supported in any well-known manner from the cross-bars of the frame *c*. The rear end of the connecting-rod is connected to a valve cam 54, which operates a spring-restrained valve 55 to admit, cut off, and exhaust the air to and from the tube 45, said tube being provided with air inlet and outlet openings in its cap 56.

The independent motor is supplied with air under pressure from the air-tank 25 through pipe 57 and branch pipe 58, the latter being connected with the three cylinders of the independent motor by pipe 59. Leading in opposite directions from the pipe 58 are two branch pipes 60 60, which supply air to each air-chamber of the cylinders of the engines. Thus it will be seen that air is admitted to each air-chamber 20 direct from the supply-tank 25, the supply of air to the engine-cylinders being regulated by the valves 21 and the valves controlled by the cams 50. Also leading from the pipe 58 is a pipe 61, which is provided with branches 62 62, one branch leading to the tube 45 of one engine and the other branch leading to the tube 45 of the other engine.

Driving and reversing gear.—The sleeve 3 of each sprocket-wheel 3′ also carries on its inner end an internal gear-wheel 63, which meshes with a gear-wheel 64, attached to one end of a short shaft 65, journaled in the projection of a bearing-block 66, secured on the central cross-bar of the frame *c*. (See Fig. 11.) Attached to the other end of the shaft 65 is another gear-wheel 67, which meshes with a gear-wheel 68, loose on the shaft 2. The inner face of the gear-wheel 68 is provided with clutching-teeth 69, which engage similar teeth on the end of a slidable clutch 70, keyed on the main shaft, the other end of said clutch being provided with clutching-teeth adapted to engage corresponding teeth on the inner end of the sleeve 3.

Mechanism for operating the clutch mechanism and for controlling the supply of oil and air.—Journaled in bearings 71, mounted on the front cross-bar, is a rockable shaft 72, provided with wheels 73 73, having cam-grooves 74 in their outer peripheries. Fulcrumed on an arm 76, projecting from each bearing-block 66, is a lever 77, which has one end bifurcated and secured to the slidable clutch and the other end provided with a roller 78, operating in the cam-groove 74. Rigidly secured on the rockable shaft are two gear-wheels 79 79, which are adapted to mesh with rack-bars 80 80, pivoted to the arms of a fulcrumed lever 81. The lever 81 is provided with a spring-actuated pawl 82, arranged to engage a toothed segment 83 to hold the lever at any desired position. Also secured on the rockable shaft are cams 84 and 85, which operate the supply-valves 86 and 87. The cams 84 operate the valves 86 to control the supply of oil to the oil-chambers 10, and the cams 85 serve to operate the valves 87 to control the supply of air to the chamber 20. As the shaft 72 is rocked in one direction the supply of oil and air is turned on and the clutches moved to engage the gear-wheel 68, and when rocked in the opposite direction the supply of oil and air is cut off and the clutches moved to engage the sleeve 3 to reverse the direction of movement of the vehicle. By manipulating the lever 81 a great or small charge of oil and air may be supplied to the respective chambers.

Steering mechanism.—Each end of the front axle is provided with a vertical hub 88, in which is journaled the vertical portion of a right-angle arm 89, the horizontal portion of said arm serving as the spindle for the vehicle-wheel. Rigidly secured to the upper end of the vertical portion of each arm 89 is a toothed segment 90, which meshes with a worm-wheel 91, journaled in a bracket 92, pivoted to the axle. One end of the shaft of each worm-wheel projects through the bracket and is provided with a sprocket-wheel 93, a sprocket-chain 94 connecting the two wheels together. Set-screws 95 95 serve to adjust the engagement of the worm-wheels with the toothed segments and to prevent their accidental disengagement.

The numerals 96 96 indicate two air-cylinders having a piston 97 common to each. The center portion of the piston-rod is provided with a toothed rack 98 and each end with a head 99, one head working in one cylinder and the other head in the other cylinder, as shown in dotted lines in Fig. 7. Air under pressure is supplied to the cylinders from the air-supply pipe 57 by means of pipes 100 and 101, the two cylinders being connected by air-pipe 102. Journaled in a bracket 103 is a sprocket-wheel 104, adapted to engage to sprocket-chain 94, and a gear-wheel 105, adapted to engage the rack 98. Extending upward from the pipe 101 is a tube 106, and within the tube is a rod 107, provided with an operating-lever 108, carrying a pointer. On the upper end of the tube is a segment 109, provided with degree-marks. Seated in the pipe 101 at its connection with the pipe 100 and with the tube is a three-way valve, which is operated by the rod 107 and lever 108.

By manipulating the lever air from the supply-tank may be turned into either cylinder, and as the air rushes in the piston is forced to move the gear-wheel 105, which being rigid in the shaft with the sprocket-wheel 104 causes said sprocket-wheel to move the sprocket-chain 44 to cut the front vehicle-wheels.

In order to obtain a smooth and easy working of the double piston, a small quantity of glycerin is placed in each cylinder 96.

While I have shown and described a mechanism for steering the vehicle, it is not my intention to claim it herein, as it will be made the subject-matter of a future application.

The igniting device.—Passing through the head 9 of the cylinder of each engine is a shaft 109, carrying on its inner end a contact-point 110 and provided on its outer end with an arm 111. A spring 112 bears against the arm 111 and serves to maintain the contact-point in normal contact with a toothed "sparker" 113, secured on the inner end of a shaft 114, which passes through each head 9 and has secured on its outer end a four-arm ratchet-wheel 115. On the outside of each head 9 is a rockable sleeve 116, which carries at one end a pawl 117, adapted to engage the arms of the ratchet-wheel, and at its other end an arm 116′, adapted to be engaged by a cam 118, secured on the shaft 47. The sleeve extends outwardly from the cylinder-head and is attached to the said head by means of a screw-rod passing through it, a spring serving to keep the arm in constant contact with the face of the cam. The shaft 109 is properly insulated from the cylinder-head and is connected with one pole of a battery 119, the other pole of the battery being in electrical connection with the sparker. Each device is operated by its particular cam, which causes, as the cam-shaft rotates, the pawl of the fulcrumed sleeve 116 to move the ratchet one step and the sparker to move four steps or points, so that four successive sparks are rapidly made, thereby positively insuring an explosion of the explosive mixture in each engine-cylinder.

An engine constructed upon the plan of my invention will prove economic in the consumption of oil and will work silently, smoothly, and regularly.

It will be noticed that the means (air-pressure) for returning the piston on its back stroke is positive in its character and that the piston is returned with the same positiveness whatever may be its position, whether at rest at half or any part of its working stroke.

The operation of the engine is as follows: The oil and air tanks having received their necessary supply and it is desired to start the machine, the controlling-lever 81 is operated to cause the cams to open the oil and air valves to admit oil and air into their respective chambers, and thence to the cylinder. The air being under pressure, the oil is atomized as it enters the cylinder. When the required supply of oil and air has entered the cylinder, the explosion takes place, the igniter-cam being so arranged that it will cause the igniting device to act at the proper time. The explosion of the mixture will force the piston on its working or outward stroke, imparting motion to the driving-shaft through the medium of the piston gear-wheel 32, which causes the clutch-disk to engage the fly-wheel. When the piston has reached the limit of its stroke, it will be returned by the force of the air rushing into the tube 45, the air being admitted by the valve 55, which has been opened by the cam 52 operating the connecting-rod 53 and its cam 54. At the same time the piston is being forced back by the pressure of the air the cam 51 causes the exhaust-valve to open and permit the remaining portion of the expanded gas to escape through the exhaust-passage 30, a portion having already escaped through the ports 30′. As soon as the piston is returned the cycle is repeated. Of course it will be understood that in the present instance the engines perform the work alternately—that is to say, while the piston of one engine is making its working stroke the piston of the other engine is on its return stroke, the cams of one engine being differently positioned to those of the other engine.

When the engine is at rest and it is desired to start the machine, the admission of air into the cylinders will set the engine in motion, thus giving it an initial starting before the explosion takes place. This is accomplished by means of the cams 50, which are set on the independent or auxiliary motor-shaft 47 in such manner that the air-valves are operated slightly in advance of the oil-valves. This is an important feature of my invention, as it enables me to do away with the usual crank starting device.

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

1. In a gas-engine, the combination of a cylinder, a piston, mechanisms supplying air and oil to said cylinder, the air being under pressure, whereby an initial movement may be given to the piston by the pressure of said air before the explosion, mechanism supplying the air, under pressure, to return the piston, and an independent motor operating the air and oil supplying mechanisms.

2. In a gas-engine, the combination of a cylinder, a piston, valves supplying air and oil to the explosion end of the cylinder, the air being under pressure, whereby an initial movement may be given to the piston by the pressure of said air before the explosion, a valve supplying air, under pressure, to return the piston, an air-supply under pressure, mechanism operating the several valves, and an independent motor operating the valve mechanism.

3. In a gas-engine, the combination of a cylinder, a piston, valves supplying air and oil to the explosion end of the cylinder, a valve supplying air to return the piston, an independent shaft carrying cams, adapted to operate the several valves, an air-supply under pressure, and an independent motor operating said shaft, whereby the cams are caused

to alternately open the valves to admit air and oil to the explosion end of the cylinder and to return the piston.

4. In a gas-engine, the combination with the cylinder and piston thereof, of a shaft operated independently of the motive power of the engine, an air-valve, a cam on said shaft for operating said valves to supply air to the engine-cylinder, and means for supplying air to the rear end of the piston to return it on its back stroke.

5. In a free-piston gas-engine, the combination with the cylinder and piston thereof, of an air-supply reservoir, an air-chamber inclosing the rear end of the piston, and means for alternately supplying air to the front of the piston and to the rear of the same.

6. In a free-piston gas-engine, the combination with the cylinder and piston thereof, of an air-supply reservoir, and auxiliary shaft, a motive power, independent of the engine-driving power, for driving said shaft, and means for alternately supplying air to the front end of the piston and to the rear end thereof.

7. In a free-piston gas-engine, the combination with the cylinder and piston thereof, of an air-chamber, independent of the engine-cylinder, receiving the rear end of the piston, said chamber being provided with air inlet and exhaust ports, a valve arranged to alternately open and close said ports, an air-supply reservoir, and means for alternately supplying air to the front and rear ends of said piston.

8. In a free-piston gas-engine, the combination with the cylinder, air-supply valve and piston thereof, of an air-chamber, independent of the engine-cylinder, receiving the rear end of the piston, said chamber being provided with air inlet and exhaust ports, a shaft carrying cams, and an independent motor for operating said shaft whereby said cams are alternately operated to supply air to the front and rear ends of the piston.

9. In a free-piston engine, the combination with the cylinder and piston thereof, of an air-chamber receiving the rear end of the piston, said chamber being provided with an air-inlet and an exhaust-port, a valve arranged to open and close both the air inlet and the exhaust port, and means for operating the valve.

10. In a free-piston engine, the combination with the cylinder and piston thereof, of an air-chamber receiving the rear end of the piston, said chamber being provided with an air-inlet and an exhaust-port, a valve arranged to open and close both the air-inlet and the exhaust-port, a cam arranged to operate the valve, a rod connected to the cam, and a rotatable cam arranged to operate the rod and thereby the valve-cam and valve.

11. In a free-piston gas-engine, the combination with the main cylinder and piston thereof, said piston provided with a rack, of an independent air tube or cylinder receiving the free end of said piston, a driving-shaft carrying a gear-wheel adapted to mesh with the piston-rack, and a motor, independent of the main motive power, for causing a supply of air to enter the air-tube to positively return said piston on its back stroke.

12. In a free-piston gas-engine, the combination with the main cylinder and piston thereof, said piston being provided with a rack, of an independent air tube or cylinder receiving the free end of the piston, a driving-shaft carrying a gear-wheel adapted to mesh with the piston-rack, and a motor, independent of the main motive power, for causing a supply of air to enter behind the piston to give the engine its initial movement and supplying air to the tube or cylinder to positively return said piston on its back stroke, whereby motion is imparted to the driving-shaft.

13. In a free-piston gas-engine, the combination with the main cylinder and piston thereof, said piston being provided with a rack, of an independent air tube or cylinder receiving the free end of the piston, said air-tube being provided with air-inlets and exhaust-ports, a valve arranged to alternately open and close said ports, and a motor, independent of the main motive power, for causing a supply of air to enter the air-tube to force the piston on its return stroke.

14. In a gas-engine, the combination with the oil and air supply valves and means for operating the valves to force the oil and air into the engine-cylinder, of a free-acting piston, an air tube or cylinder receiving the free end of the piston, said air-tube being provided with air-inlets and exhaust-ports, a valve arranged to alternately open and close said ports, and a motor, independent of the main motive power to cause air to be supplied to the air-tube to force said piston on its back stroke.

15. In a gas-engine, the combination with the oil and air supply valves, and a shaft provided with means for operating the valves to force the oil and air into the engine-cylinder, of a free-acting piston having its free end operating in an independent tube or cylinder, air inlet and exhaust valves in said tube, and a motor independent of the main motive power, for driving the shaft, whereby air and oil are supplied to the main or engine cylinder and air to the independent cylinder to force the piston on its return stroke.

16. In a gas-engine, the combination with the oil and air valves, and a shaft provided with means for operating the valves to force the oil and air into the engine-cylinder, of a free-acting piston, an independent air tube or cylinder receiving the free end of the piston, said air-tube being provided with air inlet and exhaust ports, a valve arranged to alternately open and close said ports, means for operating said valve, and a motor, independent of the main motive power, for driving the shaft, whereby air and oil are supplied to the main or engine cylinder and air to the

independent cylinder to force the piston on its return stroke.

17. In a gas-engine, the combination with the oil and air valves, and a shaft provided with means for operating the valves to force oil and air into the engine-cylinder, of a free-acting piston, said piston being provided with a rack, an independent air tube or cylinder receiving the free end of the piston, a driving-shaft carrying a gear-wheel adapted to mesh with the piston-rack, and a motor, independent of the main motive power, for operating the valve-operating shaft to supply air and oil to the engine and air to the tube or cylinder to return said piston on its back stroke.

18. In a gas-engine, the combination with the oil and air valves, and a shaft provided with means for operating the valves to force oil and air into the engine-cylinder, of a free-acting piston, said piston being provided with a rack, an independent air tube or cylinder receiving the free end of the piston, said air-tube being provided with air inlet and exhaust ports, a valve arranged to alternately open and close said ports, a driving-shaft carrying a gear-wheel adapted to mesh with the pinion-rack, and a motor, independent of the main motive power, for driving the valve-operating shaft, whereby air and oil are supplied to the engine and air to the tube or cylinder to return said piston on its back stroke.

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

WILLIS A. SWAN.

Witnesses:
GUY E. PADGETT,
J. R. NOTTINGHAM.