(No Model.)

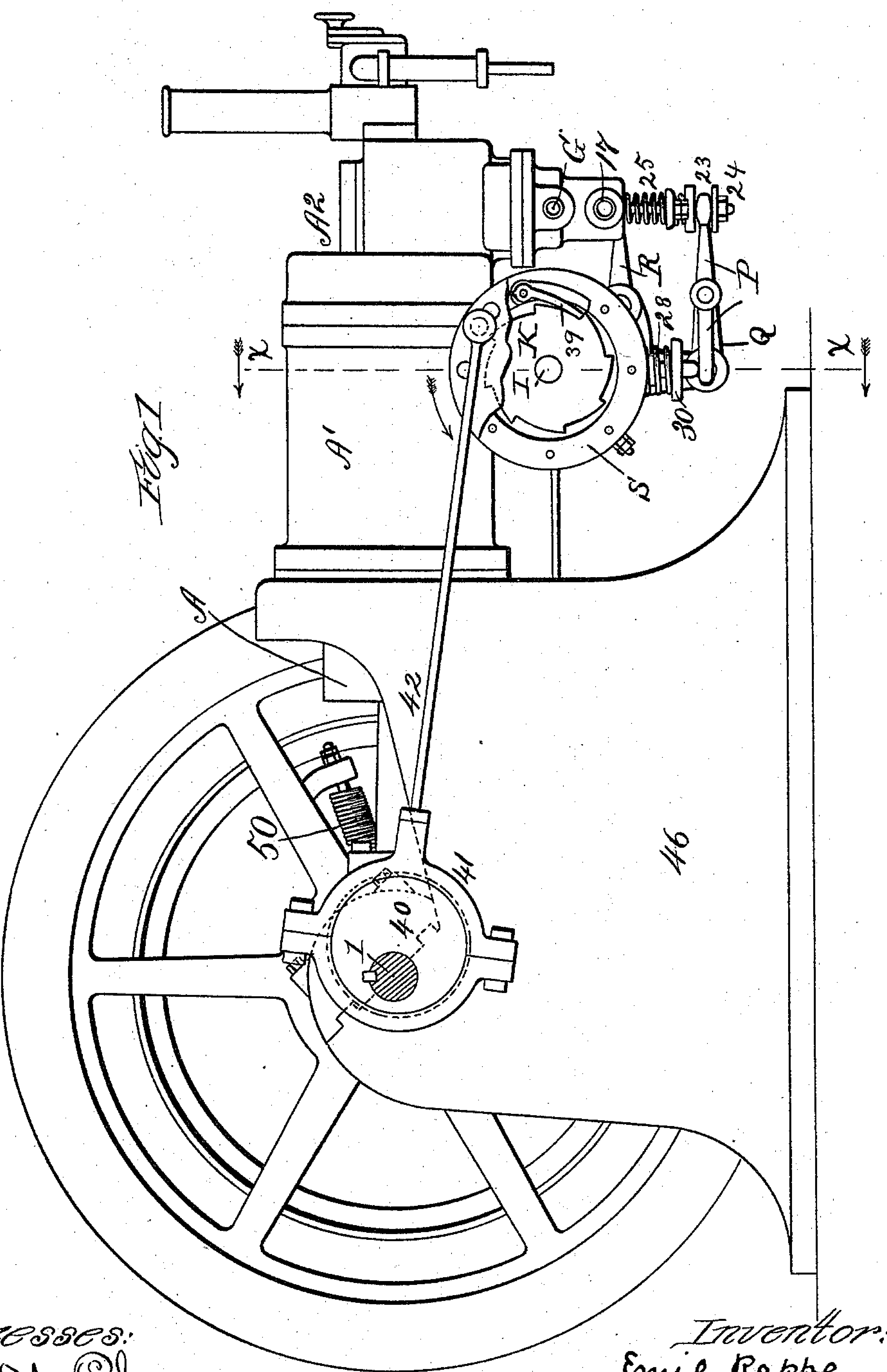
5 Sheets—Sheet 1.

E. RAPPE.

GAS ENGINE.

No. 571,498.

Patented Nov. 17, 1896.



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(No Model.) 5 Sheets—Sheet 2.

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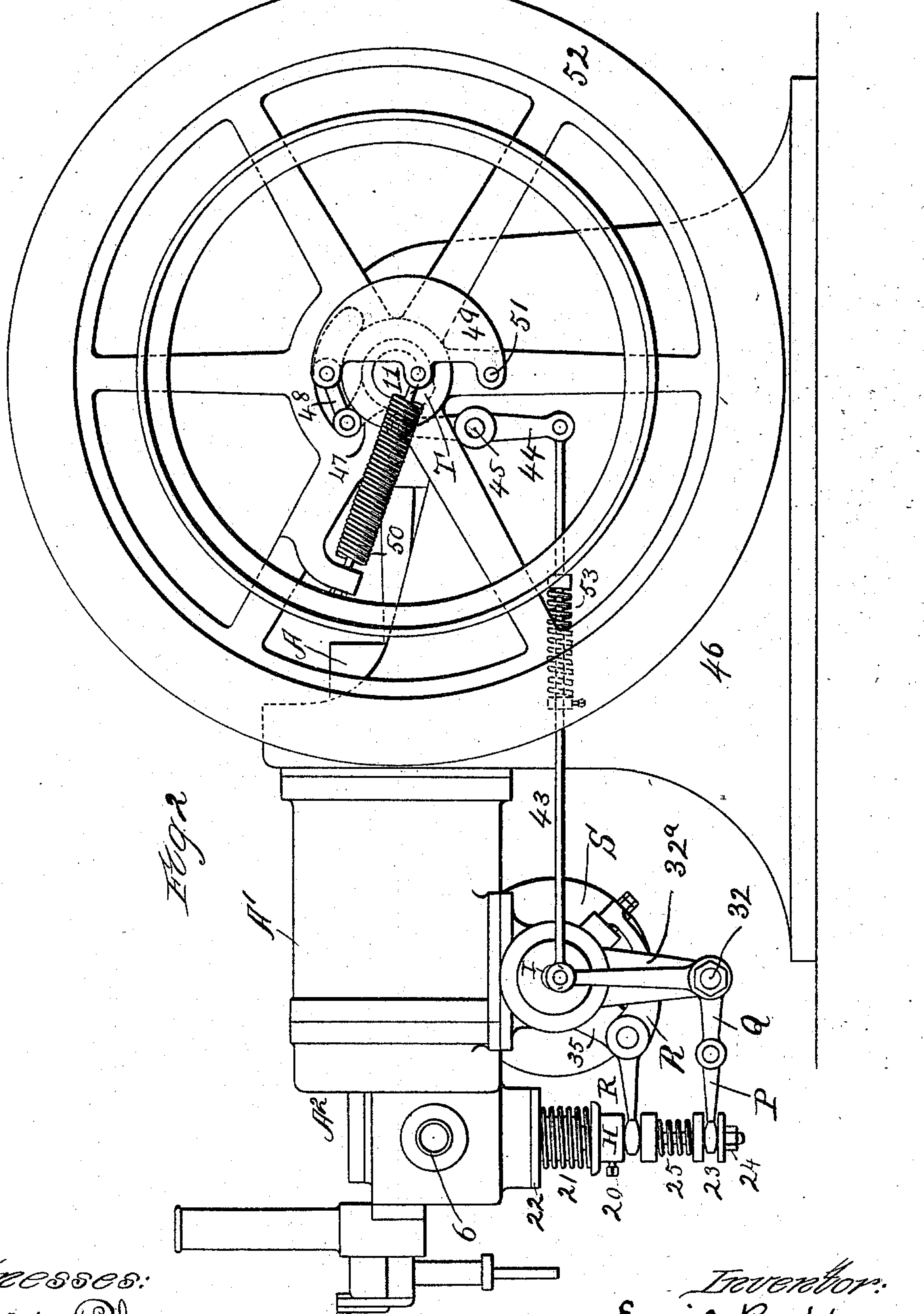

Fig. 2

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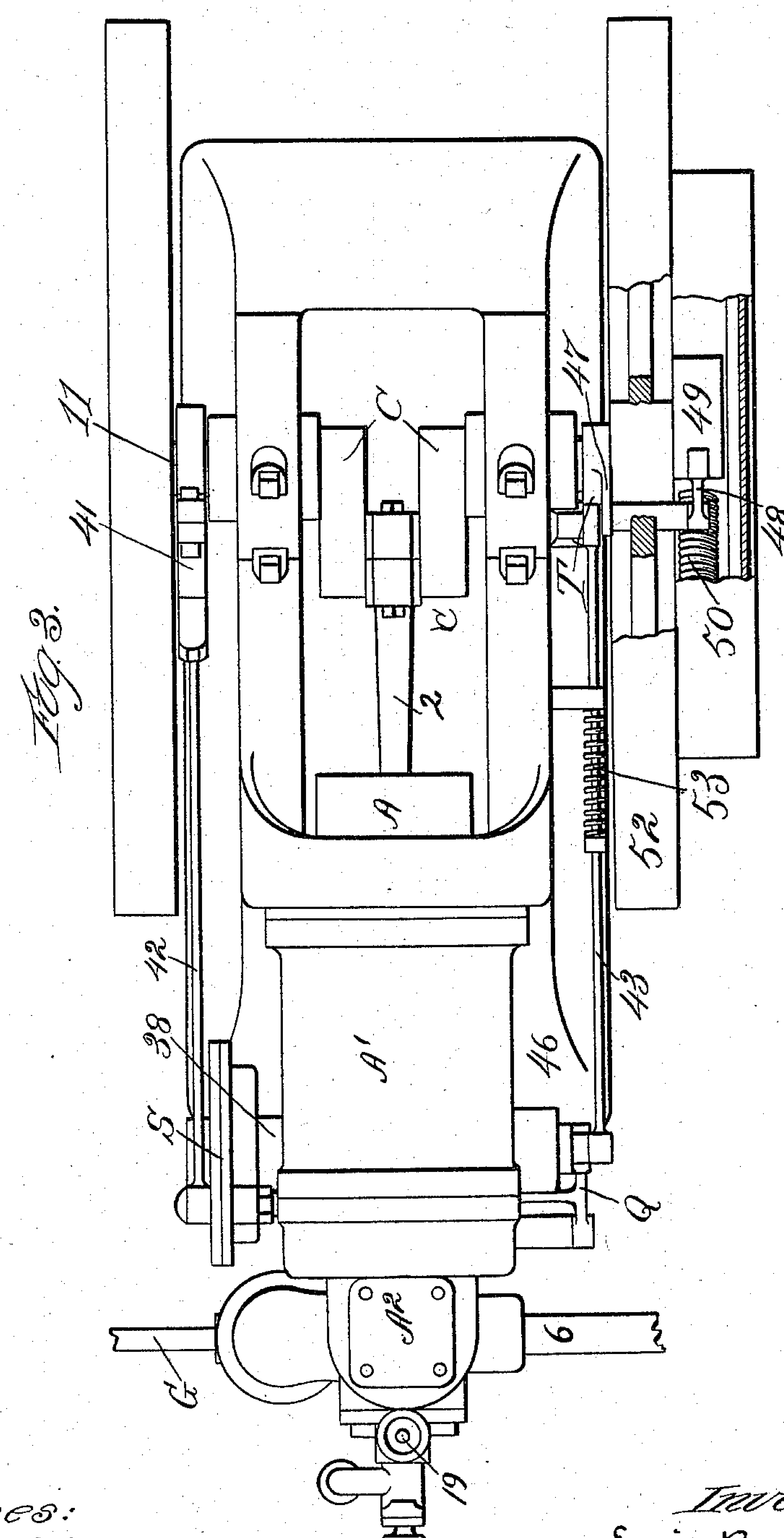

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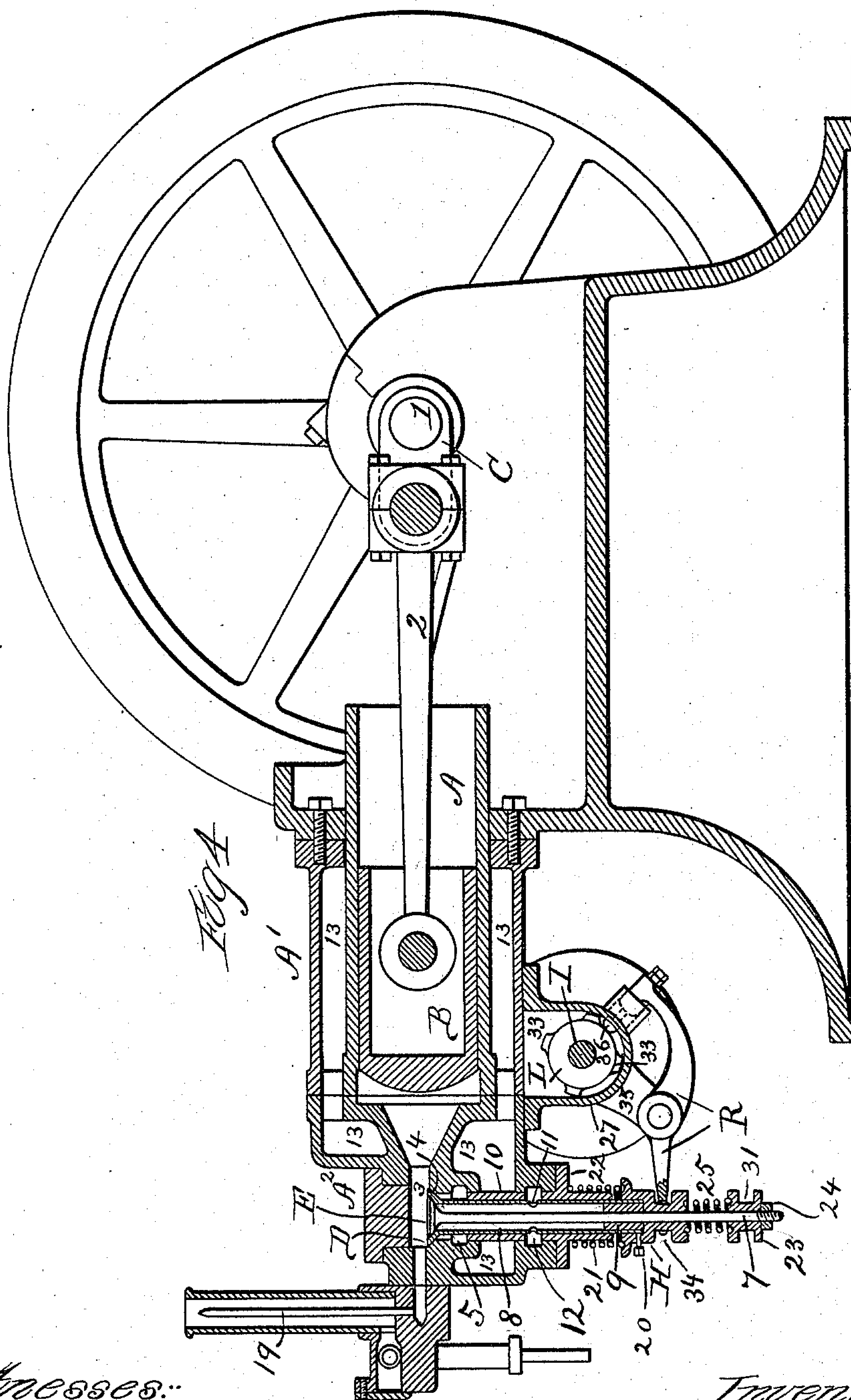
Fig. 4

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(No Model.) 5 Sheets—Sheet 5.

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Fig. 5

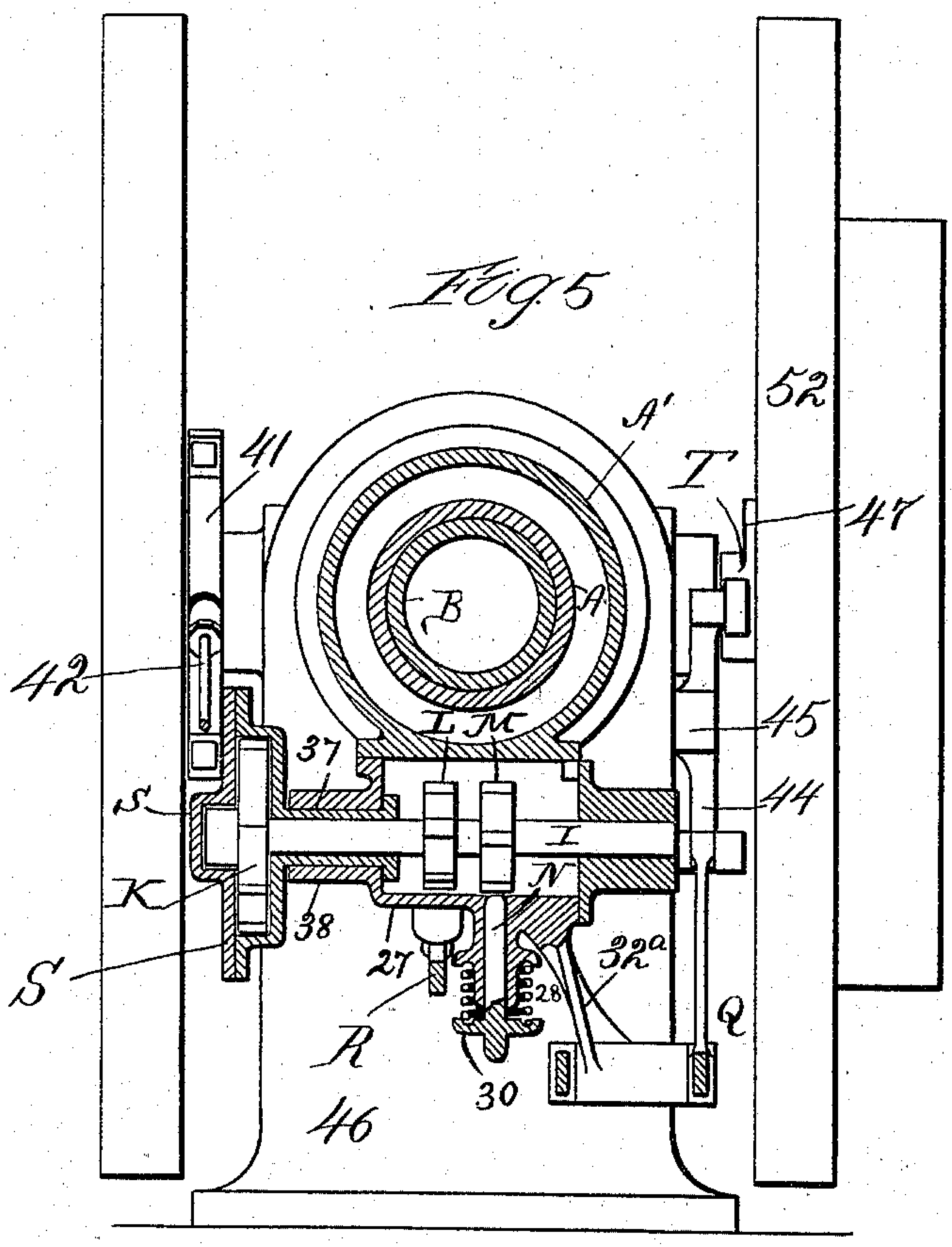


Fig. 8

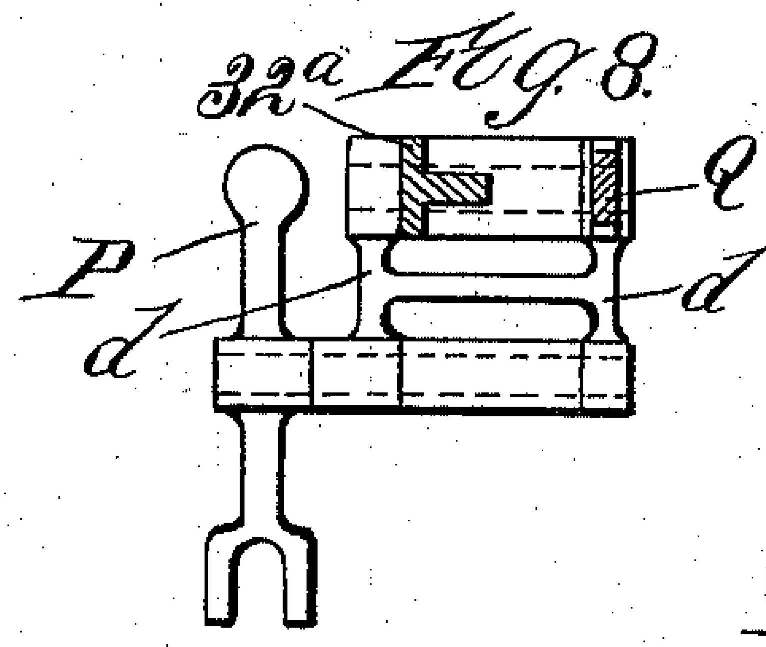


Fig. 6

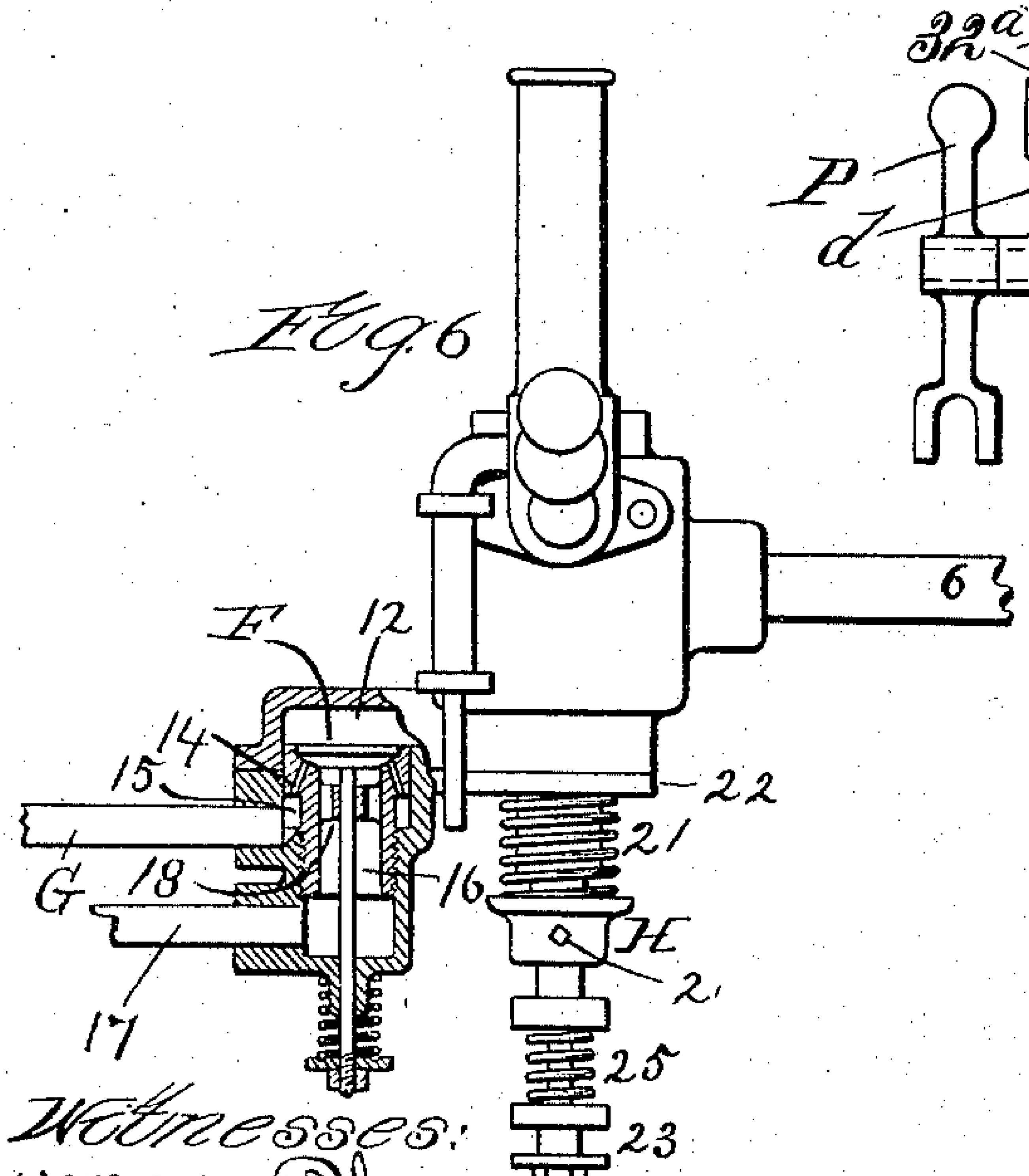
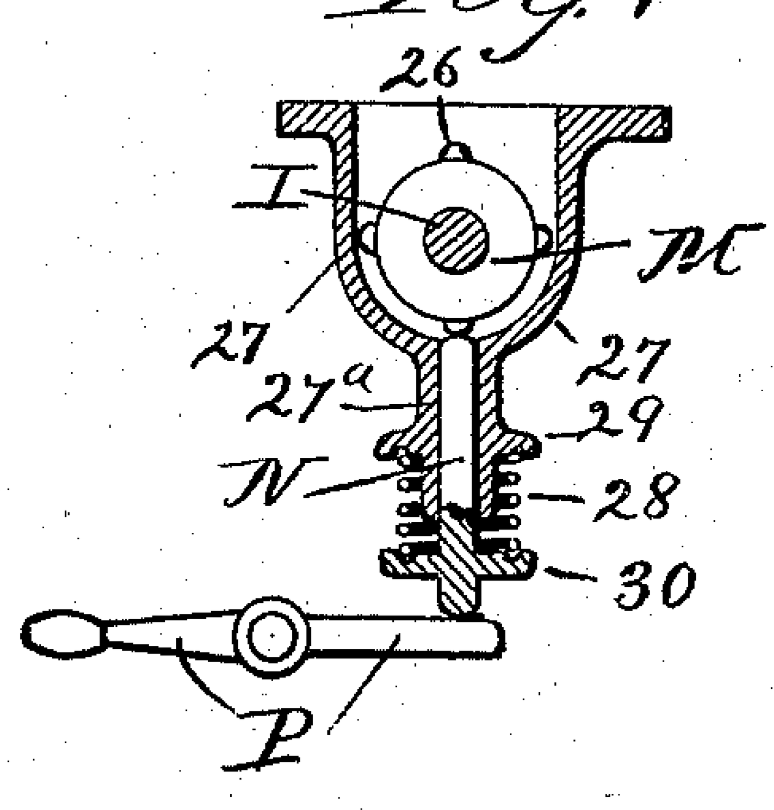


Fig. 7



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UNITED STATES PATENT OFFICE.

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GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 571,498, dated November 17, 1896.

Application filed January 29, 1894. Serial No. 498,355. (No model.)

To all whom it may concern:

Be it known that I, EMIL RAPPE, a subject of the King of Sweden and Norway, residing at Chicago, in the county of Cook and State of Illinois, have invented a certain new and useful Improvement in Gas-Engines, of which the following is a specification.

My invention relates to gas-engines of the "Otto" or four-stroke cycle type, that is to say, engines in which four strokes are required for each working stroke.

Prominent objects of my invention are to simplify the construction and at the same time provide a method of governing which in steadiness of running serves to bring the efficiency of the engine up to a standard attained by the automatic-cut-off steam-engine.

To the attainment of the foregoing and other useful ends my invention consists in matters hereinafter set forth.

In a gas-engine characterized by my invention the exhaust-port is opened and closed by an exhaust-valve, which is made hollow, so as to provide a supply-passage which communicates with a supply-port. The supply-passage, through the exhaust-valve, is opened and closed by a supply-valve which seats upon the exhaust-valve, so that while the supply-valve can be opened independently of the exhaust-valve both valves will be raised when the exhaust-valve is opened, and at the same time the supply-passage will be closed by the supply-valve. The supply-valve is at proper moments opened from a cut-off cam which is subject to an automatic governor on the fly-wheel, and the exhaust-valve is at proper times opened from an intermittingly-rotating cam. The speed of the engine determines the moment at which the supply-valve is closed, this regulation being due to the adjustment of the cut-off cam by the governor. The cam from which the exhaust-valve is opened is operated from a pawl-and-ratchet device, which is in turn operated from an eccentric in the main shaft, the pawl-and-ratchet device and said cam being timed with relation to the action of the piston, so as to operate and open the exhaust-valve at proper moments. Said pawl-and-ratchet device also controls and operates another cam or stop device which, at times when it is necessary to keep the supply-valve closed, acts in a way to temporarily break connection between the supply-valve and cut-off cam, so that regardless of the operation of the cut-off cam the supply-valve will remain closed.

In the accompanying drawings, Figure 1 represents in side elevation a gas-engine embodying my invention. Fig. 2 represents in elevation the opposite side thereof. Fig. 3 is a top plan view. Fig. 4 is a longitudinal vertical section. Fig. 5 is a cross-section on lines x x in Fig. 1. Fig. 6 is a detail showing the mixing-valve in vertical section and representing in front end elevation a portion of the machine. Fig. 7 is a detail showing a section taken transversely through the cam-shaft and its casing with the lever P in elevation. Fig. 8 is a top plan of the two levers P and Q.

In said drawings, A indicates the cylinder, and B the piston. The piston is connected with and operates a crank C on the rotary driving-shaft I, in the usual way; for example, the piston is connected with said crank by an ordinary pitman 2. The cylinder is shown surrounded by a water-jacket A', which is at one end united with what is generally termed the "back" head A^2 of the cylinder.

The exhaust-valve D and the suction or supply valve E are arranged to open into a contracted extension portion 3 of the piston-chamber, said extension portion or chamber being formed within said back head A^2 of the cylinder. The exhaust-valve, while adapted to permit the discharge of the products of combustion, also provides a supply-passage for the admission of gas and air or vapor to the cylinder, the supply-passage thus formed being opened and closed by the supply-valve E. To such end the chamber 3 has a port for the exhaust-valve D, which latter closes upon an annular seat 4 around the inlet end of the port. When the exhaust-valve is raised from its seat the exhaust of the products of combustion takes place through said port downwardly to the lateral port or passage 5, from whence such products are carried to the discharge-pipe 6, Fig. 3. The stem 7 of the supply-valve E extends downwardly through the stem 8 of the exhaust-valve, and the supply-valve proper is arranged to close upon the upper end of the exhaust-valve. The exhaust-valve and its stem are therefore made hollow, so as to provide a supply-passage, which is opened and closed by the valve E. With reference to valve E the exhaust-valve is conveniently made flaring or conical, so as to properly close upon its allotted annular seat 4 and also provide at its upper end a suitable seat for the supply-valve E. The hollow stem of the exhaust-valve is closed at its lower end by a plug 9, and is arranged to work within a suitable bushing or bearing 10, positioned in the back head A^2. The hollow stem of the discharge-valve is also provided with inlet-ports 11, arranged to open within a gas and air supply passage 12 within the back head A^2, in which way the supply can enter the hollow stem and thence pass into the chamber 3, (or, as it may be stated, pass into the cylinder,) when the supply-valve is raised independently of the exhaust-valve. The bushing 10 is surrounded by a continuation of the water-chamber 13, which surrounds the cylinder, whereby the same is kept cool by the water circulating about it.

Any suitable means for properly mixing air and gas and supplying the same to port 12 can be employed. The means for such purpose illustrated in Fig. 6 comprises a spring-controlled valve F, having its annular seat bored to provide a series of ducts or ports 14. When the valve is open said ports establish communication between the passage 12 (shown in Figs. 4 and 6) and an annular chamber 15, which is formed within the body or casing of the valve and in communication with the gas-supply pipe G. The port or passage 16, which is opened and closed by said valve, is supplied by the air-supply pipe 17 and has a bearing 18 for the valve-stem provided with a series of openings for the upflow of air. By such arrangement air and gas may mix within passage 12 when the valve is open. I do not, however, claim any particular kind of mixing-valve, since any known or suitable construction can be used. It is also here observed that the mixture, after being admitted into and compressed within the cylinder, can be fired by any convenient or suitable method of ignition. The construction illustrated shows an ordinary ignition-tube 19, but electrical ignition or ignition by heat generated by the compression of the air and gas can be used without in anywise departing from the spirit of my invention.

With further reference to the supply and exhaust valves a shouldered collar H is secured by a bolt or set-screw 20 (see particulary Fig. 4) to the stem of the exhaust-valve, and a spring 21 is arranged between said collar and an abutment 22 on the stationary frame or back head A^2, so as to normally hold the exhaust-valve closed. The stem 7 of the supply-valve E works through the plug or closed lower end 9 of the hollow exhaust-valve stem and also works through said collar H thereon. At a point below collar H the supply-valve stem is provided with a stop or collar 23, which seats upon a nut 24 on the lower threaded portion of the stem. A spring 25 is arranged between collars H and 23, so as to normally hold the valve E closed, it being observed that collar 23 can be adjusted by adjusting nut 24, and thereby vary the tension of spring 25. By such arrangement it will be seen that by raising the exhaust-valve the supply-valve will rise with it, but will remain closed by reason of its spring 25, while, on the other hand, the valve E can be raised against its allotted spring 25 independently of valve D, it being observed that spring 25 should be lighter than spring 21 to permit such action.

As a means for operating the valves D and E, I provide the following devices: I indicates a transversely-arranged cam-shaft arranged below and near the back end of the cylinder. This shaft carries a ratchet K and a couple of cams L and M, respectively allotted to the exhaust and supply valves. The cam M is formed with a series of peripherally-arranged cam projections 26, and both cams are inclosed by a suitable casing 27. The lower portion of this casing provides a hollow bearing 27^a, Fig. 7, for a movable push-pin N, which is normally depressed by a spring 28, arranged between a shoulder 29 (see particularly Fig. 7) on the casing and shoulder 30 on the lower end portion of the push-pin. A vibratory lever P is arranged subject to engagement with the push-pin and is employed for operating valve E. One end of the lever is arranged for engaging the lower end of the push-pin, and its opposite end is arranged to engage in a notch or annular groove 31, Fig. 4, in collar 23 on the stem of valve E.

The vibratory lever P is arranged alongside of and pivotally supported upon one end of a lever Q (shown in Fig. 2) in the form of a bell-crank pivoted at 32 upon a suitable bracket 32^a, the operation of said bell-crank being hereinafter described. The cam L on shaft I is also provided with a series of cam projections 33 for operating a vibratory lever R, which engages a notch or groove 34 in collar H on the exhaust-valve spindle for the purpose of operating the exhaust-valve. Said lever R is conveniently pivoted upon a bracket 35, Fig. 4, and carries at one end an adjustable wearing-pin 36, arranged for engagement with the cam projections 33 of cam L. The ratchet K is arranged within a rotary reciprocating case or pawl-carrier S, having a hollow journal 37, Fig. 5, which turns in a suitable bearing 38 on the main frame of the engine. This case S carries a spring-controlled pawl 39, Fig. 1, for engaging ratchet K and receives an oscillatory or rotary reciprocating motion from an eccentric 40 on shaft I, as best shown in Fig. 1, wherein the strap 41 is shown arranged upon the eccentric and connected with the oscillatory case or pawl-carrier S by a rod or pitman 42, it being observed that by such arrangement the pawl will positively engage and operate the ratchet at regular intervals, and hence intermittingly actuate the cam-shaft I, from which the two valves are operated. The ratchet K, for example, has eight teeth, and the cams L and M have four cam projections each.

Now, with further reference to levers P and Q, the upper arm of the bell-crank lever Q is connected by a rod 43 (see particularly Fig. 2) with the lower end of a vibratory lever 44. Said lever 44 is arranged to swing upon a stud 45, screwed into the bed-plate 46 of the machine, and has its upper end (shown in dotted lines) subject to and operated by the cut-off cam T, which is also shown in dotted lines in Fig. 2. This cut-off cam consists of a cam-sleeve arranged loose upon shaft I, and has an arm 47, connected by link 48 with a governor-weight 49, which latter is subject to a spring 50 and pivoted at 51 upon the balance-wheel 52. The particular form of governor employed is immaterial, since any form or construction of fly-wheel governor suitable for controlling cam T and automatically adjusting the same about the shaft can be used.

It will be understood that the upper arm of the lever 44 is maintained in engagement with the cut-off cam T by spring 53, said spring being arranged for compression between a projection from the bed-plate and a collar on the rod 43, (see Figs. 2 and 3,) and that the cam is rotated with the balance-wheel and operates the lever by reason of its high or low portions; also, that said cam is automatically adjusted or timed by the governor with reference to the moment at which its high portion releases or leaves the upper arm of the lever 44.

The operation generally described is as follows: The supply-valve E is opened from cam T at the commencement of the forward "suction-stroke" of the piston and is held open during all or a portion only of such stroke, according to the cam employed, the cam herein shown being adapted to keep the valve open during a portion of the stroke and to close the valve sooner or later, according to the adjustment of the cam by the governor. During the return compression-stroke both valves are closed. The valves are likewise closed during the succeeding forward "firing-stroke," and during the following return stroke the exhaust-valve is opened to permit the exhaust of the products of combustion.

Details of action involved in the foregoing are as follows: Preparatory to the forward suction-stroke of the piston the relative positions of the pawl and ratchet, cams L and M, and levers P and Q are such as illustrated in the drawings. It will be seen therefore that at such juncture one of the projections of cam M is over pin N, thereby providing a stop or check against any rise on the part of the end of the lever P, which bears against the lower end of said pin. When therefore the high portion of cam T engages and operates lever 44, the latter, through the medium of rod 43, will turn the bell-crank lever Q in a direction to raise lever P, which is pivoted on the lower arm of lever Q. This action on the part of lever Q necessarily raises the end of lever P which engages collar 23, on the stem of valve E, and thereby causes said valve to rise independently of valve D and open, it being seen that in such case the lever P bears at one end against the temporarily-immovable pin N, and that by reason of the lifting power applied to lever P between said pin and the valve-stem the end of lever P engaging the valve-stem (or collar thereon) must of necessity rise. In other words, at such time the pin represents a temporary fulcrum at one end of lever P, the valve E represents the weight to be lifted by the other end of said lever, and the upwardly-swinging lower arm of lever Q represents the lifting power applied between said fulcrum and weight. At a time proper for closing valve E the high portion of cam T releases lever 44, and at such juncture the spring 53, previously placed under tension by the aforesaid first action of lever 44, will restore lever Q to its normal position, and thereby allow lever P to drop and permit valve E to close. After the piston has completed its forward suction-stroke three strokes on the part of the piston take place before it makes its next forward suction-stroke. Thus after its said suction-stroke it makes its return compression-stroke, then its forward firing-stroke, and then a return stroke. Between two forward suction-strokes, therefore, it is necessary to keep the supply-valve closed and to prevent the action of cam T on lever 44 during such period from opening the supply-valve. To such end the pawl or ratchet device is timed to move the projection on the cam or stop device M away from push-pin N, whereby an action on the part of lever Q will not lift the lever P, since in such case the lifting power of lever Q applied to lever P will simply swing up the end of lever P which is in contact with pin N now in condition to yield and rise against its allotted spring 28. As aforesaid, the ratchet has, for example, eight teeth, and the cam M has four projections or stops 26, and hence eight forward impulses on the part of the ratchet are necessary to make one revolution on the part of the cam M. These are therefore so relatively timed that the next projection on cam M will not be brought over the pin N until just preparatory to the next forward suction-stroke. At the return stroke following the forward firing-stroke the pawl-and-ratchet action causes one of the projections on cam L to engage the wearing-pin 36, and thereby operate lever R in a direction to raise and open the exhaust-valve D, it being seen that while the exhaust-valve when thus raised will also lift valve E the latter will remain closed, and that by separating the exhaust-port 5 from the supply-port 12 by a bushing or bearing no communication can be had between said ports. At or near the end of the return stroke next succeeding the firing-stroke shaft I again receives a rotary impulse from the pawl-and-ratchet device. This said impulse serves to free lever R from cam L and bring one of the projections of cam M over the pin N, and thus place the members in readiness for the next forward suction-stroke.

I find it more economical to cut off the supply before the piston completes its out or forward suction-stroke, thereby using one-half of what would be the entire cylinder volume when the engine is working under a maximum load, and still less for smaller loads. I also find it more advantageous to retain the original proportions of gas and air constantly, or nearly so, and vary the speed and power of the engine by varying the volume of gas and air before compression by closing valve E sooner or later, according to circumstances. When therefore the speed becomes too great, the valve E will be closed sooner from the governor through the intervening connections hereinbefore described. If, however, the speed becomes too slow, the valve will be closed later during the suction-stroke of the piston, and hence a greater volume of air and gas will be admitted to the cylinder.

What I claim as my invention is—

1. In a gas-engine, the exhaust-valve arranged to open and close the exhaust-port, and made hollow to provide a supply-passage which communicates with the supply-port, and a supply-valve for opening and closing the passage through the exhaust-valve, said supply-valve being seated on the outer face of the exhaust-valve, and both valves opening in the same direction, substantially as set forth.

2. In a gas-engine, the exhaust-valve arranged to open and close the exhaust-port, and made hollow to provide a supply-passage which communicates with the supply-port, and a supply-valve for opening and closing the passage through the exhaust-valve, said supply-valve being seated on the outer face of the exhaust-valve, and being capable of independent movement in the same direction in which the exhaust-valve moves and both valves opening in the same direction, substantially as set forth.

3. In a gas-motor, a normally-closed exhaust-valve controlling the exhaust-port and a supply-valve seated on the outer face of the exhaust-valve and controlling the passage leading through the exhaust-valve and communicating with the supply-port, both of said valves opening in the same direction and said supply-valve being subject to means for normally closing the same of less strength than the means for normally closing the exhaust-valve, whereby the supply-valve may be independently lifted from its seat on the exhaust-valve, without opening the exhaust-port, substantially as described.

4. In a gas-engine, the combination of the cylinder, the normally-closed hollow exhaust-valve, a supply-valve normally closing the passage through the exhaust-valve, said supply-valve being seated upon the outer face of the exhaust-valve and arranged to open in the same direction with the latter, and having its stem extended into and through said passage in the exhaust-valve, and mechanism, substantially as described for operating the said valves from an eccentric on the driving-shaft, substantially as set forth.

5. In a gas-engine, the combination with the supply-valve, of an adjustable cut-off cam and a governor for automatically adjusting the same, mechanism for operating the valve from said cam, and a cam or stop device for temporarily breaking power-transmitting connection, between the valve and cut-off cam, substantially as described.

6. In a gas-engine, the combination of a supply-valve, lever P for operating the same, lever Q for operating lever P, cam M, and a push-pin N arranged between said cam and lever P, substantially as described.

7. In a gas-engine, the combination of a supply-valve for supplying the cylinder, a lever P for operating the same, a lever Q carrying the lever P, and a stop device intermittingly presented as a fulcrum to one end of lever P, substantially as described.

8. The combination with the supply-valve, of the adjustable cut-off cam and a governor for automatically adjusting the same, levers P and Q connected as set forth, and power-transmitting connection between lever Q and the cut-off cam, substantially as described.

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