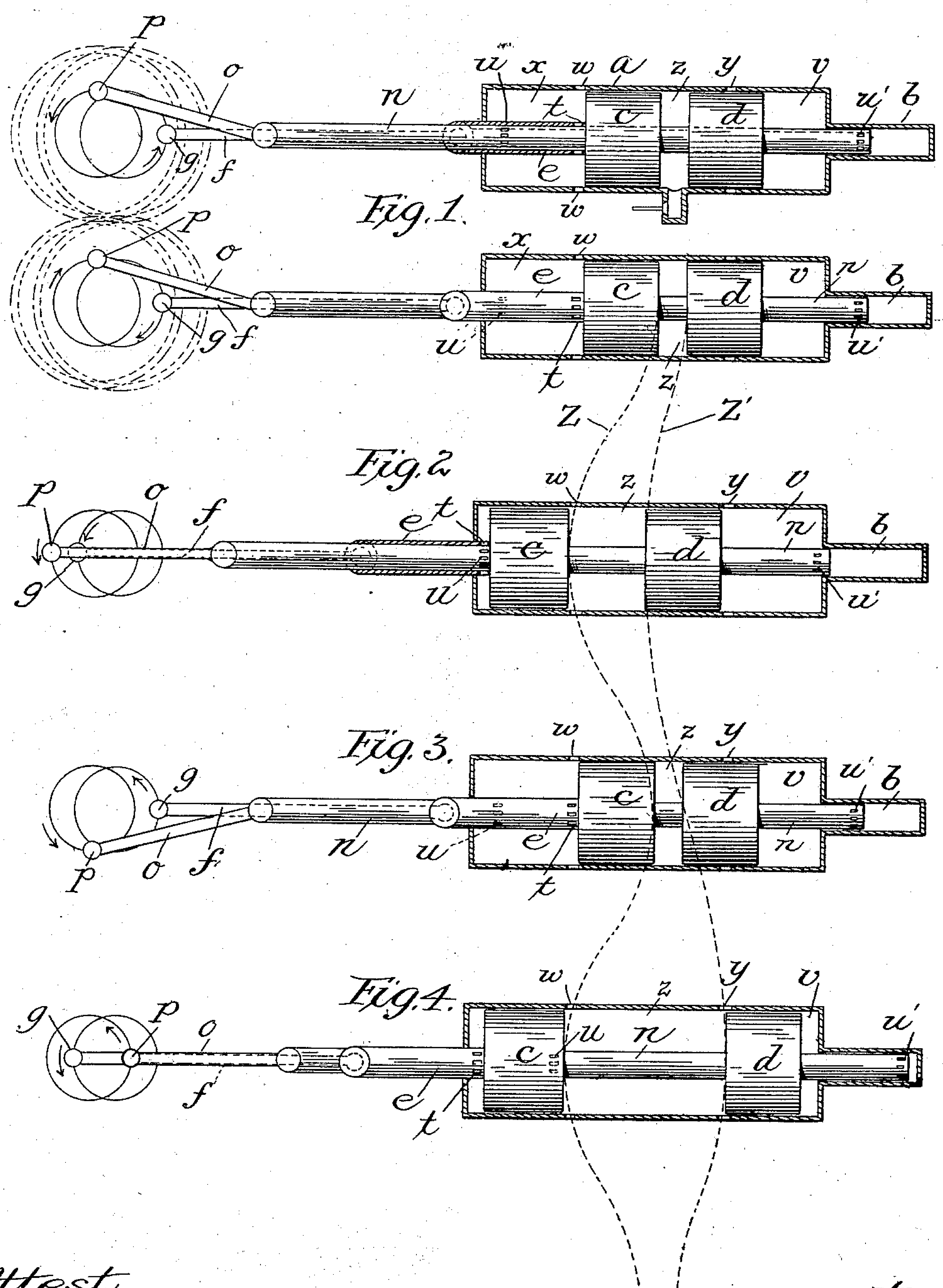
No. 702,430. Patented June 17, 1902.

J. F. HOBART.

INTERNAL COMBUSTION ENGINE.

(Application filed Mar. 30, 1901.)

(No Model.) 5 Sheets—Sheet 1.



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(No Model.) 5 Sheets—Sheet 2.

Fig. 5.

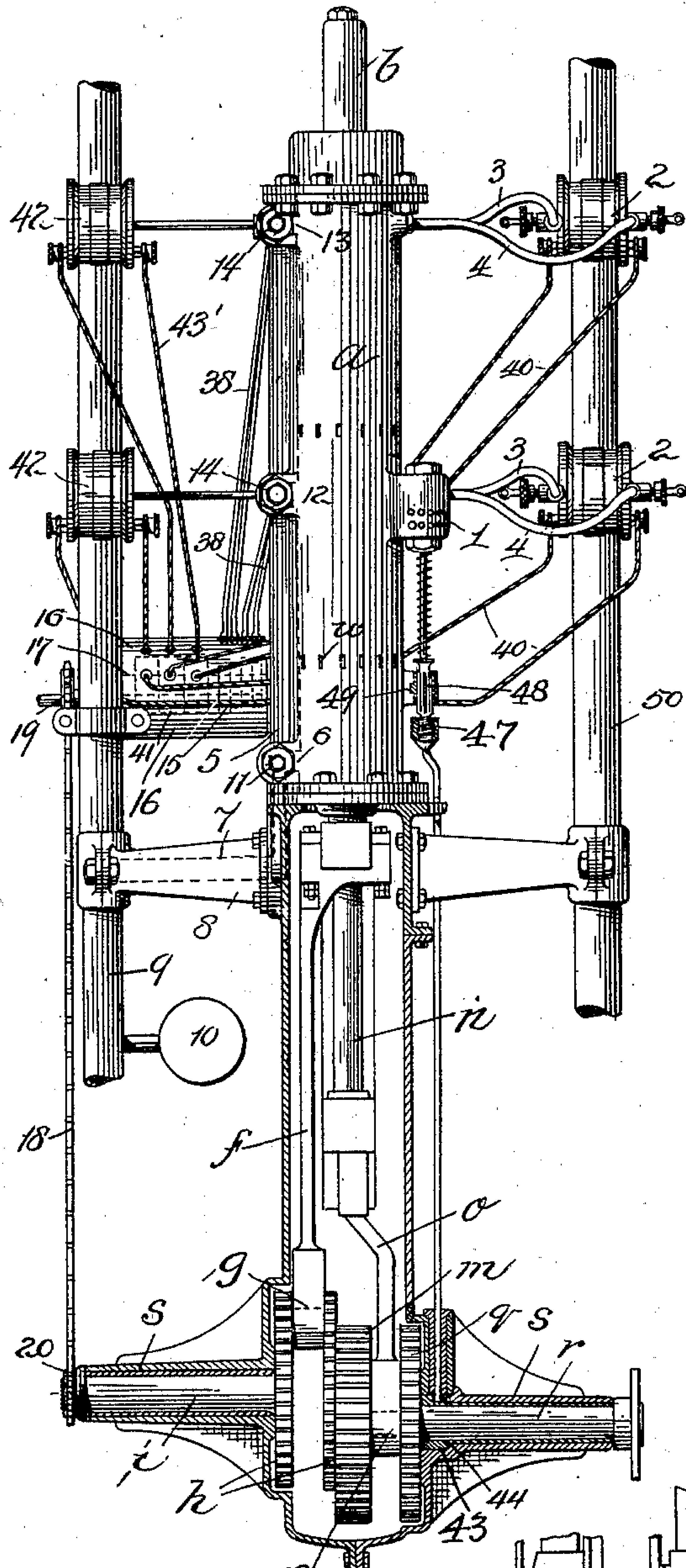

Fig. 6.

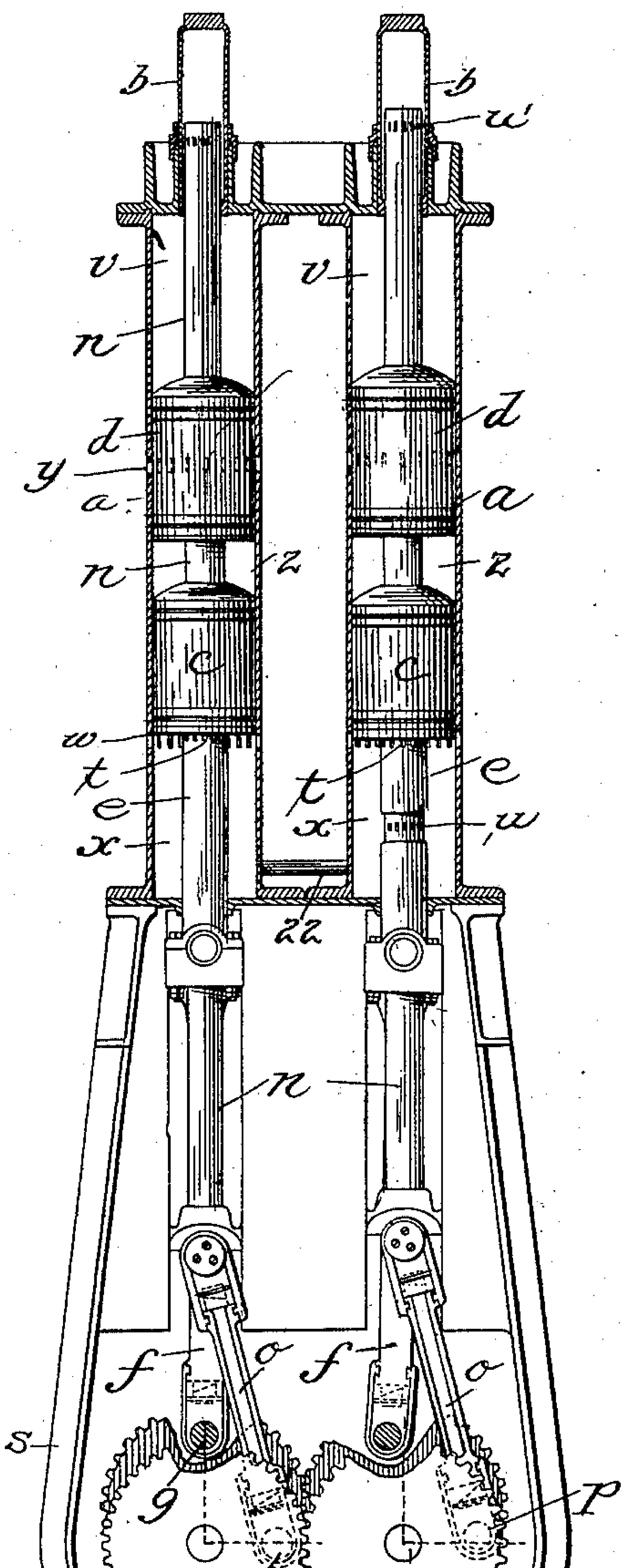

Fig. 7.

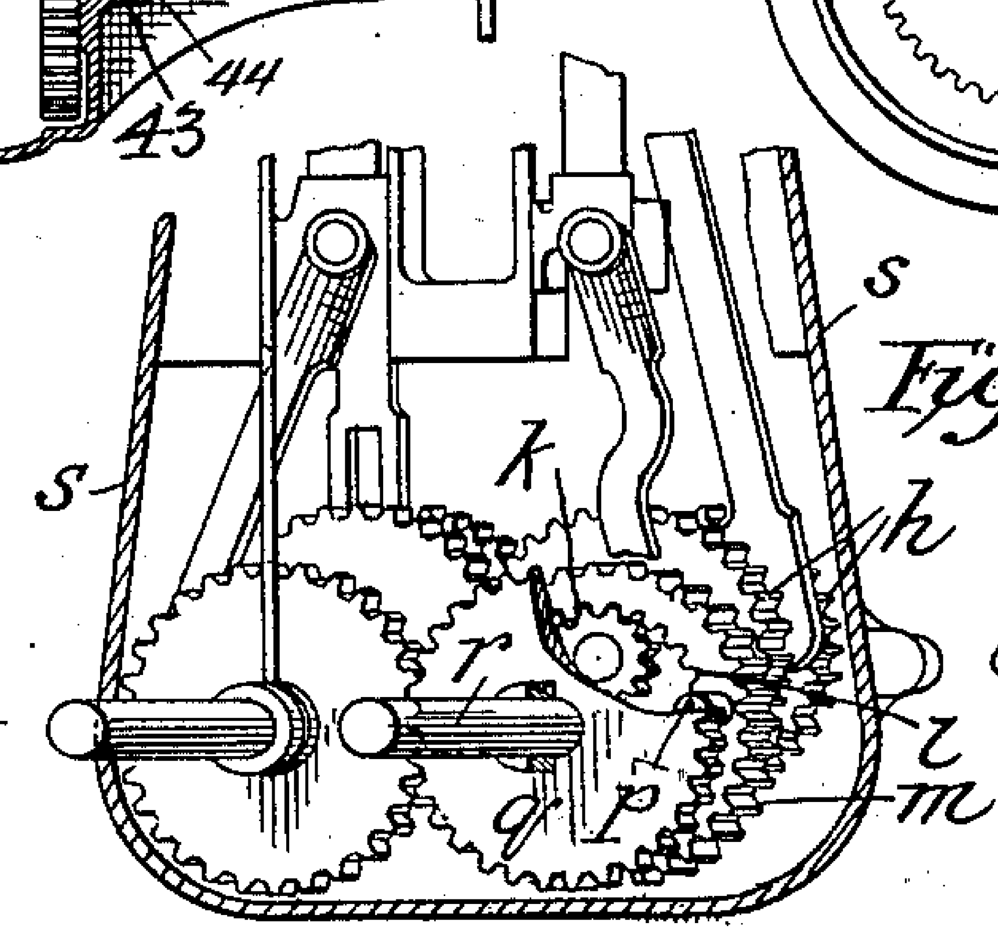

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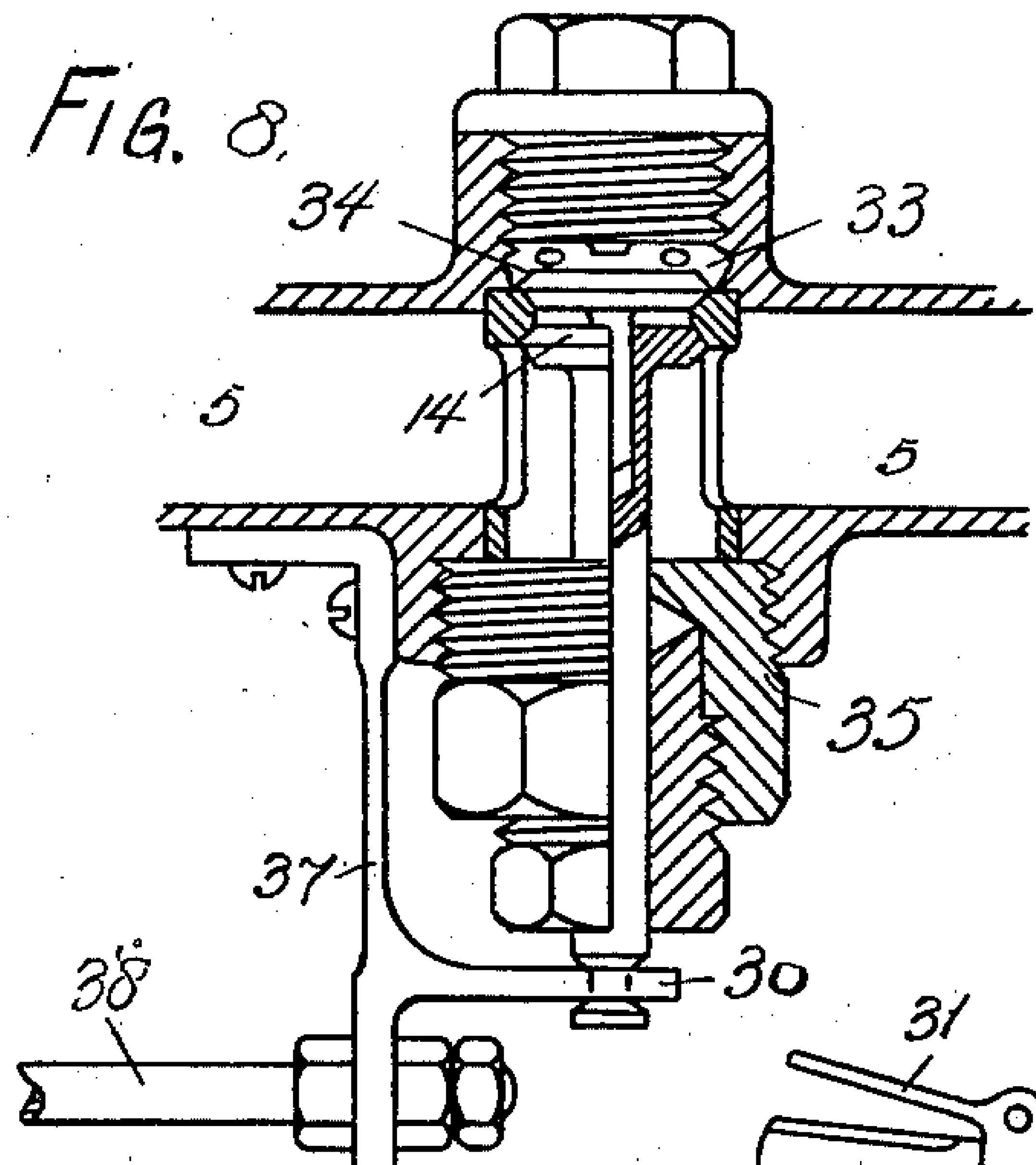
FIG. 8.



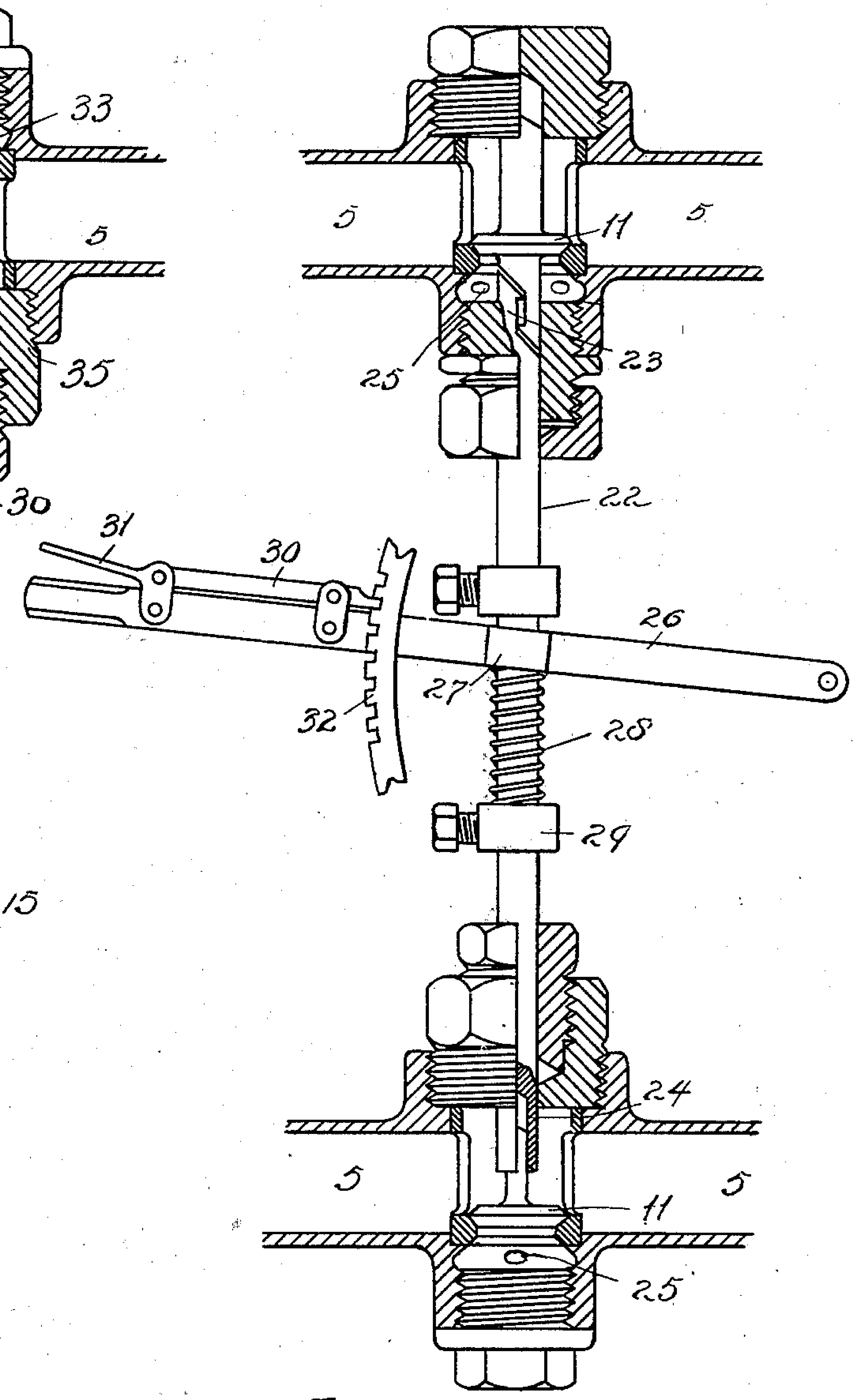


FIG. 9.

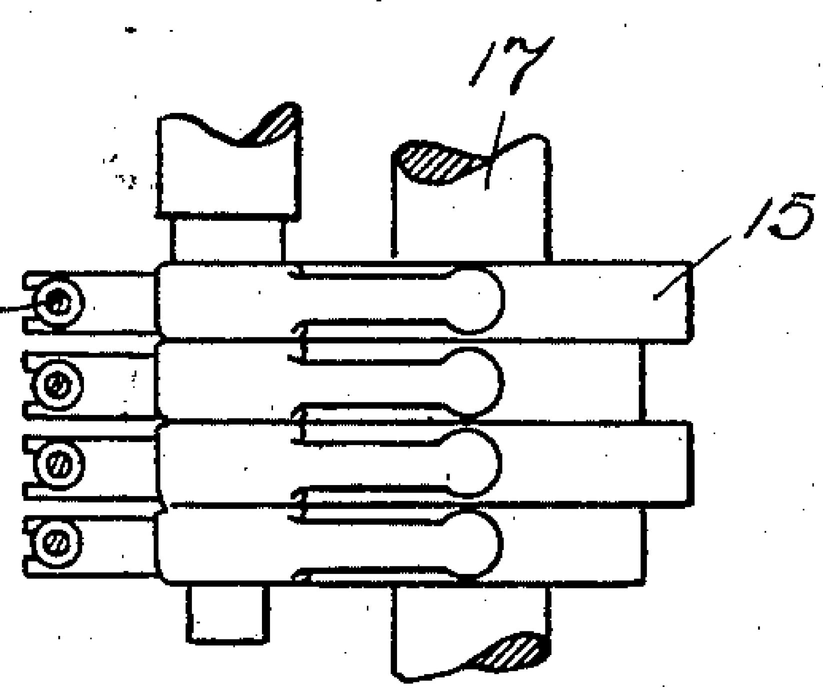


FIG. 10.

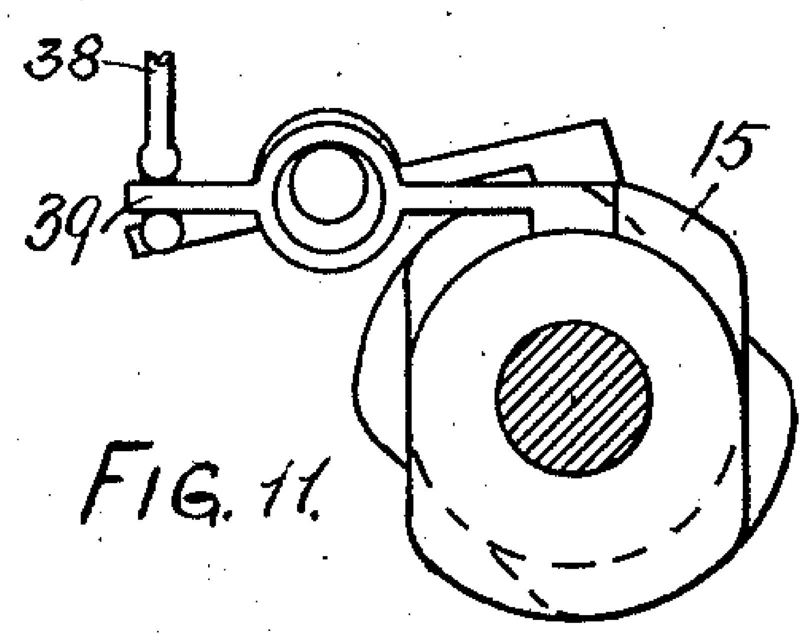


FIG. 11.

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INTERNAL COMBUSTION ENGINE.

(Application filed Mar. 30, 1901.)

(No Model.) 5 Sheets—Sheet 4.

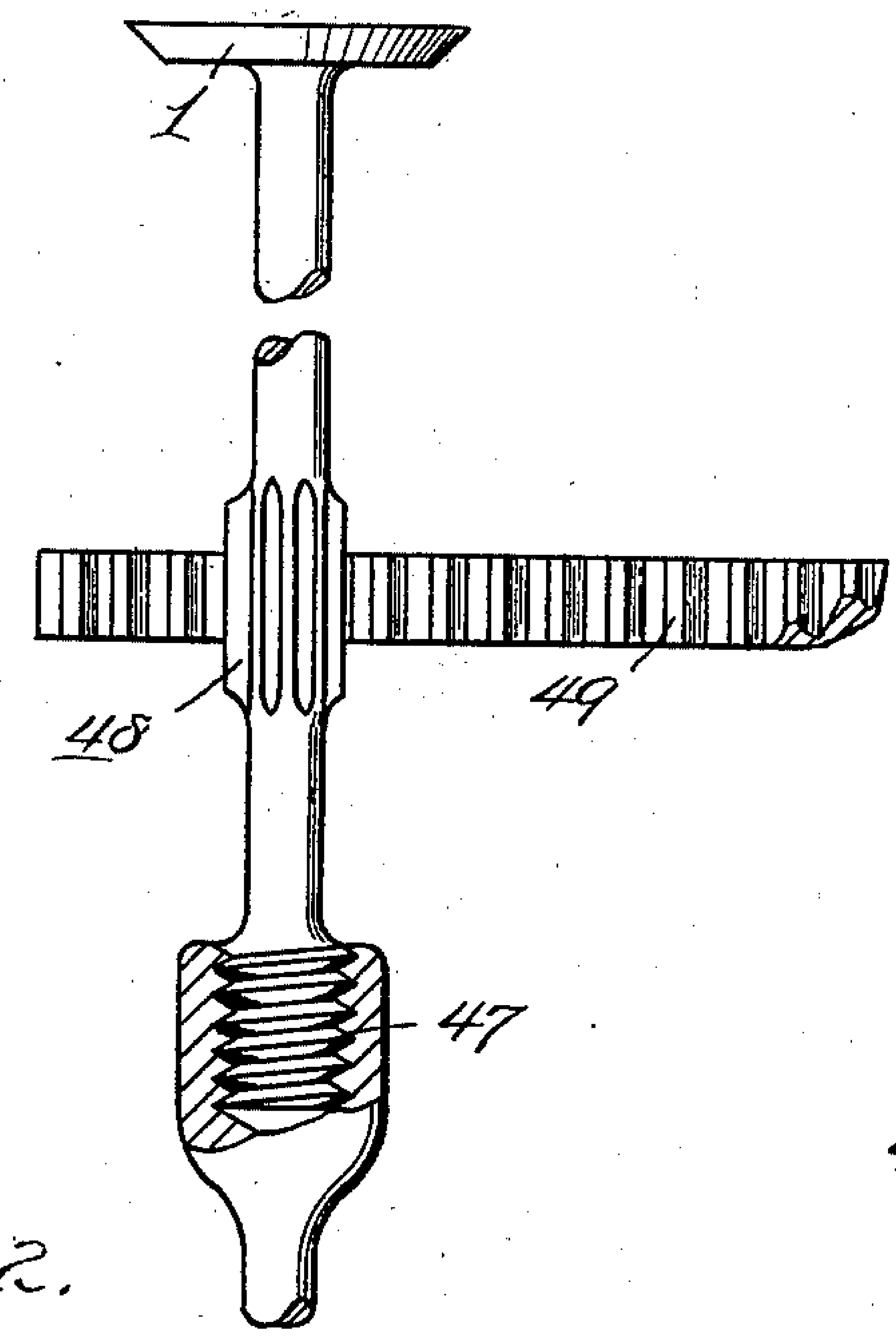
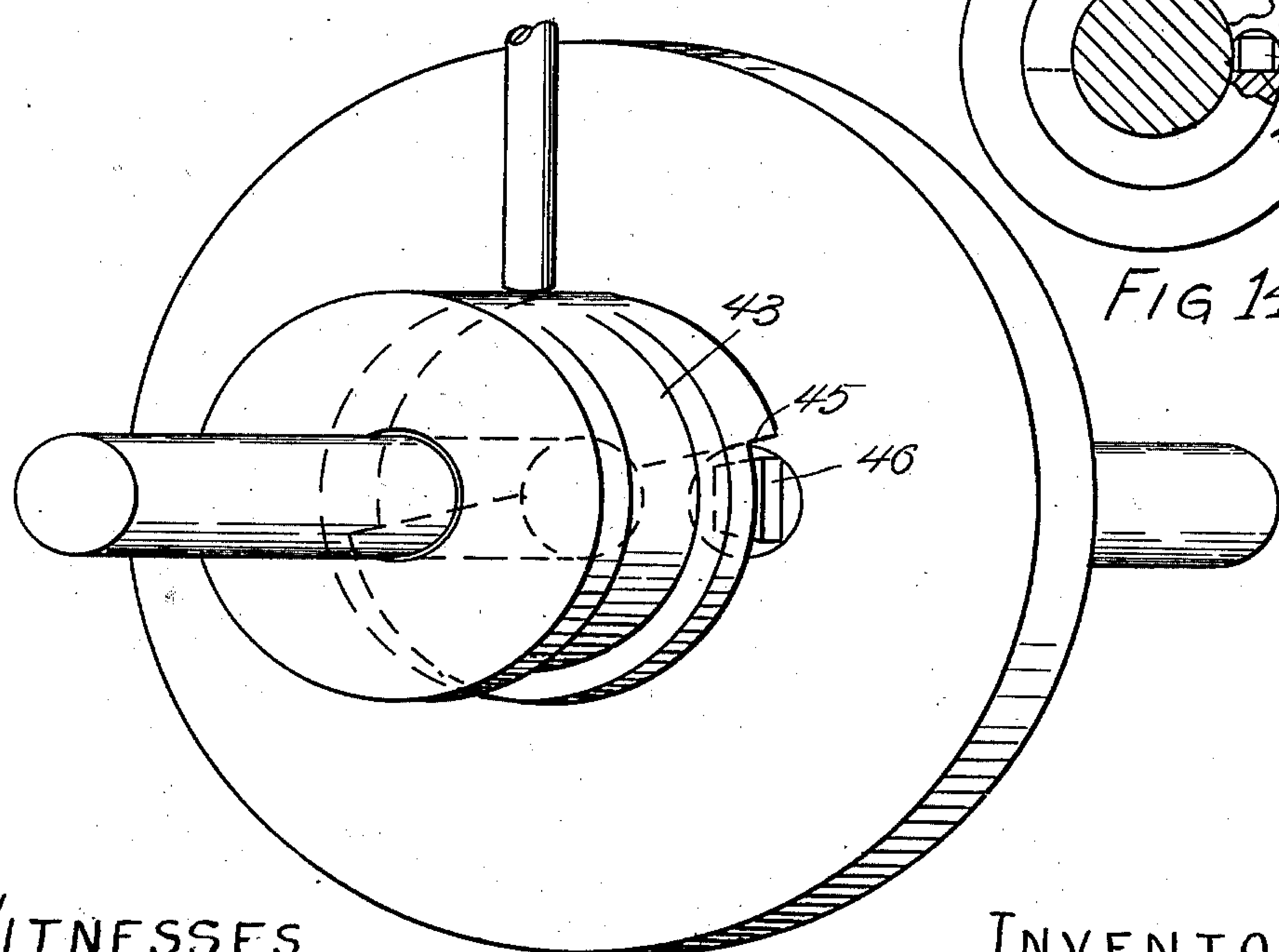


FIG. 12.



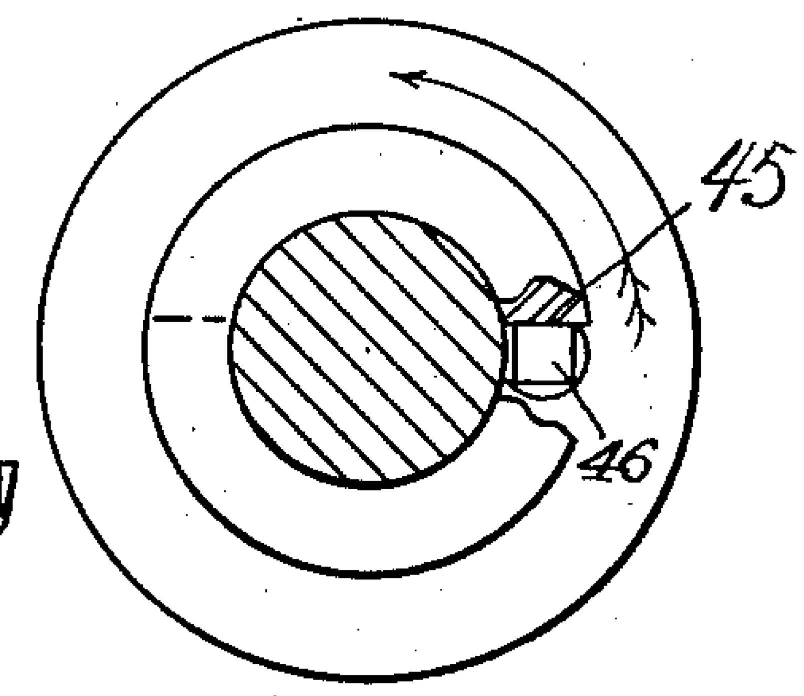


FIG. 13.

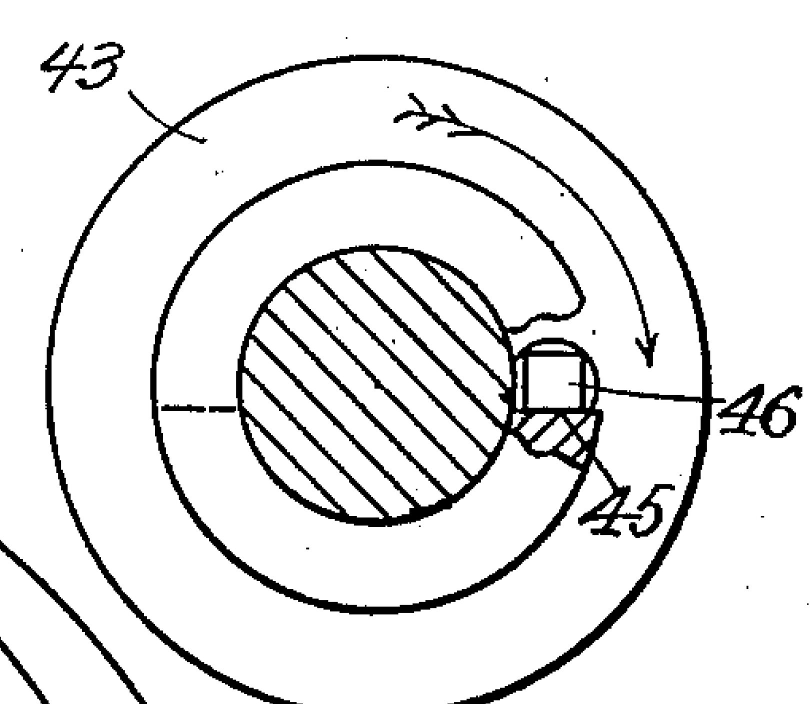


FIG 14.

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INTERNAL COMBUSTION ENGINE.

(Application filed Mar. 30, 1901.)

(No Model.) 5 Sheets—Sheet 5.

Fig. 16.

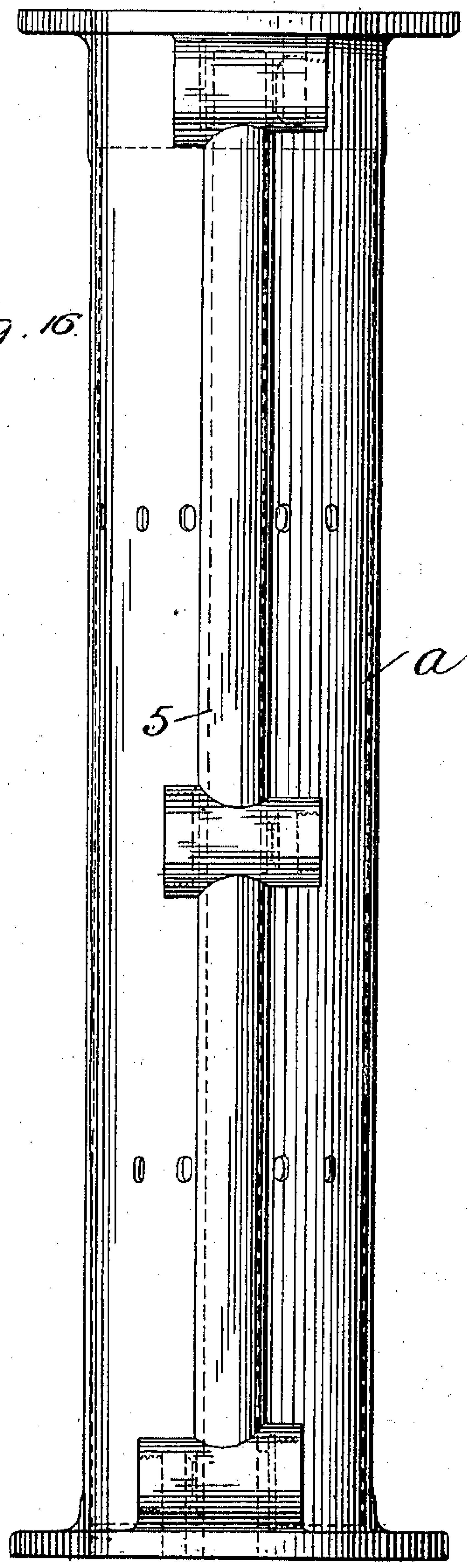


Fig. 15.

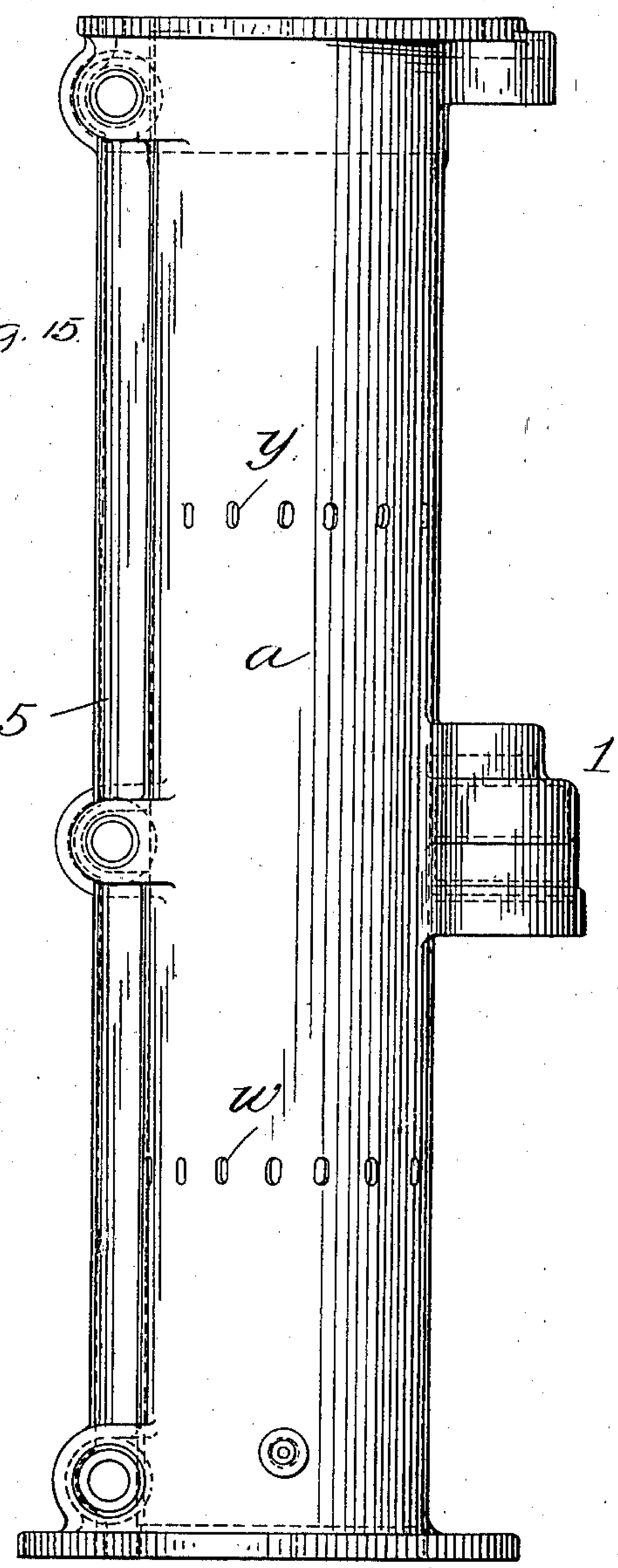
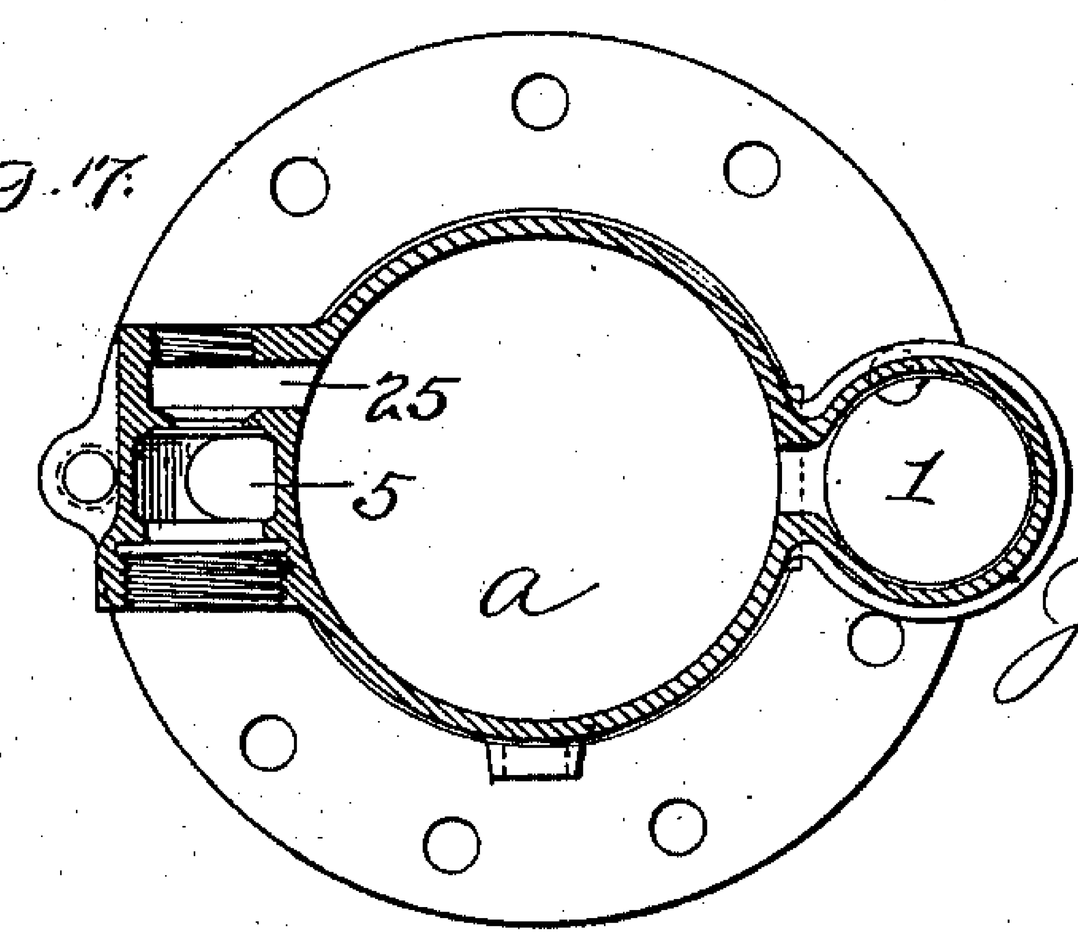


Fig. 17.



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UNITED STATES PATENT OFFICE.

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INTERNAL-COMBUSTION ENGINE.

SPECIFICATION forming part of Letters Patent No. 702,430, dated June 17, 1902.

Application filed March 30, 1901. Serial No. 53,607. (No model.)

To all whom it may concern:

Be it known that I, JAMES F. HOBART, a citizen of the United States, residing at Brooklyn, Kings county, New York, have invented certain new and useful Improvements in Internal-Combustion Engines, of which the following is a specification.

The object of my invention is to provide a hydrocarbon-engine particularly adapted to low speed for automobile-propelling purposes.

My engine is double-acting, adapted to be reversed, and capable of being attached rigidly to the driving-axle of a vehicle, permitting the operator to start the loaded vehicle without having first to give a manual impulse to the driving-shaft of the motor.

One of the main features of my invention consists in employing two pistons within a single cylinder, one of said pistons acting on the four-cycle principle and the other acting on the two-cycle principle. These pistons are geared together, and two impulses are thus derived for each revolution of the drive-shaft.

My engine is of double form, consisting of two cylinders and two sets of the pistons just mentioned, the combustions or explosions in one cylinder alternating with those in the other cylinder and the driving shafts or cranks of the two cylinders being geared together, so that four impulses are derived, occurring at different times during one revolution of the driving-shaft. I utilize one of the pistons in each cylinder as a compressing and scavenging piston; and my invention consists also in this and in other features and arrangements and combinations of parts hereinafter fully described, and pointed out in the claims.

In the accompanying drawings, Figure 1 is a view in the nature of a diagram of my invention. Fig. 2 is a similar view of one of the cylinders, with its pistons and cranks, showing the parts in a different position from that shown in Fig. 1. Figs. 3 and 4 are similar views in the nature of diagrams, showing the parts in different positions. Fig. 5 is a plan view of my invention, with a part of the vehicle-frame by which it is supported. Fig. 6 is a longitudinal section through the cylinders. Fig. 7 is a perspective view of the geared connection between the two parts of the double engine. Fig. 8 is a detail view of one of the controlling-valves. Fig. 9 is a detail sectional view showing valves for controlling the passages between the air-compression chambers and the reservoir, with means for controlling the said valves by hand. Fig. 10 is a detail view of means for controlling the compressed-air-supply valves, such as shown in Fig. 8. Fig. 11 is a side view of Fig. 10. Fig. 12 is a perspective view of a floating cam and a combined inlet and exhaust valve controlled thereby. Figs. 13 and 14 are detail views showing the manner of operating the floating cam. Figs. 15, 16, and 17 are detail views of the cylinder.

In the drawings the two cylinders of my double engine are shown at *a*, these being of substantially ordinary form, but having extensions *b* at their rear ends. A pair of pistons *c d* are arranged in each cylinder, the piston *c* having a tubular piston-rod *e*, connected by a pitman *f* with a crank-pin *g*, carried by a pair of disks *h*. One of the disks *h* carries thereon a pinion *k*, arranged to mesh with internal teeth *l* of a gear *m*, hereinafter referred to. The piston-rod *n* of the piston *d* extends through the hollow piston-rod *e* of the piston *c*, and its pitman *o* is connected with a pin *p*, which connects the disk *m* with a disk *q*, carried by the driving-shaft *r*, suitably journaled in the crank-shaft casing *s*. The pinion *k* and internal gear *l* are proportioned two to one, so that the piston *c* moves twice as fast as the piston *d*. One or more of the disks *h* belonging to one cylinder are fitted with gear-teeth, which mesh with similar teeth on the disks belonging to the other cylinder and the cranks thereof. The disks, therefore, of one cylinder move in a direction opposite to those of the other cylinder and the crank-pins of the one cylinder are set in advance of those of the other cylinder of the engine. These may be set at any desired angle apart; but I prefer one hundred and seventy-five degrees. By this I obtain absence of dead-point, and from an inspection of Fig. 6 it will be seen that while the crank-pin *g*, belonging to the left-hand cylinder, is on the dead-center the crank-pin of the left-hand cylinder is off the dead-center, which makes it impossible for a dead-point to exist with respect to the entire engine. The piston-rods, as before stated, are hollow, and openings *t* are formed in the outer piston-rod *e*, and small openings *u* are formed in the hollow inner piston-rod *n*, these two sets of openings being arranged to aline with each other in certain positions of the pistons *c* and *d*, as will be hereinafter described. The hollow piston-rod of the piston *d* extends rearwardly into the cylinder extension *b* and is provided with openings *u'*, adapted to communicate in the extreme inward position of the piston *d* with the chamber *v* at the end of the cylinder *a*. Fresh-air-supply openings *w* are provided in the cylinders, leading to the forward chambers *x* of the cylinders, and exhaust-openings *y* lead from the rear chambers *v*, said exhaust-openings being covered and uncovered by the piston *d*, and the fresh-air-supply openings to the forward chamber *x* being similarly controlled by the piston *c*. The space *z* between the two pistons is controlled by an exhaust-valve 1, which also serves as an air-induction valve to this intermediate chamber. Fuel is supplied to the rear chamber *v* and to the intermediate chamber *z* by electric pumps 2 (shown generally in Fig. 5) and connected to the chambers *v* and *z* of each cylinder through the pipes 3 4. No inlet-valves are needed, there being an open pipe direct from the cylinder to the pump, the valve of which latter does the work. The chamber *x* is utilized as a chamber for the compression of air by the piston *c*. This chamber connects with a passage 5, extending longitudinally of the cylinder through a port 6. The passage 5, at its extreme forward end, is connected through a passage 7 in the supporting truss or bracket 8 with the interior of the tube or perch 9, forming part of the supporting structure of the vehicle. This hollow perch connects with an air-reservoir, (represented, for convenience of illustration, diagrammatically at 10, Fig. 5.) Each of the cylinders is provided with the passage 5, and each passage is connected with the reservoir, so that the air compressed in the chamber *x* may pass into the reservoir to be stored therein, suitable check-valves 11, to be hereinafter particularly described, being located between the passages 5 and the compression-chambers *x* to retain the compressed air in the reservoir and in said passages. This compressed air is utilized for starting the engine, and for this purpose the passages 5 connect with the ports 12 and 13, leading, respectively, to the intermediate and rear chambers *z* and *v*. These ports are controlled automatically when it is desired to start the machine by valves 14, controlling the passage of air between the passages 5 and the said chambers, the said valves being operated at proper times and in rotation from cams 15, carried within a casing 16 on a shaft 17, which is driven from the driving-shaft *i* through chain-and-sprocket connections 18, 19, and 20. This mechanism and its action will be referred to more in detail hereinafter.

I will now describe the cycles of operation of the two pistons.

Figs. 1, 2, 3, and 4 are diagrams illustrating the action of the engine and the different positions relative to each other assumed by the pistons and the parts connected therewith. In Fig. 1 I have shown the engine of double form with two cylinders and a geared connection between them, while in Figs. 2, 3, and 4 I show but a single cylinder, as this is sufficient to illustrate the interaction of the pistons therein.

In Fig. 1 and referring to the upper of the two cylinders there shown we will assume that the parts are ready for the induction action in the space *z* between the two pistons. For this induction action the piston *c* moves from the position shown in Fig. 1 to that shown in Fig. 2, the space between the two pistons in Fig. 1 being about one inch and that between the pistons in Fig. 2 being about three inches. In this action the pistons are moving in the same direction; but as the piston *c* moves twice as fast as the piston *d* the space between them is increased to the extent shown in Fig. 2. The charge has now been drawn in, the exhaust-induction valve 1 is closed, and the pistons move to the position shown in Fig. 3, the piston *c* moving more rapidly than the piston *d* and reducing the space between them to about one inch for the compression of the intermediate charge. The ignition now takes place while the parts are in the position shown in Fig. 3, and the pistons separate on the expansion-stroke to the position shown in Fig. 4, from which position they return to the position shown in Fig. 1, during which time the space *z* is being exhausted of the foul mixture. This exhaust action begins when the piston *c* reaches its forward limit, so as to uncover the ports *w* in the cylinder, and continues during the return of this piston, the exhaust from between the pistons now taking place through the valve 1. The pistons having returned to the position shown in Fig. 1, the cycle is complete and the action is repeated. It will be noticed by observing the dotted line Z, connecting the pistons *c* of the several diagrams, that piston *c* makes two outward and two inward strokes for each combustion, and thus this piston operates upon the four-cycle principle. From an inspection of the line Z', indicating the course of the piston *d*, it will be seen that this piston makes only one complete reciprocation during this time, thus operating upon the two-cycle principle with respect to the combustion in the chamber *z*.

We will now follow out the actions in chamber *v* and their relation to those taking place in the intermediate chamber *z*.

In the chamber *v* the two-cycle action is secured, and for this purpose the exhaust of the expanded charge and the induction of fresh air takes place while the piston *d* is in the position shown in Fig. 2. In order to accomplish this, the piston-rods e and n are provided with holes, and when the piston c is on its outward stroke to the left, as shown in Fig. 2, openings t in the hollow rod e will catch up with and aline with openings u in the hollow piston-rod n of the piston d, both pistons, it being understood, moving toward the left. This alining action takes place somewhat before the piston c completes its leftward stroke and while about twenty pounds pressure of air has been attained in the chamber x. This air will be forced through the alining holes and through the piston-rod n and will be discharged into the chamber v through the openings u' of the piston-rod, which at this time have been withdrawn from the cylinder extension b and are communicating with the chamber v. At this same time the piston d has uncovered the exhaust-openings y and the expanded charge in the chamber v is forced out, and fresh air is thus let into this chamber. The fuel being fed to this chamber at any determined instant during the induction of air will vaporize by contact with the hot walls of the chamber and will mix with the fresh air. Compression now begins in chamber v, as shown in Figs. 3 and 4, and is completed when the piston d reaches the end of its outward stroke, as shown in Fig. 4, when ignition takes place in chamber v and the piston d is driven toward the left to the position shown in Fig. 1, thus completing the two-cycle action with respect to the explosion in chamber v. From the above it will be seen that an explosion takes place on either one side or the other of the piston d on each stroke, making two impulses on this piston for one complete revolution of the shaft i. One combustion takes place in the chamber z while piston d is in the position shown in Fig. 3 and in chamber v when piston d is at the end of its outward stroke resulting from this explosion in the chamber z, as indicated in Fig. 4. On the stroke of the piston c toward the left, as indicated in Fig. 4, the openings in the piston-rod do not come into alinement, and consequently the air is compressed in the chamber x during this entire stroke of the piston, and this is sufficient to compress the air to about sixty pounds, with which the reservoir is stored. Referring to Fig. 1, it will be seen that the gears connected with the cranks of the upper cylinder move in a direction opposite to that of the cranks of the lower cylinder. By reason of this relative action the pistons d and c of the upper cylinder of the pair shown in Fig. 1 are both moving toward the left, but at different speeds for the induction-stroke, which is completed when they reach the position shown in Fig. 2. In the lower cylinder, however, of the pair shown in Fig. 1 the cranks are in such a position that the pistons are ready to move apart from each other in opposite directions, and at this time the combustion takes place in this cylinder in the space z between the pistons, and it will thus be seen that the combustion or explosions in one cylinder of the double engine alternate with those in the other cylinder of the double engine. By the arrangement of the cranks of the two parts of the engine in which one set of cranks is arranged in advance of the other set dead-points are avoided in the operation of the double engine, and at the same time it will be noticed that there is a symmetrical distribution of the four power impulses, the two impulses in one cylinder alternating with those in the other cylinder. The engine therefore will start under load at any point at which it may come to rest. I employ cylinders of small diameter compared with their length, and by this a considerable expansion is obtained with a comparatively small quantity of gas to exhaust, thereby reducing the noise of exhaust and expanding the heated gases down very close to atmospheric pressure.

Referring now more specifically to the action which takes place in chamber z, the piston c acts as a scavenger for this chamber. The exhaust for the expended charge and induction-port for the fresh air is controlled by the puppet-valve 1, one of these valves being fitted to each cylinder. During compression, expansion, and explosion in chamber z said valve remains closed; but during exhaust and induction of air from and to the chamber z this valve remains open. The valve is controlled to open positively by a cam 43, loosely arranged upon the shaft r. The cam has a bearing in the crank-casing at 44. The cam has an overhanging shoulder 45 extending across it, to be engaged by the pin 46, carried by the gear q, and through this connection the cam is rotated and thus controls the opening of the exhaust-valve on the exhaust-stroke of the piston c, so that said piston will force out the exhausted mixture. The connection is such that the pin 46 will engage the shoulder 45 when the gear q rotates in either direction, according to which direction the engine is running. When the engine is reversed, the cam remains idle for one-half revolution of the engine and then the pin 46 will engage the shoulder at the opposite side of the cam, thereby operating the valve 1 in proper time for the reverse action of the engine. The connection between the valve 1 and the floating cam 43 consists of a rod having a screw-joint therein at 47. The upper part of the rod is provided with teeth 48, meshing with a rack 49, suitably carried on the machine and adapted to be operated manually. The induction exhaust-valve may remain either open or closed during nearly one-half a revolution of the engine-shaft during the action of reversing. To enable this valve to be opened or closed when it stands either closed or opened, the rack 49 is operated to turn the spindle, and thus expand or contract the screw-joint. The automatic action of the pin 46 and floating cam is illustrated in Figs. 13 and 14, which indicates that the cam may be rotated in either one direction or the other by the pin. As before stated, the hollow perch may be utilized as a compressed-air conduit, and the perch 50 may be used as a reservoir or conduit for the oil.

As before stated, the chamber x and piston c are used as means for compressing the air, the supply for which enters through the openings w. The check-valves controlling the passages between the chambers x and the passages 5 are shown in Fig. 9 at 11. These check-valves are controlled by a rod 22, extending transversely from one passage 5 to the other, said rod having a hooked end 23, engaging a stem of one of the valves 11, and having a socket 24 at its other end to receive loosely the stem of the other valve. Both valves are adapted to have movement independent of the rod 22, for which purpose the hooked connection is a loose one, as is also the socket connection. The valves are arranged to close toward the air-compressing chambers x, the ports leading to which are indicated at 25 in Fig. 9, and these valves are intended to retain the air-pressure in the passages 5 and in the reservoir, which freely communicates therewith. These valves may be controlled manually by the operation of the rod 22, for which purpose a hand-lever 26 is provided, pivoted to a suitable portion of the framework and having an eye 27, through which the rod 22 passes, with a spring 28 interposed between the lever and a collar 29 fitted adjustably to the rod 22. The lever is provided with a detent 30, controlled by the finger-lever 31, so that it may be withdrawn from the fixed rack 32 in order to shift the lever to the position desired. By moving this lever the rod 22 may be operated so that the check-valves 11 will be held rigidly on their seats, thus closing the passages between the air-compressing chambers and the air-reservoir. This arrangement is of particular value when it is necessary to operate the engine without having a supply of compressed air in the reservoir. Under such conditions, as the check-valves would not be held closed by pressure from the reservoir, it would be impossible to send a charge of air through the hollow piston-rods to the two cycle ends of the cylinders to purge the same and supply the necessary fresh air for the next mixture; but with the lever 26 valves 11 will be held closed and compressed air sent to the chambers v directly instead of at this time passing to the reservoir. The pressure upon the lever 26 may be lessened or entirely released as the compressed-air pressure rises or reaches its maximum. The admission of compressed air from the reservoir to the several chambers v and z for starting is, as before stated, controlled by the valves located at 12 and 13. These valves are shown in detail in Fig. 8, in which the valve 14 is arranged to close upon its seat toward the cylinder, the passage leading to which is indicated at 33. On the cylinder side of this valve a check-valve 34 is arranged, having its stem loosely held in the stem of the valve 14. The purpose of this check-valve is to protect the valve 14 from the energy of an explosion, it forming a complete cut-off or protection for the valve 14. The stem of valve 14 extends out through the valve-case 35 and at its outer end is connected to the arm 36 of a spring 37, attached to the cylinder and connected to a rod 38, which extends to the controller 16, which I have shown generally in Fig. 5. This controller comprises the casing, with the shaft 17 journaled therein, carrying the cams 15, which operate levers 39, engaging the rods 38, as shown in Figs. 5 and 6, the arrangement being such that the cams through the levers 39 will operate the rods 38 in any desired order, and thus open the valves in rotation to discharge compressed air into the chambers of the engine to start the same. The valve 14 is held to its seat normally by the spring 37 and also by the compressed-air pressure when this is present in the passage 5.

As before stated, electromagnetic pumps for the fuel-supply are employed, (shown at 2.) These are controlled through circuit connections 40 from contact-rings 41, rotated by the shaft 17, before described. Electromagnetic-operated make-and-break apparatus for causing the ignition-spark in each combustion-chamber is also employed, (shown generally at 42, Fig. 5,) these being controlled through circuit connections 43', leading to the contact-rings 41, before described. These parts, together with the electromagnetic pumps and the controlling mechanism 16, form no part of my present invention and need not be further described herein.

Referring, further, to the compressed-air action, the ratio of clearance in the chamber x is such that a pressure of about sixty pounds per square inch above atmospheric pressure will be maintained in the reservoir when the engine is running normally. Each alternate stroke of the pistons delivers a portion of compressed air to the reservoir if at any time the pressure therein has fallen below sixty pounds per square inch. When this pressure has been attained in said reservoir, the air compressed by piston c will simply expand again upon the return-stroke of the piston, the compressing action thereby serving as a cushion for the explosion, which takes place on the opposite side of the piston in chamber z. As before stated, this compressing action, whereby about sixty-pounds' pressure is attained, takes place at each alternate stroke of the piston. There is also a compressing action which takes place at the strokes intermediate of the alternate strokes, and this latter compression, which occurs at each revolution of the crank, compresses the air to about twenty pounds per square inch, and this, as before described, is discharged into the two-cycle chamber v to clear the same of expanded charge and supply the fresh air. This latter pressure of about twenty pounds per square inch is attained at about the time the openings in the hollow piston-rods e and n aline with each other, as before described.

I claim as my invention—

1. An internal-combustion engine, comprising two pistons, connections between the said pistons whereby one moves faster than the other, a combustion-chamber for one piston acting therewith upon the four-cycle principle and a second combustion-chamber for the other piston acting therewith upon the two-cycle principle, substantially as described.

2. An internal-combustion engine comprising a cylinder, two pistons therein and two combustion-chambers, one piston and combustion-chamber having a two-cycle action and the other piston and its combustion-chamber having a four-cycle action, substantially as described.

3. An internal-combustion engine comprising a cylinder, two pistons therein and two combustion-chambers, one piston and combustion-chamber having a two-cycle action and the other piston and its combustion-chamber having a four-cycle action, one of the combustion-chambers being common to both pistons, substantially as described.

4. An internal-combustion engine comprising a cylinder, two pistons and two combustion-chambers therein, one of said pistons having a two-cycle action and with a combustion-chamber on each side of the same, whereby said piston receives an impulse in each direction and the other piston having a four-cycle action and receiving an impulse in one direction, substantially as described.

5. An internal-combustion engine comprising a cylinder, two pistons therein, a combustion-chamber between the pistons, a second combustion-chamber for one of the pistons, the latter piston acting on the two-cycle principle and receiving an impulse in each direction and the other piston acting on the four-cycle principle and receiving its impulses from the intermediate combustion-chamber, substantially as described.

6. In combination in an internal-combustion engine, a cylinder, two pistons and two combustion-chambers therein, one piston with its combustion-chamber having a two-cycle action and the other with its combustion-chamber having a four-cycle action, the piston-rod of one piston extending through that of the other and the two to one gearing between the piston-rods, substantially as described.

7. In combination in an internal-combustion engine, a single cylinder, two independent power-pistons and two combustion-chambers in the cylinder, and an air-compression chamber in said cylinder, substantially as described.

8. In combination in an internal-combustion engine, two pistons with their combustion-chambers, an air-compression chamber and a connection between the combustion-chamber of one piston and the air-compression chamber whereby the said combustion-chamber will receive compressed air therefrom, substantially as described.

9. In combination in an internal-combustion engine, a two-cycle piston with its combustion-chamber, a four-cycle piston with its combustion-chamber and an air-compression chamber in which air is compressed by one of the pistons, substantially as described.

10. In combination in an internal-combustion engine, a cylinder, two pistons therein, a combustion-chamber intermediate the pistons, a combustion-chamber at one end of the cylinder and an air-compressing chamber at the other end of the cylinder, substantially as described.

11. In combination in an internal-combustion engine, the two pistons moving at different speeds, a combustion-chamber for each piston, an air-compression chamber, a connection between the air-compression chamber and one of the combustion-chambers leading through said piston, and a connection leading from the air-compression chamber to a point outside the engine substantially as described.

12. In combination in an internal-combustion engine, a cylinder, a piston, a combustion-chamber, an air-compressor chamber in the cylinder, a storage-reservoir, and means whereby the compressed air is controlled to pass to the storage-reservoir at times directly from the air-compressor chamber and at other times to the combustion-chamber, substantially as described.

13. In combination in an internal-combustion engine, two pistons, two combustion-chambers, an air-reservoir, a compressed-air chamber and means whereby the compressed air is at times sent to the air-reservoir or again expanded in the compressed-air chamber and at other times to one of the combustion-chambers, substantially as described.

14. In combination in an internal-combustion engine, a cylinder, a piston and a combustion-chamber therein having a two-cycle action, a second piston and a combustion-chamber therein having a four-cycle action, an air-reservoir, an air-compression chamber in the cylinder and means whereby the compressed air is caused to pass alternately to the air-reservoir or to expand again in the compression-chamber and to one of the combustion-chambers, substantially as described.

15. In combination in an internal-combustion engine, a cylinder, a piston and a combustion-chamber therein having a two-cycle action, a second piston and a combustion-chamber therein having a four-cycle action, the hollow piston-rods having openings to aline at certain times, an air-compression chamber to communicate with the hollow piston-rod through the said openings, said hollow piston-rod communicating with one of the

combustion-chambers, substantially as described.

16. An explosion-engine comprising two cylinders, a pair of pistons in each, one piston having a two-cycle action and the other having a four-cycle action, the said pistons being all connected together, substantially as described.

17. In combination, a cylinder, the two pistons therein with their combustion-chambers, one of said pistons having a four-cycle action derived from the combustion-chamber on one side and having alternately on its other side an air-compressing action and an air-transferring action, said transfer of air taking place to the combustion-chamber of the other piston, substantially as described.

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

JAMES F. HOBART.

Witnesses:
F. L. MIDDLETON,
HENRY E. COOPER.