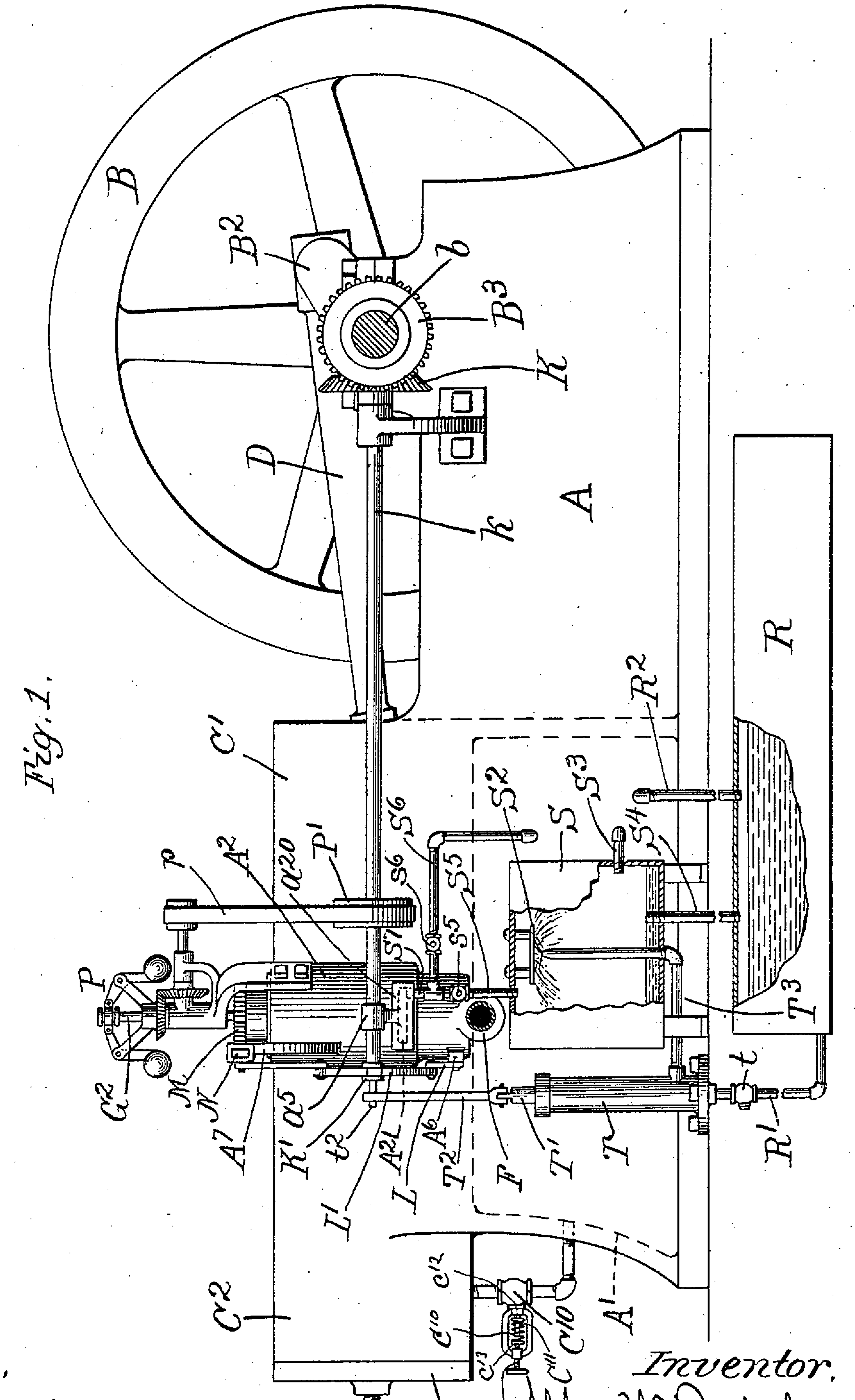
(No Model.) 3 Sheets—Sheet 1.

A. W. BODELL.

GAS OR OIL ENGINE.

No. 563,548. Patented July 7, 1896.



Witnesses.
E. T. Wray.
Jean Elliott.

Inventor.
Allen W. Bodell
by Burton & Burton
his attys

(No Model.) 3 Sheets—Sheet 2.

A. W. BODELL.

GAS OR OIL ENGINE.

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Fig. 2.

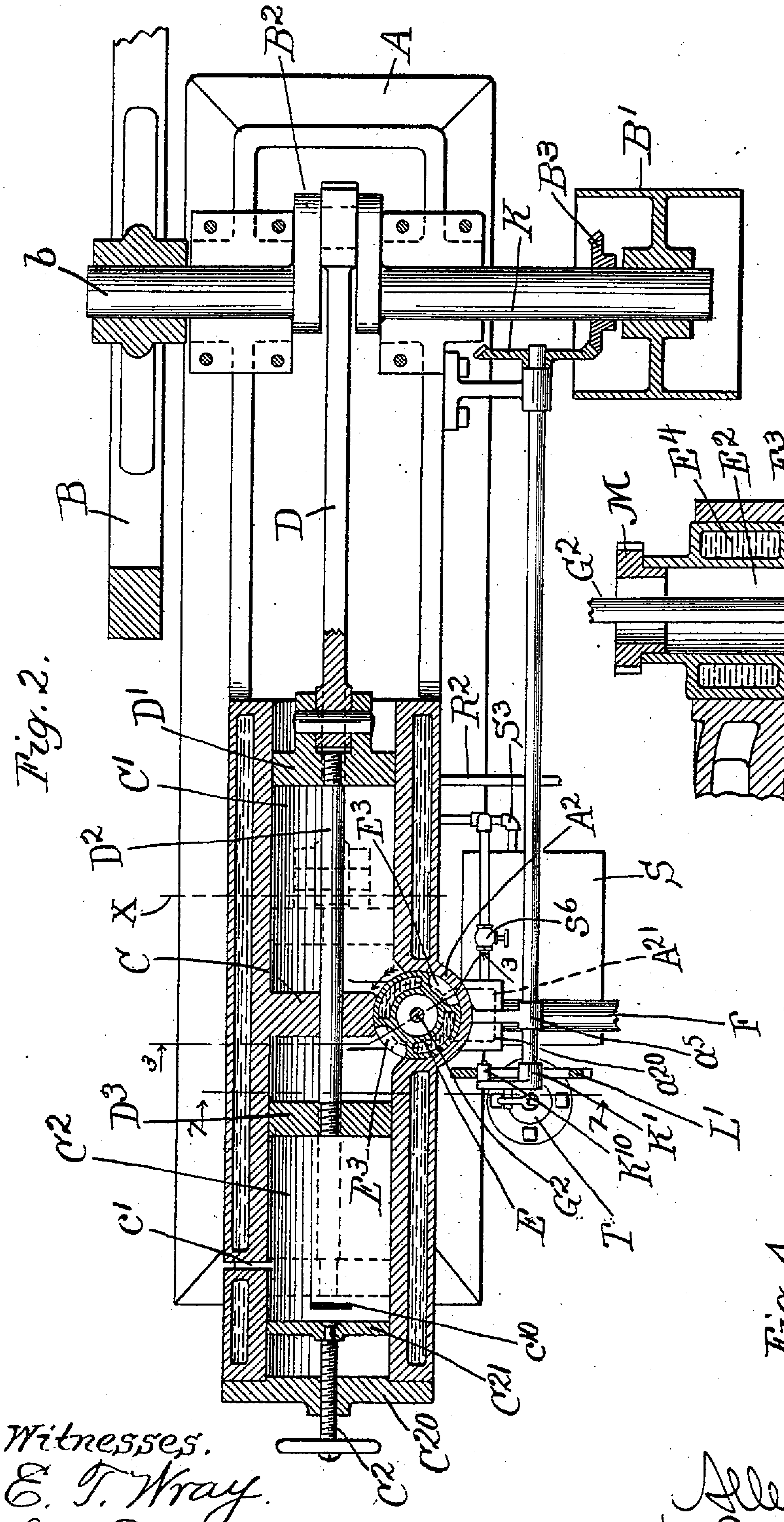


Fig. 3.

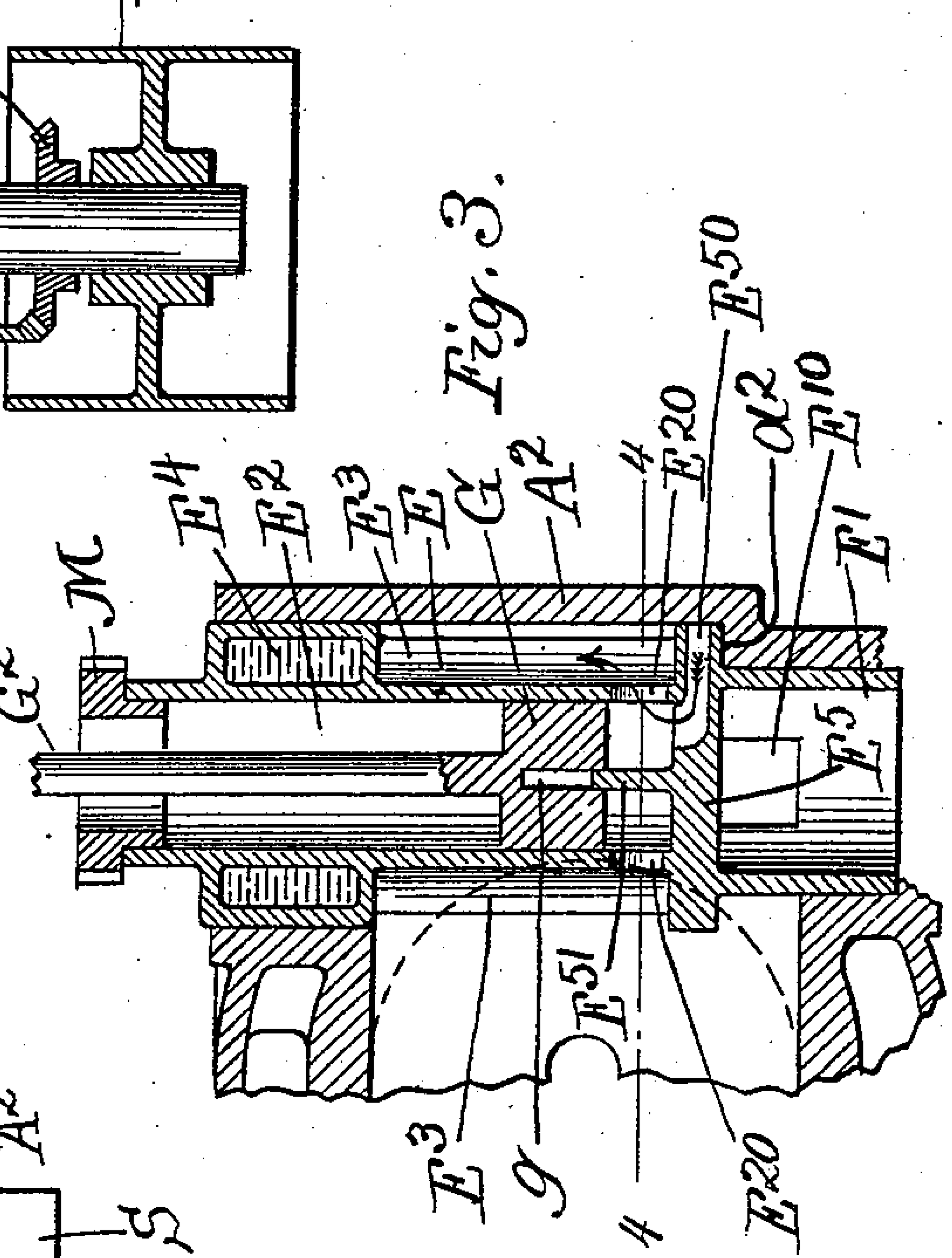
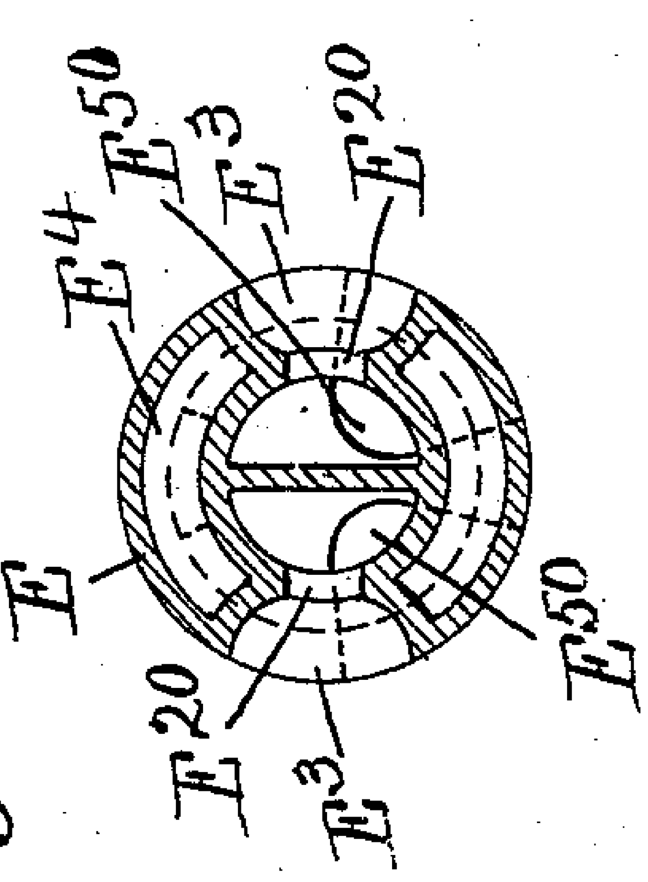


Fig. 4.



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his attys

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

(No Model.)

3 Sheets—Sheet 3.

A. W. BODELL.

GAS OR OIL ENGINE.

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Fig. 5.

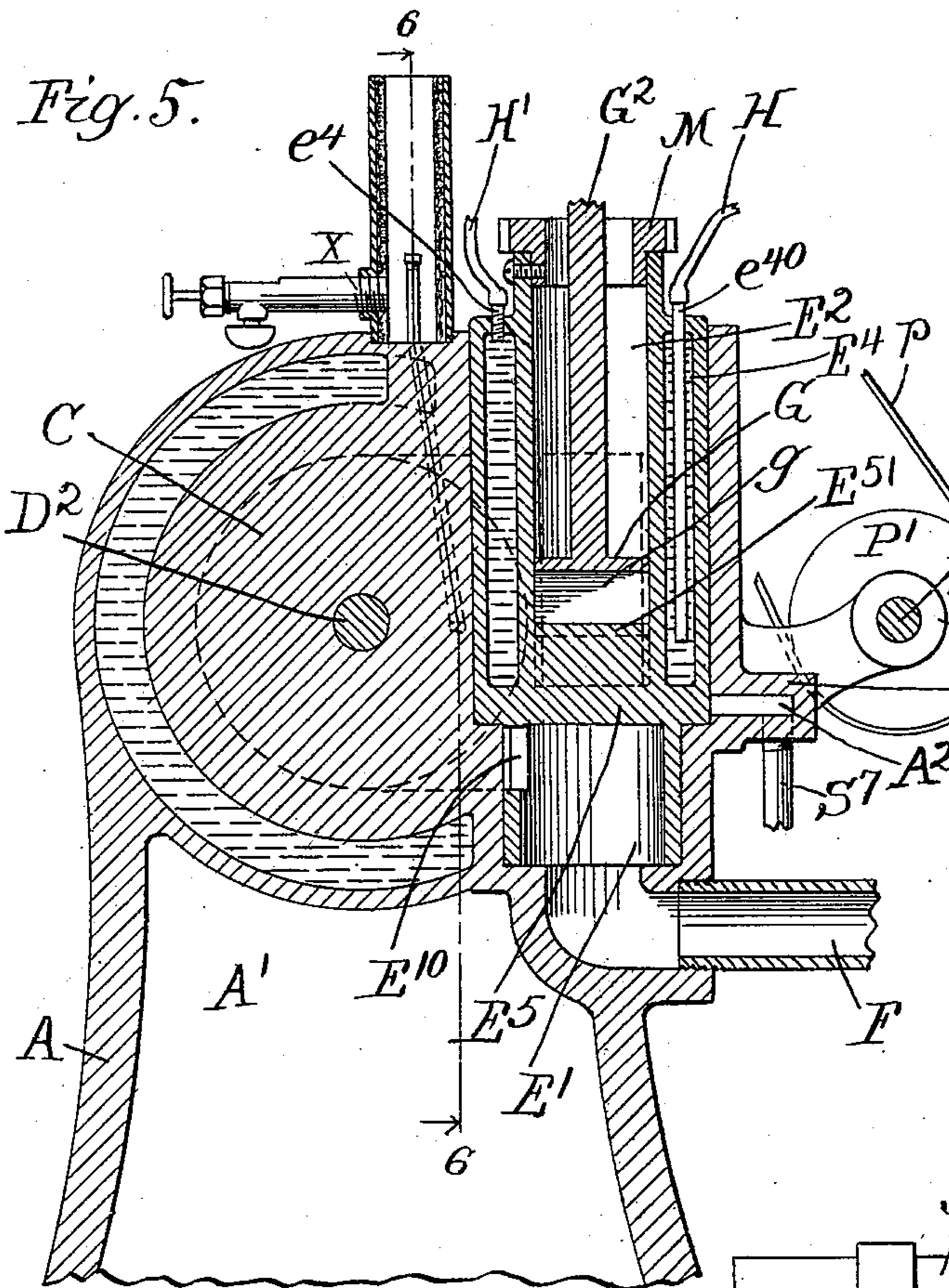
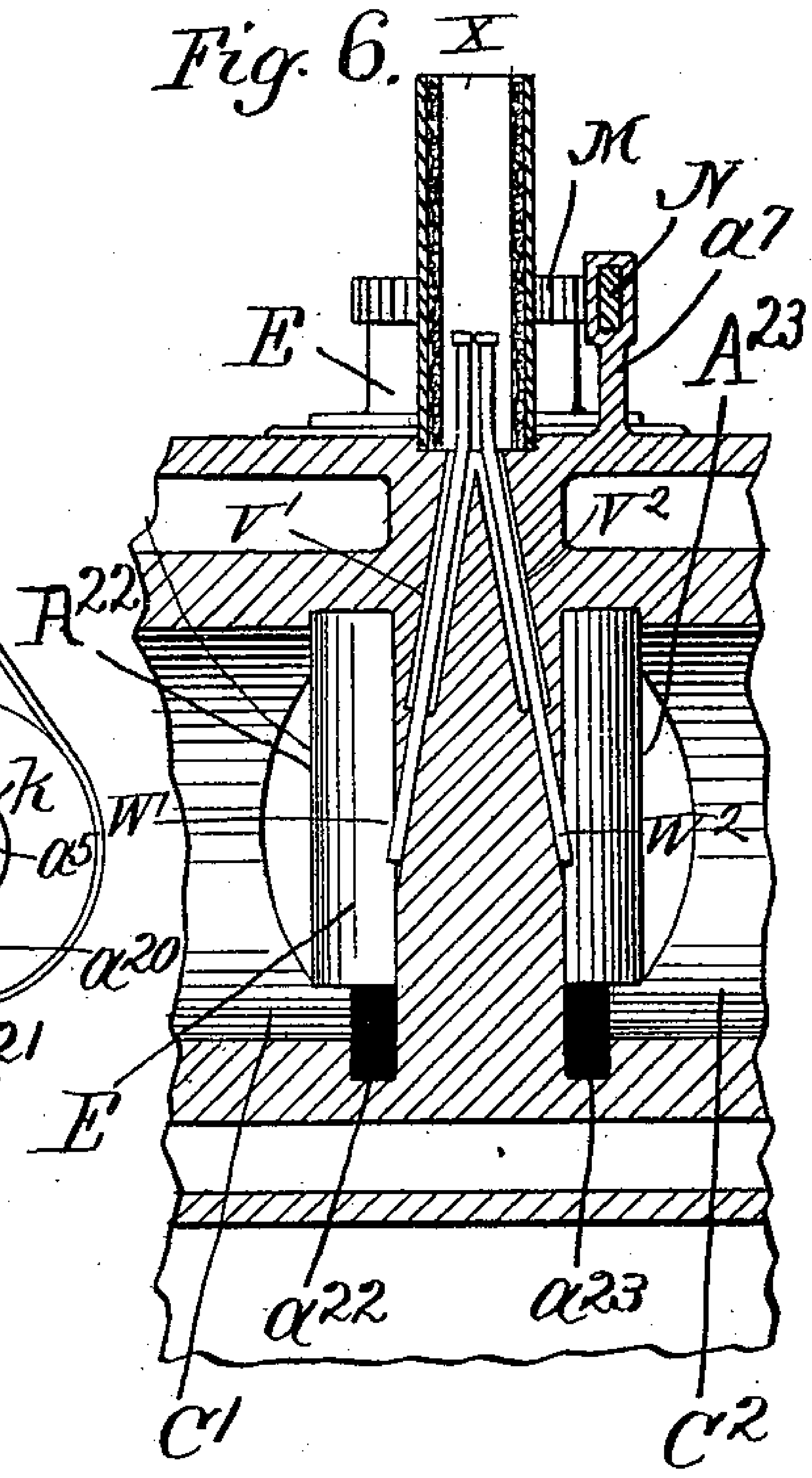


Fig. 6.



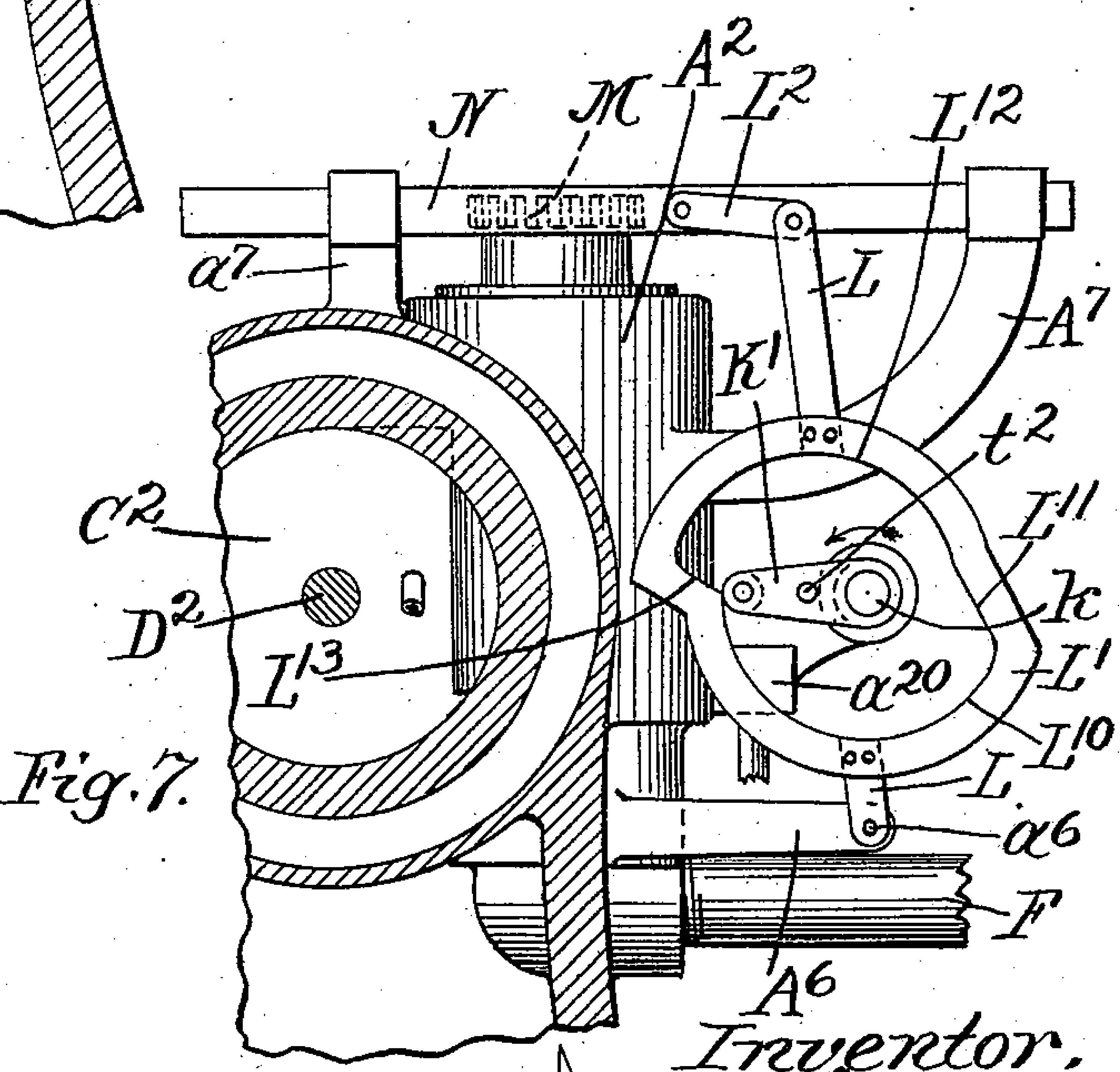


Fig. 7.

Witnesses,
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his Attys

UNITED STATES PATENT OFFICE.

ALLEN W. BODELL, OF CHICAGO, ILLINOIS.

GAS OR OIL ENGINE.

SPECIFICATION forming part of Letters Patent No. 563,548, dated July 7, 1896.

Application filed April 15, 1895. Serial No. 545,719. (No model.)

To all whom it may concern:

Be it known that I, ALLEN W. BODELL, a citizen of the United States, residing at Chicago, county of Cook, and State of Illinois, have invented certain new and useful Improvements in Gas or Oil Engines, which are fully set forth in the following specification, reference being had to the accompanying drawings, forming a part thereof.

The purpose of this invention is to provide an improved engine to be operated by the explosive force of gas or oil-vapor in which an explosion may be obtained and an impulse thereby given to the piston-rod at each movement of the same in each direction, which thus will receive four impulses instead of one, as in the more common style of gas-engines.

In the drawings, Figure 1 is a side elevation of my improved engine. Fig. 2 is a horizontal section at the axis of the piston, showing the main valve in position to deliver an explosive charge to one cylinder and permit exhaust from the other. Fig. 3 is an axial section through the main valve and its seat or chamber, showing the same in the position of receiving a charge of gas at one of its ports, the valve and the chamber being cut at the plane 3 3 on Fig. 2. Fig. 4 is a transverse section of the valve at the plane 4 4 on Fig. 3. Fig. 5 is an enlarged section, axial with respect to the valve and transverse with respect to the piston-stem, showing the connections leading to the valve-chamber and the valve in closed position. Fig. 6 is a detail section at the line 6 6 on Fig. 5. Fig. 7 is an enlarged detail section at the line 7 7 on Fig. 2, designed to show in elevation the valve-operating mechanism.

For my improved engine I provide a cast base-frame A, in the lower portion of which is formed a chamber A′ for compressed air. On this base is mounted a main shaft *b*, carrying a suitable wheel B, the power-communicating wheel B′, intermediate crank B^2, and beveled gear B^3 for actuating the valve mechanism. This frame comprises also, preferably integral with the base portion, a cylinder having two chambers C′ C^2, separated by a transverse partition C. The cylinder C′ is open at the end, and the pitman D plays into it at this end, being connected to one of the piston-heads D′, the piston-rod D^2 being rigidly connected to said piston-head at the center and extending through the partition C, in which it obtains a guide-bearing, and having secured to its farther end the second piston-head D^3. The remote cylinder C^2 is closed by a head C^{20}, which is perforated at the center and interiorly threaded for a screw-shaft c^2, which is connected swivelwise at the center of the false head C^{21} within the cylinder, and which is adapted by the connection thus described to be moved toward and from the head C^{20}, and thus to vary the extent of the cavity in the cylinder-chamber beyond the stroke of the head D^3.

c' is an air-inlet leading into the cylinder-chamber C^2 a little distance back of the extreme limit of the piston's travel outward, but not so far back of said limit but that it is closed by the piston-head when at the limit.

c^{10} is an aperture leading from the cylinder-chamber C^2 beyond the piston's travel and communicating with the air-chamber A′ in the base of the frame. At any convenient point beyond the aperture there is located a check-valve C^{10}, opening outward with respect to the cylinder and inward with respect to the air-chamber, and which is also adapted to operate as an ordinary shut-off valve, as hereinafter explained.

Although I prefer to have the aperture c' in such position that it shall not be covered by the piston in the outward stroke, the only reason for preferring such structure is that if it should be uncovered exhaust-gas would pass out through it and foul the surrounding air or require provision for conducting it away, and if this consideration is not regarded important in any given case the limitation above stated as to the position of the aperture need not be observed. In this structure it is intended to admit an explosive charge between the pistons respectively and the partition C as the pistons respectively approach the partition and explode such charge at the limit of approach, each cylinder being exhausted during the part of the return stroke prior to the admission of the new charge. This is accomplished by means of one valve having several ports and pockets. This valve E is, in general form, a cylinder seated in a cylindrical case or seat transverse to the path of reciprocation of the pistons. The cylindrical case or seat of this valve is formed at A^2, at one side of the cylinder containing the chambers C′ C^2, opposite the diaphragm or partition C. Said cylindrical seat, if produced completely, would intrude into the cylinder-chambers C′ C^2 at one side at the ends bounded by the partition C, as seen in Fig. 2. This cylindrical valve E is at its lower end reduced in diameter at the portion E′, and at this portion is hollow, and the seat or case for the valve is correspondingly formed with a shoulder a^2, below which the bore of the case is reduced to fit the reduced portion E′ of the valve.

The bottom of the case is apertured and the exhaust-pipe F is connected thereat, as seen in Fig. 5. At the side of the case A^2, opposite the partition C, the main inlet-port A^{21} is situated, said port being flat and broad and extending through about sixty-five degrees of the circumference of the case at that point. The case is cut away where it would obtrude into the corners of the cylinder-chambers C′ and C^2. The cutting away of the case at these points forms two long ports A^{22} a^{22} and A^{23} a^{23}, extending for a distance equal to the diameter of the cylinders C′ C^2 and located directly opposite said cylinders, said ports being formed both through the wall of the larger upper portion and through the wall of the similar lower portion of the case. The upper portions A^{22} and A^{23} of these ports are gas-inlet ports and the lower portions a^{22} and a^{23} are exhaust-ports. It will thus appear that the gas supply and exhaust ports in each cylinder are continuous the one with the other, being in form but one port, though in effect they are two, as will hereinafter appear. The upper and larger portion of the valve E is bored cylindrically at the center, forming a piston-chamber E^2, in which a piston G reciprocates, being actuated by the governor, as hereinafter explained. At points diametrically opposite on said upper and larger portion of the valve are formed pockets E^3 E^3. These pockets extend from the level of the bottom of the cylindrical bore E^2 up to the level of the top of the piston-cylinders C′ C^2. The remainder of the valve E is formed hollow about the cylindrical bore for the purpose of a water-chamber E^4.

A water-supply pipe e^{40}, inserted at the top of the valve, extends down within the water-chamber E^4 to nearly the bottom thereof and has the flexible water-supply pipe H connected to it, and a nipple e^4 is inserted at another point in the upper end of said chamber and a flexible outflow-pipe H′ connected thereto. These pipes extend, as will be understood, to any conveniently-located water-chamber, and serve as a means of producing water circulation through the valve to prevent the same from becoming overheated.

A diaphragm or base E^5, it will be seen, is left uncut by the cylindrical bore and water chambers and pockets above described, such base occupying a space between the horizontal plane which defines the upper end of the cylindrical cavity in the lower and smaller portion of the valve and the plane which defines the bottom of the water-chamber and cylindrical bore E^2 in the upper part of the valve. This portion E^5 seats at the main inlet-port A^{21} and would keep said port always closed but for two passages formed in said base E^5. These passages E^{50} E^{50} are located a little more than ninety degrees apart (measuring from center to center) on the circumference of the valve. They are in height equal to the height of the aperture A^{21}, and in circumferential extent at the periphery of the valve they are substantially the same as the horizontal extent of the aperture A^{21}, that is to say, occupying about sixty-five degrees of the circumference of the valve at the periphery. They each lead in radially from the periphery past the line of the wall of the cylindrical bore E^2, in which the piston G fits and travels, and they then open upwardly under the piston, but at opposite sides of the vertical rib or diaphragm E^{51}, which projects up from the base E^5, extending diametrically across the piston-chamber E^2 and entering a diametrical channel g, formed in the under side of said piston, which thus saddles said rib or diaphragm. There are thus formed two chambers at the bottom of the cylindrical bore E^2 between the piston, which is the top, and the diaphragm, which is one side, and the cylindrical wall of the chamber E^2, which forms the remainder of the inclosing wall of such chambers, and through said cylindrical wall there are formed ports E^{20} E^{20}, which lead into the pockets E^3 E^3, respectively, at the bottom of the latter, so that when either passage E^{50} is registered with the main inlet-port A^{21} of the case gas entering through said port may pass through said passage and thence through the port E^{20} into the pocket E^3; and when said pocket, by the rotation of the valve, is brought into position to register with the port A^{22} or A^{23}, as the case may be, the gas thus pocketed in the valve is delivered into the cylinder.

For the purpose of making more clear and specific the relative positions of the pockets and passages above described, I will describe the action of this valve independently of the mechanism by which it is actuated, but in relation to the movements of the pistons in the cylinders C′ and C^2. Assuming the piston D′, for example, to be at the extreme limit of its outward stroke, and the piston D^3, as necessary, at the extreme limit of its inward stroke, one of the passages E^{50} stands registered at its outer or receiving end with the main inlet-port A^{21} and one of the pockets E^3 is receiving a charge of gas, which passes into said pocket by way of the passage E^{50} and the port E^{20}. At the same time the other pocket E^3 stands registered with the aperture A^{23}, leading into the cylinder C′, and the last stage of the inward movement of the piston D^3 has caused an explosion of the gas which has just been delivered out of that pocket into the cylinder. The piston D^3 is thus driven outward and the piston D′ drawn inward. The valve E stands in unchanged position until the piston D′ has made from half to two-thirds of its inward stroke. At the point indicated by the dotted line x on Fig. 2 the valve commences to rotate in its seat in the direction of the arrow on Fig. 2. Such rotation first carries the pocket E^3 away from the port A^{23} and closes said port, and carries the exhaust-port E^{10} away from the port a^{22} and closes said port a^{22}, the exhaust-port being, for the moment, closed against the partition C. The same movement also carries the mouth of the passage E^{50} away from the port A^{21}. Continued rotation in the same direction brings the exhaust-port into registration with the port a^{23}, and brings the opposite pocket E^3 into registration with the port A^{22} and the mouth of the other passage E^{50} into registration with the port A^{21}, so that the pocket E^3, which was registered with the port A^{23}, can receive a fresh charge of gas.

It will be noticed that the exhaust from the cylinder C′ was open when the piston therein commenced to advance toward the partition C, and that exhaust-gas in said cylinder was thereby being driven out freely, and that this condition continued until the exhaust-port E^3 of the valve was carried entirely away from the port a^{22} of the cylinder, and that during the remainder of the advance of the piston D′ and retreat of the piston D^3 the contents of the cylinder C′ were being compressed. A certain degree of compression was effected before the pocket E^3 began to lap onto the port A^{22} and to discharge its gaseous contents into the cylinder-chamber, and during the remainder of the inward travel of the piston the gas was being compressed until at the limit of such inward travel explosion is produced in the cylinder C′, as at the commencement explosion had occurred in the cylinder C^2.

It will be noticed that at the same time that the pocket E^3 began to deliver its gas contents into the cylinder C′ the exhaust began to open from the cylinder C^2 and was fully open during the whole time that the pocket E^3 stood fully registered with the aperture A^{22}, so that the burned gas in the cylinder C^2 nearly recovers its normal tension before the return stroke of the piston in that chamber commenced upon the explosion of the new charge in the opposite cylinder. Thus an explosion is obtained against each piston just before it reaches the inward limit of its travel. The force of this explosion operates with a pull upon the piston and not by a push, as in the more usual form of engine.

I will now describe the mechanism by which this movement of the valve is produced. Journaled in bearings formed on or rigid with the frame A is a shaft k, extending parallel with the piston's travel, driven by a beveled gear K, which meshes with and receives motion from the beveled wheel B^3 on the main shaft b. At the opposite ends of said shafts k, beyond the remote bearing a^5, it has a crank K′. Below this crank an arm A^6 projects horizontally from the base-frame A and affords a fulcrum at its extremity for a lever L, which, between its ends, comprises an open cam L′, within which the crank K′ rotates, a stud and roll K^{10} on the end of the crank, traveling against the interior edge of the cam L′, and actuating the cam, and thereby the entire lever L, back and forth as the crank revolves. A hollow gear M is secured at the top and concentric with the valve E, and a rack-bar N, adapted to mesh with this gear, is provided with slide-bearings in a bracket-arm A^7 and a lug a^7, the former projecting off from the valve-case A^2 at the side and the latter projecting from the top of the cylinder C′. A short link L^2 connects the upper end of the lever L to the rack-bar N, so that the rocking of the lever over its fulcrum at a^6 on the arm A^6 reciprocates the rack and gives rotary oscillation about its vertical axis to the valve. The form of the cam is designed to give the valve the motion above described, said form being such that the cam may be divided into four elements—L^{10}, concentric about the shaft when the lever is rocked to its extreme position toward the cylinder C; L^{11}, eccentric through about twenty-five degrees of the rotation of the crank, so that while rotating through said twenty-five degrees the lever is rocked to the opposite extreme; L^{12}, concentric about the shaft when the lever is at its opposite extreme, and L^{13}, eccentric about the shaft through about twenty-five degrees of the rotation of the crank, so that while revolving through said twenty-five degrees the lever is rocked back to its first-mentioned position.

The governor P is driven by a belt p, deriving motion from a pulley P′ on the shaft k. The construction of the governor is the most familiar construction of centrifugal governors, being such that the centrifugal movement of the governor-balls gives a vertical thrust to the rod G^2, which is the stem of the piston G, which plays over the rib or partition E^{51} within the central cylindrical bore E^2 of the valve E. At the lowest speed of the governor, or at rest, the piston-head G stands high enough to leave the ports E^{20} fully uncovered, and at the highest speed would thrust low enough to close said ports. Thus the extent of the available opening for the passage of gas through said ports is diminished as the speed increases, and thereby the quantity of gas admitted to the pocket E^3 during the instant in which the passage E^{50} stands registered with the port A^{21} is regulated, and the charge for explosion decreased as the power needed to maintain the motion is diminished, and the charge increased as the work to be done tends to diminish the speed and make a greater charge necessary to maintain it.

I will now describe the devices for carbureting the air to the proper explosive degree and for securing uniformity in this respect.

As above stated, the base of the frame A is occupied by an air-chamber A′. To produce compression of air in this chamber to any desired extent, the end of the cylinder-chamber C^2 is closed as above described. At any convenient place, preferably depressed for safety and represented as below the bed of the engine, I locate a gasolene-reservoir R.

S is a carbureting-chamber, which may be formed integral with the frame, and is most conveniently located just below the exhaust-pipe F. T is a pump located alongside this carbureting-chamber, whose plunger T′ is operated by a link or pitman T^2, connected to a wrist-pin t^2 on the crank K′. The pump receives its supply through the pipe R′, leading from the lower part of the reservoir R up into the base of the pump-cylinder, a check-valve t preventing the return of the liquid into the reservoir through said pipe. T^3 is the discharge-pipe from this pump. This pipe leads up through the bottom of the carbureting-chamber, and terminates in a nozzle with a single fine aperture near the top of the carbureting-chamber, immediately underneath a horizontal spreader S^2. A pipe S^3 connects the air-chamber A′ with the carbureting-chamber S, admitting compressed air to the latter. A drain-pipe S^4 leads back from the lower part of the carbureting-chamber into the gasolene-reservoir R. A pipe R^2 leads from the air-chamber A′ to the top of the reservoir R, and thus communicates air-pressure to the liquid in said reservoir.

It will be understood that the gasolene will be forced from the reservoir R by the air-pressure therein up into the pump-cylinder, and that the plunger T, descending without the necessity of any piston, but merely by displacement, will force a quantity of the gasolene through the discharge-nozzle against the spreader S^2, causing it to be dispersed in a fine spray and fall as a fine shower through the carbureting-chamber, which is full of compressed air, which thereby becomes charged with gasolene-vapor, the gasolene flowing off through the waste-pipe S^4 back into the reservoir. The cubic capacity of the carbureting-chamber is so great with respect to the quantity of the vapor required for each charge let into the cylinders that the air will remain exposed in the carbureting-chamber to the gasolene showers, which are produced therein at each rotation of the shaft k, long enough to become saturated with such vapor, even when the engine is doing its maximum work and requiring the maximum quantity of gas. The condition of saturation of the air with the vapor is substantially a uniform one, the air being at an approximately uniform temperature and of approximately uniform dryness when it is forced into the chamber A′, and the gasolene being of substantially uniform quality, and this is an important feature of the result attained by the means described. From the top of the carbureting-chamber a pipe S^5 extends and is joined by a pipe S^6, leading from the air-chamber pipes, said pipes being provided with a regulating-valve s^5 s^6, respectively. These valves will be so set from time to time, as variations in the quality of the gasolene or condition of the air may make adjustment necessary, as to give a mixture in the pipe S^7, which leads from their junction to the vestibule to the boss a^{20}, the proper explosive character, which therefore, it will be seen, will be uniform throughout all variations in the speed of the engine and the quantity of such mixture used at each charge.

At any convenient point between the orifice which leads from the cylinder C′ beyond the travel of the piston and the compressed-air chamber A′ a check-valve C^{10} is necessarily interposed to retain the compressed air in the chamber A′. The false cylinder-head C will be adjusted to produce the desired tension in the air-chamber, and in practice the capacity of the space beyond the piston in the cylinder and the passage therefrom to the valve may be considered without regard to the capacity of the passage beyond the valve and the air-chamber A′ in determining where to adjust the false head. Thus, for example, if ten pounds pressure is found desirable in the air-chamber in order to enable the explosive charge to properly force its way into the cylinder against the tension which will be produced therein by the returning piston, and if, in order to start the engine, therefore, ten pounds pressure has been produced in the air-chamber by any extraneous means—as an air-pump—it is evident that no air will be forced into the chamber from the cylinder unless the false cylinder-head is adjusted to such a position with respect to the stroke of the piston that ten pounds tension shall be produced in the cylinder; and if after starting it is desired to increase the tension above ten pounds, the false cylinder-head would be set proportionately farther into the cylinder.

I prefer to make the check-valve so that it may serve also as a shut-off valve, or so that it may require an amount of tension in excess of the tension in the air-chamber A′ to force it open, and for this purpose this check-valve may be made, as shown, with a spring C^{10}, tending to seat it, coiled around its protruding stem c^{11} and stopped upon the collar c^{12} on said stem, a screw C^{12}, operating in a yoke c^{13} on the valve-body, having a disk C^{13}, against which the spring stops at the end opposite the collar c^{12}, so that by setting the screw inward the tension of the spring may be increased to any desired degree, and by setting it sufficiently inward the disk may be brought against the end of the stem and positively secure the valve seated. This device is useful whenever it is desired to employ the adjustable false cylinder-head for the purpose of checking the motion of the engine. Thus the valve C^{10} being set so that it will not open under less than fifty pounds pressure, and the false cylinder-head being set up until the action of the piston forces the valve open, a resistance of fifty pounds to the square inch is exerted against the piston, and this may be increased until the resistance exceeds the momentum of the engine, and thereby it will be rapidly brought to rest.

It will be evident that by advancing the false cylinder-head into the cylinder during the retreat of the piston from that end the movement may be effected easily by the operator, and any desired resistance may be obtained in the interval between two strokes, if the valve A^{11} is shut tight. Since there might be danger of stopping the piston so suddenly that the momentum of the fly-wheel and machinery would be destructive of the engine, it will usually be desirable not to seat the valve A^{11} tight, but to adjust it so that it will open to a pressure less than that which would stop the engine too suddenly. The operator may then, with a little practice, manipulate the adjustable head in such manner as to bring the engine to rest more promptly and steadily than by any possible friction-brake mechanism, and the device is especially convenient for the purpose of controlling large engines where the situation is such that it is essential to prevent the fly-wheel coming to rest with the crank "on the center," for the head may be manipulated quickly back and forth as the crank approaches the center and the point of stopping very nicely controlled.

On account of the fact that the force of the explosion in this engine is exerted against the pistons in a direction to pull and not to push on the piston-rod, it is possible to use a much lighter rod with an engine of the same proportions than in the ordinary structure in which the force is exerted so as to push on the piston.

In the top of the bridge or partition wall C^2 I drill two ducts V' and V^2, opening into the ends of the cylinder-chambers, respectively, as near as possible to the ports A^{22} and A^{23}, respectively. Preferably, the upper part of these ducts is bored out larger than the lower end, for a purpose which will be explained. W' W^2 are pipes having their upper ends capped, which are driven or screwed tight into the lower smaller portion of the ducts B' B^2, respectively, and which extend above the upper surface of the cylinders, and are there inclosed within a pipe X, which may be called a "chimney," its purpose being to confine and afford draft for a flame-jet, which is discharged from the nozzle X' at the base of said chimney against the upwardly-protruding ends of the pipes W' W^2. The flame from the jet-nozzle X' is produced by gasolene fed to the nozzle, which is, in effect, an ordinary gasolene-jet burner requiring no further specific description. The flame thus directed against the ends of the pipes W' W^2 is made sufficient to heat said pipes to incandescence or to such temperature as necessary to ignite the explosive charge when suitably compressed by the advance of the piston, as already explained, a portion of such charge, as it escapes from the valve-pocket, being driven up into the pipe W' or W^2 and ignited therein when the necessary tension is produced. A very fine orifice may be made in the cap of each of the pipes W' and W^2, so that the burned gas may escape therefrom and permit the live gas to reach the most heated portion of the pipe. This expedient may not be found necessary in many instances.

I insert the pipes W' and W^2 into drilled holes larger than the pipes, so that they may be insulated as far as possible from the larger body of metal, and may therefore more easily be heated to the required temperature by the gasolene-jet.

I claim—

1. In a gas-engine, in combination with two cylinders end to end suitably walled apart from each other at their proximate ends, and a piston-rod carrying two piston-heads, one in each cylinder; a cylindrical valve whose axis is in a plane transverse to that of the cylinders; and a cylindrical seat for the same laterally opposite the proximate ends of the cylinders; said seat having an inlet-port for gas and having outlet-ports leading to the cylinders respectively at their proximate ends; the valve adapted to oscillate in its seat to admit gas received at said inlet-port to said cylinders alternately: substantially as set forth.

2. In a gas-engine, in combination with the two cylinders end to end, a piston and two piston-heads thereon playing in said cylinders respectively; a cylindrical valve whose axis is transverse to that of the said cylinders having in its cylindrical periphery pockets to receive charges of gas; the cylindrical case for said valve having a gas-inlet port and two gas-outlet ports leading to the cylinders respectively, the pockets on the valve being situated relatively to the ports of the case to adapt the valve oscillating in said case to alternately carry said pockets respectively from the gas-inlet port to the gas-outlet ports leading to the cylinders respectively: substantially as set forth.

3. In combination with two cylinders located end to end and suitably walled apart at their proximate ends, the piston-rod guided in such wall and carrying a piston-head in each cylinder; a valve case or seat located laterally opposite to the proximate ends of said cylinders, and having gas-inlet ports and exhaust-ports leading into said cylinders respectively at their proximate ends; a valve adapted to travel to and fro in such seat and at each action in each direction to uncover the inlet-port of one cylinder and the exhaust-port of the other: substantially as set forth.

4. In a gas-engine, in combination with the

two cylinders located end to end and suitably walled apart at their proximate ends, the piston-rod having two piston-heads playing in said cylinders respectively; a cylindrical valve and a case for the same located laterally opposite the proximate ends of the cylinders; said cylinders having each an inlet-port and an exhaust-port communicating with said valve-case, said gas having a gas-inlet port medially opposite the inlet-ports leading to the cylinders; the valve seated in said case adapted to oscillate about its axis therein having two peripheral pockets adapted to receive charges of gas from the gas-inlet port and carry the same to the cylinders respectively and having a central cavity at one end and a lateral port from said central cavity constituting the exhaust-port and located between the radial planes which define the proximate sides of said pockets on the side toward the cylinders; and means for oscillating said valve in its case to carry said pockets from gas-receiving position alternately to the inlet-ports of said cylinders and simultaneously to carry the exhaust-port of the valve back and forth between the exhaust-ports of the cylinder respectively: substantially as set forth.

5. In a gas-engine, in combination with two cylinders located end to end and suitably walled apart at their proximate ends, the piston-rod playing through such wall and carrying a piston-head in each of said cylinders; a cylindrical valve located laterally opposite the proximate ends of said cylinders and having its case formed in the substance of the wall of said cylinders and intruding laterally into said cylinders at their proximate ends, said valve-case having a gas-inlet port substantially opposite the middle line of the partition-wall between said cylinders, and the valve having peripheral pockets adapted, as the case oscillates, alternately to travel from position at which they may receive gas from the inlet-port of the case, to the cylinder-chambers respectively and open therein where the valve intrudes into said chambers respectively: substantially as set forth.

6. In a gas-engine, in combination with the two cylinders located end to end and suitably walled apart at their proximate ends, the piston-rod playing through such wall and carrying a piston-head in each of said cylinders, the cylindrical valve situated laterally opposite the proximate ends of the cylinders and having its case formed in the substance of the wall of said cylinders and intruding into the cylinder-chambers at their proximate ends, said case having a gas-inlet port opposite the partition-wall between the cylinders; the valve having two peripheral pockets at one side of a transverse plane and a central pocket at the other side of such plane, and a lateral port from said central pocket between the radial planes which define the proximate sides of the peripheral pockets on the side of the valve toward the cylinders, said peripheral pocket and the ports from said central pocket being adapted as the valve oscillates in its case, to communicate with the cylinder-chambers where the valve intrudes thereinto; and means for oscillating the valve to carry the lateral port of the central pocket from one cylinder to the other past the partition-wall between them, and the peripheral pockets alternately from communication with the gas-inlet port, to the cylinders respectively: substantially as set forth.

7. In a gas-engine, in combination with two cylinders located end to end and having a partition-wall between them at their proximate ends; two pistons carried by a common stem and playing in said cylinders respectively; suitably-valved gas-inlet ports leading into said cylinders respectively at their proximate ends; ducts in said partition-wall leading from the proximate ends of the cylinders respectively adjacent to the gas-inlet ports thereof, and pipes connected to said ducts respectively and projecting above the partition-wall, and means for heating said pipes: substantially as set forth.

8. In a gas-engine in combination with the cylinder and the piston which reciprocates therein, a compressed-air chamber communicating with the cylinder beyond the piston's outward travel, whereby the movement of the piston impelled by the explosion tends to force the air into such chamber, a carbureting-chamber and communication thereto from the compressed-air chamber, a valve which controls the admission of gas from the carbureting-chamber to the cylinder, adapted to admit the gas to the latter during each incoming or return stroke of the piston, whereby the tension produced in the compressed-air chamber by the piston at its outward stroke serves to force the gas into the cylinder against the tension produced therein by the piston at its return stroke, substantially as set forth.

9. In a gas-engine, in combination with the cylinder and the piston reciprocating therein, the compressed-air chamber communicating with the cylinder beyond the outward travel of the piston; an oil-reservoir communicating freely with the compressed-air chamber; a carbureting-chamber also communicating with the compressed-air chamber; a pump having valved communication to receive oil from the reservoir but not to return the same, the discharge-passage from such pump leading into the carbureter and a waste or backflow passage for oil from the lower part of the carbureter to the oil-reservoir, and ducts leading respectively from the air-chamber and from the upper part of the carbureter and making junction with each other; valves in said ducts respectively adjustable at will, and a valve which controls communication between the junction of said ducts and the cylinder, and suitable means for operating the same automatically to admit the combined charge of air and gas to the cylinder: substantially as set forth.

10. In a gas-engine, in combination with a cylinder and a piston which reciprocates therein, a false or adjustable head in the cylinder beyond the travel of the piston; an outlet from the cylinder between the piston and such head, and a valve controlling such outlet adapted to be adjusted to vary the pressure at which it opens; and means for adjusting the position of the adjustable head when the engine is in action: substantially as set forth.

11. A tubular valve which controls the admission of the explosive charge to the cylinder, the inlet-passage for such charge comprising a duct leading to the interior cavity of the valve and a port through the wall of the valve from said interior cavity, a piston adapted to reciprocate in the cavity of the valve to control the port through the wall thereof, and a centrifugal governor connected to the stem of said piston to reciprocate it according to the varying speed of the governor, substantially as set forth.

12. In a gas-engine in combination with the cylinder and a piston reciprocating therein, a hollow cylindrical valve whose axis is in a plane transverse to that of the cylinder, and a cylindrical seat for the same laterally opposite the inner end of the cylinder, said seat having a gas-inlet port, the valve having an exterior pocket or cavity E^3, the valve having a transverse diaphragm or head E^5, an inlet-port leading through said diaphragm into the interior cavity of the valve, a port through the wall of the valve from said interior cavity to the exterior cavity or pocket whereby the gas to reach the inlet-port of the seat must pass within the valve and out through the wall thereof, the piston G adapted to reciprocate in the interior cavity of the valve to regulate the opening of the port through the wall thereof, and a centrifugal governor connected to the stem of said valve and operating the same longitudinally in the cylindrical-valve cavity according to the speed of the governor, substantially as set forth.

In testimony whereof I have hereunto set my hand, at Chicago, Illinois, this 12th day of April, 1895.

A. W. BODELL.

Witnesses:
JEAN ELLIOTT,
LILLEY JOHNSTONE.