No. 610,034. Patented Aug. 30, 1898.

(No Model.) 3 Sheets—Sheet 1.

A. H. DINGMAN.

GAS ENGINE.

(Application filed June 25, 1897.)

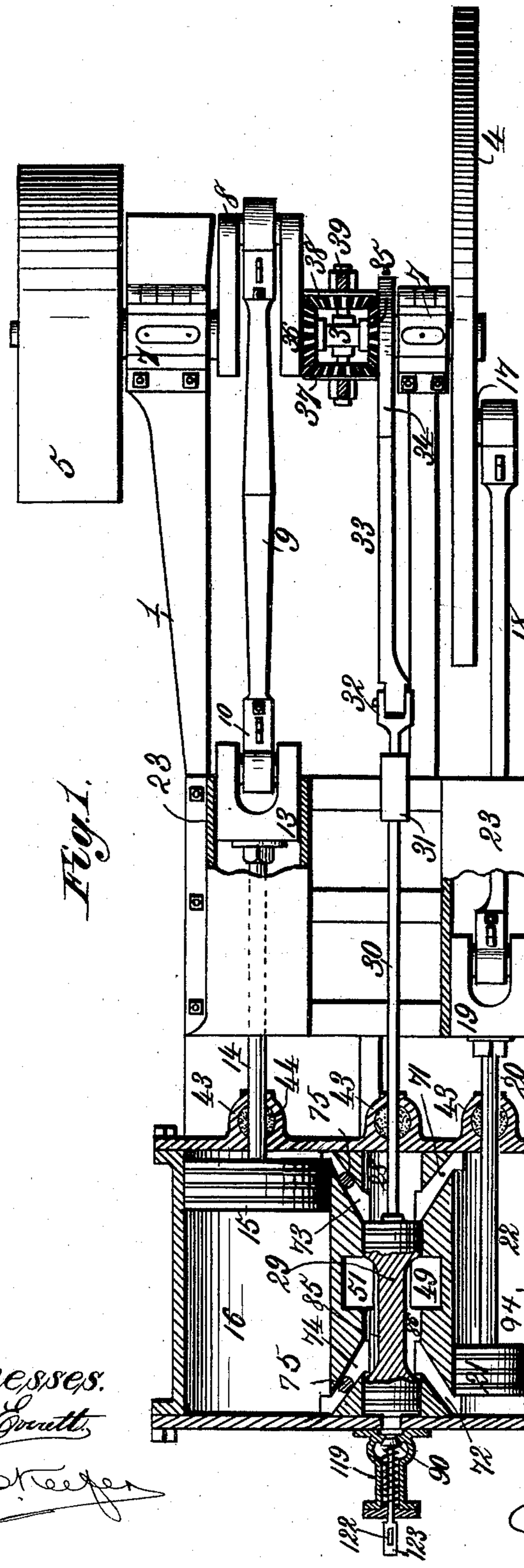

Fig. 1.

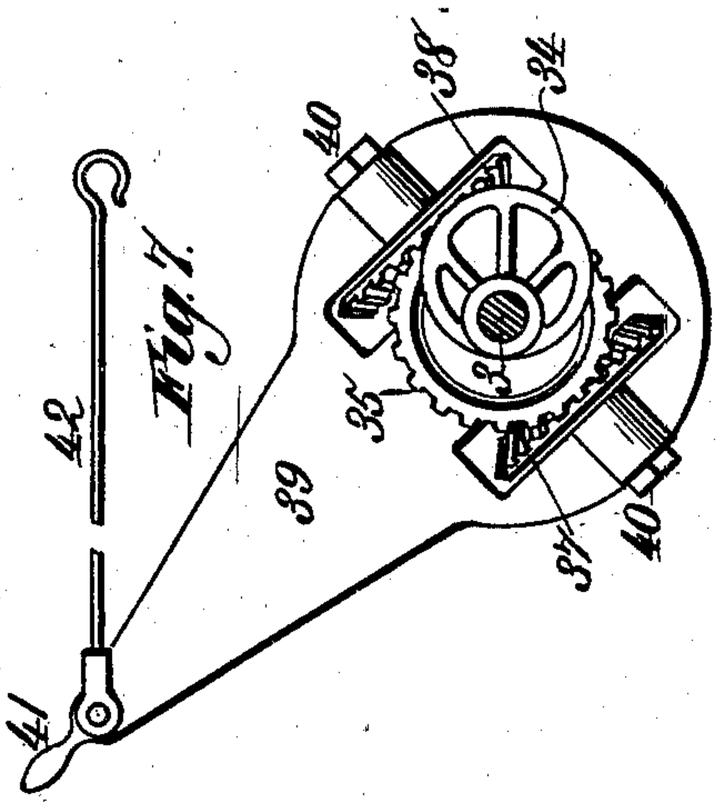

Fig. I.

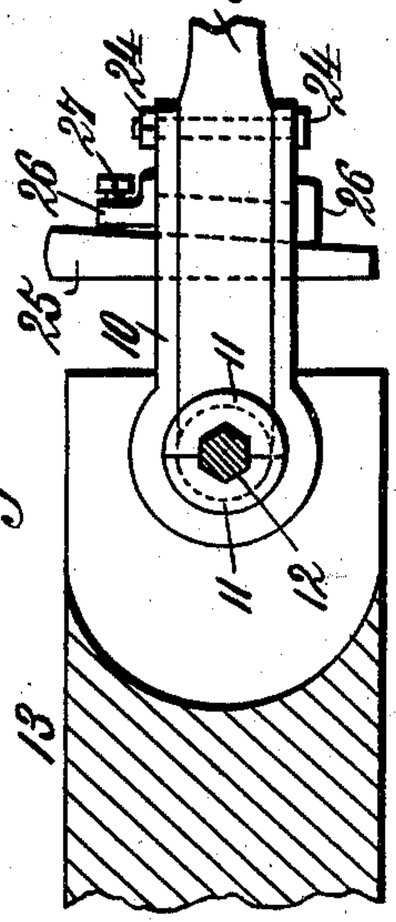

Fig. II.

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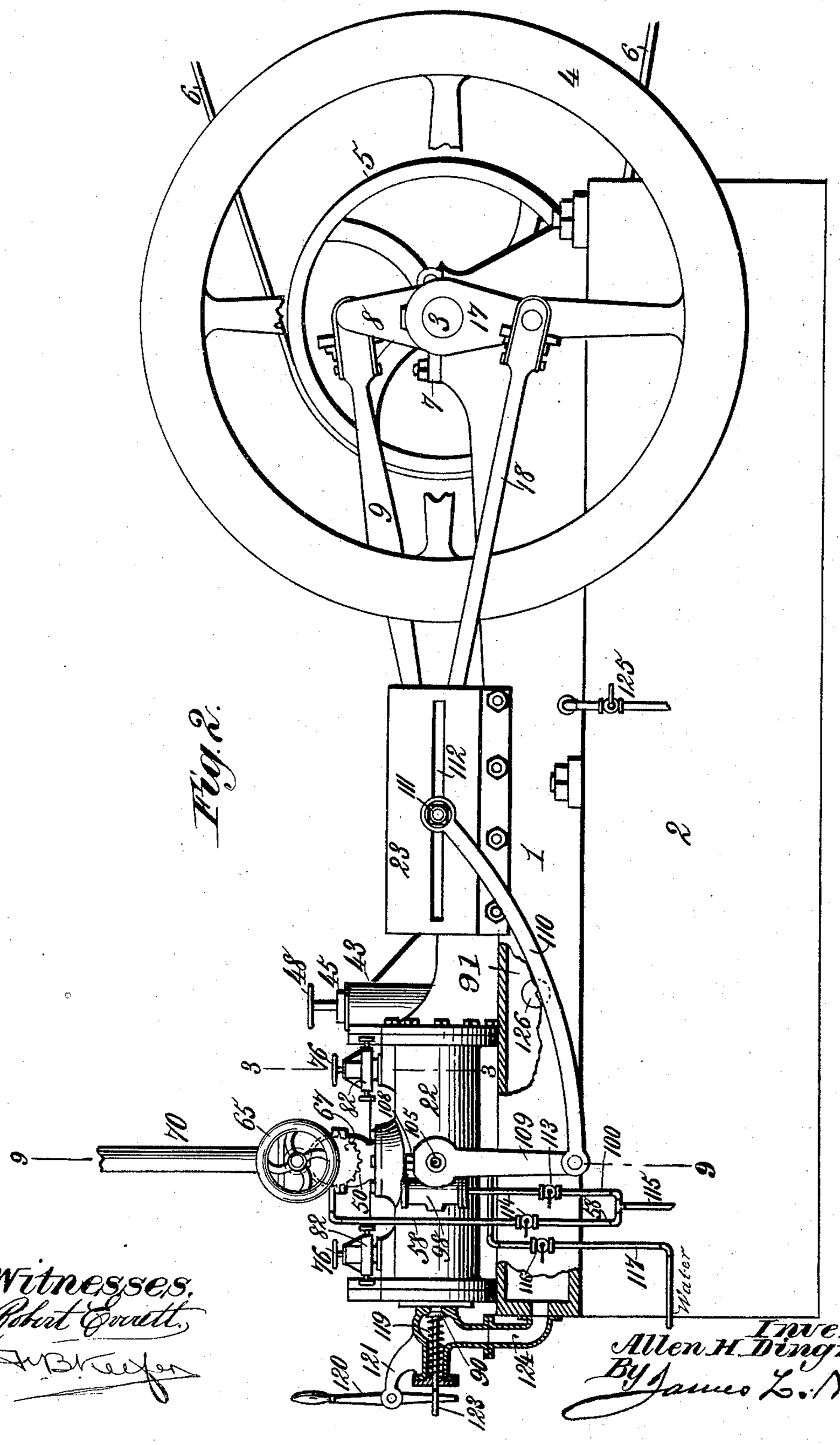
3 Sheets—Sheet 2.



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GAS ENGINE.

(Application filed June 25, 1897.)

(No Model.) 3 Sheets—Sheet 3.

Fig. 9.

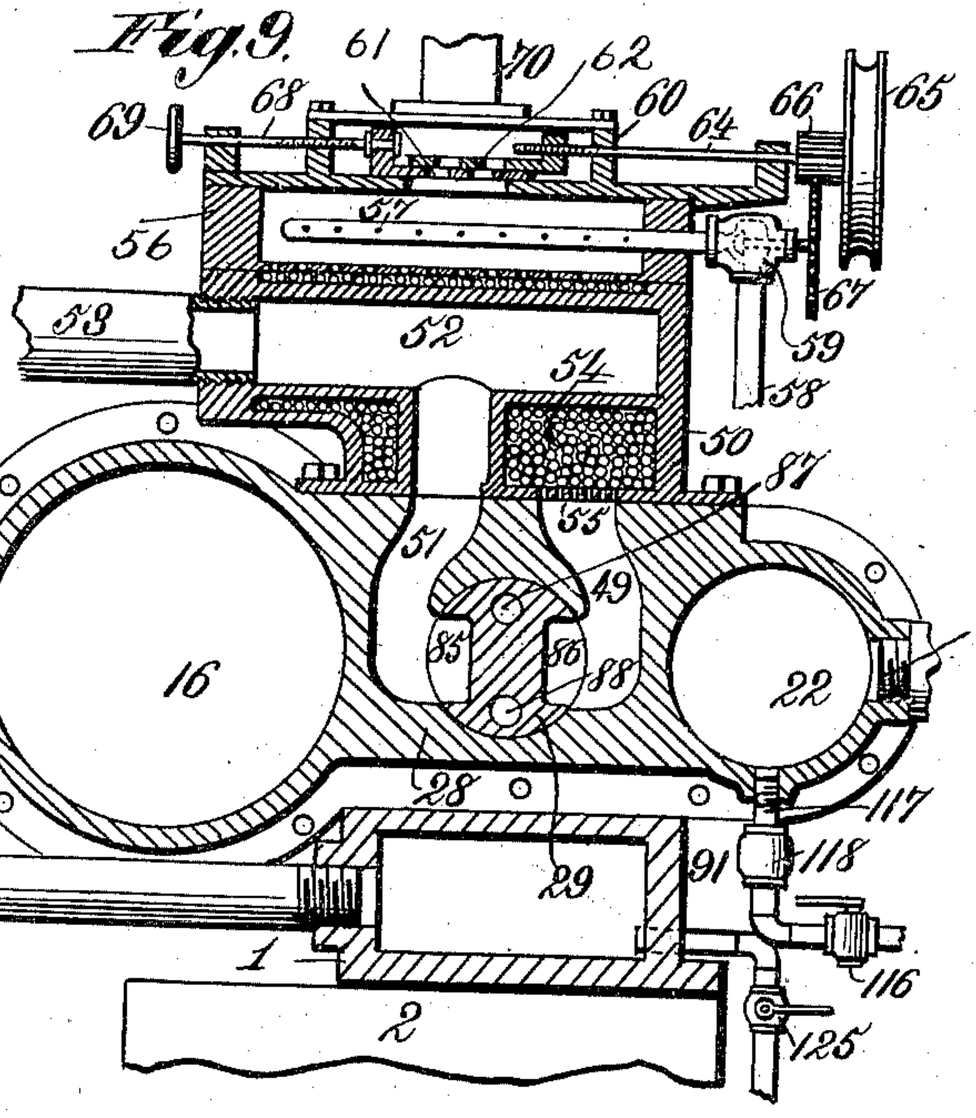


Fig. 6

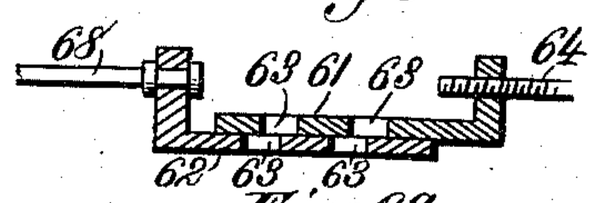


Fig. 6a.

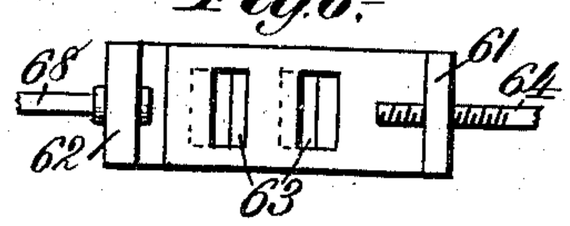


Fig. 8.

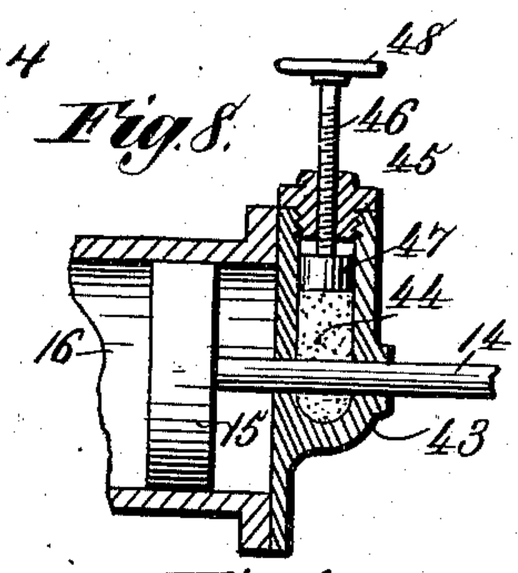


Fig. 3.

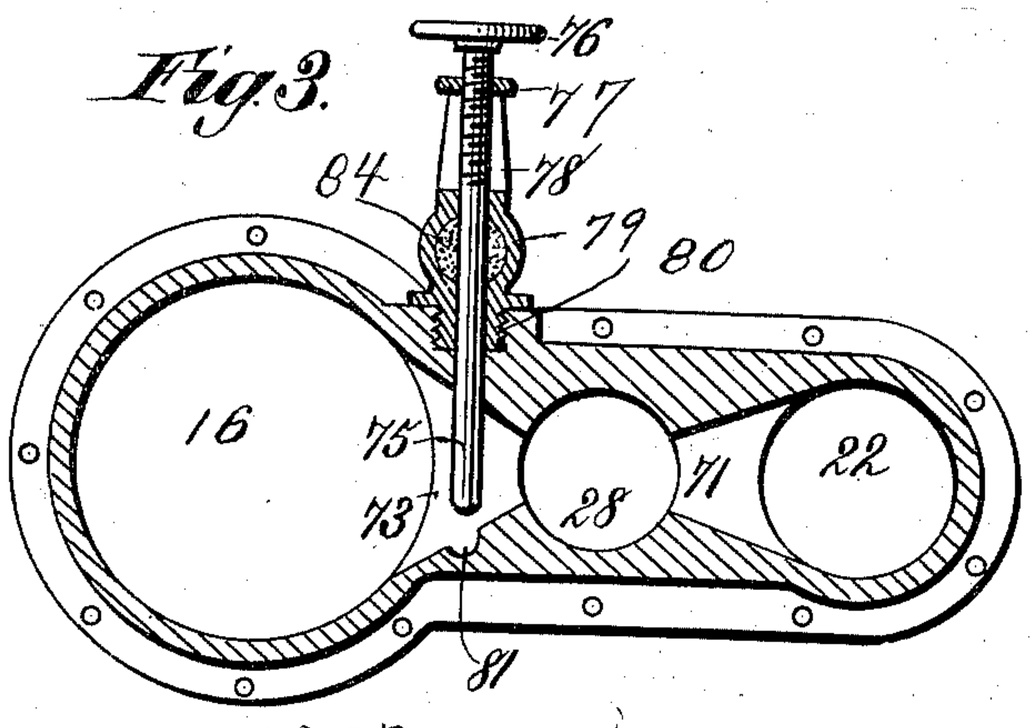


Fig. 4.

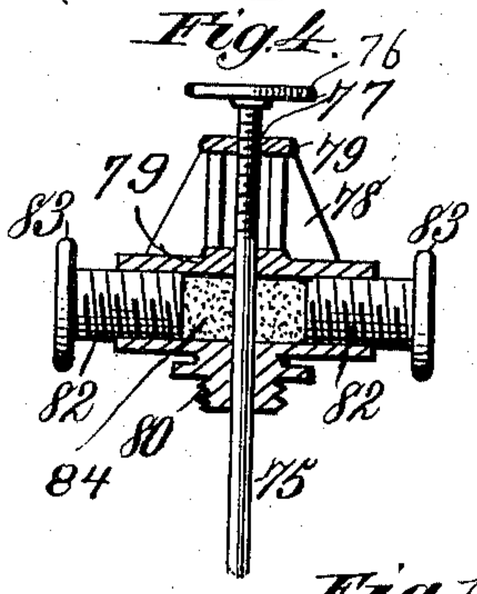


Fig. 10a

Fig. 10.

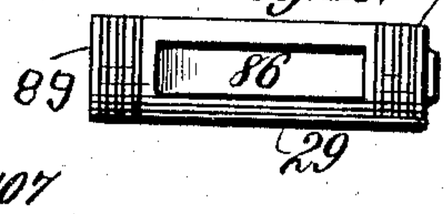


Fig. 5a.

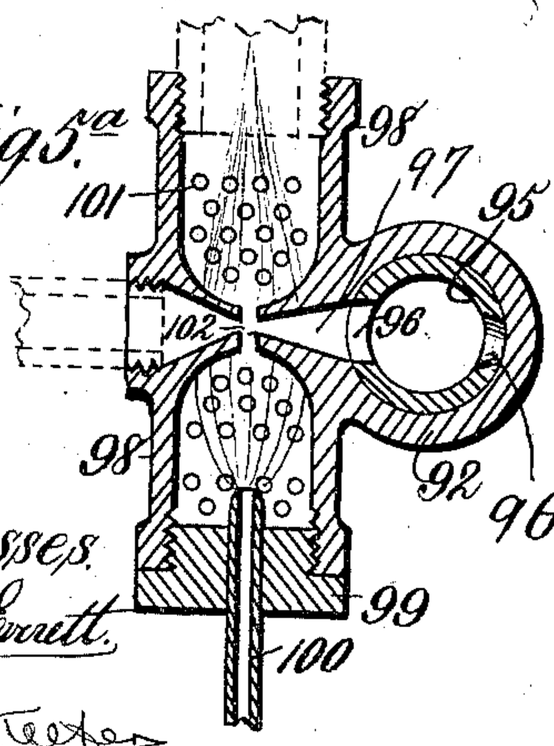
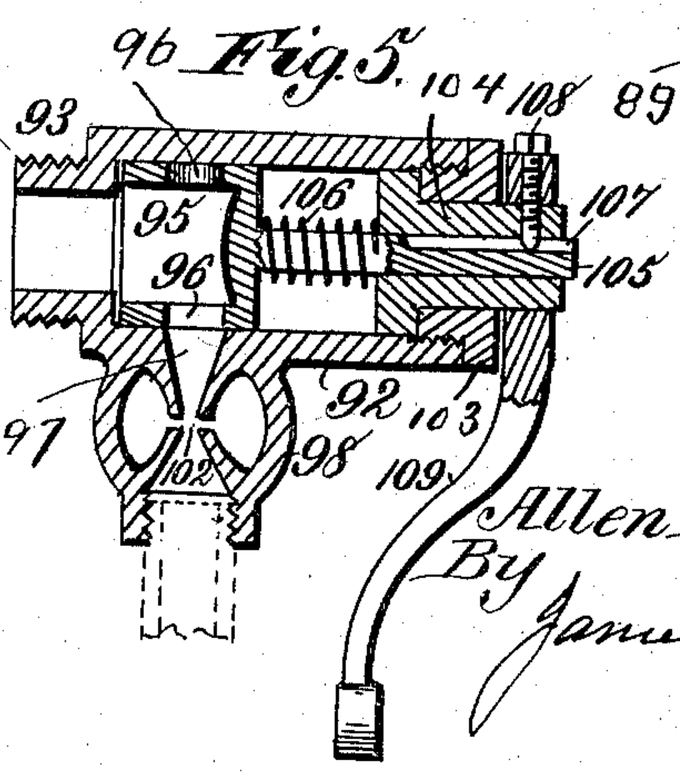


Fig. 5.



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UNITED STATES PATENT OFFICE.

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GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 610,034, dated August 30, 1898.

Application filed June 25, 1897. Serial No. 642,291. (No model.)

To all whom it may concern:

Be it known that I, ALLEN H. DINGMAN, a citizen of the United States, residing at De Haven, in the county of Allegheny and State of Pennsylvania, have invented new and useful Improvements in Gas-Engines, of which the following is a specification.

This invention relates to gas-engines, and has for its objects the various improvements in construction and combination of engine parts as hereinafter described.

The engine is more particularly designed to be operated by the explosion of natural or artificially-prepared combustible gas or gases in combination with atmospheric air; but it may be also wholly or partly operated by steam.

One of the principal purposes of my invention is to provide for the accumulation of gas at a very high pressure by operation of the engine, the accumulated gas to be used for driving other engines or for the operation of pumps or various machinery and for other purposes, either alone or in connection with steam plants.

In the annexed drawings, illustrating the invention, Figure 1 is a plan of my improved gas-engine in part horizontal section. Fig. 2 is a side elevation of the same, partly in section. Fig. 3 is a cross-sectional detail view on the line 3 3 of Fig. 2, showing the engine-cylinders and one of the port cut-off valves. Fig. 4 is a sectional elevation illustrating the packing for the port cut-off valves. Figs. 5 and 5ª are sectional views of the igniter or combustion-jet. Figs. 6 and 6ª show the double air-valve in longitudinal section and top view, respectively. Fig. 7 is a view of the positive reverse-gear. Fig. 8 is a sectional view of a packing-box for a piston-rod or valve-stem. Fig. 9 is a cross-section on the line 9 9 of Fig. 2 through the engine-cylinders, vaporizer, and gas-accumulator. Figs. 10 and 10ª are views of the main engine-valve. Fig. 11 is a sectional view of a cross-head connection.

Referring to Figs. 1 and 2 of the drawings, the numeral 1 designates the bed-plate or base portion of the engine-frame, which may be supported on an engine-block 2, as shown. At the forward end of the engine-frame is mounted the crank-shaft 3, that carries at one end the balance-wheel 4 and at the other end a pulley or band-wheel 5 for attachment of belting 6 to transmit power. As shown in Figs. 1 and 2, the crank-shaft 3 is mounted in journal-boxes having hinged caps or covers 7, which keep the shaft in better line and are stronger, more durable, have fewer bolts, and are more easily and conveniently adjusted than caps of ordinary construction.

To the main crank 8 of the engine-shaft 3 is attached one end of a main connecting-rod 9, the other end of which connects by means of a strap 10 with brasses 11 on a wrist-pin 12, carried by a sliding cross-head 13, Figs. 1 and 11, to which is secured the piston-rod 14 of the main piston 15, working in the main cylinder 16, that is supported on a rear portion of the engine-frame.

There is connected with the engine-shaft 3 another crank 17, which may be cast integral with the balance-wheel 4, as shown. To a wrist on this crank 17 is attached one end of a connecting-rod 18, Figs. 1 and 2, the other end of which connects with a sliding cross-head 19, to which is secured the piston-rod 20 of a piston 21, working in a combustion cylinder or chamber 22, that is supported parallel with the main engine-cylinder.

For each sliding cross-head 13 and 19 there is provided on the engine-frame a cylindrical guide 23, conforming to the preferably cylindrical shape of the cross-head therein. Each cross-head 13 and 19 is recessed at one end, as shown. In this recessed portion of each cross-head is situated a wrist-pin 12, that is preferably cast integral with the cross-head and made polygonal or hexagonal in cross-section, as shown in Fig. 11. The brasses 11 have polygonal inner faces conforming to the shape of the wrist-pin 12, and their outer surfaces are curved to conform to the end of the connecting-rod and its strap. This strap 10 is secured to the connecting-rod by means of a bolt and nut 24, a key 25 and gib 26 being provided to take up wear in the cross-head connections, and a set-screw 27 is mounted in the gib to hold the key in position. The manner of attaching a connecting-rod to the wrist-pin 12, Fig. 11, is the same for both cross-heads

13 and 19, and similar connections may be provided for attachment of the respective connecting-rods 9 and 18 to the crank-wrists of the engine-shaft. As the brasses 11 do not move on the wrist-pins 12 there can be no wear between them. The wear that comes between the brasses, connecting-rods, and straps is easily taken up by adjustment of the fastenings, and when the brasses are worn out they can be readily replaced with new ones that will always fit the wrist-pins, the brasses being made conveniently interchangeable, and thus the cross-heads will not have to be changed to get a new pin. The cylindrical form of the cross-heads 13 19 and guides 23 greatly reduces the lost motion from wear and provides for a very steady movement. The provision of the two cylinders 16 and 22, with their pistons connected to the two cranks 8 and 17 set in different planes, obviates a dead-center.

Between the two engine-cylinders 16 and 22 there is a preferably cylindrical valve-chamber 28, provided with suitable ports, as hereinafter explained. In this valve-chamber 28 there is a slide-valve 29, provided with a stem 30, for which there may be arranged a guide 31 on the engine-frame. The valve-stem 30 connects by a knuckle-joint 32 with an eccentric-rod 33, driven by an eccentric 34, which is secured to a bevel gear-wheel 35, that is loose on the engine-shaft. There is secured to and carried by the engine-shaft 3 or its main crank 8 a bevel gear-wheel 36, and the two bevel gear-wheels 35 and 36, one loose and the other fast on the shaft, are joined together by two bevel gear-wheels 37 and 38, that are placed on opposite sides of the shaft and revolubly supported in a reversing-lever 39, Fig. 7, provided with set screws or studs 40, on which the wheels 37 and 38 are arranged to turn. The reversing-lever 39 is capable of being rocked on the shaft 3 as a center and is provided with a handle 41 and also with a somewhat-lengthened hand-rod 42, by which the lever can be operated from a distance. If it be supposed that the engine is running forward, with the reversing-valve gear in the position as represented in Fig. 7, then it will be obvious that by drawing the lever 39 forward through one-quarter of a circle the eccentric 34 will be moved one-half way around or to the opposite side of the engine-shaft, thus reversing the position of the valve 29, and thereby reversing the engine.

There is cast onto the forward head of each cylinder 16, 22, and 28 a cylindrical vertically-extended packing-box 43, Figs. 1, 2, and 8, through each of which is passed the piston-rod of one of the engine-pistons 15 21 or the stem of the main engine-valve 29, as the case may be. Any suitable packing material 44 is placed in each box around the piston-rod or valve-stem. In one end of the packing-box is a bushing 45, through which is screwed a stem 46, carrying on its inner end a follower 47 and provided at its outer end with a hand-wheel 48, whereby the follower may be screwed down onto the packing 44 to tighten it around the piston-rods and valve-stem, respectively.

It may be preferable to cast the cylinders 16 22, intermediate valve-chamber 28, and their suitable ports all in one body, as shown in Figs. 1, 3, and 9. By reference to Figs. 1 and 9 it will be seen that the valve chamber or cylinder 28 is provided at one side, about midway its length, with an inlet-port 49, through which enters a mixture of gas and air from a vaporizer 50, that is bolted to the upper side of the engine-cylinder casting. An exhaust-port 51 leads from the valve-chamber 28 at a point opposite the inlet-port. This exhaust-port 51 communicates with an exhaust chamber or T 52, inclosed in the vaporizer 50, as shown in Fig. 9, and provided with an exhaust-pipe 53, discharging into the atmosphere. The vaporizer-chamber 50 is filled with balls 54, of brass, copper, or other suitable metal or refractory material, and these are so disposed around and in contact with the exhaust T 52 as to become thoroughly heated by the hot exhaust-gases escaping through the said T. A perforated plate 55, Fig. 9, is secured over the port 49 to support the balls 54 at that point. Secured to the upper side of the vaporizer 50 and communicating therewith is a gas-box 56, Fig. 9, in which is a perforated gas-pipe 57, connecting with a gas-supply pipe 58 on the outside. At the junction of these gas-pipes 57 and 58 there is a gas-valve 59 to control the supply of gas to the vaporizer. Above the gas-box 56 and communicating therewith is the casing 60 of a main air-valve 61 and sub air-valve 62, Figs. 6, 6ª, and 9. Both of these are slide-valves, and each is provided with a number of rectangular openings or perforations 63, as shown. The valves 61 and 62 are placed one on top of the other, and when the openings 63 of one valve register with the openings of the other valve a flow of air will be permitted to pass into the gas-box 56 for mixture with the gas therein. When one or the other valve 61 62 is moved in a proper direction, the admission of air can be regulated as required, or the supply can be entirely cut off. It will be seen that the main air-valve 61 is controlled by a stem 64, having a hand-wheel 65 thereon and provided with a pinion 66, meshing with a gear-wheel 67 on the stem of the gas-valve 59, so that both may be operated together; but as it may happen that when the gas-pressure in the pipe 58 is very high more gas than air may be admitted to the engine it is advisable to provide the independent sub air-valve 62, having stem 68 and hand-wheel 69, so that more air may be admitted or its regulation controlled independent of the jointly-operated main air-valve and connected gas-valve. An air-supply pipe 70 may be connected with the casing 60 of the double air-valve.

At the front end of the combustion-cylin-

der 22 there is a diagonal port 71 to and from the valve-chamber 28, and a similar port 72 is provided at the back end of the combustion-cylinder for communication with the corresponding portion of the valve-chamber. Like ports 73 and 74 are provided to establish communication between the valve-chamber 28 and main engine-cylinder 16 at its front and back ends, respectively. All these ports 71 to 74 are arranged diagonally, as shown in Fig. 1.

To control or shut off the ports 73 and 74, for a purpose hereinafter explained, it is preferable to provide in each of said ports an adjustable cut-off valve 75, Figs. 3 and 4. Each valve 75 consists of a straight stem having its upper portion threaded and provided with a hand-wheel 76 on its upper end. The threaded portion of the valve screws through a threaded hole in the top 77 of a casing 78, that projects vertically from a cylindrical and horizontally-placed packing-box 79, through the center of which the valve 75 is passed at a right angle. This cylindrical packing-box 79 is provided on its under side with a threaded boss or nipple 80, through which the valve 75 also extends. The boss or nipple 80 is screwed into a suitable recess provided in the top of the cylinder-casting, which is also suitably cored, as at 81, Fig. 3, to provide a seat for the closed-down valve. The interior of the packing-box 79 is screw-threaded from end to end, and in each end is received a screw 82, Fig. 4, provided with a wheel 83, by which the screw can be turned to exert compression on a suitable packing material 84, that is placed in the box 79, and around the portion of the valve 75, that is extended through said box. The valves 75 are designed to be screwed down through the ports 73 and 74 to partly or entirely close them, when desired, and more especially when it is required to accumulate power by preventing its entire expenditure in the main engine-cylinder, as hereinafter explained. The manner of packing the straight cylindrical valves 75 through the screws 82, exerting compression from both ends of the packing-box 79 upon the packing 84 therein, provides a most reliable means for preventing the leakage of gas or fluid pressure around the valve. Where convenient, this manner of securing compression from both ends of a packing-box can be applied as well to the construction shown in Fig. 8 and previously described.

The main engine-valve 29 is cylindrical, as shown in Figs. 1, 10, and 10^a. It is provided with two grooves 85 and 86, located longitudinally in opposite sides of its central portion, and it also has two longitudinally-extended perforations or passages 87 and 88, Fig. 9, one on each side, alternating with the said grooves. A number of packing-rings 89 may be provided on the ends of the valve. The grooves 85 and 86 are to establish communication between the several ports of the valve-chamber 28 and engine-cylinders 16 and 22, respectively. The two longitudinally-extended perforations 87 and 88 are designed to allow a part of the exploded gas from the front end of the combustion-cylinder 22 to pass through the main valve 29 to a valve 90, Figs. 1 and 2, that controls communication with an accumulating and drainage chamber 91, located in the engine-bed or at any other convenient point. These perforations 87 and 88 also provide for balancing the valve 29, so that the pressure will be always equal at its opposite ends.

The combustion-jet, Figs. 5 and 5^a, for exploding the gas, consists of a cylindrical body 92, one end of which is provided with a threaded nipple 93, by which the jet or igniter is screwed onto the side of the combustion-cylinder 22 at an opening 94, Figs. 1 and 9. This cylindrical body 92 constitutes a casing for a cylindrical hollow valve 95, which is closed at its outer end and open at the inner end. The valve 95 is provided in its periphery with two ports 96 near the closed valve end. These ports 96 are adapted to register alternately with a doubly-tapering tubular opening 97 on one side of the igniter-body 92, one port registering at each end of the engine-stroke. The doubly-tapering tubular opening 97 intersects the vertically-longitudinal axis of a gas-ignition chamber 98, that is at right angles with the igniter-body 92 and integral therewith. This gas-ignition chamber 98 is threaded in both ends and has a centrally-perforated bushing 99 screwed into its lower end. Through the perforation of the bushing 99 is passed a gas-pipe 100, the upper end of which constitutes a burner within the gas-ignition chamber 98, that is provided with inlets 101 for admission of air to support combustion. There are also provided openings 102 in the contracted central portion of the doubly-tapered tube 97 at about the center of the ignition-chamber 98 and directly in the flame from the gas-jet. For imparting steadiness to the flame by improving the draft, if necessary, there may be screwed into the upper end of the ignition-chamber 98 a suitable length of pipe, as indicated by dotted lines in Fig. 5^a, and, as also shown by dotted lines, there may be screwed a suitable length of pipe into the outer screw-threaded end of the tapered tube 97 to conduct away any waste gases of combustion that may escape at each explosion of the combustible or explosive gas and air mixture employed in the engine.

Into the outer end of the igniter-body 92 is screwed a bushing 103, that loosely supports a gland 104, through which is passed the stem 105 of the igniter-valve 95, a spring 106 being placed around the said valve-stem between the gland and the valve-body. The valve-stem 105 is provided with a longitudinal groove 107, that receives the end of a set-screw 108, by which there is attached to the said gland 104 and valve-stem 105 an arm 109,

which is concerned in imparting an oscillatory or rocking movement to the igniter or combustion-jet valve 95, while the engagement of the set-screw 108 in the groove 107 is such as to permit the required longitudinal movement of the valve as controlled by its spring. The valve-arm 109 connects by a rod 110, Figs. 1 and 2, with a stud 111 on the sliding cross-head 19, a slot 112 being formed in the cylindrical guide 23 for passage of said stud. Through the movement of this cross-head 19 the valve 95 is rocked, so that one or the other of its ports 96 will register with the tube 97 of the ignition-chamber 98 at each end of the stroke of the piston 21 in the combustion or explosion cylinder.

In order to start the engine, the gas should first be ignited as it issues from the pipe 100 into the ignition-chamber 98, Fig. 5[a]. By reference to Fig. 2 it will be seen that there is a gas-key 113 on the pipe 100, by which the supply of gas can be turned off and on at will. There is a similar gas-key 114 on the pipe 58, leading to the gas-box 56 of the gas-and-air mixer or vaporizer 50, hereinbefore described. As shown in Fig. 2, the gas-pipes 58 and 100 are preferably arranged as branches of a common gas-supply pipe 115.

After igniting the gas at the pipe or burner 100 the engine balance-wheel 4 should be revolved a few times by hand to cause a suction in the engine-cylinders and main-valve chamber 28, and the gas-valve 59 and air-valves 61 62 are opened by a proper manipulation of their hand-wheels 65 69, so as to give the required proportions of gas and air in the mixture to be employed for operating the engine. The air entering through pipe 70 into the chamber 56 is there mixed with gas from the perforated gas-pipe 57, and from this chamber or box 56 the gas-and-air mixture passes around the exhaust-T 52 and between or among the balls 54 in the vaporizer 50 and so onward to the inlet-port 49 of the main-valve chamber 28, Figs. 2 and 9. From this port 49 the vaporized mixture of gas and air passes into the groove 86 of the valve 29, then, say, through the port 72 into the combustion-clyinder 22, behind the piston 21, so that as the piston moves forward the combustion-cylinder 22 will be filled with the gas-and-air mixture. Now let it be supposed that the cylinder 22 has already been filled with mixed gas and air on the front side of the piston 21 and the valve 29 has just moved back as the engine passes over the center, as represented in Fig. 1. The valve 95 of the combustion-jet or igniter has just opened with one of its ports 96 in register with the tube 97, so that the gaseous mixture from the cylinder 22 will pass through the said valve into the said tube 97, where it will be exploded by coming in contact with the gas-flame in the ignition-chamber. When the explosion takes place, the valve 95 will be forced back against the spring 106; but after the piston 21 passes the port 94, Fig. 1, the gas-pressure on the valve 95 is relieved, and the valve will be returned by its spring, though neither valve-port 96 will again register with the tube 97 until the piston 21 has reached the end of its stroke. At this time the valve 95 is again opened by the arm 109, actuated from the engine cross-head, and the gas will then be exploded on the rear side of the piston 21 in the combustion-cylinder. After the gas is exploded in the combustion-cylinder 22 it passes, say, through the port 71, adjacent end of the valve-chamber 28, and port 73 to the front of the piston 15 in the main engine-cylinder 16, where it operates to force the said piston back. The exploded gas, which has previously done its work in the main cylinder 16 and is behind the piston 15, passes out through the port 74 into the groove 85 of the main valve 29, then into the exhaust-port 51, and thence through the exhaust-T or chamber 52 into the exhaust-pipe 53, Fig. 9, from which it escapes to the atmosphere. As the exhaust-gas is very hot, it heats the exhaust-T 52, which in turn heats the copper or brass balls 54 of the vaporizer 50, thus vaporizing any liquids or moisture that may be contained in the incoming mixture of gas and air passing among said balls to the inlet-port 49 of the main-valve chamber. This vaporizer is provided more especially for gas taken direct from oil or oil-wells and which contains a small quantity of both crude oil and gasolene.

After the engine has been in operation for a while a quantity of water may be turned on at a cock 116, Figs. 2 and 9, to pass through a pipe 117, provided with a check-valve 118, into the middle of the bottom side of the combustion-cylinder 22, just under the port 94, for the combustion-jet or igniter. This water is immediately vaporized by the heat of the exploded gas and operates on the engine-pistons, together with the other gas or gases, just as steam would. Only a sufficient quantity of water is turned on at any time to keep the engine within the limits of a proper working temperature. Thus no water-jacket is required around the engine-cylinders, and as the vapor of the water takes the place of an equal volume of exploded gas it follows that this engine requires just that much less gas and is that much more economical than the ordinary gas-engine.

By reference to Fig. 1 it will be seen that the exploded gas from the igniter-valve 95 and combustion-cylinder 22 always enters the main-valve chamber 28 through either one of the ports 71 72 on its way to the main engine-cylinder 16 through either one of the ports 73 74, connecting with the said main-valve chamber. It will also be seen that gas can pass from either end of the main-valve chamber 28 through the longitudinal perforations 87 88 of the main valve.

Now it will be seen by reference to Fig. 1 that the piston 15 is about four times as large as the piston 21. Therefore be the force of the explosion in the cylinder 22 great or small it

will be four times as much in the cylinder 16. As the pistons 15 and 21 always move in opposite directions and as the pressure of the exploded gases is always on the same corresponding sides of the pistons 16 and 21, it is obvious that the exploded gases act upon the piston 21 with a retarding force of one-fourth; but by reason of the greater area of the piston 15 the exploded gases exert a working force four times as great as the retarding force, and thus drives or moves the engine as intended. It follows, therefore, that the engine will operate with greater or less power regardless of the pressure on the piston 21, and no matter how great the pressure on the piston 21 the force will always be three times greater or four times as great on the larger piston 15 by reason of its greater area and by reason of the direct communication between the two pistons 15 and 21 and always on the same corresponding sides. The force of the explosion does not act upon the piston 21 to produce any power in the engine; but the exploded gases are acted upon by the piston 21 and forced from the cylinder 22 to the cylinder 16 by reason of the greater area therein. It is the force exerted upon the larger piston 15 which operates every other part of the engine, and thus operates the small piston 21.

The object of the piston 21 and cylinder 22 is to act as a pump drawing in or filling with the mixed gases and then forcing the exploded gases into the main cylinder 16. The cylinder 22 differs from a pump, however, in that it is a complete combustion and cooling chamber, in which the mixed gases are exploded and the heat therefrom reduced to a working temperature without any great loss of power. The explosion takes place immediately at the beginning of each stroke.

It will be seen that when the engine is in operation the two longitudinal holes through the main valve 29 will be filled with exploded gases under pressure, which will be released into the charge of mixed gases at the end of each stroke, causing an increased pressure of the charge of mixed gases, forcing the same into the exploder, thus causing an immediate explosion. These longitudinal holes in the valve 29 are again refilled when the explosion takes place.

It is to be understood that the explosion does not take place on both sides of the piston 21 at the same time, but alternately, the opposite side of the piston 21 or the side opposite to the explosion always filling with mixed gases as the piston proceeds on its stroke. Were both cylinders 22 and 16 the same size, the pressure of the gases would be balanced and there would be neither power nor motion produced. The mixed gases pass in through the port 49, groove 86, and port 72, Fig. 1, and fill up the space behind the piston 21 as this piston moves forward on its stroke, and the spent or exhausted gases behind the piston 15 pass out of the cylinder 16, port 74, groove 85, and exhaust-port 51, as represented. The exploded gases pass or are forced out of the cylinder 22 by the piston 21 and pass through the port 71, through the front end of the valve-chamber 28, through the port 73, then in front of the main piston 15, driving it backward, and thus operate the engine, as represented. This operation is exactly repeated for the opposite stroke and by means of the corresponding opposite ports as the main valve 29 is moved forward by the eccentric 34, and thus produces continuous motion, as represented. As the gases leave the small cylinder 22 and expand to fill the larger cylinder 16 the pressure will fall to less than one-half and the volume will be increased four times.

The check-valve 90 at the rear end of the main-valve chamber 28 is held normally closed by a spring 119, Figs. 1 and 2, but can be opened, when desired, by means of a hand-lever 120, that is fulcrumed to an arm 121, projecting from the valve-casing. One end of this lever 120 engages a slot 122 in the stem 123 of the check-valve 90, which may be of any suitable or well-known form. The casing of the check-valve 90 is connected with the drainage or accumulator chamber 91 through an elbow 124, Fig. 2, or other suitable passage. This accumulator or drainage chamber 91 is preferably located in the bed of the engine or may be formed as a part of the bed-plate 1, as shown, and it is provided with a drain-cock 125 and with a pipe or pipes 126, through which surplus or accumulated gas may be taken to operate other engines or pumps, &c., or for use in starting this engine.

If after the engine is started it is desired to accumulate a quantity of exploded gas to operate other engines or various machines, the port cut-off valves 75, Figs. 3 and 4, should be screwed down until they nearly close the ports 73 74 to and from the main engine-cylinder. Now a greater quantity of gas and air should be turned on by the hand-wheel 65, so that a great quantity of exploded gas will be produced in the combustion-cylinder 22, and then by means of the hand-lever 120 the check-valve 90 will be opened. The surplus gas being unable to enter the main cylinder 16 (the cut-off valves 75 being shut down) will pass from both ends of the main-valve chamber 28 through the longitudinal passages 87 88 of the main valve 29, and thence through the opened check-valve 90 into the accumulator and drainage chamber 91, where, if desired, the accumulated gas can be stored until required for use. From this chamber 91 the accumulated gas may be taken by the pipe 126 to operate various other engines, pumps, or other machines. Another object of the chamber 91 is to provide for drainage of any liquids that may condense from vapors contained in the exploded or burned gases and any solid products of combustion which said liquids may contain in so-

lution, all being drawn off by the drain-cock 125 from time to time. The accumulator or drainage chamber 91 also affords the advantage of maintaining a more uniform pressure of gases for operating other machinery, and thus has the same object as the dome on a steam-boiler. It will be obvious, also, that when this engene is at rest and there is an accumulation of gas in the chamber 91 it will be only necessary to open the check-valve 90 in order to start the engine by back pressure from the accumulator.

What I claim as my invention is—

1. In an engine, the combination with the main cylinder and its piston, and a combustion-cylinder and its piston, of a cylindrical valve-chamber intermediate the two said engine-cylinders and provided with centrally-located inlet and exhaust ports and with ports that communicate with the ends of the engine-cylinders, and a cylindrical main valve located in the said valve-chamber and provided in its opposite sides with grooves to connect the ports of the engine-cylinders with the inlet and exhaust ports of the valve-chamber and having longitudinal perforations between the said grooves, substantially as described.

2. In an engine, the combination with the two cylinders and their pistons, a valve-chamber intermediate the said cylinders and provided with an inlet-port and an exhaust-port and with ports to and from the engine-cylinders, and a main engine-valve in said valve-chamber, of a vaporizer-chamber communicating with the inlet-port of said valve-chamber, an exhaust-chamber located in the vaporizer-chamber and communicating with the exhaust-port of the said valve-chamber, metal balls or refractory material placed in the vaporizer-chamber around the inclosed exhaust-chamber, a gas box or chamber communicating with the vaporizer-chamber and provided with a perforated gas-inlet pipe, a gas-valve, an air box or chamber communicating with the gas-box and provided with an air-valve, and means for operating the gas-valve and air-valve jointly, substantially as described.

3. In an engine, the combination with the vaporizer, the gas-box communicating with the vaporizer, and an air-box communicating with the said gas-box, of a perforated gas-inlet pipe extended into the gas-box and provided with a gas-valve, a main air-valve geared with the said gas-valve for joint operation, and an independently-operated sub air-valve, substantially as described.

4. In an engine, the combination with a main cylinder and its piston and a combustion-cylinder and its piston, and means for supplying said combustion-cylinder with an explosive gas, of an igniter or combustion-jet composed of a valve-chamber and an ignition-chamber, the said valve-chamber being intermediate the combustion-cylinder and said ignition-chamber and having a perforated tubular passage extended through the ignition-chamber, means for maintaining a flame in the said ignition-chamber around the said tubular passage, and a valve located in the said valve-chamber of the igniter and actuated from a moving part of the engine, substantially as described.

5. In an engine, the combination with a main cylinder and its piston and a combustion-cylinder and its piston, and means for supplying the said combustion-cylinder with an explosive gas, of an igniter or combustion-jet provided with a valve actuated from a moving part of the engine and adapted to control an explosion of gas in the combustion-cylinder at the end of each stroke, substantially as described.

6. In an engine, the combination with the main engine-cylinder and its piston, a combustion-cylinder and its piston, a valve-chamber intermediate and communicating with said cylinders, and a main engine-valve located in said chamber, and provided with longitudinal passages, of an accumulator-chamber provided with a drainage-cock, a check-valve intermediate the main-valve chamber and said accumulator, cut-off valves for the ports between the main-engine-valve chamber and main engine-cylinder, and a pipe leading from the accumulator-chamber, substantially as described.

7. In an engine, the combination with the main engine-cylinder and its piston, the combustion-cylinder and its piston, the main-engine-valve chamber having ports communicating with the engine-cylinders and the longitudinally-perforated main engine-valve located in said chamber, of the cut-off valves in the ports between the main engine-cylinder and main-valve chamber, an accumulator-chamber adapted to communicate with the main-valve chamber and provided with an outlet-pipe for conducting accumulated pressure to another engine or machine, and a valve to control communication between the main-valve chamber and said accumulator-chamber, substantially as described.

8. In an engine, the combination with the main engine-cylinder and its piston, the main-valve chamber having ports communicating with said main cylinder, and an accumulator-chamber communicating with the said main-valve chamber, of cut-off valves for the ports between the main-valve chamber and main cylinder, each of said cut-off valves consisting of a straight cylindrical body screw-threaded at one end and supported in a packing-box with which the threaded portion of the valve is engaged, a hand-wheel for said valve, and screw-threaded followers for compressing the packing around said valves, substantially as described.

9. In an engine, the combination of the engine-cylinders and their pistons, a crank-shaft with which the piston-rods are connected, a main engine-valve intermediate the

two engine-cylinders and actuated from an eccentric on the main shaft, a reversing-gear for said valve, mechanism for exploding gas in one of the engine-cylinders, and an accumulator for gas-pressure adapted to have valve-controlled communication with the main-engine-valve chamber, substantially as described.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

ALLEN H. DINGMAN.

Witnesses:
SEBASTIAN A. HEISEL,
WILLIAM B. COCHRAN.