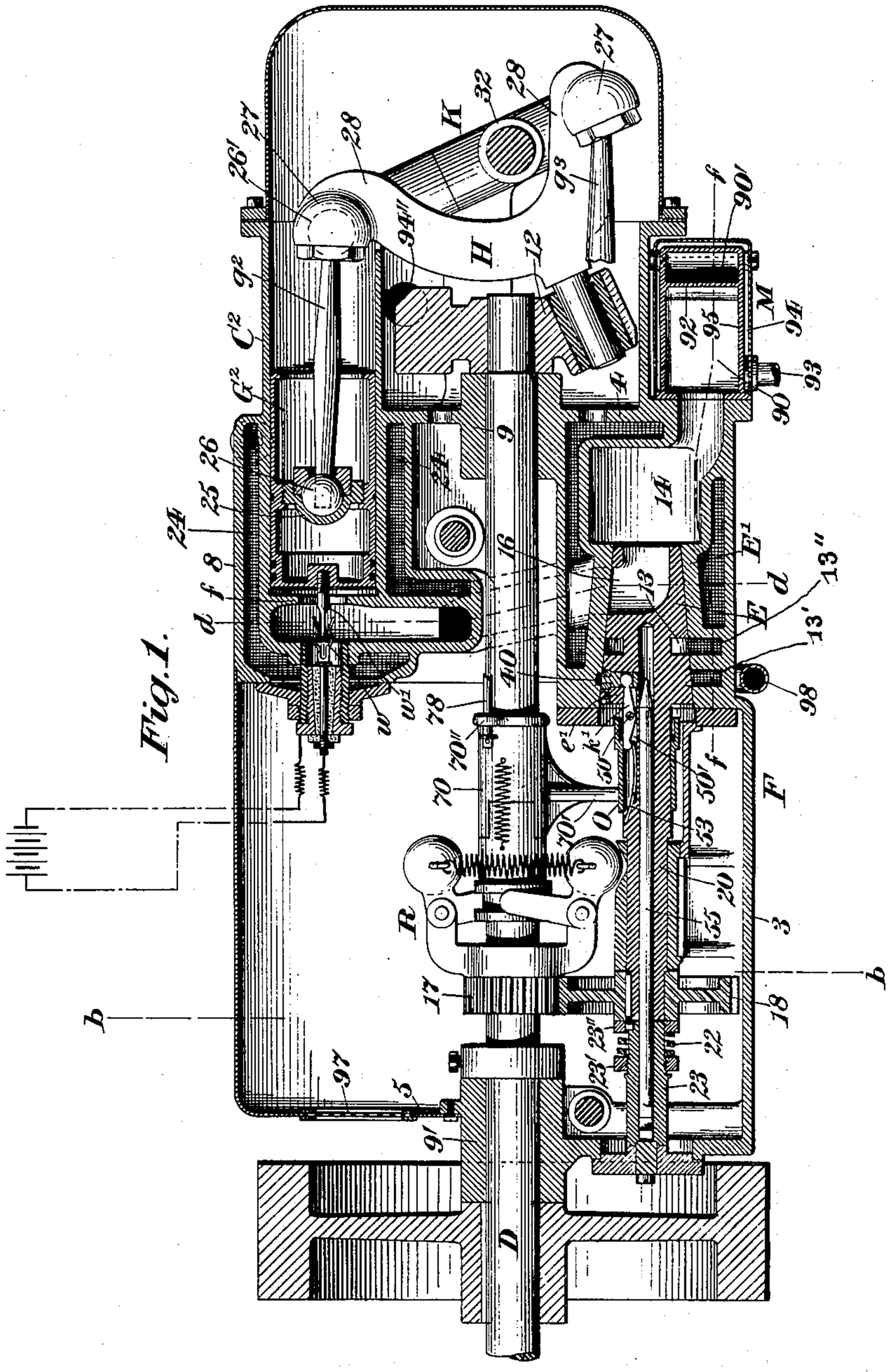
(No Model.) 5 Sheets—Sheet 1.

H. C. BAKER.

GAS ENGINE.

No. 580,444. Patented Apr. 13, 1897.

Fig. 1.



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(No Model.) 5 Sheets—Sheet 2.

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GAS ENGINE.

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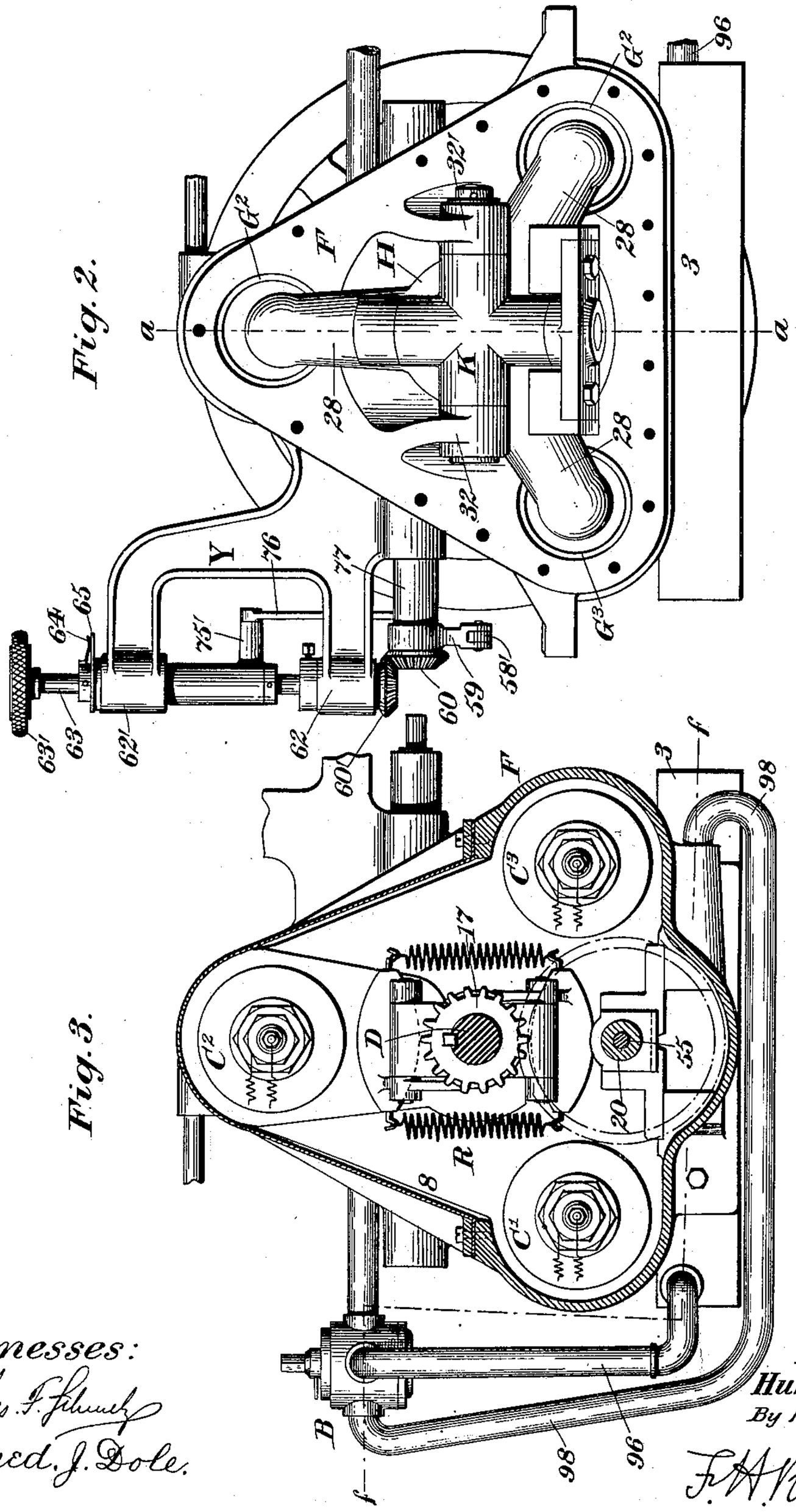

Fig. 2.

Fig. 3.

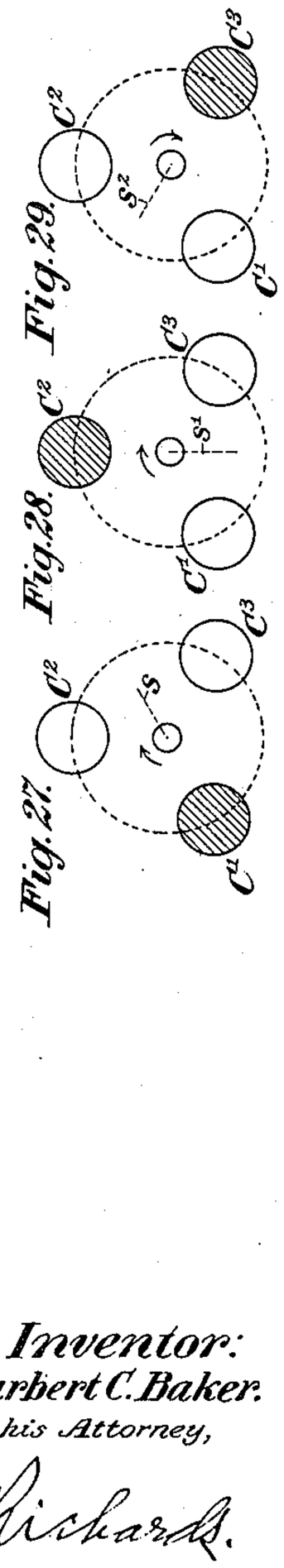

Fig. 29.

Fig. 28.

Fig. 27.

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(No Model.) 5 Sheets—Sheet 3.

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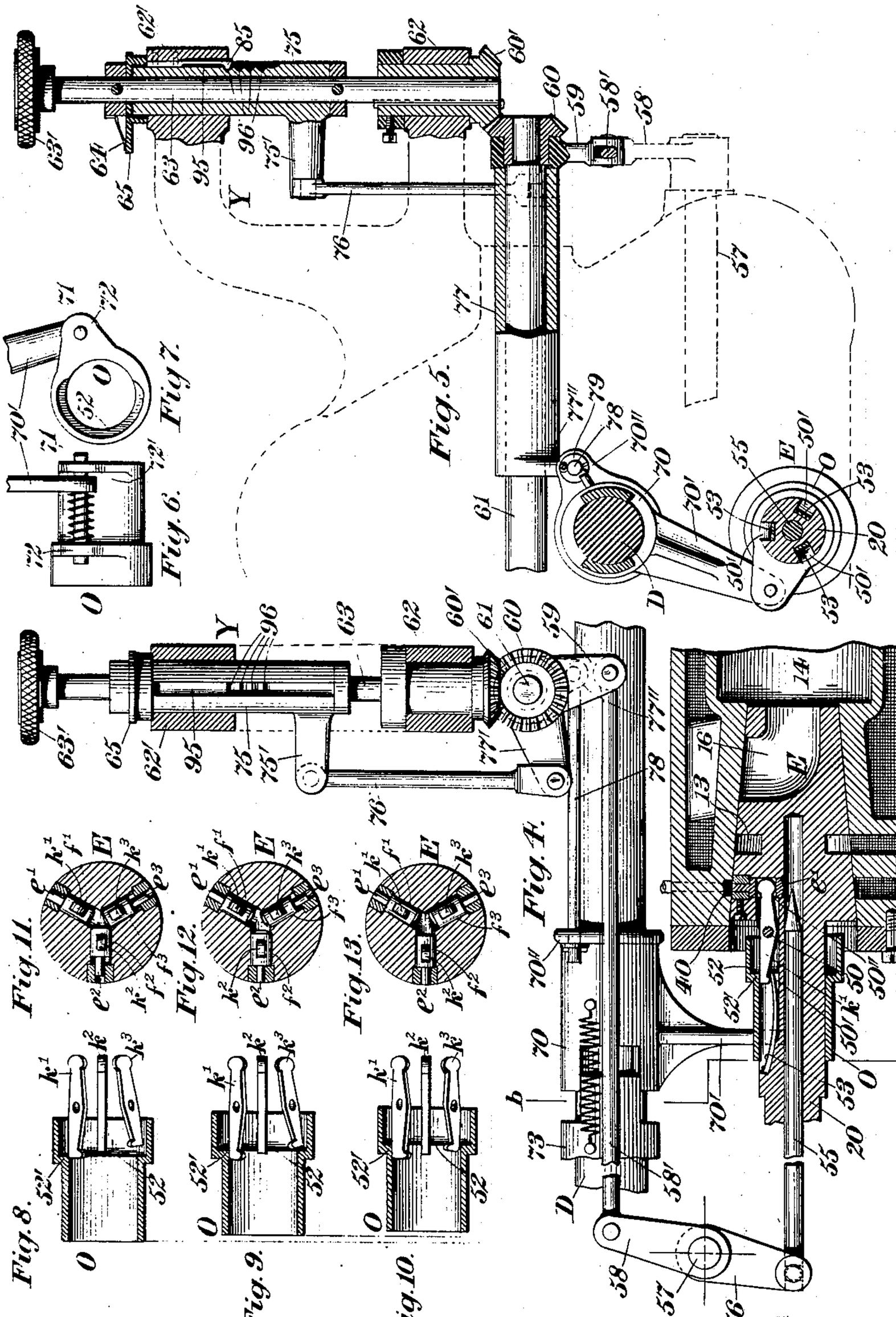

Fig. 5.

Fig. 6. Fig 7.

Fig. 8. Fig. 9. Fig.10.

Fig.11. Fig.12. Fig.13.

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(No Model.) 5 Sheets—Sheet 4.

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GAS ENGINE.

No. 580,444. Patented Apr. 13, 1897.

Fig. 17.

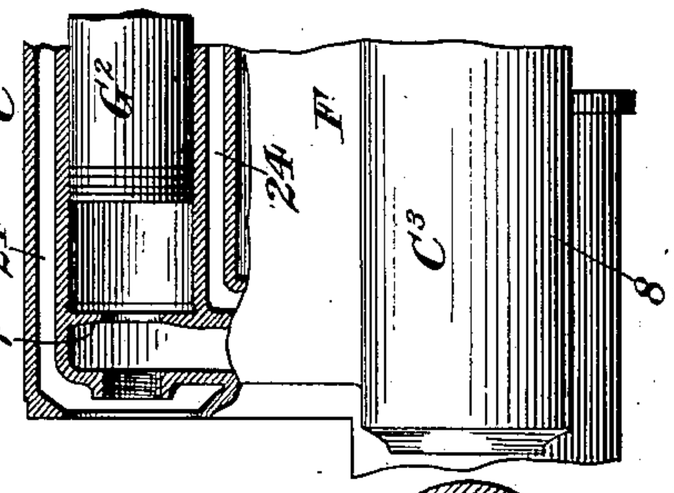


Fig. 21.

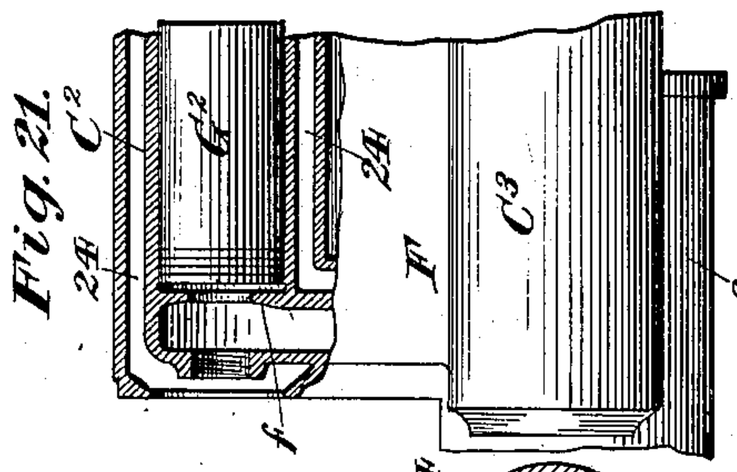


Fig. 16.

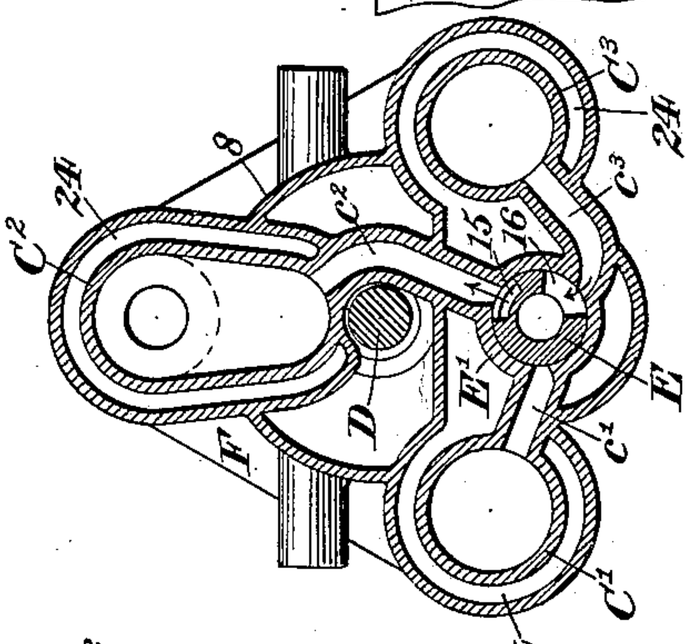


Fig. 20.

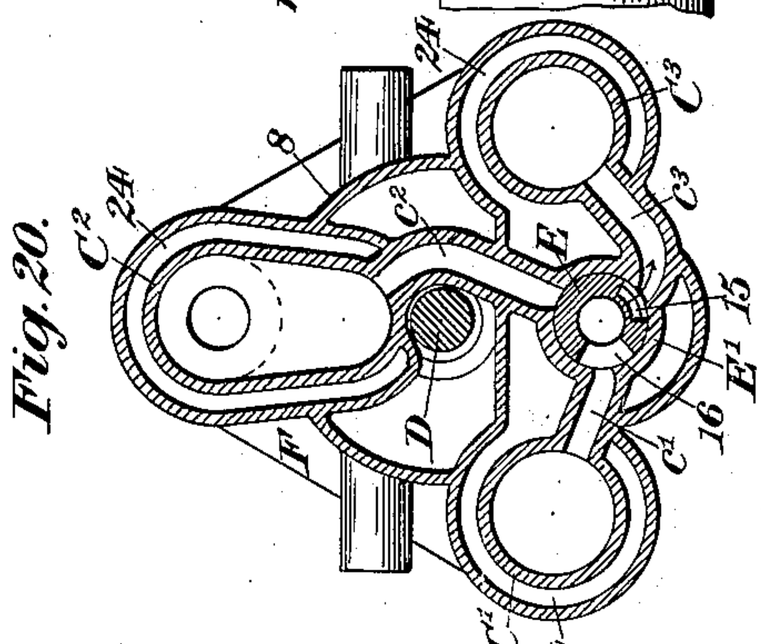


Fig. 15.

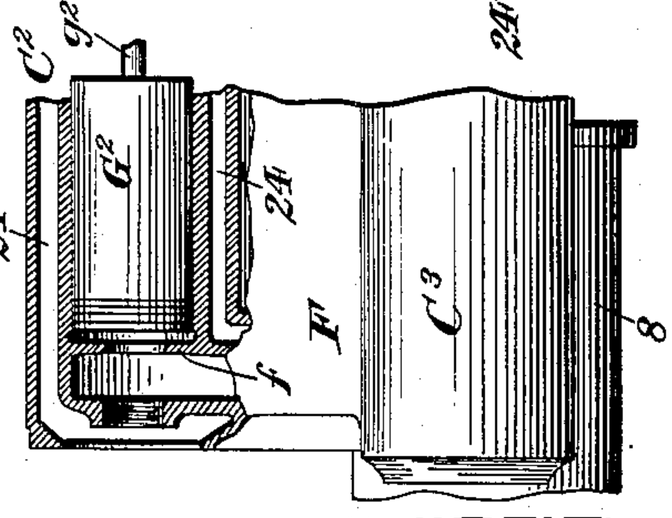


Fig. 19.

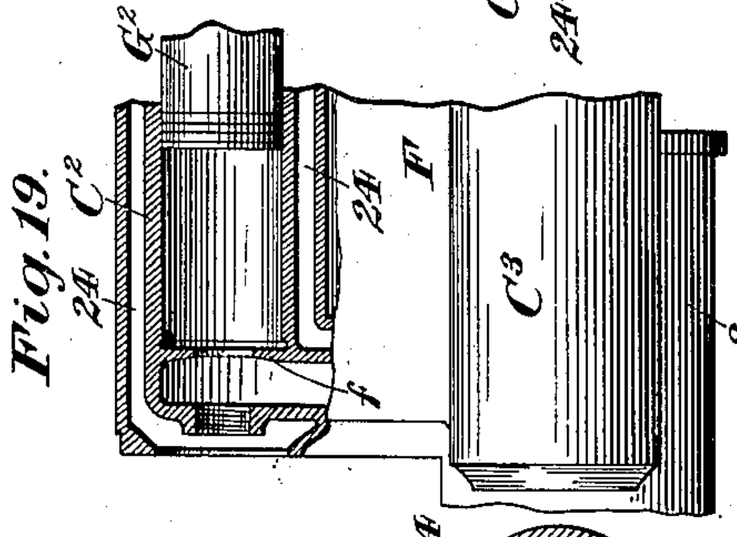


Fig. 14.

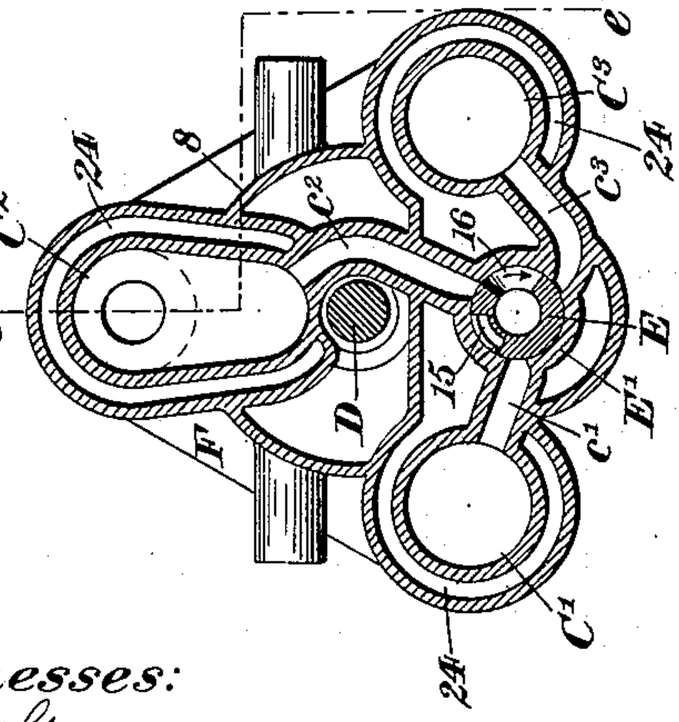
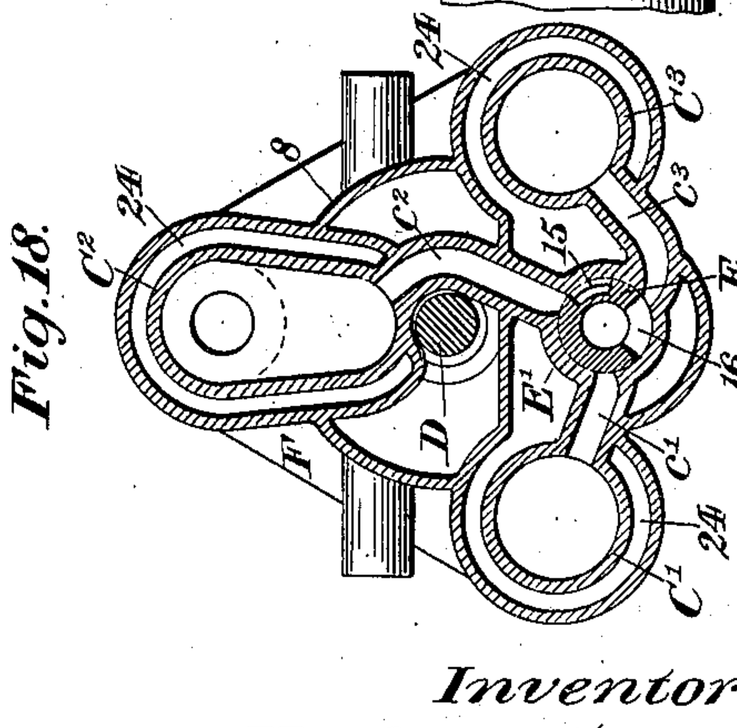


Fig. 18.



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5 Sheets—Sheet 5.

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GAS ENGINE.

No. 580,444. Patented Apr. 13, 1897.

Fig. 22.

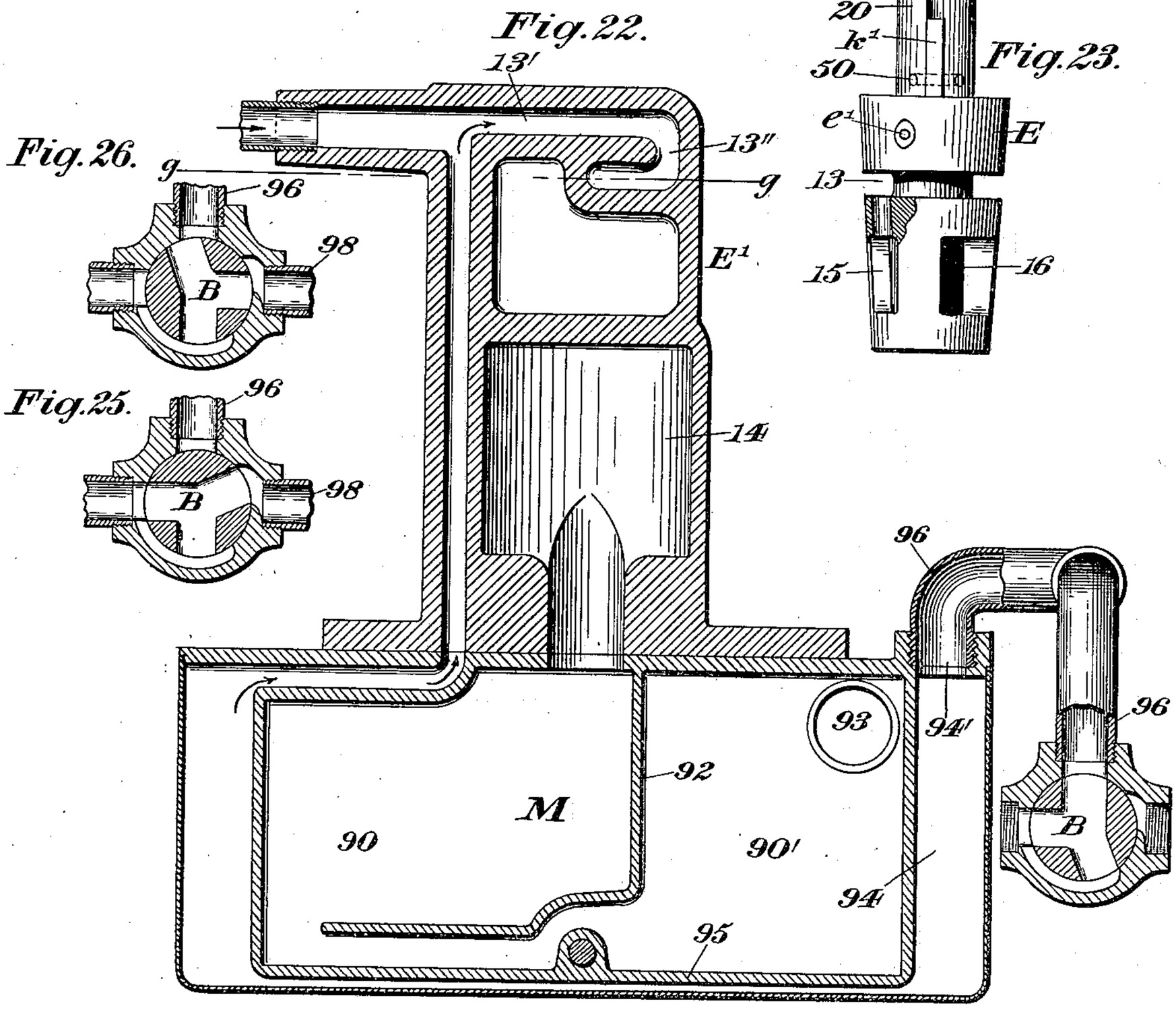
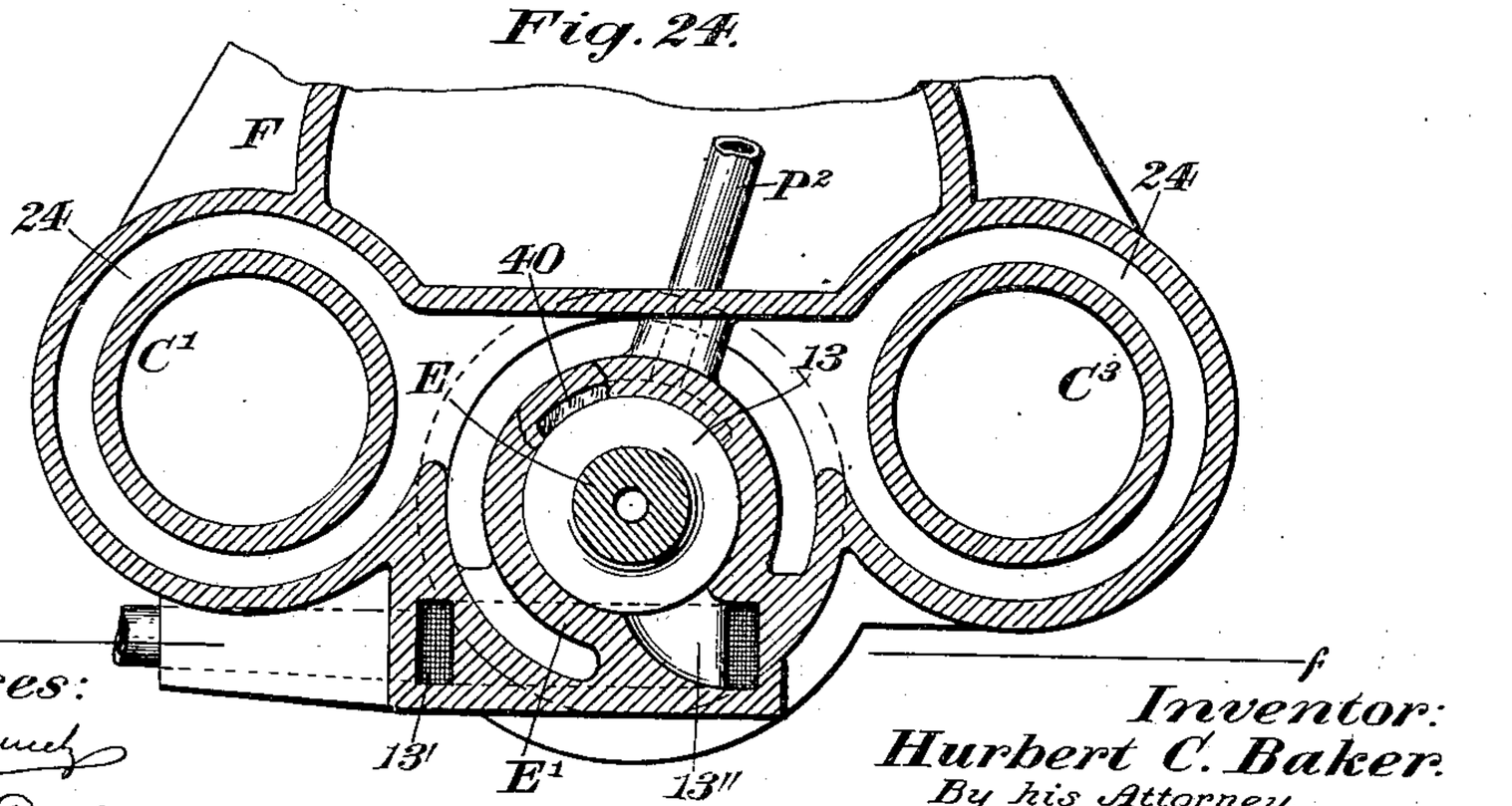


Fig. 23.

Fig. 26.

Fig. 25.

Fig. 24.



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UNITED STATES PATENT OFFICE.

HURBERT C. BAKER, OF HARTFORD, CONNECTICUT.

GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 580,444, dated April 13, 1897.

Application filed July 9, 1896. Serial No. 598,579. (No model.)

To all whom it may concern:

Be it known that I, HURBERT C. BAKER, a citizen of the United States, residing in Hartford, in the county of Hartford and State of Connecticut, have invented certain new and useful Improvements in Gas-Engines, of which the following is a specification.

This invention appertains to gas-engines of that class described in Letters Patent of the United States No. 563,249, granted to me July 7, 1896, or more particularly to engines of that class in which the power for driving the piston is derived from the explosion, within an explosion-chamber in the piston-cylinder, of a suitable explosive, such as a mixture of air and naphtha or air and any suitable liquid hydrocarbon; and the invention relates more specifically to the valve mechanism and accessory devices for producing the explosive mixture and for supplying said mixture to the explosion-chamber of the piston-cylinder in regulated quantities proportionate to the work it is desired the engine shall perform.

The gas-engine constituting the subject-matter of my present invention is somewhat in the nature of an improvement upon the gas-engine described in the patent referred to, although certain details thereof are applicable to gas-engines generally.

One object of my present invention, in addition to that of producing an improved compact and efficient gas-engine as a whole and one which may be run at a high rate of speed and develop the maximum amount of power to a given quantity of gas consumed, is to provide, in connection with explosion-chambers of a gas-engine cylinder, improved liquid-feeding and gas-distributing mechanism embodying certain instrumentalities of a novel character and whereby the so-called "explosive charges" may be supplied to the piston-cylinder at definite intervals and whereby the individual or successive quantities of volatile liquid hydrocarbon going to make up the successive explosive charges may be arbitrarily increased or decreased during the operation of the engine, to thereby regulate the explosive efficiencies of such charges.

A further object of the invention is to provide, in connection with a series of cylinders and a governor of a gas-engine, a rotary liquid-feed device having a series of reciprocative feeders or feed-pistons corresponding in number to the number of engine-cylinders, and to provide instrumentalities controlled by the speed of the governor for independently or successively nullifying the feeding operation of such feeders when the engine reaches or passes a predetermined speed limit, also to provide means controlled by the rotation of the feed device for periodically imparting inward and outward strokes to the feed-pistons, to thereby draw in and expel a predetermined quantity of liquid hydrocarbon at different points, respectively, in the rotative movement of the feed-valve, and also to provide means for arbitrarily increasing or decreasing the effective strokes of the feeders or feed-pistons, to thereby increase or decrease the quantity of liquid fed at each working stroke of said feeder or piston, as may be required when using different kinds or grades of liquid hydrocarbon for operating the engine.

In the drawings accompanying and forming part of this specification, Figure 1 is a vertical longitudinal section, partly in elevation, of a gas-engine embodying my present improvements, said section being taken in dotted line *a a*, Fig. 2, looking toward the right hand in said figure. Fig. 2 is a front end view of the engine as seen from the right hand in Fig. 1, some parts thereof being removed and other parts thereof being partly broken away. Fig. 3 is a cross-sectional view of the engine, taken in dotted line *b b*, Fig. 1, and looking toward the right hand in said figure. Fig. 4 is a sectional side elevation of a portion of the engine as seen from the right hand in Fig. 2, said figure showing the liquid-feed and gas-distributing devices partially in section and also showing in elevation certain of the instrumentalities which control the movements of the liquid-feeders. Fig. 5 is a sectional end elevation showing certain of the elements illustrated in Fig. 4 as seen from the right hand in said figure, the diametrical outline of the engine and a part of the engine-frame being shown in dotted lines. Figs. 6 and 7 are side and end views, respectively, of the shiftable cut-off device operable for nullifying the operations, singly and successively, of the liquid-feeders. Figs. 8, 9, and 10 are sectional side views of certain of the instru-

mentalities which control the movements of the liquid-feeders, said figures showing, respectively, three successively-advanced positions of the cut-off device or sleeve with relation to the three feeder-actuating levers, Fig. 8 showing the cut-off device in position for nullifying the operation of one actuating-lever and the feeder it operates, Fig. 9 showing the cut-off device in position for nullifying the operation of the two levers and their respective feeders, and Fig. 10 showing said cut-off device in position for nullifying the operation of the entire set of levers and their respective feeders. Figs. 11, 12, and 13 are cross-sectional views of the liquid-feed device, said Figs. 11, 12, and 13 being companion figures to Figs. 8, 9, and 10, respectively, and showing, respectively, one, two, and three liquid-feeders locked against operative movement, as will be the case when the cut-off device and feeder-actuating levers are in the positions shown in Figs. 8, 9, and 10, respectively. Fig. 14 is a cross-sectional view, on a relatively small scale, of a portion of the engine, taken on a line corresponding with the dotted line *d d*, Fig. 1, and showing the position of the gas-distributing valve or engine-valve when the upper piston of the series is near the end of its exhausting stroke and in the position it occupies preparatory to the admission of a charge to the combustion-chamber of this cylinder, this figure being intended to show the position of the distributing-valve immediately preceding the admission of an explosive charge to one of the cylinders, in which position communication between the inlet and exhaust ports of the valve and the port-passages of the cylinders is cut off. Fig. 14 is the first of a series of groups of figures illustrating successive positions of the distributing-valve or engine-valve and the corresponding relative positions of one piston during one complete rotation of the crank-shaft of the engine, said groups of figures collectively showing one complete reciprocation of the piston, whereby a charge is drawn into the explosion-chamber and compressed ready to be subsequently fired. Fig. 15 is a sectional side view of a portion of the engine, said section being taken on a line corresponding to the dotted line *e e*, Fig. 14, and showing a piston in the dead-stroke position when the engine-valve is in the position shown in Fig. 14. Fig. 16 is a cross-sectional view, similar to Fig. 14, showing the distributing or engine valve advanced sufficiently to bring its induction-port in communication with the duct of the upper cylinder and the exhaust-port thereof in communication with the duct of the right-hand cylinder. In this position of the valve the upper cylinder is drawing in the explosive charge and the products of combustion are being exhausted from the lower right-hand cylinder. Fig. 17 is a sectional side view, similar to Fig. 15, showing the relative positions of the piston when the valve is in the position shown in Fig. 16. Fig. 18 is a cross-sectional view, similar to Figs. 14 and 16, the engine-valve being advanced sufficiently to cut off communication between the induction-port of the valve and the ducts of the engine-cylinder, said valve being shown in the position it occupies upon inauguration of the pressing stroke of the piston. Fig. 19 is a sectional side view, similar to Figs. 15 and 17, showing the upper piston at the forward end of its dead-stroke or in the position it occupies when the valve is in the position shown in Fig. 18. In this position of the piston the explosive charge has been drawn into the cylinder ready to be compressed. Fig. 20 is a cross-sectional view, similar to Figs. 14, 16, and 18, showing the valve advanced sufficiently to bring the induction-port in communication with the lower right-hand cylinder and its exhaust-port in communication with the lower left-hand cylinder, communication between the valve and upper cylinder being cut off, this being the position of the valve during the operation of the explosive charge and during the explosion of said charge. Fig. 21 is a sectional side view, similar to Figs. 15, 17, and 19, showing the piston in the position it occupies when the valve is in the position shown in Fig. 20 and just preparatory to the explosion of the compressed charge contained in this cylinder. Fig. 22 is a cross-sectional view, on a relatively large scale, of a portion of the main body of the engine, taken in a line corresponding with the dotted line *f f*, Figs. 1, 3, and 24, said figure showing the means whereby air is admitted to the valve-chest. Fig. 23 is a plan view, partly in section, of the liquid-feeding and gas-distributing valve or devices. Fig. 24 is a cross-sectional view of a portion of the engine, taken on a line corresponding to the dotted line *g g*, Fig. 22. Figs. 25 and 26 are cross-sectional views of the three-way valve which controls the admission of air to the valve-chest. Figs. 27, 28, and 29 are similar graphical diagrams illustrating, in the order of their enumeration, three successive explosions of the explosive charges in the three cylinders and illustrating the relative alternating order of the explosions in said three cylinders, this group of figures illustrating one cycle of explosions alternately in the successive cylinders during one and one-third of a rotation of the crank-shaft of the engine.

Similar characters designate like parts in all the figures of the drawings.

For convenience the improvements or instrumentalities constituting the subject-matter of my present invention are shown and described in connection with a gas-engine which in many respects is similar to the gas-engine described in the patent hereinbefore referred to; and it is desired to state in this connection that any suitable liquid hydrocarbon mixed with air for generating a highly-combustible gas or explosive mixture may be employed to operate the engine; and to enable the use of different kinds and qualities

of liquid hydrocarbon without changing the effective operation of the engine I have provided instrumentalities for arbitrarily changing with precision the quantity of liquid hydrocarbon in the explosive charges, according to the grade, quality, or kind of liquid hydrocarbon it is desired used, as will be hereinafter fully described.

In the preferred embodiment thereof shown and described the gas-engine has three cylinders, which are designated by C′, C², and C³, respectively, and are equidistantly disposed about and in parallelism with the main or crank shaft D. It will be understood, however, that any number of cylinders arranged in any suitable manner may be employed within the scopes and limits of this invention, although in most cases it is preferable to employ three cylinders, as shown in the drawings. Therefore it is not desired to limit this invention to any particular number of cylinders or to the particular disposition thereof.

In the present instance the cylinders C′, C², and C³ of the engine are shown integral with the base of framework, (designated in a general way by F.) This framework, which may be of any suitable construction for carrying the stationary and working parts of the engine, which preferably may be a one-piece casting, comprises a suitable bed-plate 3, the front and rear end walls 4 and 5, respectively, and the main body portion 8, in which the cylinders C′, C², and C³ are formed and in which the parts of the cylinders are located, as will be understood by reference to Figs. 1, 2, and 3 of the drawings.

It will be understood that while it is desirable to cast the cylinders and framework together in one piece this construction may be modified without departure from my present invention.

Located in convenient relation to the three cylinders C′, C², and C³ is a valve-chest E′, which is herein shown similar in a general way to the valve-chest designated by the same character in the patent hereinbefore referred to, said valve-chest having a conical valve-seat the axis of which is shown located in the vertical plane of and parallel to the main shaft D. Leading from the valve-chest E′ are three port-passages c', c^2, and c^3, which communicate with the cylinders C′, C², and C³, respectively.

In the preferred form thereof herein shown and described each cylinder has on its interior, near the rear end thereof, a perforated flange f, which practically divides the cylinder into two communicating chambers—that is, a piston-chamber and an explosion-chamber—and also affords a convenient means for disseminating and thoroughly mixing the constituents of the explosive charge before and during the compression of the charge and preparatory to the ignition and explosion of said charge, which is a matter of considerable importance in engines of this class, as it precludes the possibility of an explosion of a charge before its constituents are thoroughly commingled.

To prevent overheating of the cylinders and valve-chest, a water-space 24 is formed around said cylinders and valve-chest after the usual manner of engine construction, and a constant circulation of water or other suitable fluid may be maintained in said space in any usual or suitable manner.

The main shaft D of the engine, which will for convenience be herein termed the "crank-shaft," is shown journaled at its front and rear ends in suitable bearings 9 and 9′ on the front and rear walls 4 and 5 of the engine-frame, as shown most clearly in Fig. 1 of the drawings. This shaft is shown located in horizontal parallelism with the axis of and midway between the three cylinders C′, C², and C³, respectively, and is provided at its forward end with a crank 12, which is connected by a universal actuator with the pistons of the cylinders C′, C², and C³, as will be hereinafter described.

The general construction and operation of the piston mechanism—to wit, the pistons, crank-shaft, crank-shaft actuator, and connections—may be similar to that of like parts described in the patent hereinbefore referred to.

The pistons (designated by G′, G², and G³, respectively) of the cylinders C′, C², and C³, respectively, are each shown tubular and open at the forward end thereof. The piston-rods (designated by g', g^2, and g^3, respectively) are each shown provided with balls 26 and 26′, one at each end thereof, the ball 26 of which is seated for universal movement in a ball-socket 25, located upon the interior of the piston near the middle portion thereof, and the ball 26′ of which is seated for universal movement in a ball-socket 27, formed in the outer end of a radially-disposed arm 28 of the crank-actuator, which actuator is supported and connected to the crank 12 of the crank-shaft D to have a universal oscillatory movement.

As a convenient means for supporting the oscillatory crank-shaft actuator in operative relation with the three pistons G′, G², and G³ and to permit a free universal movement thereof this actuator is shown comprising two members, (designated in a general way by H and K, respectively,) one of which members, as K, is pivotally supported, as at 32 and 32′, in suitable bearings on the frame of the engine with its axis in a horizontal plane at right angles to and in alinement with the axis of the main shaft D, and the other of which members, as H, is pivotally supported on the member K with its axis of movement at right angles, or substantially so, to the axis of movement of said member K, the construction and organization of this actuator being shown substantially the same as the construction and organization of the actuator described in the patent hereinbefore referred

to, the member H being pivotally connected at its inner end to the crank 12 of the main shaft D of the engine, which crank is counterweighted for obvious reasons.

As a convenient and novel means for periodically feeding successive definite quantities of liquid hydrocarbon to a mixing conduit or chamber and mixing the same with air to produce explosive charges of requisite efficiencies and for distributing said explosive charges to the several cylinders in proper order, and as a means for arbitrarily regulating the feed independent of the operation of the engine-governor and irrespective of the speed of the engine, I have provided in operative relation with the port-passages of the several cylinders a so-called "liquid-feeding" and "gas-distributing" apparatus, which, in addition to the actuating and controlling mechanism therefor, comprises, practically, two independent devices—to wit, a rotative feed device embodying, preferably, a series of independently-operable reciprocatory feeders which are adjustable for regulating the quantity of the liquid fed, and a gas-distributing device in operative connection with the feed device and adapted for controlling the introduction of the explosive charges to the several cylinders.

In the preferred form thereof shown in the drawings the liquid-feed device and gas-distributing device are in the nature of a unitary apparatus and may be hereinafter referred to collectively as the "feeding and distributing apparatus" or "feeding and distributing valve" and independently as the "liquid-feed device" and "gas-distributing device," respectively. It will be obvious, however, that the construction and general organization of the feed device and distributing device might be variously modified without departure from this invention.

The feeding and distributing apparatus in the preferred form thereof shown in the drawings comprises a rotative axially-recessed valve member (designated in a general way by E) which is shown in the nature of a plug-valve situated in a valve-chest E′, having an axially-bored stem 20, which is journaled in suitable bearings on the framework of the engine, said valve also having an inlet-port 15 and an exhaust-port 16 in position for periodically communicating in alternating order with the port-passages c', c^2, and c^3 of the piston-cylinders C′, C², and C³ during the rotation of said valve member, one or more (herein shown as three) liquid-feeders or feed-pistons (designated in a general way by e', e^2, and e^3, respectively) carried by said valve member, a liquid-duct P², having its discharge end in communication with a reservoir or liquid-chamber 40, which is shown as a depression formed in the inner face of the valve-chest in juxtaposition to the path of movement to the liquid-feeders and which constitutes a reservoir for supplying liquid to the pockets in which the feed-pistons work during the operation of the engine and for holding a surplus of liquid over and above that required for one charge, means for actuating the valve member, means for controlling the movements of the liquid-feeders, and means for supplying air to the valve-chest, all of which will be hereinafter more fully described.

In the preferred form thereof herein shown the liquid-feeders e', e^2, and e^3 are in the nature of piston-valves seated for reciprocatory movement in radially-disposed pockets f', f^2, and f^3, formed in the valve member E, said pockets extending from the periphery of the valve member to and communicating with the axial opening in said member, as will be understood by reference to Figs. 1 and 5 of the drawings, said pockets being located near the outer end of the valve member in position to communicate with an oil-reservoir and a mixing-passage alternately. This oil-reservoir is shown as a depression 40, formed in the upper face of the inner face of the valve-chest E′ between said valve-chest and the valve member E and in juxtaposition to the path of movement of the oil-feeders e', e^2, and e^3.

As a means for actuating the valve member E direct from the crank-shaft D, to thereby establish communication between the inlet and exhaust ports 15 and 16, respectively, with the port-passages of the piston-cylinders at the requisite time and in the order required, the crank-shaft D is furnished with a driving-pinion 17, which meshes with a driven pinion 18, fixed to the valve-stem 20, the relative size and arrangement of the two pinions being such that the valve will make one complete rotation during two complete rotations of the crank-shaft D and in an opposite direction.

As a means for holding the valve member E to its seat I have provided a resilient abutment at the outer end of the valve-stem, which in the form shown is in the nature of a spring 22, carried upon a sleeve 23, secured to the framework in axial alinement with the valve-stem, which spring is shown located between suitable washers 23′ and 23″, one of which bears against the end of the valve-stem and the other of which bears against a flange on said sleeve. Other means, however, may be provided for effecting this end without departure from my present invention.

In the preferred form thereof herein shown the valve member E, which, as before stated, is in the nature of a rotary plug-valve, is shown peripherally grooved, as at 13, to form a circular gas-conduit or passage-way for conducting the explosive mixture from the mixing-chamber of the valve-chest to the inlet-port of said valve. The inlet-port 15 of the valve-chest, which is formed longitudinally in the periphery of the valve member E, is open at one end to the circular gas-conduit 13, as shown most clearly in Fig. 23, and the exhaust-port 16, which is open at one end of

the periphery of the valve member E, has its outlet end preferably coincident with the axis of the valve member and is open at this end to an exhaust-chamber 14, located in the valve-chest in advance of the inner end of the valve member, as shown most clearly in Figs. 1 and 22.

As a convenient means for obviating the obnoxious noises incident to the exhaust in most engines of this class I have provided in connection with the exhaust-chamber 14 of the engine a so-called "muffler-box," (designated in a general way by M,) having a series of communicating compartments (herein shown as two compartments) 90 and 90′, separated from each other by an exhaust deflector or partition 92. One of said compartments, as 90, is shown communicating with the exhaust-chamber 14 of the valve-chest, and the other of said compartments, as 90′, is shown having an exhaust-conduit 93, leading to the outer atmosphere, as shown most clearly in Figs. 1 and 22 of the drawings. This deflecting-partition will in practice be of such construction as to cause the exhaust to traverse the entire length of the receiving-compartment 90 before being admitted to the exhaust-compartment 90′. The construction and organization of the parts of the muffler-box may be variously modified without departure from this invention.

In engines of this class it is frequently highly advantageous in producing the gaseous explosive mixture to heat the air to a comparatively high degree before mixing the liquid hydrocarbon therewith, and as a convenient means for supplying hot air to the mixing-chamber of the valve-chest the muffler-box is furnished with a hot-air compartment 94, which surrounds the inlet and exhaust compartments 90 and 90′ by a partition 95, which constitutes the outside walls of the muffler-box proper, separating the compartments 90 and 90′ from the compartment 94. This hot-air compartment 94 is shown having an inlet 94′ near the exhaust end of the muffler-box at one side of the partition 95, and has an outlet end near the opposite end of the muffler-box, as shown most clearly in Fig. 22, said outlet communicating with the mixing-chamber or main air-passage 13′, which is located near the lower part of the valve-chest and intersects the path of movement of the liquid-feeders e', e^2, and e^3, said air-passage extending horizontally to the opposite side of the valve member and having a branch 13″, which communicates with the circular passage-way 13 in the valve member E, as will be readily understood by comparison of Figs. 1, 4, 22, and 24 of the drawings.

As a means for supplying air to the hot-air compartment 94 a pipe or conduit 96 leads from the inlet-opening 94′ of said compartment to the interior of the engine-case, as shown at 94″, air being supplied to the interior of the engine-case through a screen 97 at one end of said case, as shown most clearly in Fig. 1.

As a convenient means for supplying moderately cool air to the mixing-chamber of the valve-chest E′ direct from the interior of the engine-case I have provided, in connection with the main air-passage 13′ of the valve-chest and the conduit 96, which leads from the interior of the engine-case to the hot-air compartment of the muffler-box, an air-supply pipe 98, and as a convenient means for cutting out one or the other supply-conduit 96 or 98, so that air may be supplied direct from the interior of the engine-case to the mixing-chamber of the valve-chest, or may be supplied to said mixing-chamber from the interior of the engine-case through the hot-air compartment 94, or may be partially supplied to the mixing-chamber 13′, both from the engine-case direct and through the hot-air compartment 94, I have provided at the juncture of the two conduits 96 and 98 a three-way valve, (designated in a general way by B,) which is shown rotatably supported in a suitable valve-case and has ports adapted for communicating with the conduits 96 and 98 and with the interior of the engine-case, as will be readily understood by a comparison of Figs. 3, 22, 25, and 26 of the drawings, the ports of the valve being so disposed that the conduit 98, which leads to the mixing-chamber 13′ direct from the valve, may be cut off, as shown in Fig. 22, thus insuring the delivery of hot air from the hot-air compartment 94 to the mixing-chamber 13′, or the hot-air compartment 94 may be cut off, as shown in Fig. 25, thus supplying moderately cool air from the engine-case direct to the mixing-chamber 13′, or both conduits 96 and 98 may be partially cut off, as shown in Fig. 26, thus supplying a mixture of moderately cool and hot air to said mixing-chamber.

The provision of some suitable means—as, for instance, means such as described—for regulating the temperature of the air before mixing the same with the liquid hydrocarbon to produce the explosive charge is of material importance in engines of the class specified, as air may be artificially heated by the heated products of combustion, or the residuum of the explosive charges of the engine may be conducted to the mixing-chamber of the valve-chest when the engine is running in an intensely cold atmosphere, thereby obviating the injurious cooling of the air-supply, which would otherwise accrue from the low temperature of the engine-case or other extraneous causes.

As a means for automatically reciprocating the liquid-feeders or feed-pistons e', e^2, and e^3 to cause them to first draw in and then expel liquid hydrocarbon at different predetermined points, respectively, in the rotative movement of the feeder-carrier or valve member E, I have provided, in connection with said feed-pistons, oscillatory actuators, (des-

ignated by k', k^2, and k^3,) each of which is shown in the nature of a lever pivoted at 50 substantially midway of the ends between the adjacent walls of a groove 50′, formed longitudinally in the periphery of the valve-stem 20, with which said lever rotates about the axis of the valve member E. These actuating-levers have their inner ends shiftably seated in transverse slots or grooves 50″ in the feed-pistons and are oscillated to effect a reciprocatory movement of the feed-pistons, preferably through the medium of the cam-face 52 of a shiftable sleeve or cut-off device O, which surrounds the outer ends of said actuating-levers, these outer ends of the actuating-levers being normally held in contact with the cam-face 52 of the cut-off device or sleeve, preferably by means of springs 53, bearing against the under faces of the outer ends of said actuating-levers, as shown most clearly in Figs. 1 and 4 of the drawings. This cut-off device is held as against rotative movement with relation to the valve member E and the cam-face 52 thereof, which effects the working stroke of the feed-pistons and is so constructed and so disposed with relation to the reservoir 40 and the mixing-chamber 13′ of the valve-chest that an inward movement of each feed-piston will be effected at that point in the rotative movement of the valve member when said piston is in juxtaposition to the reservoir 40 and an outward movement of said feed-piston will be effected when the piston arrives in juxtaposition to the mixing-chamber 13′.

By constructing the feed-pistons to have a reciprocatory movement, as described, and providing means for reciprocating said pistons automatically it will be seen that each inward stroke of a piston will forcibly draw in a charge of liquid when said feed-piston arrives opposite the liquid-reservoir 40 and will forcibly expel this charge when said piston arrives opposite the mixing-chamber of the valve-chest, which is an improvement of material advantage over liquid-feeding devices of ordinary construction wherein the liquid is fed to the mixing-chamber by its own gravity through a regulated opening, as it insures the feeding of the charges in predetermined and absolutely precise quantities.

In engines of the class specified as heretofore made considerable difficulty has been experienced from the non-provision of means operable for arbitrarily regulating the quantity of the liquid charges and for arbitrarily also automatically reducing or increasing the number of liquid charges admitted to the engine cylinder or cylinders in a given length of time; and it is one of the chief objects of my present invention to provide means in connection with the liquid-feeders whereby the working strokes of the liquid-feeders may be arbitrarily increased or decreased, so as to increase or decrease the quantities of liquid fed at each reciprocation of a feeder, and also to provide independent devices or instrumentalities, one of which is automatically controlled by the governor of the engine and the other of which is independently and arbitrarily operable, for nullifying the effective operation of the liquid-feeders independently and successively, as will be hereinafter more fully described.

For the purpose of arbitrarily regulating the working strokes of the feed-pistons e', e^2, and e^3, which, as before stated, are radially disposed with respect to the axis of the valve member E, I have provided a feed-stroke limiter which in the form thereof herein shown is in the nature of a rod 55, shiftably supported in the axial bore or recess of the valve-stem 20 and has a conical working end, the axis of which intersects at right angles the radial axes of movement of the feed-pistons, the working end of said feed-stroke limiter acting as a wedge-abutment for the ends of the feed-pistons and will, when in position between adjacent ends of the feed-pistons, limit the inward strokes of said feed-pistons. This feed-stroke limiter is shown connected at its outer end to the free end of the depending crank-arm 56, carried on a rock-shaft 57, which is journaled in suitable bearings in the engine-frame; and as a means for actuating this rock-shaft to shift the feed-stroke limiter with relation to the feed-pistons said rock-shaft is shown furnished near its outer end with an upwardly-extended crank-arm 58, which is connected, by means of a connecting-rod 58′, to the crank-arm 59, fixed to the hub of a bevel gear-wheel 60, carried on a shaft 61, journaled in the engine-frame in advance of and above the rock-shaft 57, which gear 60 meshes with a gear 60′, journaled in an arm 62 of a bracket Y on the frame of the engine, and which gear 60′ is splined to the longitudinal shiftable shaft 63, which is provided at its upper end with a hand-wheel 63′, by means of which said shaft may be turned to rotate the gears, and, through the medium of the connections described, shift the feed-stroke limiter longitudinally inward or outward, as desired, with relation to the feeders. This operating-shaft 63 may, as shown, be provided near its upper end with a pointer 64, cooperating with an indicator-dial 65 for indicating the position of the feed-stroke limiter and the quantity of liquid fed at each working stroke of a feed-piston.

It is desired to state in the above connection that the means for operating the feed-stroke limiter may be materially modified without departure from this invention.

For the purpose of automatically or arbitrarily nullifying the effective operations of the feed-pistons the cut-off device O, which coöperates with the feed-piston-actuating levers, and which, as before stated, is in the nature of a sleeve shiftably supported for movement longitudinally upon the valve-stem 20 and longitudinally of the feed-piston actuators, has an internal offset or reducing portion 52′, adapted for overriding the outer free

ends of said actuators and to shift said ends inward sufficiently to lock the feed-pistons in their extreme outward or ineffective positions.

It will be seen by reference to Figs. 8 to 13, inclusive, that when the cut-off device or sleeve O is in the position shown in Fig. 8 the internal offset portion engages one of the feed-piston-actuating levers, as k', which locks said lever against movement and holds the feed-piston e', actuated by said lever, in the extreme outward ineffective position shown in Fig. 11. When said cut-off device is advanced to the position shown in Fig. 9, the levers k' and k^2 will be locked against movement and the effective operations of the feed-pistons e' and e^2 will be nullified, and when the cut-off device is further advanced to the position shown in Fig. 10 the entire set of feed-levers k', k^2, and k^3 will be locked against movement, and the effective operations of all of the feed-pistons will be nullified.

As a means for shifting the cut-off device or sleeve O to successively nullify the operations of the different liquid-feeders I have provided, in connection with the crank-shaft D, a shifting member which is shown in the nature of a sleeve 70, having a depending-arm 70′, which preferably has a yielding connection with the cut-off sleeve O, said arm being shown shiftably engaging a pin 71, fixed to ears 72 and 72′, a spiral spring being interposed between one of said ears and the arm 70′ and being adapted for cushioning the thrust of said arm in case the sleeve meets with an obstruction during its engagement. This shifting member is shown normally held in interlocking engagement with another shiftable member 73, supported upon the crank-shaft D, and which member is operatively connected with and is adapted to be operated by the governor, (designated in a general way by R.) This governor R may be of any suitable construction and be connected to the shiftable member 73 in any suitable manner for moving said member longitudinally of the crank-shaft during variations in the speed of the governor to thereby actuate the shifting member 70 and nullify, through the medium of the cut-off device, the operation of one or more liquid-feeders, as will be understood by comparison of Figs. 1 and 4 and Figs. 6 to 13, inclusive, of the drawings. It will therefore be seen that the cut-off device may be automatically actuated by the governor of the engine to stop the effective operation of one or more liquid-feeders, and that the construction and organization of the governor and the connections between the cut-off device and governor will be such that when the engine reaches a predetermined speed limit said governor will immediately act to nullify the operation of one, two, or all of the liquid-feeders, according to the excess of speed over and above the normal speed limit of the engine.

As a means for arbitrarily stopping the effective feed operation of and for locking one or more liquid-feeders in an ineffective position I have provided, in connection with the shifting member 70, hand-operable instrumentalities which in the preferred form thereof herein shown consists of a sleeve 75, fixed to the operating-shaft 63, which constitutes the primary actuator for the feed-stroke limiter 55, which sleeve is shown splined in a bearing on the arm 62′ of the bracket Y and is provided at the lower end thereof with a lateral-projecting arm 75′, to which is pivoted a pitman 76, which in turn is pivoted at its lower end to an arm 77′ upon a rocking sleeve 77, journaled upon the shaft 61, which sleeve has a downwardly-projecting crank-arm 77″, to which is pivoted an operating-rod 78, the opposite end of which extends through an opening in a flange 70″ on the shifting member 70 and is furnished with a head 79, which normally abuts against the inner face of said flange when the operating-shaft 63 is elevated to shift the cut-off device to the position shown in Figs. 4 and 8 of the drawings.

By the construction and organization of the cut-off-device-actuating instrumentalities herein shown and described it will be seen that the governor of the engine may operate to shift the cut-off device to the position shown in Fig. 1 without interfering with the position of the hand-operated instrumentalities, which are operable for effecting the same end; that the hand-operated instrumentalities may have a movement entirely independent of the movement of the governor, so that the hand-operated instrumentalities may be set to stop the effective operation of one or more liquid-feeders, as when it is desirable to reduce the normal speed of the engine, and that the governor will be effective for stopping the operation of the remaining operative liquid-feeders when the engine has reached this preselected speed limit, which is a matter of considerable importance in engines of this class, as it permits a change to be made in the normal speed limit of the engine arbitrarily and at the same time renders the engine-governor operable for stopping the engine when the speed limit is reached or passed.

When it is desired to increase or decrease the working stroke of the feed-pistons to increase or decrease the quantity of liquid in each explosive charge, as is required when using different kinds of liquid hydrocarbons, it is simply necessary to impart a rotative movement in one or the other direction to the hand-wheel 63′ of the operating-shaft 63, and when it is desired to arbitrarily nullify the effective operation of one or more feeders it is simply necessary to lift the operating-shaft 63, which will carry the sleeve 75 upward with it and shift the cut-off device, as will be readily understood by reference to Figs. 4 and 5 of the drawings, the shaft 63 constituting a rotatable actuator for operating the feed-stroke limiter and the sleeve which is carried by said shaft, but which is held as against rotative movement, constituting a reciprocatory actu-

ator for operating the cut-off device. This reciprocatory actuator is setable at three different positions, and as a means for automatically engaging and locking the sleeve in one or the other of its positions I have provided a spring-actuated detent 85, which is secured to the interior of the bearing in which the sleeve is seated and constitutes a feather which extends into the keyway 95′ of the sleeve and locks said sleeve against rotative movement relatively to its bearing, this detent being in the nature of a spring having a V-shaped head at its free end, which normally engages in one or the other of the notches 96, formed in the keyway of said sleeve, as shown most clearly in Figs. 4 and 5 of the drawings.

As a convenient means for igniting the explosive charge in the explosion-chambers of the cylinders I have provided in connection with each cylinder a spark-producer controlled by the retractive movement of the piston of said cylinder. This spark-producer, which may be herein termed the "igniter," consists, in the preferred form thereof herein shown, of two spark-producing members *w* and *w′*, one of which, as *w*, extends through an insulating bearing secured in the exploding end of the piston in position for engaging the member *w* at the end of the retractive stroke of the piston. The member *w* is shown having a bifurcated inner end, the prongs of which will preferably be resilient and will be bent to form wipers for engaging the headed end of the member *w′*, as will be readily understood by reference to Fig. 1 of the drawings. These members constitute the contact-points or electrical terminals of a suitable source of electrical supply, such as a battery represented in Fig. 1, and designated by W. The member *w* has its terminal so constructed that the headed end of the member *w′* will engage between and have a rubbing contact with said terminals just before it reaches the end of its pressing stroke to thereby produce a spark, said headed end of the member *w′* being released by the spring terminals of the member *w* when the piston arrives at the end of its retractive stroke.

Inasmuch as the general operation of the several pistons of the engine and the valve member E is the same as that described in the patent hereinbefore referred to, and inasmuch as the drawings and descriptions thereof are sufficiently full and concise as to facilitate an understanding of the relative operations of the pistons by any one skilled in the art, it is deemed unnecessary in my present application to enter into a detail description of the general operation of the engine. During the operation of the engine the liquid hydrocarbon is admitted through the supply-pipe P^2 into the reservoir 40, where it passes to the liquid-feeders *e′*, e^2, and e^3 and is carried around by the valve member E and deposited, charge by charge, at regular intervals into the mixing-chamber 13′, where it is mixed with the air introduced through the hot-air or cool-air conduits, as hereinbefore described, whence it is conducted to the circular passage of the valve member E and is distributed by the induction-port 15 of said member to the successive cylinders alternately and at regular intervals during the rotation of the valve member E, where it is exploded at each compression movement of each piston through the medium of the spark-producing members *w* and *w′*, which effects an impulse of the piston of said cylinder, thereby rotating the crank-shaft D, one explosion taking place at every two-thirds of a rotation of the crank-shaft, which will be more fully understood by reference to the diagrammatic Figs. 27, 28, and 29 of the drawings, which figures represent, respectively, by dotted lines *s′*, s^2, and s^3 three successive positions of the crank 12 during three successive explosions, and which figures represent, respectively, by cross-section circles the alternating order in which the explosions take place.

By a comparison of Figs. 14 to 21, inclusive, and Figs. 27, 28, and 29 it will be seen that in one cycle of operations, and correspondingly in the successive cycles of operations, the gas is first drawn in and then compressed and then exploded in each cylinder, and that these operations take place alternately with respect to similar operations in other cylinders—that is to say, when the gas is being exploded in the cylinder C′ the products of combustion are being exhausted from cylinder C^2 and gas is being drawn into cylinder C^3; next, cylinder C′ is being exhausted, the gas in cylinder C^2 is being exploded, and the gas in cylinder C^3 is being compressed; next, the gas is being drawn into cylinder C′, is being compressed in cylinder C^2, and is being exploded in cylinder C^3, and, next, gas is being compressed in cylinder C′, is being fired in cylinder C^2, and the products of combustion are being exhausted from cylinder C^3. From this description of the alternating order of operation of the successive pistons in the cylinders it will be apparent that the work is uniformly distributed, and that the engine is well balanced and will run with uniformity and with little vibration.

The working parts of the engine will be lubricated in any suitable and usual manner.

Having described my invention, I claim—

1. A liquid-feed device comprising a rotative member having a series of reciprocatory liquid-feeders, combined with instrumentalities for rotating said member and for automatically reciprocating the liquid-feeders during the rotation of said member.

2. In an engine of the class specified, a liquid-feed device embodying a carrier and one or more reciprocatory liquid-feeders, combined with means for operating the carrier and embodying instrumentalities connected to automatically and intermittently reciprocate the feeder or feeders.

3. In an engine of the class specified, the

combination with a liquid-conduit and with a mixing-chamber, of a liquid-feed device comprising a rotatable carrier and a series of reciprocatory liquid-feeders carried by said carrier in position to communicate with the liquid-conduit of the mixing-chamber, alternately; means for rotating said carrier; and means organized and connected to automatically impart inward and outward strokes to said feeders at predetermined points in the rotative movements of said carrier and to thereby cause said feeders to draw in and expel the liquid at different points in the rotative movement of said carrier.

4. In an engine of the class specified, a liquid-feeding device comprising a carrier and a reciprocatory liquid-feeder, combined with means for actuating the carrier; means for automatically reciprocating said liquid-feeder; and an arbitrarily-operable feed-stroke limiter in operative relation with, and effective for limiting the feed-stroke of, the liquid-feeder.

5. The combination with an engine-cylinder having suitable port-passages in communication with a valve-chest, and with an air-supply and a liquid-supply; of liquid feeding and controlling mechanisms comprising a carrier; a series of reciprocatory liquid-feeders located on said carrier in operative relation with the liquid and air supplies; actuating mechanism for said carrier; and liquid-feeder-actuating devices in operative connection with, and effective for independently and automatically reciprocating, the liquid-feeders at predetermined points in the movement of the carrier.

6. The combination with an engine-cylinder having suitable port-passages in communication with a valve-chest and with an air-supply and a liquid-supply, of liquid feeding and controlling mechanisms comprising a carrier embodying a series of reciprocatory liquid-feeders located in operative relation with the liquid and air supplies; actuating mechanism for said carrier; liquid-feeder-actuating devices in operative connection with, and effective for independently and automatically reciprocating, the liquid-feeders at predetermined points in the movement of the carrier; and an arbitrarily-operable feed-stroke limiter in operative relation with, and effective for limiting the effective strokes of, the liquid-feeders.

7. The combination with an engine-cylinder and with a valve-chest having a port-passage in communication with said cylinder and with the piston, the main shaft, and the connections between the piston and main shaft; of a liquid-feeding and gas-distributing apparatus comprising a valve member having inlet and exhaust ports in position to communicate, alternately, with the port-passage; a liquid-supply conduit and an air-supply passage communicating at different points, respectively, with the interior of the valve-chest; means for actuating the valve member; a series of reciprocatory liquid-feeders carried by the valve member in position to communicate with the liquid-supply conduit and air-supply passage; and means controlled by the movements of the valve member for automatically effecting inward and outward strokes to the liquid-feeders as they come in juxtaposition with the liquid-conduit and air-supply passage, respectively, and thereby cause said feeders to draw in and expel liquid at different predetermined points in the movement of the carrier.

8. The combination with an engine-cylinder and a valve-chest having a port-passage in communication with said cylinder and with the piston, the main shaft, and the connections between the piston and main shaft; of a liquid-feeding and gas-distributing apparatus comprising a valve member having inlet and exhaust ports in position to communicate, alternately, with the port-passage; a liquid-supply conduit and an air-passage communicating at different points, respectively, with the interior of the valve-chest; means controlled by the rotation of the main shaft for actuating the valve member; a reciprocatory liquid-feeder carried by the valve member in position to communicate with the liquid-supply conduit and air-supply passage, alternately; means controlled by the movements of the valve member for automatically effecting inward and outward strokes of the liquid-feeder as it comes in juxtaposition with the liquid-conduit and air-supply passage, respectively; and hand-operated instrumentalities embodying a shiftable feed-stroke limiter in operative relation with, and effective for limiting the working stroke of, the liquid-feeder.

9. In an engine of the class specified, a liquid-feeding device comprising a carrier and a series of reciprocatory liquid-feeders, in combination with means for actuating the carrier; actuating mechanism in connection with, and effective for automatically reciprocating, the liquid-feeders; a shiftable feed-stroke limiter in operative relation with, and effective for limiting the working strokes of, the liquid-feeder; means organized and connected to arbitrarily actuate the feed-stroke limiter; and a cut-off device operable for successively nullifying the effective operations of the liquid-feeders.

10. In an engine, the combination with a main shaft, piston-cylinders, valve-chest communicating with said cylinders and with the pistons and connections between said pistons and main shaft; of a rotative valve member located in the valve-chest and geared to the main shaft and having inlet and exhaust ports adapted to communicate with the engine-cylinders; a series of radially-disposed reciprocatory liquid-feed pistons carried by said valve member; a series of oscillatory actuators, one in connection with each feed-piston; means effective on the rotation of the valve member for automatically oscillating the feed-piston actuators to impart inward and outward

strokes to the feed-pistons at predetermined points in the rotative movement of the valve member; and liquid and air supply conduits in operative relation with the feed-pistons.

11. The combination with an engine-valve chest, of a liquid-feeding mechanism comprising a feed-piston carrier; a feed-piston supported for reciprocatory movement in a feed-pocket in said carrier; an oscillatory feed-piston actuator supported on and movable with said carrier and having the inner end thereof in operative connection with the feed-piston; a cam bearing against the outer face of the outer end of said feed-piston actuator and effective on the movement of the carrier for shifting said piston in one direction; a spring bearing against the inner face of the outer end of said actuator and normally effective for shifting the piston in the opposite direction; and means for actuating the carrier to automatically effect an inward and outward stroke of said piston at predetermined points in the movement of said carrier.

12. The combination with an engine-valve chest, of a liquid-feeding mechanism comprising a rotative feed-piston carrier; a series of feed-pistons supported for reciprocatory movements in radial feed-pockets in said carrier; an oscillatory feed-piston actuator rotatable with said carrier and having the inner end thereof in operative connection with the feed-pistons; a cam bearing against the outer faces of the outer ends of said feed-piston actuators and effective for shifting the said pistons outward; springs bearing against the inner faces of the outer ends of said actuators and effective for shifting the pistons inward; means for rotating the carrier, whereby the pistons will have inward and outward movements imparted to them at different predetermined points in the rotative movement of the carrier; and independent instrumentalities organized and connected to arbitrarily limit or nullify the working strokes of the feed-pistons.

13. In an engine of the class specified, the combination with a piston-cylinder and with a valve-chest having a liquid-conduit and an air-supply passage, of a liquid-feeding device embodying reciprocating liquid-feed pistons operable for forcibly drawing liquid from the oil-conduit and for forcibly discharging the same into the air-passage-actuating mechanism for the feed device, embodying means controlled by the movement of said feed device for automatically imparting inward and outward strokes to the feed-pistons concurrently with the arrival of said pistons in juxtaposition to the liquid-conduit and air-passage, respectively.

14. In an engine of the class specified, the combination with a valve-chest, of an axially-recessed valve member supported for rotative movement in said chest and having a series of radially-disposed piston-receiving pockets which extend from the axial opening to the periphery of said valve member; a series of reciprocatory feed-pistons located in said pockets with their inner ends intersecting the axial recess of the valve member; piston-actuating levers pivotally connected to the valve member and having their inner ends in engagement with the feed-pistons; a sleeve having a cam-face located in the path of rotative movement of, and normally in bearing engagement with the free outer ends of, the piston-actuating levers; means for rotating the valve member, whereby a reciprocatory movement will be imparted to the feed-pistons; a shiftable feed-stroke limiter extending into the axial recess of the valve member and operable for limiting the working strokes of the pistons; and means for arbitrarily shifting said feed-stroke limiter toward and away from the ends of said pistons.

15. The combination with an engine-cylinder, a crank-shaft, and means for rotating said crank-shaft; of a combined liquid-feeding and gas-distributing apparatus comprising a rotative valve member in geared connection with the crank-shaft and having inlet and exhaust ports in position for intermittently communicating with the engine-cylinder; one or more radially-disposed reciprocatory liquid-feed pistons carried by said valve member; means controlled by the rotation of the valve member for actuating the feed-pistons; a liquid-supply in operation with the liquid-feeders; and an air-supply in operative relation with said feeders and with the induction-port of the valve member.

16. In an engine of the class specified, the combination with the cylinder or cylinders thereof; of an apparatus for generating an explosive mixture, which apparatus consists of a liquid-supply conduit and an air-supply conduit; a normally continuously-rotative valve member; one or more radially-disposed reciprocatory liquid-feeders carried by said valve member; means connected to normally rotate said valve member; and means controlled by the rotation of said valve member for automatically imparting inward and outward working strokes to the liquid-feeder at different predetermined points, respectively, in the rotative movement of said valve member.

17. In an engine of the class specified, a liquid-feed device comprising a valve member having a plurality of relatively independent feed-piston pockets and a plurality of independently-operable feed-pistons supported for reciprocatory movements in said pockets, in combination with means for actuating the valve member; oscillatory devices controlled by the movements of the valve member for actuating the pistons; hand-operated instrumentalities for arbitrarily stopping the feed operation of one or more of the pistons to reduce the normal speed limit of the engine; means controlled by the valve-member-actuating means for automatically nullifying the operations of others of the pistons when the engine reaches its speed limit; and means for

arbitrarily changing the effective strokes of the feed-pistons.

18. In an engine of the class specified, a valve member having a series of independently-operable reciprocatory liquid-feeders; in combination with a series of actuating-levers connected at their inner ends with said feeder and having their outer ends located one in advance of the other; a shiftable cut-off device having a lever-locking portion and adapted on the shifting movement of said device for successively engaging and locking the said levers in positions to prevent the effective operations of the successive feeders; and shifting mechanism in connection with said device.

19. In an engine of the class specified, the combination with the engine-cylinder, crank-shaft, and actuating mechanism for said crank-shaft; of a valve-chest; a valve member rotatably supported in said valve-chest and having one or more radially-disposed liquid-feeders; levers for actuating said feeders; a cut-off device shiftably supported on the stem of the valve member and operable for locking one or more of said levers against movement; an engine-governor; means controlled by the engine-governor for automatically shifting the cut-off device to nullify the operation of one or more of the liquid-feeders; and hand-operated instrumentalities organized and connected to shift the cut-off device independent of the movements by the engine-governor.

20. The combination with the exhaust-port of an engine-valve; of a muffler-box having a series of communicating compartments, one of which communicates with the exhaust-port of the engine-valve and another of which has an outlet or exhaust opening therein.

21. In an engine of the class specified, the combination with a valve-chest and with the exhaust-port of a valve member; of a muffler-box having a series of relatively separated communicating compartments, one of which is in communication with the exhaust-port of the valve member and another of which has an outlet-opening; a hot-air compartment surrounding said muffler-box and having an outlet in communication with the valve-chest and having an inlet-conduit; an independent air-conduit communicating with the valve-chest and valve; a three-way valve having ports adapted to communicate with the inlet-conduit of the hot-air compartment and with the hot-air conduit of the valve-chest and having another port adapted to communicate with the interior of the engine-case, the construction and organization of the valve being such that the operation thereof may be admitted direct from the interior of the engine-case to the valve-chest, or to the valve-chest through the hot-air compartment, or from the engine-case and hot-air compartment simultaneously.

22. In an engine of the class specified, the combination with the valve-chest and with the exhaust-port of the engine-valve; of a muffler-box in communication with the exhaust-port and having a hot-air compartment surrounding the same; and a valve-controlled apparatus for arbitrarily conducting air direct from the interior of the engine-case to the interior of the valve-chest, or from the interior of the engine-case to said valve-chest through the hot-air compartment, substantially as described.

23. In an engine of the class specified, the combination with the mixing-chamber; of a liquid-feeding and gas-distributing apparatus; of a hot-air compartment adapted to be heated by the exhaust of the engine; and means, substantially as described, for supplying heated air from the hot-air compartment, or from the engine-case, or from both, arbitrarily, to the mixing-chamber, or supply air direct from the interior of said engine-case to the mixing-chamber, or cool and hot air in predetermined proportions, substantially as described.

24. The combination with the liquid-feeders in an engine of the class specified and with the shiftable feed-stroke limiter and shiftable cut-off device in operative relation with said feeders, of a reciprocatory device and a rotative device having a common actuator and one of which is effective for operating the feed-stroke limiter and the other of which is connected with, and is operable for actuating, the cut-off device.

25. The combination with the shiftable feed-stroke limiter and with the shiftable cut-off device in operative relation with the liquid-feeders in an engine of the class specified, of independent actuating devices therefor comprising two concentric rockable members, one of which is supported by the other and one of which is in operative connection with, and is effective for shifting, the feed-stroke limiter and the other of which is in operative connection with, and is effective for shifting, the cut-off device; gears for rocking one of said members; an operating-shaft splined to one of said gears and provided at the outer end thereof with means for rotating and reciprocating said shaft; a sleeve carried on said shaft and having an arm in operative connection with, and adapted for rocking, the other of said members; a sleeve shiftable longitudinally with the operating-shaft; and a detent for holding the sleeve and shaft in their longitudinally-adjusted positions.

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Witnesses:
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