963,318.

A. G. PACE.

GAS AND OIL ENGINE.

APPLICATION FILED JAN. 16, 1905.

Patented July 5, 1910.

5 SHEETS—SHEET 1.

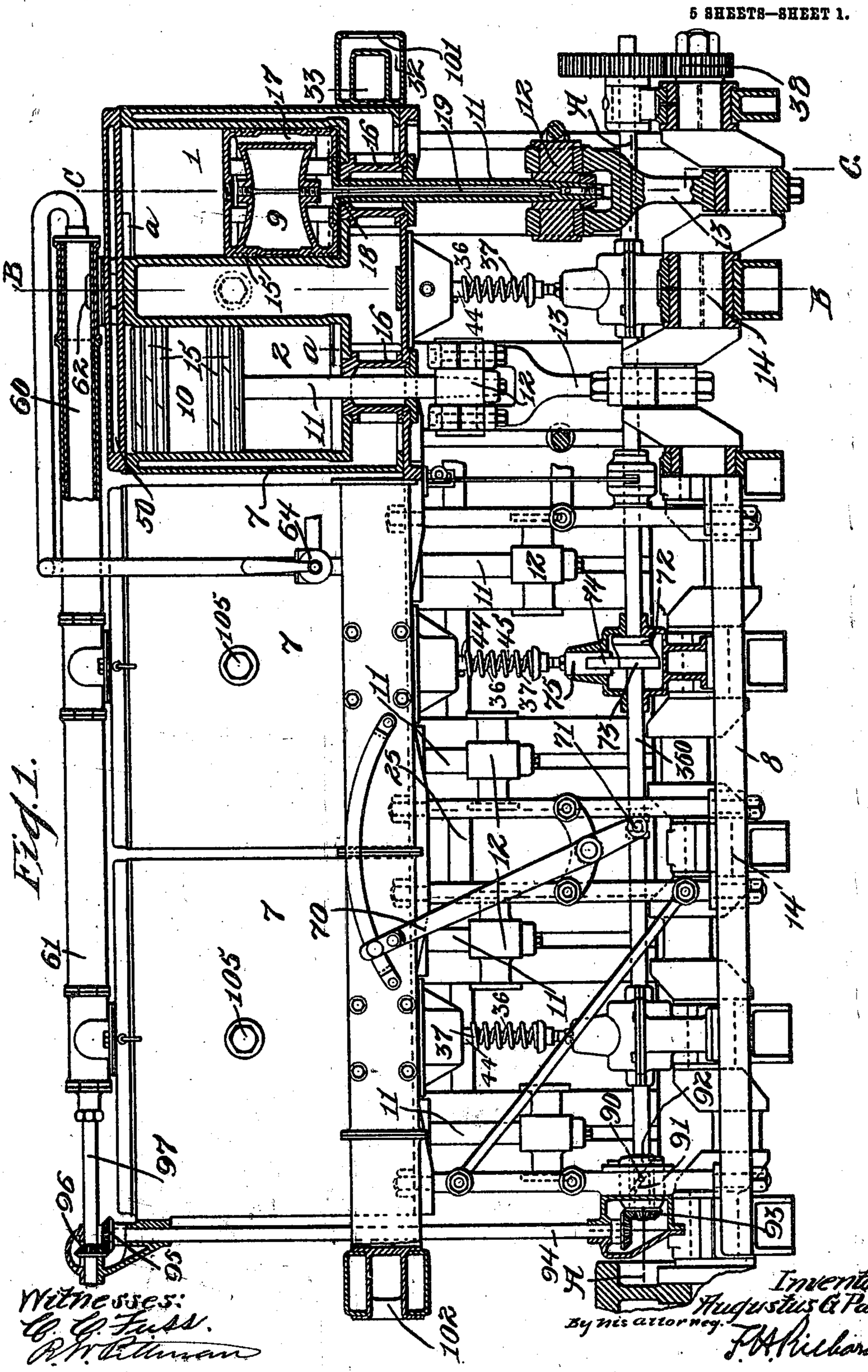

Fig. 1.

Witnesses:
C. C. Fuss.
B. F. Bellman

Inventor
Augustus G. Pace
By his attorney.
F. A. Richards.

A. G. PACE.

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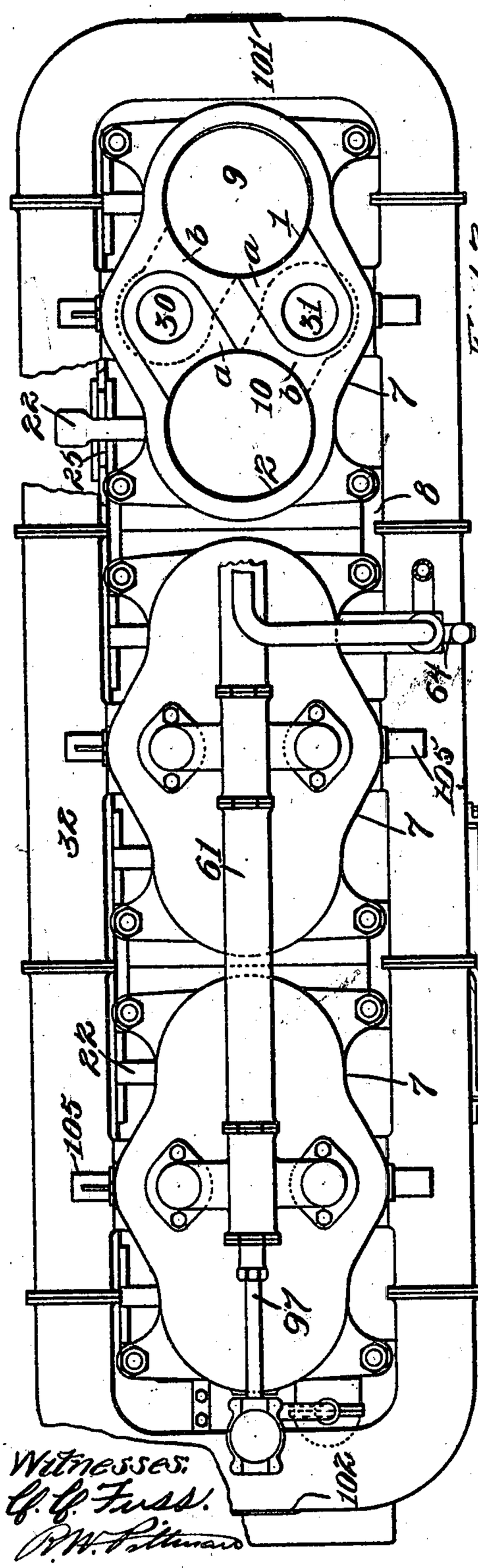

Fig. 2.

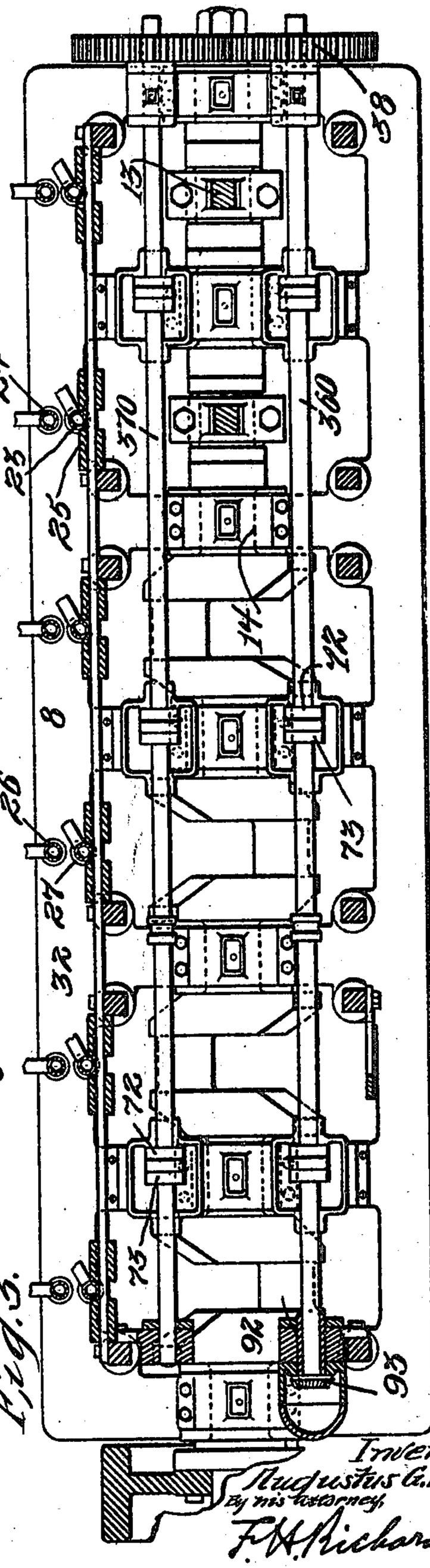

Fig. 3.

Witnesses:
C. C. Fuss.
B. W. Pittman

Inventor
Augustus G. Pace
By his attorney,
F. H. Richards.

A. G. PACE.

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5 SHEETS—SHEET 3.

Fig. 5.

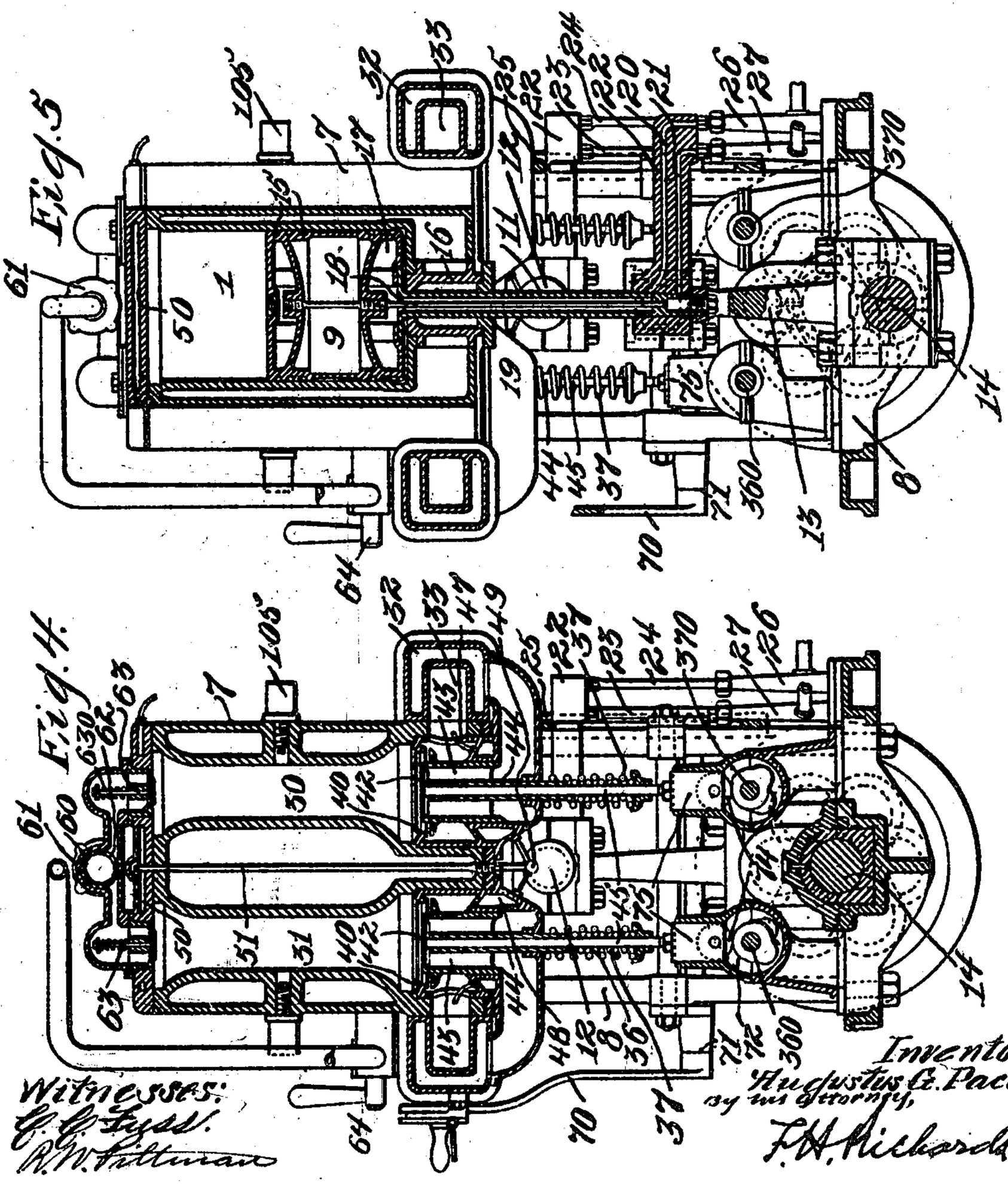

Fig. 4.

Witnesses:
C. C. Tyrell.
R. W. Pittman

Inventor:
Augustus G. Pace.
by his Attorney,
F. A. Richards.

A. G. PACE.

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5 SHEETS—SHEET 4.

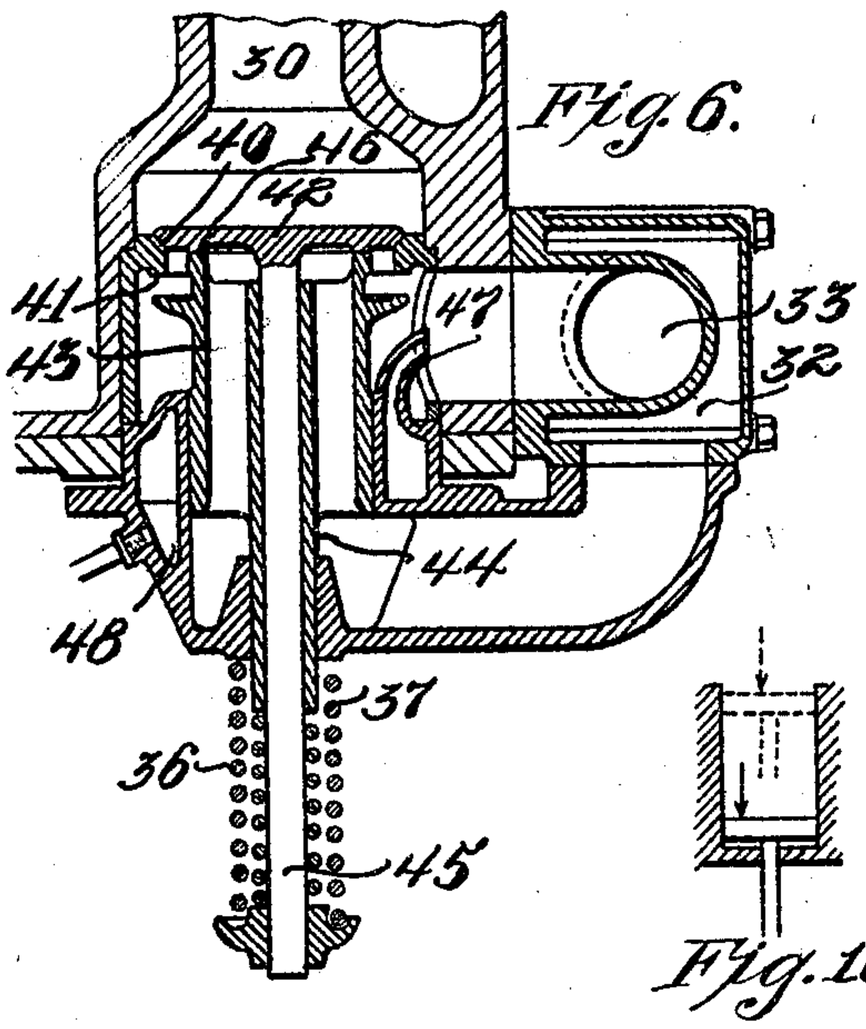

Fig. 6.

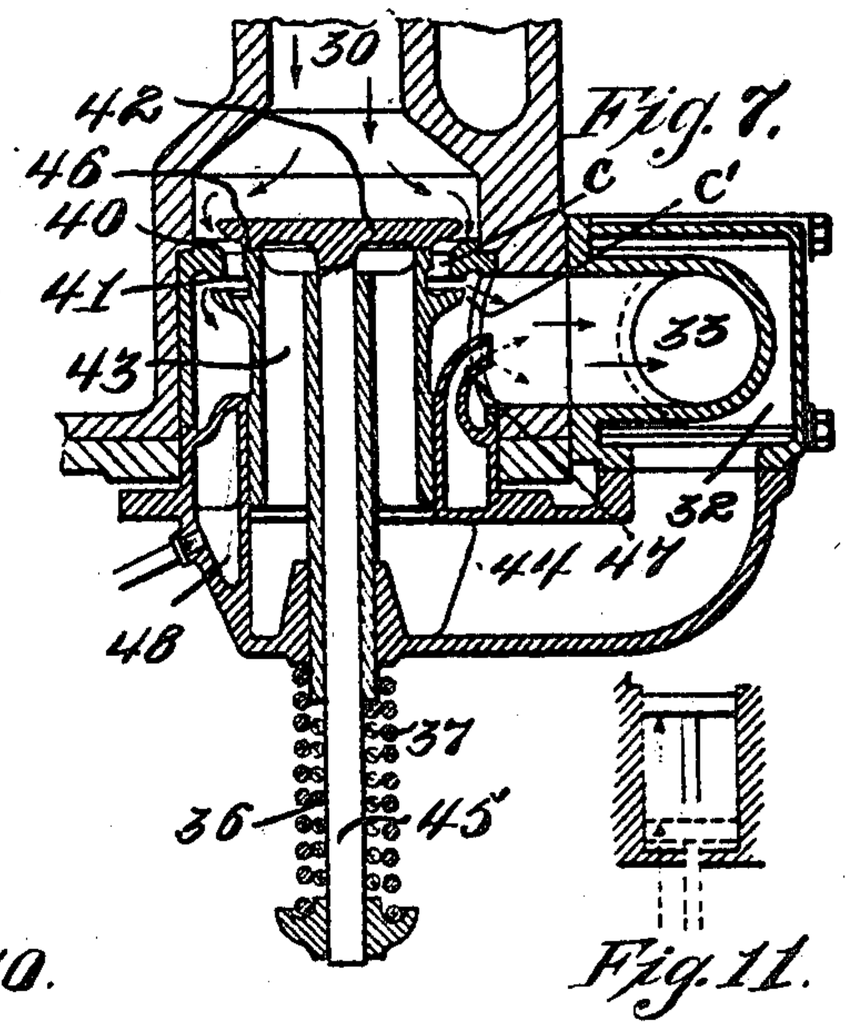

Fig. 7.

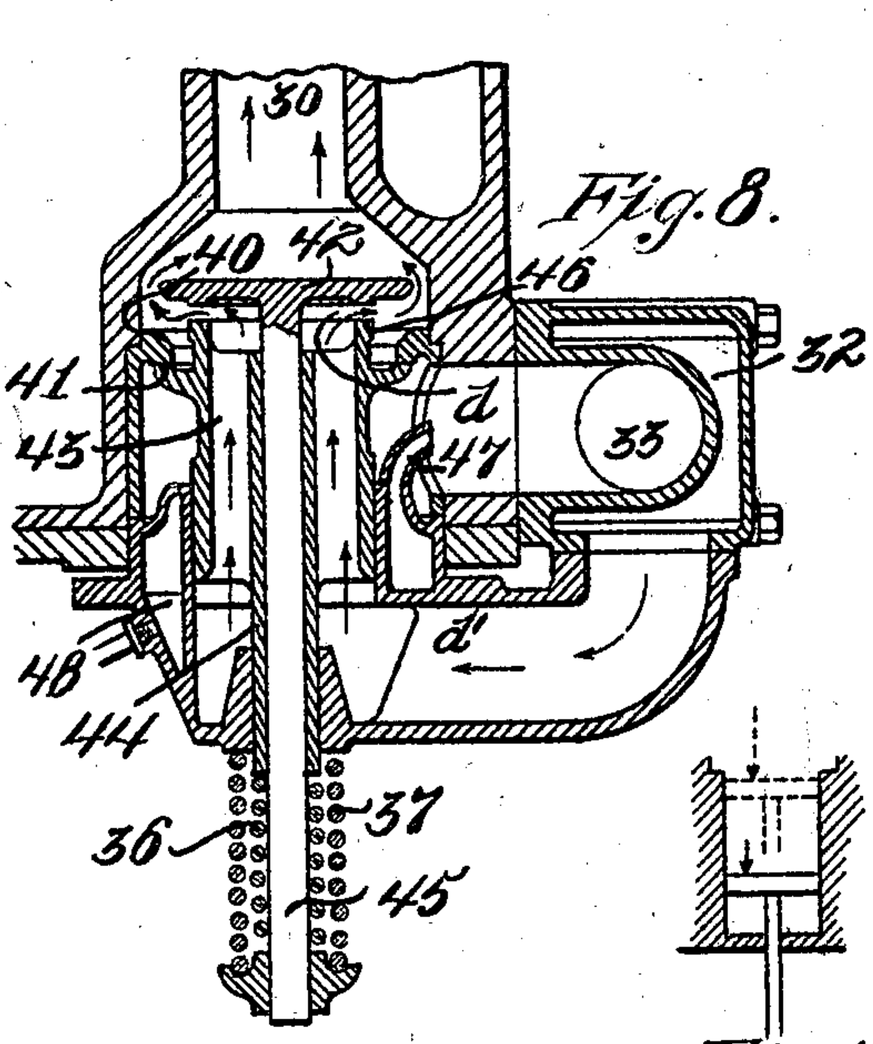

Fig. 8.

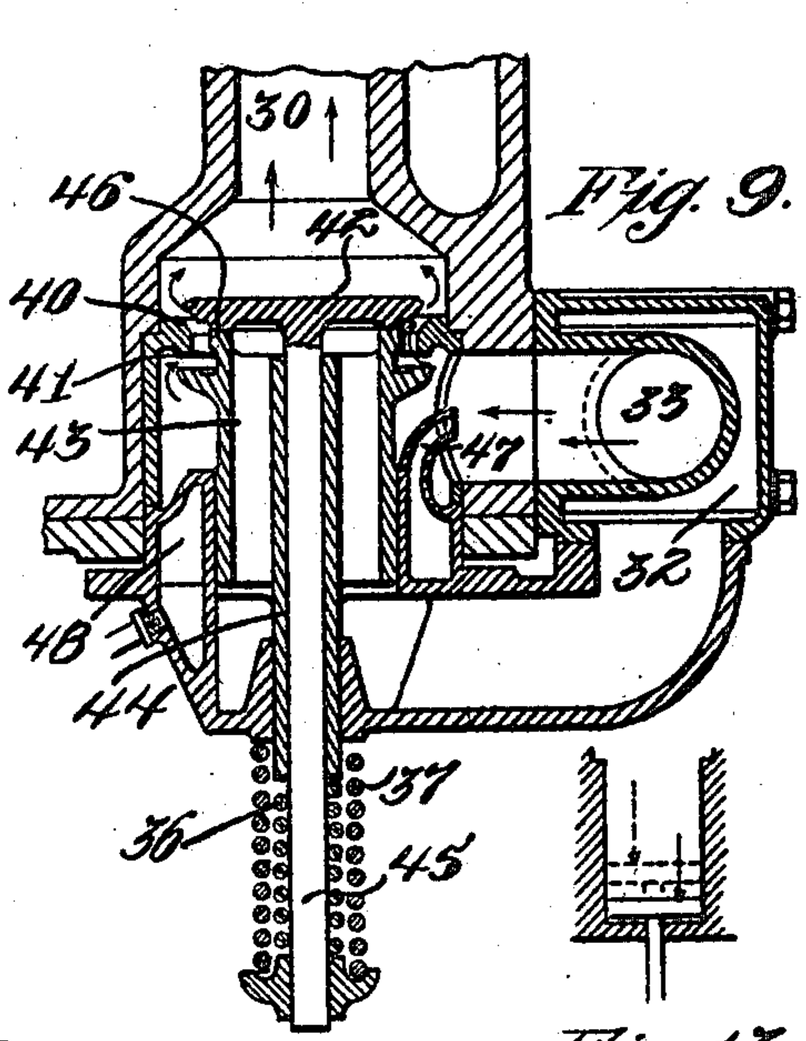

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 12.

Fig. 13.

Witnesses:
Fred E. Maynard.
E. C. Frisbee.

Inventor:
Augustus G. Pace,
By his Attorney,
F. A. Richards.

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A. G. PACE.

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Patented July 5, 1910.

5 SHEETS—SHEET 5.

Fig. 16.

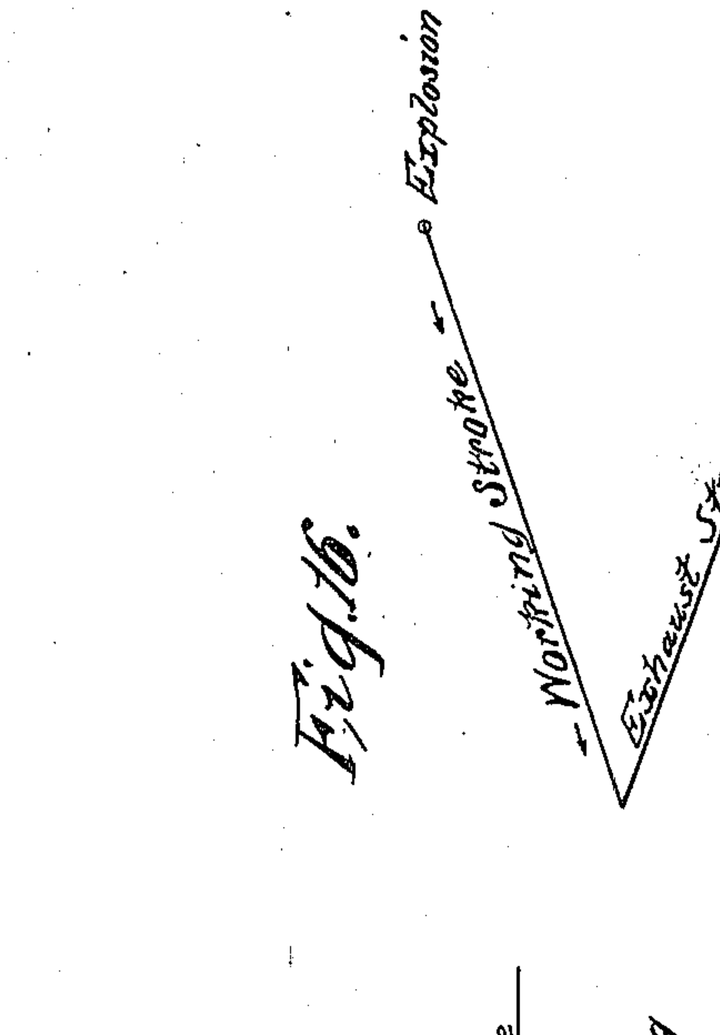


Fig. 14.

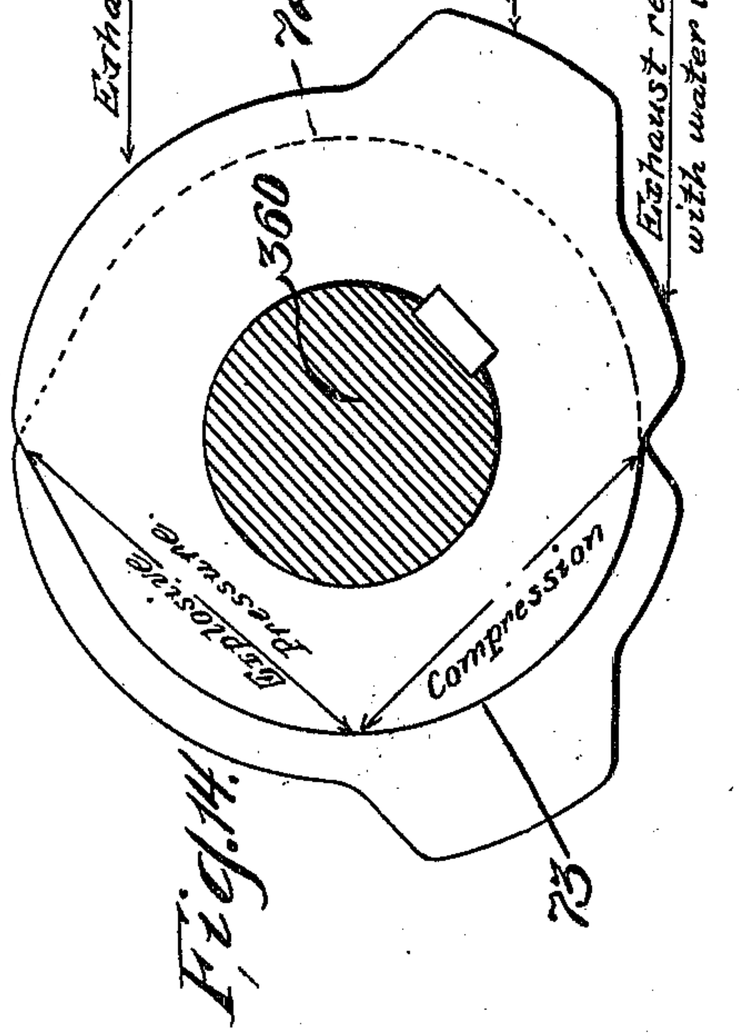
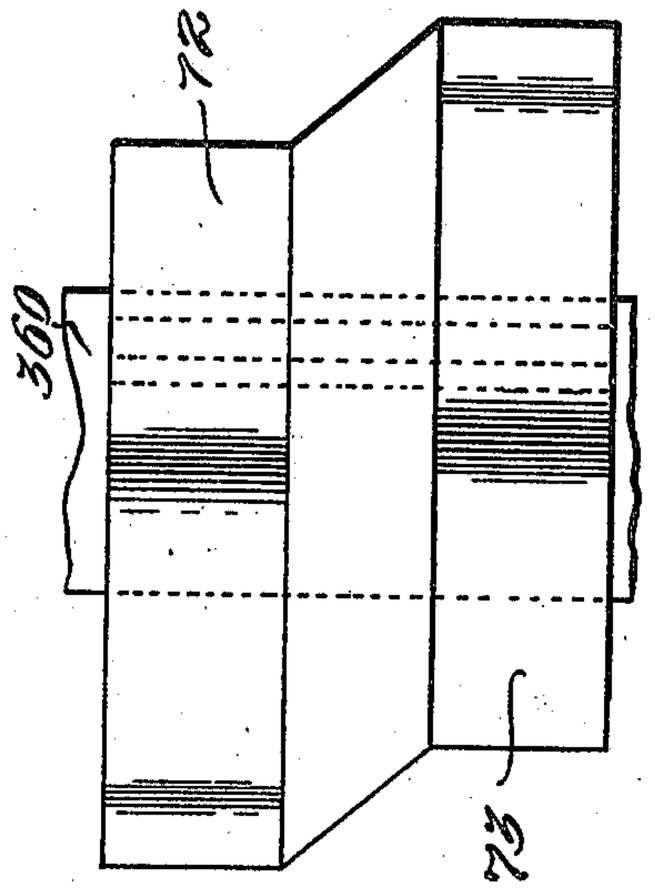


Fig. 15.



Witnesses:
C. C. Fuss.
B. W. Pittman

Inventor:
Augustus G. Pace,
By his attorney,
F. H. Richards.

UNITED STATES PATENT OFFICE.

AUGUSTUS G. PACE, OF NEW YORK, N. Y.

GAS AND OIL ENGINE.

963,318. Specification of Letters Patent. Patented July 5, 1910.

Application filed January 16, 1905. Serial No. 241,191.

To all whom it may concern:

Be it known that I, AUGUSTUS G. PACE, a citizen of the United States, residing in the borough of Manhattan, city of New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Gas and Oil Engines, of which the following is a specification.

This invention relates to gas and oil engines, the object of the invention being to provide an improved engine in which the exhaust mixed with water-vapor or steam is utilized in conjunction with fresh combustible material for running the engine, whereby increased power and material economy is obtained.

A further object of the invention is the provision of an improved organization of mechanism in which the water used for cooling the working parts is fed to the exhaust passage, from which it is drawn in the form of steam mixed with the exhaust products into the piston cylinder and then carried into the fresh oil and air.

A further object of the invention is the provision of an improved engine in which the same may be started by means of one fluid and after starting run by means of another fluid comprising a mixture of oil and air commingled with a mixture comprising the exhaust and water-vapor or steam.

A further object of the invention is the provision of an improved engine so organized that during the major part of one stroke of the pistons fresh combustible material will be drawn into the cylinder and during the rest of such stroke exhaust mixed with water-vapor or steam will be drawn in to be compressed with such fresh material prior to ignition, thus adding to the charge from the beginning of the compression stroke of the pistons and increasing the weight of the charge and decreasing the mean temperature of the working fluid by the pressure of water-vapor.

In the drawings accompanying and forming part of this specification, Figure 1 is a front elevation of this improved engine, a pair of cylinders being shown in section. Fig. 2 is a top or plan view thereof, parts being broken away to more clearly illustrate the subject-matter of the present improvement. Fig. 3 is a horizontal sectional view taken in line A—A Fig. 1. Fig. 4 is a vertical cross sectional view taken in line B—B Fig. 1. Fig. 5 is a similar cross sectional view taken in line C—C Fig. 1. Figs. 6, 7, 8 and 9 are detail views of a portion of the valve mechanism for controlling the working of the pistons, such views illustrating different portions of the valves. Figs. 10, 11, 12 and 13 illustrate, respectively, the positions of a piston during the several positions of the valves shown in Fig. 6, 7, 8 and 9. Figs. 14 and 15 are detail views of one of the cams controlling the valves. Fig. 16 is a diagrammatic view illustrating the cycle of one of the pistons.

Similar characters of reference designate corresponding parts in all the figures of the drawings.

The present invention is in part an improvement upon the subject-matter shown and described in my contemporaneously pending application No. 727,176, filed August 24, 1899, and in my Patent Reissue No. 11,775, dated September 26, 1899.

As a preface to a further description of the present improvement I desire to state that the organization herein shown and described may be more or less varied without departing from the scope of the invention, which comprises in a general way a mechanism embodying piston mechanism, combustion chambers and valve mechanism, so organized that the force which operates at one side of one piston simultaneously operates at the other side of another piston, so that said pistons are simultaneously operative in opposite directions each under a force equal to the force exerted on its companion piston, the present organization being such that for an appreciable part of the stroke of the pistons in one direction fresh combustible material, such as air and oil, will be drawn into the combustion chambers, and then during the remainder of the strokes of such pistons in the same direction exhaust products of combustion previously driven from the piston cylinders, mixed with water-vapor or steam, will be drawn into the combustion chambers and mixed with the fresh combustible material previously drawn in and then compressed.

The present engine is shown as a four-cycle triple engine, that is to say, it is made up of six piston cylinders assembled in pairs. The six piston cylinders 1, 2, 3, 4, 5 and 6 are, as stated, assembled in pairs as 1—2, 3—4,

5—6, each pair being located in a suitable casing 7, which forms a water jacket around the cylinders for cooling purposes, the said casings being supported by suitable framework 8. Located in each of the cylinders is a piston, the pistons 9 and 10, respectively, of cylinders 1 and 2 being shown in Fig. 1. The pistons are connected by suitable piston rods 11, with cross heads 12, which in turn by means of connecting rods 13, are connected to a crank shaft 14, journaled in the framework. Each piston is suitably provided with packing rings 15, to form an air tight connection with the walls of its piston cylinder. The piston rods also project through suitable stuffing boxes 16, in the usual manner. Each piston is provided with a suitable water jacket which is in the form of a chamber 17, located in the piston or head in communication with a pair of passages, one as 18, comprising the hollow piston rod, and the other a tube 19, located therein and communicating with that end of the piston opposite to that in which the hollow piston rod opens. This hollow piston rod and tube are, respectively, in communication with a pair of passages 20 and 21, located in an extension 22, of the cross head with which pipes 23 and 24 are connected for movement with the cross head in its guideways 25, such pipes sliding in stand pipes 26 and 27, one of which is connected with a source of supply, while the other constitutes the overflow so that water will pass through one passage into the piston and from thence out through the other passage.

In communication with each pair of cylinders is a pair of combustion chambers 30 and 31. Each combustion chamber communicates, by a passage or port *a*, with the top of one cylinder, and by a passage or port *b*, with the bottom of the other, (see Fig. 2), so that under an explosive force one piston will be moved in one direction while its companion piston will be moved in the opposite direction simultaneously. Such communications are, however, arranged in alternation, that is to say, one chamber communicates with the top only of one cylinder, while the other chamber communicates with the top only of the other cylinder. Leading to each combustion chamber is a pipe or passage 32, for the admission of fresh combustible fluid, and a pipe or passage 33, for the exhaust of the spent products of combustion, these passages, in the present instance, being in the form of continuous pipes or tubes encircling the cylinder casings and located one tube within the other, the outer tube 32 being utilized for the admission of fresh combustible fluid and therefore connected with a suitable carbureter not shown, at one end 101, of the engine, the inner tube 33, being used as the exhaust passage and shown communicating with the atmosphere at the opposite end 102 of the engine. Each tube has, as stated, suitable connection with each combustion chamber, such communications being controlled by valve mechanisms, each of which, in the present instance, comprises a pair of valves maintained in their closed positions, respectively, by means of springs 36 and 37, and opened by suitable cam mechanism, carried by cam shafts 360 and 370 suitably supported in the framework.

In one form of the present improvement two puppet valves could be used in place of the two shown, they being merely operated by a suitable cam or cams to accomplish the purpose about to be set forth. In the present instance, however, two valves are provided both operated by the same cam in proper sequence. Each combustion chamber is provided at its lower end, or adjacent to that end which communicates with the supply and exhaust passages 32 and 33, respectively, with a pair of oppositely located valve seats 40 and 41, the upper one as 40, for the engagement of one valve 42, and the other as 41, for the engagement of the other valve 43. One of the valves, as 43, is shown as a cylindrical member having a hollow stem 44 for the passage of the rod or stem 45 of the other valve 42, and which cylindrical member is also provided with a valve seat 46 for the valve 42. The communication between the exhaust passage and the combustion chamber during the exhaust is controlled by both of said valves, as will be best seen in Fig. 7, in which the passage *c* is open for the passage of the spent products of combustion from the cylinder to the exhaust passage. The supply of fresh combustible material is controlled by the valve 42, (see Fig. 8), through the passage *d*, which opens into the hollow valve, which in turn communicates with the supply passage leading to the carbureter. For the purpose of mixing the exhaust with water and to transform such water into steam or water-vapor, a suitable water supply pipe or nozzle 47, is provided, preferably adjacent to such set of valves and which is in communication with the exhaust passage. This supply pipe is in communication with a water chamber or jacket 48 surrounding the valves and to which jacket water is supplied by suitable passages 49, (see Fig. 4), leading from a suitable source of supply or from the water jacket 50, which surrounds the combustion chambers, preferably by a pipe 51 opening at the highest point of the water so as to prevent flooding of the engine. The water is heated prior to its passage into the exhaust passage when supplied from the water jacket referred to and the size of the nozzle or opening of the supply pipe limits the amount of water supplied to the exhaust passage.

For starting the engine which may be done by a suitable fluid, such for instance as air or steam, a rotary valve 60 is provided in communication with a source of compressed air or steam, this valve being mounted in a tube or casing 61 and provided with three openings 62, one for each pair of combustion chambers. The openings are not located in alinement, however, so that only one opening communicates with a combustion chamber at a time. The admission of the air to each combustion chamber is controlled by a spring actuated or puppet valve 63, which is forced open by the air under pressure when the cock 64 is turned to permit its passage from the storage tank, or other source of supply, the said valve being closed at the proper time when the pressure within the chamber 30 rises sufficiently to permit some elastic device as a spring 630 to become active.

The fluid supply valves are controlled, as hereinbefore stated by suitable cam mechanism one for each set of valves, carried on a pair of cam shafts 360 and 370, driven by means of suitable gearing 38 from the crank shaft. The particular construction of the cam, which is a duplex one, is clearly shown in Figs. 14 and 15, from which it will be seen that during a certain part of the rotation of each cam, designated as "exhaust", both valves 42 and 43 will be shifted from the positions shown in Fig. 6 to those in Fig. 7, opening the passage *c* to permit the exhaust or spent products of combustion to pass from the cylinders and the combustion chamber through the passage *c'* to the exhaust pipe 33, whereupon that part thereof which does not pass from the exhaust passage will be mixed with the water passing through the supply nozzles. This exhaust is effected by means of the pistons moving in one direction, Fig. 11. On the return of the pistons in the opposite direction, Fig. 12, they will draw in a fresh supply of combustible material, to wit, air and oil, from the carbureter through the supply pipe 32 and passage *d'*, the valve 43 having closed on its seat 41, and the valve 42 opened the passage *d* by means of that part of the cam designated as "mixture". This supply continues throughout an appreciable portion of the stroke of the piston, as for instance three-quarters thereof, (see Fig. 12), when the valve 42 is closed upon its seat 46 by its spring, Fig. 9, thus shutting off the supply of fresh material, at which time the valve 43 is allowed to move by that part of the cam marked "exhaust returning with water-vapor", from its seat 41, thus reopening the passage *c* leading to the exhaust, so that during the remaining part of the strokes of the two pistons, Fig. 13, the exhaust, mixed with water-vapor or steam, is drawn into the cylinders and mixed with the supply of oil and air, and then compressed on the next stroke of the piston, the valves at this time and during the working strokes of the pistons resulting from the explosion being closed, Fig. 6, and during which time that part of the cam marked "compression" and "explosive pressure" is ineffective on the valves. This cycle continues throughout the second pair of cylinders. When, however, it is desired to reverse the engine the cam shafts are shifted by means of the lever 70, connected to such shafts and suitably pivoted, as at 71, to the framework, whereupon each cam is shifted laterally with its shaft so as to bring a different cam portion, as 72, which, however, is a duplicate of the other portion 73 of the cam, into engagement with the roll or disk 74, which is carried by a plunger 75 in engagement with the valve stems 44 and 45, so that the same cycle will take place, but the engine will run in the opposite direction since the pistons will be operated in a reverse manner. At the same time the shifting of the cam shafts, one of which is provided with a pin 90, projecting into a diagonal slot 91, of a sleeve 92 mounted thereon carrying a bevel gear 93, tends to rotate this gear, and thereby a vertical spindle or shaft 94 carrying a bevel gear 95 in mesh with a similar gear 96 fixed to a shaft 97 connected with the rotary air supply valve 60, thereby rotating such valve so that the air supply passage, shown for instance in Fig. 4 as communicating with one combustion chamber, is rotated so as to communicate with the opposite combustion chamber. There is a lead of about 90° in the admission and upon reversing the lead is changed, so that a supply of air is admitted in front of the pistons to retard the same and with a tendency to force them in the opposite direction and the next supply or charge of air will be admitted to the cylinders to give the pistons a reverse motion, the cam mechanism being formed as hereinbefore described to correspond therewith and therefore to so operate the valves that the engine is reversed. The cam shafts revolve only at one-half the speed of the crank shaft so that the air valves open only at every other revolution.

In using compressed air or other fluid to start the pistons such fluid will produce the first working stroke. Referring to the diagram of Fig. 16, the charge of compressed air, or other fluid, will be admitted at the explosion point, that is, its valve will be opened by virtue of the low pressure existing within the chambers which would otherwise be filled with the compressed charge and the explosion, but the compressed air will be admitted when there is no explosion and will continue to be admitted during practically the entire working stroke. Then during the

exhaust stroke the compressed air will be exhausted. At the stroke of inspiration the charge will be taken in in the ordinary manner, then the compression will take place at the compression stroke and the explosion will occur, but if the ingredients for the charge have not been sufficiently mixed or compressed, or are too poor to produce an explosion, the repetition of the admission of air will then ensue and the working stroke will again be performed by the starting fluid. If the next compression stroke is followed by an explosion no starting fluid will be admitted, but assuming that at starting there are a succession of explosions and misses, the starting fluid will be admitted after each miss and perform the working stroke and get the engine started. This will continue and after the engine is in proper working order the valve 64 may be shut off by the operator. But assuming that he neglected to shut off such valve 64, there will not be a waste of compressed air, because the air will only be admitted when the explosion fails to follow the compression stroke.

As a result of the organization described a smaller amount of air charged with oil-vapor is drawn in from the carbureter than would otherwise be required, the cylinders being filled to their full capacity by the exhaust mixed with steam which adds pressure at the beginning of the compression stroke of the piston, increasing the weight of the charge and decreasing the mean temperature of the working fluid by the presence of the water-vapor which by actual test has been found to be of advantage. The admission of water to the exhaust pipe also tends to cool the same as well as charge the exhaust.

While in the present organization each set of pistons for about three-quarters of a stroke draws in fresh combustible material from the carbureter, and then during the remainder of such stroke draws in exhaust mixed with steam, it is to be understood that the amount of fresh combustible material, as well as the amount of exhaust and steam drawn into the combustion chamber and cylinders is determined, of course, by the construction of the cam mechanism which can be constructed and timed to admit more or less as occasion may require. The igniters 105 are connected with a suitable commutator arranged to distribute the current to the proper igniter, the commutator being so arranged that the spark may be advanced or retarded at the will of the operator.

Inasmuch as my present improvements relate chiefly to features of construction not requiring any particular kind of crank shaft or connections therefrom to the pistons of the cylinders I have herein, and particularly in some of the claims, employed the term "piston mechanism" for indicating that part of the engine which comprises the pistons in the cylinders respectively and some suitable means for connecting such pistons with transmitting devices suitable for delivering the power from the engine for use.

Having thus described my invention, I claim:

1. In an engine of the class described the combination of a plurality of cylinders, piston mechanism therefor, a plurality of combustion chambers alternately communicating each with one end of one and the opposite end of the other cylinder, an exhaust passage surrounding said cylinders, a supply passage also surrounding said cylinders, and valve mechanism for controlling the admission of fresh combustible material to the combustion chambers and the exhaust therefrom.

2. In an engine of the class described, the combination of a plurality of cylinders, piston mechanism therefor, a plurality of combustion chambers alternately communicating each with one end of one and the opposite end of the other cylinder, an exhaust passage surrounding said cylinders and a supply passage also surrounding said cylinders, one of said passages being located within the other, and valve mechanism for controlling the admission of fresh combustible material to the combustion chambers and the exhaust therefrom.

3. In an engine of the class described the combination of a plurality of cylinders, piston mechanism therefor, a plurality of combustion chambers alternately communicating each with one end of one and the opposite end of the other cylinder, an exhaust passage surrounding said cylinders and a supply passage also surrounding said cylinders, said supply passage being located within the exhaust passage, and valve mechanism for controlling the admission of fresh combustible material to the combustion chambers and the exhaust therefrom.

4. In an engine of the class described the combination of a plurality of cylinders, piston mechanism therefor, a plurality of combustion chambers alternately communicating each with one end of one and the opposite end of another cylinder, an exhaust passage surrounding said cylinders and a supply passage also surrounding said cylinders, valve mechanism for controlling the admission of fresh combustible material to the combustion chambers and the exhaust therefrom, and means for supplying water to the exhaust passage, the organization being such that fresh combustible material is drawn into the cylinders during a portion of one stroke of the pistons and exhaust mixed with water drawn into such cylinders during the remaining portion of the same stroke of such pistons.

5. In an engine of the class described, the combination of a plurality of cylinders, pis-

ton mechanism therefor, a plurality of combustion chambers alternatingly communicating each with one end of one and the opposite end of another cylinder, an exhaust passage surrounding said cylinders and a supply passage also surrounding said cylinders, one of said passages being located within the other, valve mechanism for controlling the admission of fresh combustible material to the combustion chambers and the exhaust therefrom, and means for supplying water to the exhaust passage, the organization being such that fresh combustible material is drawn into the cylinders during a portion of one stroke of the pistons and exhaust mixed with water drawn into such cylinders during the remaining portion of the stroke of such pistons.

6. In an engine of the class described, the combination of a pair of cylinders, a pair of combustion chambers communicating alternately with said cylinders each with one end of one and the opposite end of the other, piston mechanism for said cylinders, and means for controlling the starting of the engine and comprising a rotary valve geared to the piston mechanism and having an opening adapted to be rotated into position to communicate with either one of the combustion chambers.

7. In an engine of the class specified, the combination of a series of cylinders located in pairs, a pair of combustion chambers for each pair of said cylinders alternately communicating each with one end of one and the opposite end of the other cylinder, piston mechanism for said cylinders, means for controlling the starting of the engine and comprising rotary valve mechanism connected with the piston mechanism, the valve having an opening for each pair of combustion chambers, one of said openings communicating with one or the other of the combustion chambers of each pair.

8. In an engine of the class specified, the combination of a series of cylinders located in pairs, a pair of combustion chambers for each of said cylinders alternately communicating each with one end of one and the opposite end of the other cylinder, piston mechanism for said cylinders, means for controlling the starting of the engine and comprising a rotary valve connected with the piston mechanism and having an opening for each pair of combustion chambers, one opening communicating with one or the other of the combustion chambers of either pair, and valve mechanism for controlling the admission of air to the combustion chambers.

9. In an engine of the class described, the combination of a pair of cylinders, a pair of combustion chambers communicating alternately each with said cylinders at one end of one and the opposite end of the other, piston mechanism for said cylinders, and means for controlling the starting of the engine and comprising a rotary valve geared to the piston mechanism and having an opening adapted to rotate into position to communicate with either one of the combustion chambers, and valve mechanism for controlling the admission of air to said combustion chambers.

10. In an engine of the class described, the combination of a plurality of cylinders located in pairs, a pair of combustion chambers communicating with each pair of cylinders alternately each with one end of one and the opposite end of the other cylinder, valve mechanism for controlling the operation of said combustion chambers, piston mechanism for said cylinders, an exhaust passage located around said cylinders and communicating with each of said combustion chambers, a supply passage also located around said cylinders and communicating with each of said combustion chambers, a rotary valve for controlling the starting of the engine, said valve having an opening for each pair of combustion chambers and rotatable into position to communicate with either one of the pair of combustion chambers.

11. In an engine of the class described, the combination of a plurality of cylinders located in pairs, a pair of combustion chambers communicating with each pair of cylinders alternately, each with one end of one and the opposite end of the other cylinder, valve mechanism for controlling the operation of said combustion chambers, piston mechanism for said cylinders, an exhaust passage located around said cylinders and communicating with each of said combustion chambers, a supply passage also located around said cylinders and communicating with each of said combustion chambers, one passage located within the other, a rotary valve for controlling the starting of the engine, said valve having an opening for each pair of combustion chambers and rotatable into position to communicate with either one of the pair of combustion chambers.

12. In an engine of the class described, the combination of a plurality of cylinders located in pairs, a pair of combustion chambers communicating with each pair of cylinders alternately, each with one end of one and the opposite end of the other cylinder, valve mechanism for controlling the operation of said combustion chambers, piston mechanism for said cylinders, an exhaust passage located around said cylinders and communicating with each of said combustion chambers, a supply passage also located around said cylinders and communicating with each of said combustion chambers, the supply passage being located within the exhaust passage, a rotary valve for

controlling the starting of the engine, said valve having an opening for each pair of combustion chambers and rotatable into position to communicate with either one of each pair of said combustion chambers.

13. In an engine of the class described, the combination of a plurality of cylinders located in pairs, a pair of combustion chambers communicating with each pair of cylinders alternately, each with one end of one and the opposite end of the other cylinder, valve mechanism for controlling the operation of said combustion chambers, piston mechanism for said cylinders, an exhaust passage located around said cylinders and communicating with each of said combustion chambers, a supply passage also located around said cylinders and communicating with each of said combustion chambers, a rotary valve for controlling the starting of the engine, said valve having an opening for each pair of combustion chambers and rotatable into position to communicate with either one of the pair of combustion chambers, and means for supplying water to the exhaust passage, the organization of the engine being such that during a portion of one stroke of each pair of pistons fresh combustible material will be drawn into the cylinders and during the remaining portion of the same stroke exhaust mixed with water will be drawn into said cylinders.

14. In an engine of the class described, the combination of a plurality of cylinders located in pairs, a pair of combustion chambers communicating with each pair of cylinders alternately, each with one end of one and the opposite end of the other cylinder, valve mechanism for controlling the operation of said combustion chambers, piston mechanism for said cylinders, an exhaust passage located around said cylinders and communicating with each of said combustion chambers, a supply passage also located around said cylinders and communicating with each of said combustion chambers, the supply passage being located within the exhaust passage, a rotary valve for controlling the starting of the engine, said valve having an opening for each pair of combustion chambers and rotatable into position to communicate with either one of the pair of combustion chambers, and means for supplying water to the exhaust passage, the organization of the engine being such that during a portion of one stroke of each pair of pistons fresh combustible material will be drawn into the cylinders and during the remaining portion of the same stroke exhaust mixed with water will be drawn into the same cylinders.

15. In an engine of the class described and having a plurality of cylinders provided with communicating passages and connections substantially as set forth, the combination of a pair of cylinders, piston mechanism therefor, a pair of combustion chambers communicating alternately with said cylinders, each with one end of one and the opposite end of the other cylinder, valve mechanism for controlling the operation of said combustion chambers, duplex cam mechanism provided with connecting devices operable as set forth for controlling said valve mechanism, and means for throwing either one or the other of said cam mechanisms into operative position.

16. In an engine of the class described and having a plurality of cylinders provided with communicating passages and connections substantially as set forth, the combination of a pair of cylinders, piston mechanism therefor, a pair of combustion chambers communicating alternately with said cylinders, each with one end of one and the opposite end of the other cylinder, valve mechanism for controlling the operation of said combustion chambers, duplex cam mechanism provided with connecting devices operable as set forth for controlling said valve mechanism, and means for shifting said cam mechanism laterally thereby to effect a reversal of the engine.

17. In an engine of the class described and having a plurality of cylinders provided with communicating passages and connections substantially as set forth, the combination with a pair of cylinders, piston mechanism therefor, a pair of combustion chambers communicating alternately with said cylinders, each with one end of one and the opposite end of the other cylinder, valve mechanism for controlling the operation of said combustion chambers, duplex cam mechanism provided with connecting devices operable as set forth for controlling said valve mechanism, means for shifting said cam mechanism laterally thereby to effect a reversal of the engine, and rotary valve mechanism operative to communicate with either one of the combustion chambers and connected with said cam mechanism, the organization being such that on the shifting of the cam mechanism laterally the rotary valve will be shifted so that the lead will be changed and communication will be established with the combustion chamber in front of the piston.

18. In an engine of the class described, the combination of a series of cylinders located in pairs, piston mechanism for each of the cylinders including crank mechanism, a pair of combustion chambers for each pair of cylinders alternately communicating therewith each with the end of one and the opposite end of the other cylinder, valve mechanism for controlling the working of the combustion chambers, laterally shiftable cam shafts in gear with the crank shaft, duplex cams laterally movable with said shafts

and effective to control the valve mechanisms in either direction the engine is running, rotary valve mechanism controlling the starting of the engine and in gear with one of said cam shafts and shifted into a different position on the lateral movement of said cam shaft.

Signed at Nos. 9 to 15 Murray street, New York, N. Y., this 14th day of January 1905.

AUGUSTUS G. PACE.

Witnesses:
CHAS. LYON RUSSELL,
JOHN O. SEIFERT.