No. 620,554. Patented Feb. 28, 1899.

J. W. EISENHUTH.

AIR AND GAS ENGINE.

(Application filed Nov. 16, 1897.)

(No Model.) 6 Sheets—Sheet I.

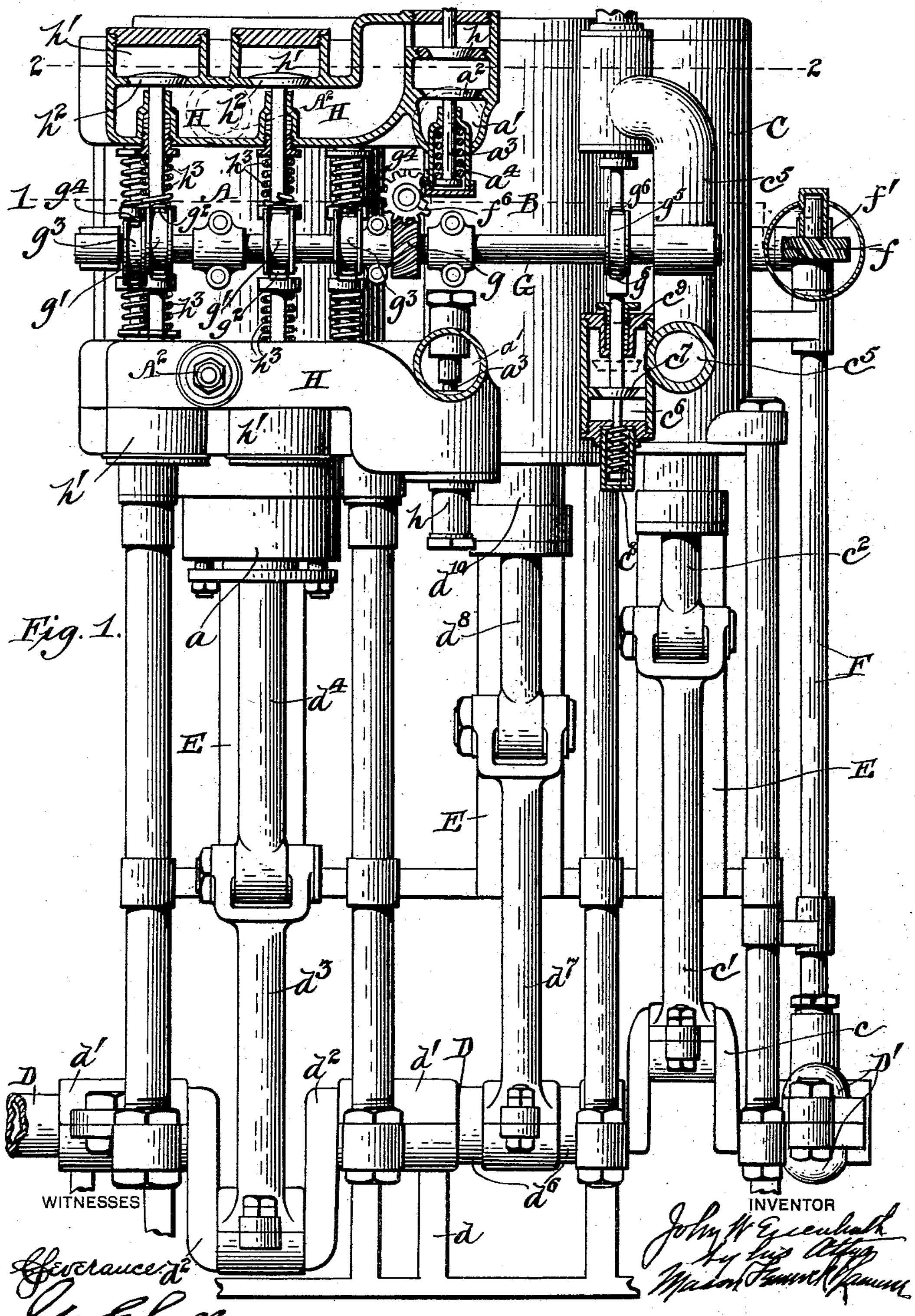

Fig. 1.

WITNESSES

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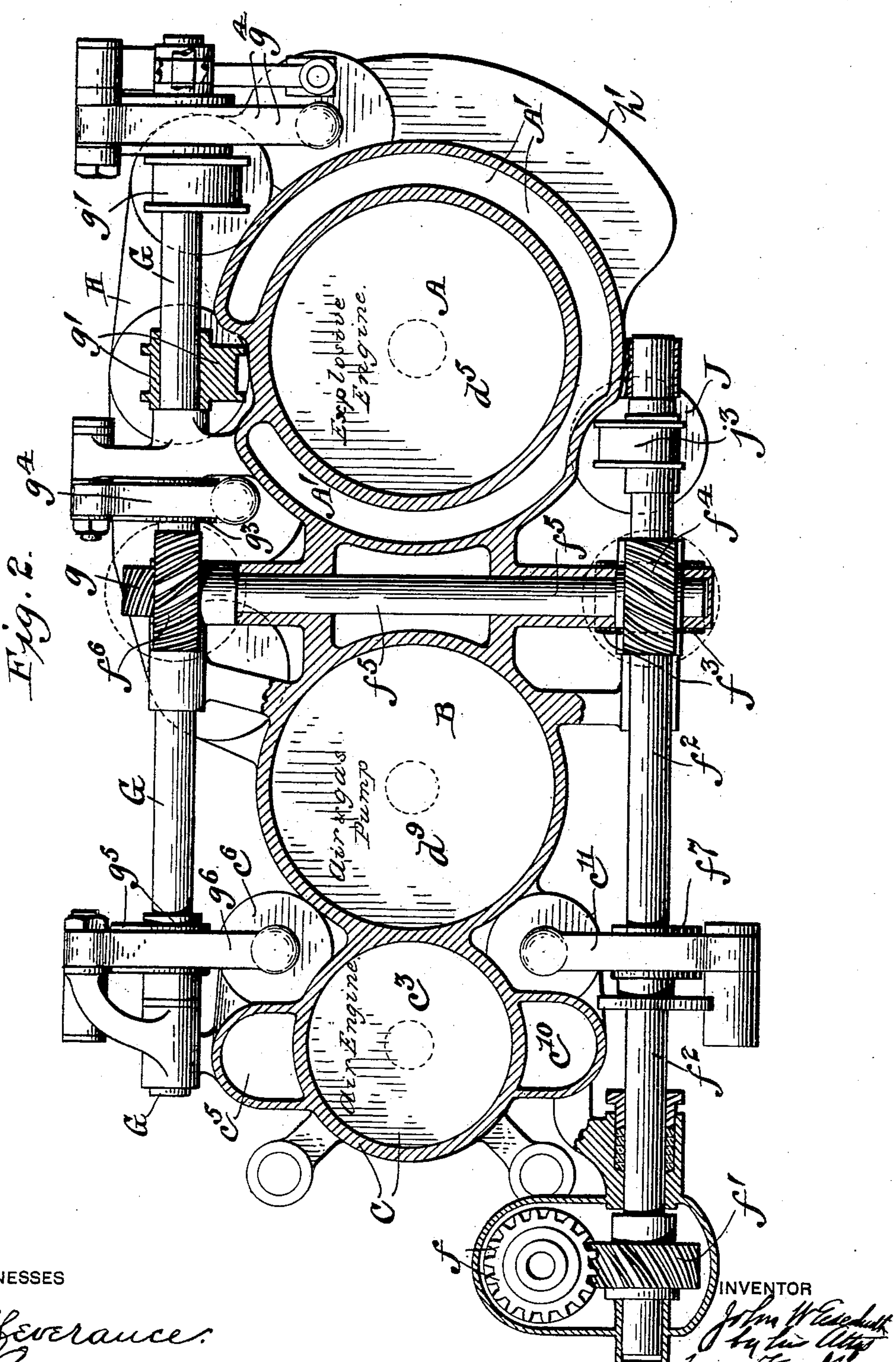
(No Model.) **6 Sheets—Sheet 2.**



WITNESSES

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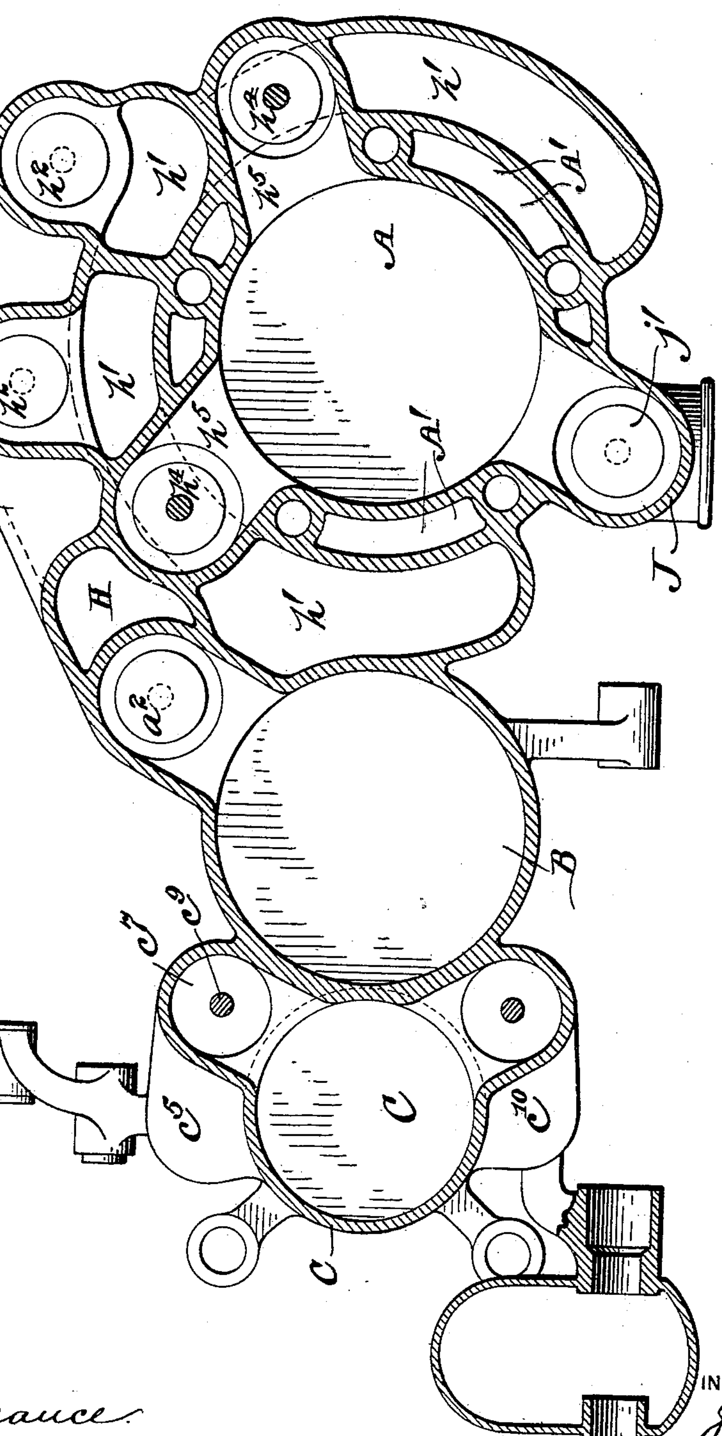
Fig. 3.



WITNESSES

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(No Model.)

6 Sheets—Sheet 4.

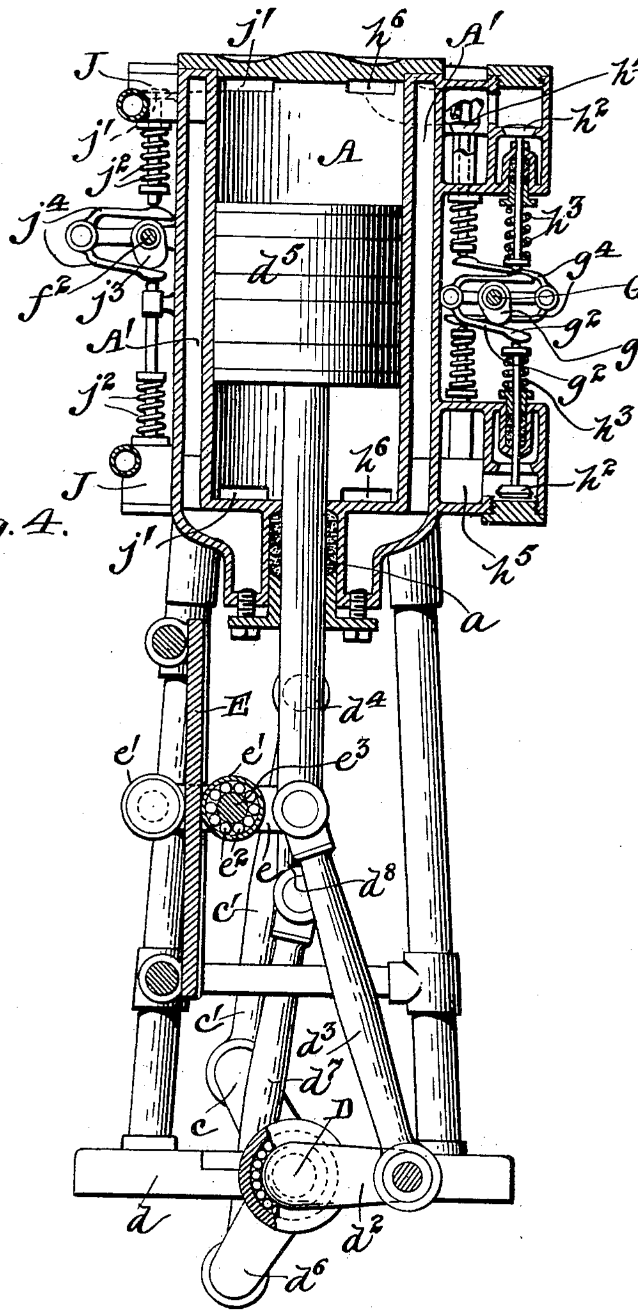

Fig. 4.

WITNESSES

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No. 620,554. Patented Feb. 28, 1899.

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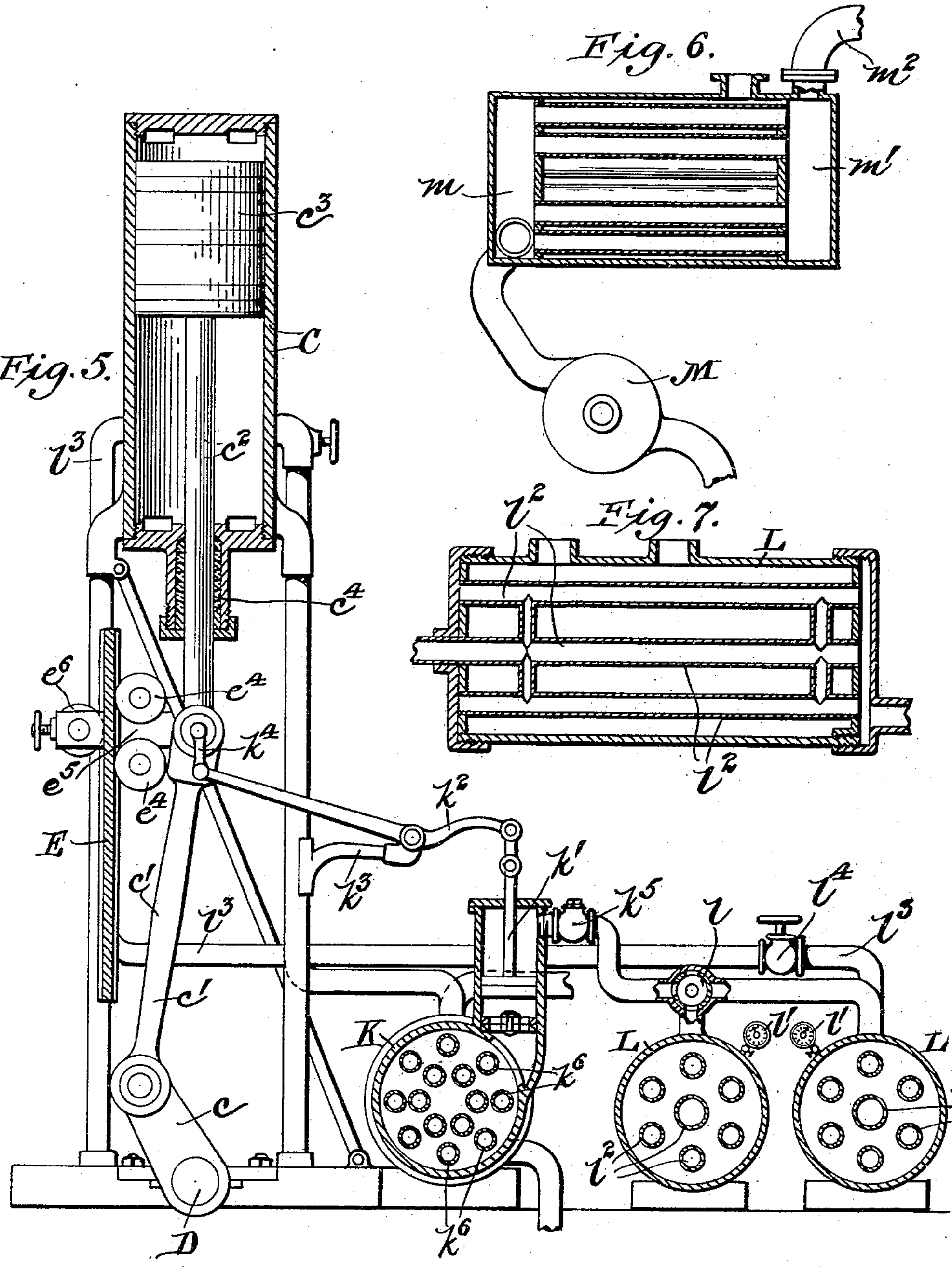
AIR AND GAS ENGINE.

(Application filed Nov. 16, 1897.)

(No Model.) 6 Sheets—Sheet 5.



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No. 620,554. Patented Feb. 28, 1899.

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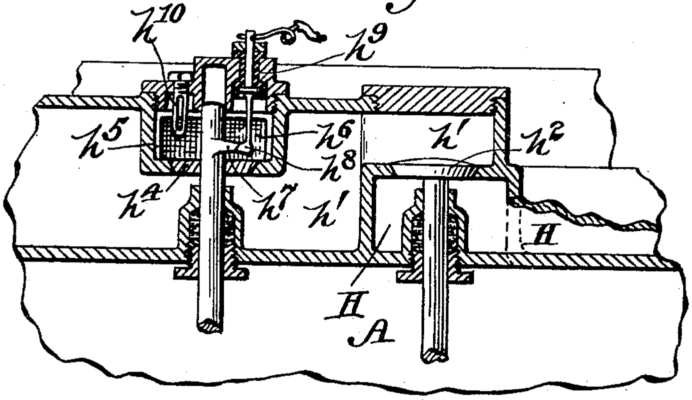
AIR AND GAS ENGINE.

(Application filed Nov. 16, 1897.)

(No Model.) 6 Sheets—Sheet 6.

Fig. 8.



WITNESSES

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UNITED STATES PATENT OFFICE.

JOHN W. EISENHUTH, OF NEW YORK, N. Y., ASSIGNOR TO ELLA V. EISENHUTH, OF SAME PLACE.

AIR AND GAS ENGINE.

SPECIFICATION forming part of Letters Patent No. 620,554, dated February 28, 1899.

Application filed November 16, 1897. Serial No. 658,717. (No model.)

To all whom it may concern:

Be it known that I, JOHN W. EISENHUTH, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Air and Gas Engines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to improvements in air and gas engines, and more particularly to that class of engines which are adapted to use mixtures of air and gas or oils to operate a piston and also adapted to use compressed air for operating a piston.

It consists in providing an engine with one or more cylinders adapted to be operated by a mixture of gas or oil and air and one or more cylinders adapted to be operated by compressed air, the said cylinders being adapted to be operated to assist each other, and means for controlling the admission and exhaust of the air and gas mixtures and the compressed air.

It further consists in providing an engine with a cylinder adapted to use a gas or oil and air mixture, a cylinder for compressing the said air and gas or other mixture and forcing it into the first-mentioned cylinder, and in also providing it with a cylinder adapted to receive compressed air to assist in operating the engine in conjunction with the aforesaid air and gas or oil mixture cylinder.

It also consists in certain other novel constructions, combinations, and arrangements of parts, all of which will be hereinafter more fully described and claimed.

In the accompanying drawings, Figure 1 represents a front elevation of my improved air and gas engine, portions thereof being shown in section to more fully reveal the construction. Fig. 2 represents a horizontal transverse section through the cylinders of the said engine on the line 1 1 of Fig. 1. Fig. 3 represents a similar sectional view taken on the line 2 2 of Fig. 1. Fig. 4 represents a vertical central section through the air and gas cylinder. Fig. 5 represents a vertical section taken centrally through the compressed-air cylinder, also showing a condenser and compressed-air tanks connected therewith. Fig. 6 represents a central vertical section of the condenser. Fig. 7 represents a central vertical section through one of the compressed-air tanks. Fig. 8 represents a detail sectional view illustrating the communication between a compression-chamber of the gas-engine and an exploding-chamber and also showing the means for producing a spark to ignite the gaseous mixture.

A in the drawings represents a cylinder adapted to receive an air and gas or oil mixture for operating the piston therein.

B represents a compressing-cylinder for compressing gaseous mixtures to be used in cylinder A.

C represents a cylinder adapted to receive charges of compressed air for operating the piston therein, and D represents the main shaft of the engine.

In constructing gas-engines I find upon repeated experiments that a great saving in the use of gas or oil can be obtained by the use of compressed air to assist in operating the engine, a great increase of power being at the same time contributed by this combination. The compressed-air mechanism of the engine when constructed in accordance with my invention is ever ready to start the operation of the engine, as well as to assist in its continued action.

As illustrated in the drawings, I prefer to construct my improved gas-engine with three cylinders, one of which is to be operated by an air and gas or oil mixture, the second of which is adapted to compress the said mixture and force it into the said cylinder, and the third of which is adapted to be operated by compressed air. The main shaft D of the engine is preferably mounted in a suitable base-frame, as *d*, being journaled in bearings, as *d'*, at one or more points upon the said frame. Formed upon said shaft are cranks adapted to be operated by the cylinders of the engine, the crank d^2 being connected by means of a pitman d^3 with a piston-rod d^4, which extends into the cylinder A. The piston-rod d^4 is provided with a piston d^5 of suitable size, which fits into the cylinder A and is adapted to be reciprocated therein for imparting movement to the crank d^2. A suitable packing-gland, as a, is adapted to surround the piston-rod d^4 and prevent any leakage or escape of the gaseous mixtures which explode in the cylinder A. The main shaft D also carries a crank, as d^6, which operates a pitman d^7. The pitman d^7 is connected with a piston-rod d^8, which extends into the compressor-cylinder B, and has secured to it a piston d^9, which is caused to reciprocate in the cylinder B through the action of the crank d^6, so as to draw in and compress an air and gas mixture and force the same into the compression-chambers and exploding-chambers of the gas-cylinder A. The piston-rod d^9 may also be provided with a suitable packing-gland, as d^{10}. A crank c is also formed upon the shaft B and is connected with a pitman c', which in turn is pivotally connected with a piston-rod c^2, which extends into the compressed-air cylinder C. The piston-rod c^2 carries a piston c^3, which is adapted to be reciprocated in the cylinder C by the charges of compressed air forced into the same. The piston-rod c^2 is also provided with a packing-gland, as c^4, to prevent the leakage of the compressed air. In order to guide the outer ends of the piston-rods d^4, d^9, and c^2, suitable guides, as E, are secured to the frame of the engine and are adapted to be engaged by roller-bearings connected with the cross-head of each piston-rod. As illustrated in Fig. 4 of the drawings, the cross-head may be provided with an extension, as e, adapted to extend through a slot formed in the guide-plate E and carrying bearing-rollers, as e', which engage the front and rear surfaces of the guide-plate E, and thus form a guide to direct the movement of the piston-rods. While the rollers e' may be of any suitable construction, yet I prefer to mount them on ball or roller bearings, as e^2. (Illustrated in Fig. 4 of the drawings.) In this construction the roller e' consists of an outer rim portion between which and a stud or shaft e^3, secured to the extension e, are interposed balls or rollers to afford an antifriction-bearing for the said rim portion. As illustrated in Fig. 5, the numbers of rollers upon each side of the guide-plate may be increased. As illustrated in the said figure, two rollers, as e^4 e^4, are mounted upon the cross-head extension e^5, in front of the guide-plate E, a single roller, as e^6, being mounted on the rear side of the said guide-plate. As also illustrated in this figure, the rear roller may be made adjustable, being journaled in movable blocks, as e^7, which slide in guide-slots, as e^8, formed in the extensions of the cross-head. An adjusting-screw, as e^9, is adapted to engage the said block to adjust it with reference to the guide-plate. It will be seen that by this construction any wear of the parts can be readily taken up by manipulating the adjusting-screw e^9.

I make no claim under this application for the construction of roller-bearing cross-heads and the guides therefor, as illustrated in connection with the rest of the mechanism shown in Figs. 4 and 5 of the drawings, as the same constitutes the subject-matter of another application filed by me on the 10th day of February, 1899.

The main shaft of the engine D is provided with a spiral gear adapted to engage a corresponding spiral gear upon the lower end of a vertical shaft F, mounted in suitable bearings upon the frame of the engine. The said spiral gears are preferably inclosed in an oil-tight casing, as D′, so that the gears may be made to run in oil and thoroughly protected from dust and dirt. The upper end of the shaft F carries a spiral gear, as f, which meshes with a corresponding spiral gear f', secured to a shaft f^2. The said gears f f' are also mounted in a dust-tight casing. The shaft f^2 is preferably mounted horizontally of the engine and suitable bearings formed thereon and extends along behind the cylinders A, B, and C. It also carries a spiral gear-wheel, as f^3, which meshes with another spiral gear, as f^4, secured to one end of a horizontal shaft f^5, which is mounted in the frame of the engine and extends transversely of the same, preferably between the cylinders A and B, to the forward side of the engine. It is provided upon its forward end with a spiral gear, as f^6, which is adapted to mesh with and actuate a spiral gear g, mounted upon a shaft G. The shaft G is arranged upon the front of the engine and is journaled in suitable bearings formed thereon, the said shaft G and the shaft f^2 being adapted to operate the valves of the engine, as will be hereinafter more fully described.

The means for mixing the gas or oil with air for use in my improved engine forms no part of this invention, and it is therefore not illustrated nor described, it being accomplished by any suitable means and fed to the engine through inlet-pipes, as a' a'. The compressing-piston d^9 upon being reciprocated draws or sucks the air-mixture into the cylinder B from the said inlets a' a' through valve-controlled openings therein. These openings are controlled by the valves a^2 a^2, which have stems a^3 and engage a suitable bearing. A spring, as a^4, engages a shoulder formed upon the said stems and normally holds the said valves in their closed position. The shape of the valves as illustrated in the drawings is such that the gas and air mixture can be drawn into the compressing-cylinder, but cannot pass back through the valve again. After drawing the charge of gas and air mixture into the cylinder the piston d^9 is then adapted upon the return stroke to compress and force the said mixture through a valved opening into the compression chambers or passages H H, there being two of these chambers arranged at each end of the compressing-cylinder.

The entrances to the compression-chambers are also controlled by means of spring-operated valves h h, which are so formed that a charge may be forced into the compression-chambers, but cannot return into the compressing-cylinder. Each compression-chamber H H communicates with two exploding-chambers h' h', formed at each end of the cylinder A, the entrance into the said exploding-chambers being controlled by the valves h^2. These valves are held closed normally by springs, as h^3 h^3, surrounding their stems and engaging annular shoulders formed thereon. These springs h^3 h^3 are made sufficiently stiff and strong to hold the valves h^2 h^2 closed against the pressure of the air and gas mixture in the compression-chambers H until they are forced open by suitable mechanism, as will be hereinafter described. The exploding-chambers h' h' communicate with the interior of the cylinder A through the valved openings leading to the entrance-ports of the said cylinder. The valves h^4, which control these openings, are mounted in suitable packing-bearings formed in the walls of the exploding-chambers, the stems of the said valves being extended into passage-ways h^5, leading to the ports h^6 of the cylinder A. As it is always desirable to ignite the explosive mixture whenever it is forced into the cylinder A, the stem of each valve h^4 is provided with a contact, as h^7, adapted to engage a spring-contact h^8, mounted in the wall of the chamber h^5. The end of the contact h^8 extends through the wall of the said chamber and is thoroughly insulated therein, as at h^9, the outer end of the said stem portion being connected, by means of a wire, with any source of electricity. The stem of the valve h^4 is also connected with the said electrical source and normally completes a circuit therewith. It will be seen that when the valve h^4 is forced open the contacts will be separated and will snap by each other, thus breaking the circuit and producing a spark which will ignite the gas mixture at once and simultaneous with its entrance into the cylinder A. While this sparking mechanism may be used constantly, yet after the engine has been running awhile and becomes thoroughly heated a platinum point or stud, as h^{10}, may be used for this purpose, the said stud being mounted so as to extend into the passage-way h^5 and being kept red-hot by the heat of the engine. The cylinder A is preferably provided with two inlet-ports at each end thereof, and therefore two exploding-chambers, as above described, which are adapted to be charged alternately. By this construction one exploding-chamber can be thoroughly exhausted of the spent and burned gases while the other is being recharged. This construction is of great importance, as it operates to prevent the parts from becoming too highly heated and gives ample time for the thorough exhaustion of the spent gases and prevents the liability of any back firing of the gas mixture into the compression-chambers. Each end of the cylinder A is further provided with exhaust-ports, as j, which communicate with exhaust-chambers J J. These exhaust-chambers are provided with valves, as j', which are normally held closed by springs j^2 and are adapted to be opened at the proper time by mechanism to be described hereinafter. In order to operate the valves h^2 h^2, controlling the communication between the exploding-chambers and the compression-chambers, I mount cams, as g' g', upon the shaft G, the said cams being adapted to engage forked levers, as g^2 g^2, pivotally mounted upon the engine. The free ends of the levers g^2 engage the ends of the said valve-stems and force them open in accordance with the movement of the said cams. The cams are adapted to operate the valves alternately to cause the proper charging of exploding-chambers. In order to operate the valves h^4 h^4, controlling the entrance of the gaseous mixture into the cylinder A, I also secure to the shaft G suitable cams, as g^3, which engage levers g^4, pivotally mounted upon the frame of the engine. The free ends of these levers engage the ends of the said valve-stems and operate them in accordance with the movement of the cams. The cams are so timed as to operate the said valves h^4 alternately at the proper time. In order to force the valves j', controlling the exhaust-passages, at the proper time, I secure a cam j^3 to the shaft f^2. The said cam engages levers j^4 j^4, which are adapted to come in contact with the ends of the valve-stems and force them open in accordance with the movement of the said cam j^3. The gearing between the shafts f^2 and G is so constructed as to cause the latter shaft to revolve but once upon every two revolutions of the former shaft in order to produce the required movement of the various cams above described.

The cylinder C is adapted to receive its supply of compressed air through an inlet-passage c^5. The passage c^5 connects with the ends of the cylinder C by means of valve-controlled passages c^6. The valves c^7, which control these passages, are adapted to be held normally closed by means of springs c^8 and are so constructed that the air can only pass through them when the valves are opened by means of suitable mechanism. In order to open the said valves, a cam, as g^5, which engages levers g^6, the said levers being adapted to operate the valves c^7 through their stems c^9, is mounted upon the shaft G. The cam g^5 is adapted to open the said valves alternately to allow the compressed air to enter the ends of the cylinder C alternately as desired. Upon the other side of the cylinder is formed an exhaust passage-way c^{10}, communicating with both ends of the cylinder and connected with valve passage-ways. These passage-ways are provided with valves similar to the valves c^7 c^7 and are adapted to be operated by means of levers, as c^{11} c^{11}, similar to the levers g^6 g^6, which levers c^{11} are operated at the proper time by means of a cam f^7, secured to the shaft f^2. The cam f^7 is so mounted on the shaft f^2 as to exhaust the cylinder alternately to correspond with the charging thereof. In constructing the cylinders of my engine, while they may be formed separately, yet they are cast all in one piece with the exception of the heads, which may be secured in place afterward in any suitable manner. The gas-cylinder A is preferably constructed with a water-jacket, as A′, surrounding the same to assist in keeping the temperature of said cylinder from reaching too high a point.

In connection with my improved mechanism above described I also assist the operation of my engine and materially increase its power and economy by means of certain condensing heating apparatus, as will now be described. The exhaust from the compressed-air cylinder is conducted through a pipe, as k, to a condensing-cylinder K and is adapted to be exhausted therefrom by means of a pump, as k', of any suitable construction, which is connected with the said condenser. In order to operate the piston of the pump k', I connect the same with a lever, as k^2, the said lever being fulcrumed upon an arm k^3 upon the frame of the engine. The other end of the lever k^2 is connected by means of a link k^4 with the cross-head of the piston-rod c^2. It will be seen that upon the reciprocation of the piston-rod c^2 the lever k^2 will be rocked and communicate a reciprocating movement to the piston or pump k'. The pump k' is connected by means of suitable piping with compressed-air cylinders, as L, and the pump k' is then adapted to draw out the exhaust from the condenser K and force it after it has been cooled therein into the compressing tanks or cylinders L L, a check-valve k^5 being used in the said piping to prevent any backflow of the compressed air into the pump. In order to cool the air and exhaust from the air-cylinder, I contemplate providing the condenser with a series of pipes, as k^6 k^6, through which a cooling liquid, as cold water or other suitable fluid, may be passed. By making the pipes k^6 numerous and reasonably thin the heated air from the engine may be quickly condensed or cooled.

In Fig. 6 of the drawings I have illustrated one way in which water or other cooling liquid may be forced into the condenser. In this view M illustrates a circular pump adapted to draw water from any suitable source and force it into one end of the condenser, as at m. It would then pass through the pipes therein to the opposite end of the condenser, as at m', and out through a discharge-pipe m^2. It will be apparent that the water might be caused to flow through the said condenser by placing a head of water above the said condenser and allowing it to pass out through the pipes thereof. Any other means may be employed for forcing the water through the condenser. After the exhaust from the air-engine has been thus cooled it can be compressed in the air-tanks L L more easily than if it remained in a heated condition. By means of the use of a three-way cock, as l, the pump may be caused to compress the air in but one tank at a time, so that the compressed air from the other tanks may be used to run the air-engine cylinder. Gages, as l', may be mounted upon the tanks L to indicate the amount of compression which the air inside has undergone. In order to further increase the capabilities of my improved engine, I also contemplate heating the air in the said tanks to increase its expansive power before using it in the air-chamber. For this purpose I utilize the hot exhaust from the gas-cylinder A, passing the same through suitable pipes, as l^2, which run through the air-tanks L. These pipes l^2 may be extended from end to end of the said tanks L, as illustrated in the drawings, or they may be arranged in a coil form. Any other arrangement of pipes can be used without departing from the spirit of my invention. It will be readily seen that by passing the exhaust from the gas-engine I will be enabled to use the great heat which is generated by the action of the said cylinder, and thus greatly increase the expansive power of the air in the tanks for use in the air-cylinder. The air-cylinders are connected with an air-engine by any suitable pipe or pipes, as l^3, controlled by a suitable cock or cocks l^4. While I have illustrated in the drawings two tanks L L, yet it will be apparent that I can use any number of tanks. Among other advantages accruing from the use of a number of tanks L may be mentioned this, that the pump need not be required to compress air in the cylinder which is being used to run the gas-engine and which is under increased pressure by reason of the heated exhaust from the gas-cylinder.

In constructing an engine in accordance with my invention I find it of great advantage to arrange the cranks at points upon the circle of their travel which shall be one-third the distance of the said travel with relation to their cranks upon the said shaft. By this construction the pitmen of the different cranks will never be upon a dead-center at the same time and the pistons of the gas-cylinder and the air-cylinder will greatly aid each other in their operation.

It will be apparent from the above description that I have produced an engine which is capable of great power and yet one which is simple in construction and operation. An engine constructed in this manner is under perfect control and may be started at any time, for by reason of the system of compressed-air tanks some of the tanks will always be charged with compressed air and can be used in the air-cylinder at any time to start the engine. The continued use of the compressed air in the air-cylinder adds greatly to the power of the engine, and on account of the system of cranks by which the different piston-rods used in my invention are connected to one common shaft the air-engine is adapted to aid the gas-engine and the compressor at all dead-centers, thus increasing the smooth running of the engine. By means of my system of condensing the air which has been highly heated in the engine and compressing it in tanks for use again and heating the said air after being compressed I produce great economy in the forces used in the engine and increase its power and capability to a great extent. I also contemplate conducting the exhaust from the gas-engine after its heat has been utilized to increase the expansive power of the air in the air-tanks to the condenser and cooling it in conjunction with the air from the air-cylinder and compressing it therewith in the air-tanks. This, in addition to the use of the said exhaust again, prevents any noise which would otherwise accrue from discharging the exhaust into the open air. It will be apparent, however, that I may discharge the exhaust directly into the open air without affecting the construction and operation of my device.

Although I have above described the use of a pump for forcing cold liquids through the pipes of the condenser for cooling the hot air and exhaust from the engine, yet it will be apparent that I could employ a fan or blower of any suitable construction for forcing cold air through the said pipes to cool the exhaust and cause the condensation of the same without departing from the spirit of my invention. I could also use any other similar mechanism for accomplishing these ends.

In Fig. 1 of the drawings I have indicated at A^2 a valve of any suitable construction which is adapted to act as a snifting-valve or a safety-valve, it being constructed like the other valves in the engine and loaded with a spring of suitable stiffness to prevent its opening under the ordinary action of the engine. In the case of an accidental firing of the explosive mixture in the compression-chamber from any cause these valves will act as safety devices and prevent any harm from coming to the engine-casing. I contemplate using any suitable form of safety-valve for this purpose.

Having now described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In an air and gas engine, the combination with a main shaft provided with crank portions, of pistons connected to the same, cylinders to inclose the said pistons, means for running one of said pistons by means of a gaseous or explosive mixture, means for operating another piston by compressed air, a third piston being operated by one of the cranks in conjunction with the piston in the gas-cylinder to compress and force the gaseous and explosive mixture into the said gas-cylinder, substantially as described.

2. In a gas-engine, the combination with a suitable cylinder, of a compressor adapted to draw in and compress a gaseous mixture from any suitable source, compression-chambers arranged at each end of the said cylinder to receive the said compressed mixture, exploding-chambers separate from the compression-chambers, means for connecting the said chambers and connecting with ports leading into the cylinder, and valves for regulating the charging and exploding of the gaseous mixture in the exploding-chambers alternately at each end of the cylinder, substantially as described.

3. In a gas-engine, the combination of a cylinder having one or more inlet-ports at each end, exploding-chambers communicating with each inlet-port, valves for regulating the admission of an explosive mixture to said ports at predetermined intervals, compression-chambers at each end of the cylinder separate from the said exploding-chambers, valves for controlling the communication between the exploding and compression chambers, a compressor adapted to force a gas and air mixture into the said compression-chamber, valves for controlling the said compressed mixture and means connected with the main shaft of the engine for controlling the operation of the valves, substantially as described.

4. In a gas-engine, the combination with a suitable cylinder, of compression-chambers formed at each end thereof, two exploding-chambers connected with each compression-chamber, valves for regulating the flow of the compressed mixture from the compression-chamber to the exploding-chambers, cams adapted to engage the stems of the said valves, springs for normally holding the said valves closed and means connected with the main shaft of the engine for operating the said cams, substantially as described.

5. In a gas-engine, the combination with a suitable cylinder, of compression-chambers adapted to receive charges of compressed exploding material, exploding-chambers separate from the compression-chambers, valves for controlling the passage of the compressed material from the compression-chamber to the exploding-chambers and from the exploding-chambers to the cylinder, levers mounted upon the engine and adapted to engage the ends of the stems of said valves, cams adapted to engage the said levers and means connecting the said cams with a moving part of the engine for operating the said cams, substantially as described.

6. In a gas-engine, the combination with a suitable cylinder, of compression-chambers formed at each end thereof, exploding-chambers interposed between the compression-chambers and the ends of the cylinders, valves for controlling the movement of the compressed mixture through the said chambers to the cylinder, a transverse shaft mounted upon the engine-cams secured to said shaft and adapted to engage the stems of said valves, spiral gearing interposed between the said shaft and a working part of the engine for communicating motion to said cams, substantially as described.

7. In a gas and air engine, the combination with suitable cylinders for receiving a gas-exploding mixture and compressed air, of compression-chambers, exploding-chambers, valves for regulating the flow of an explosive mixture through the same, exhaust-passages also connected to the said cylinder, valves for controlling the said exhaust, valves for controlling the admission of compressed air to the air-cylinder and valves for controlling the exhaust therefrom, a shaft for controlling the inlet-valves, and a shaft for controlling the exhaust-valves, cams upon said shafts engaging said valves and spiral gearing interposed between the said shafts and means connecting the said shafts with a working part of the engine for operating the same, substantially as described.

8. In a gas and air engine, the combination with suitable cylinders, of means for forcing an exploding mixture into the gas-cylinder, valves for controlling the flow of the said mixture, exhaust-passages also connected with the said cylinder, valves for controlling the said exhaust-passages, means for supplying compressed air to the said compressed-air cylinder, valves for controlling the said supply, exhaust-passages also connected with the said air-cylinder, valves for controlling the said exhaust-passages, a shaft mounted upon the said engine, cams mounted upon the said shaft adapted to engage the stems of the said inlet-valves, another shaft mounted upon the said engine, cams mounted upon the said shaft, the said cams being adapted to engage the stems of the exhaust-valves for operating the same, gearing interposed between the said shafts and means connecting the said shafts with the main shaft of the engine for imparting movement thereto, substantially as described.

9. In a gas-engine, the combination with a suitable cylinder, of a compressor for forcing a gas mixture into the same, compression-chambers to receive the same, exploding-chambers for receiving the mixture from the compression-chambers, valves for controlling the admission of the mixture from the exploding-chamber to the said cylinder, the stems of these valves extending into the passage communicating with the cylinder and being provided with a projection, a spring-contact adapted to engage the said projection when the valve-stem is closed, means for insulating the said valve-stem and the said projection, means for connecting the said valve-stem and the said contact with the poles of an electric circuit, the construction being such that upon the opening of the valve the circuit will be broken whereby a spark is produced to ignite the gas mixture, substantially as described.

10. In an air and gas engine, the combination with a suitable shaft, of a piston connected therewith, adapted to be operated by an explosive mixture, a piston connected to said shaft, and adapted to be operated by compressed air, means for delivering compressed air thereto, means for conveying away the exhaust of the air-cylinder, a condenser adapted to receive the said exhaust, a pump connected with said engine for drawing off the said exhaust from the condenser and forcing the same into tanks, tanks for receiving the said exhaust, the said tanks forming a compressed-air supply for running the compressed-air cylinder, and means for connecting the said tanks with the said engine, substantially as described.

11. In an air and gas engine, the combination with a suitable shaft, of a piston connected therewith adapted to be operated by an explosive mixture, a piston also connected with said shaft and adapted to be operated by compressed air, means for supplying compressed air to operate the air-piston, a condenser comprising a tank adapted to receive the exhaust from the air-cylinder, means for passing a cooling fluid through the said condenser for condensing the exhaust, a pump connected to said condenser, a lever mounted upon the frame of the engine and connected to the piston-rod of the air-engine, said pump being adapted to draw out the cooled air from the condenser and force it into tanks, compressed-air tanks adapted to receive a cool exhaust from the pump, a check-valve to prevent the back throw of the compressed air and means for heating the air in the compressed-air tanks for increasing its expansive power, substantially as described.

12. In an air and gas engine, the combination with a shaft, of a piston connected therewith, and adapted to be operated by an explosive mixture, a piston also connected with said shaft and adapted to be operated by compressed air, means for supplying compressed air to operate said latter piston, a condenser adapted to receive the exhaust from the said air-engine, means for forcing a cooling liquid through the said condenser to cool the exhaust, a pump connected with the said engine adapted to draw out the cooled air and force it into tanks, tanks adapted to receive the air from the pump, means for conducting the exhaust from the gas-engine through the said air-tanks whereby the great heat of the said exhaust will be imparted to the air in the compressed-air tanks for greatly increasing its expansive power, and means for connecting the said tanks with an air-cylinder for supplying compressed air thereto, substantially as described.

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

JOHN W. EISENHUTH.

Witnesses:
JOHN A. HILTON,
JAMES J. MURPHY.