No. 745,704. PATENTED DEC. 1, 1903.

G. WESTINGHOUSE.

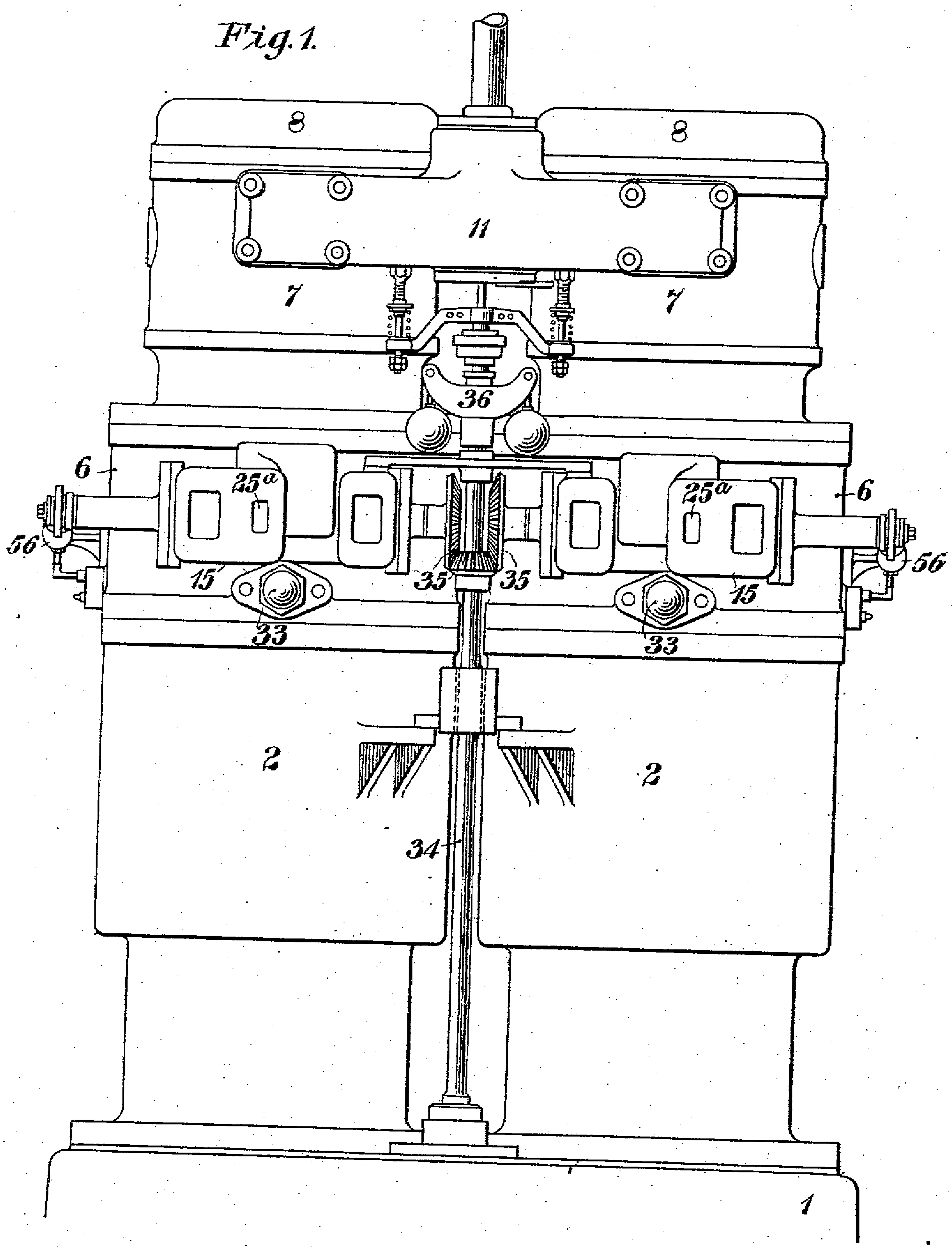
GAS ENGINE.

APPLICATION FILED APR. 30, 1901.

NO MODEL.

2 SHEETS—SHEET 1.

Fig. 1.



WITNESSES:

C. L. Belcher

J. C. Morse

INVENTOR

George Westinghouse

BY

Wesley G. Carr

ATTORNEY.

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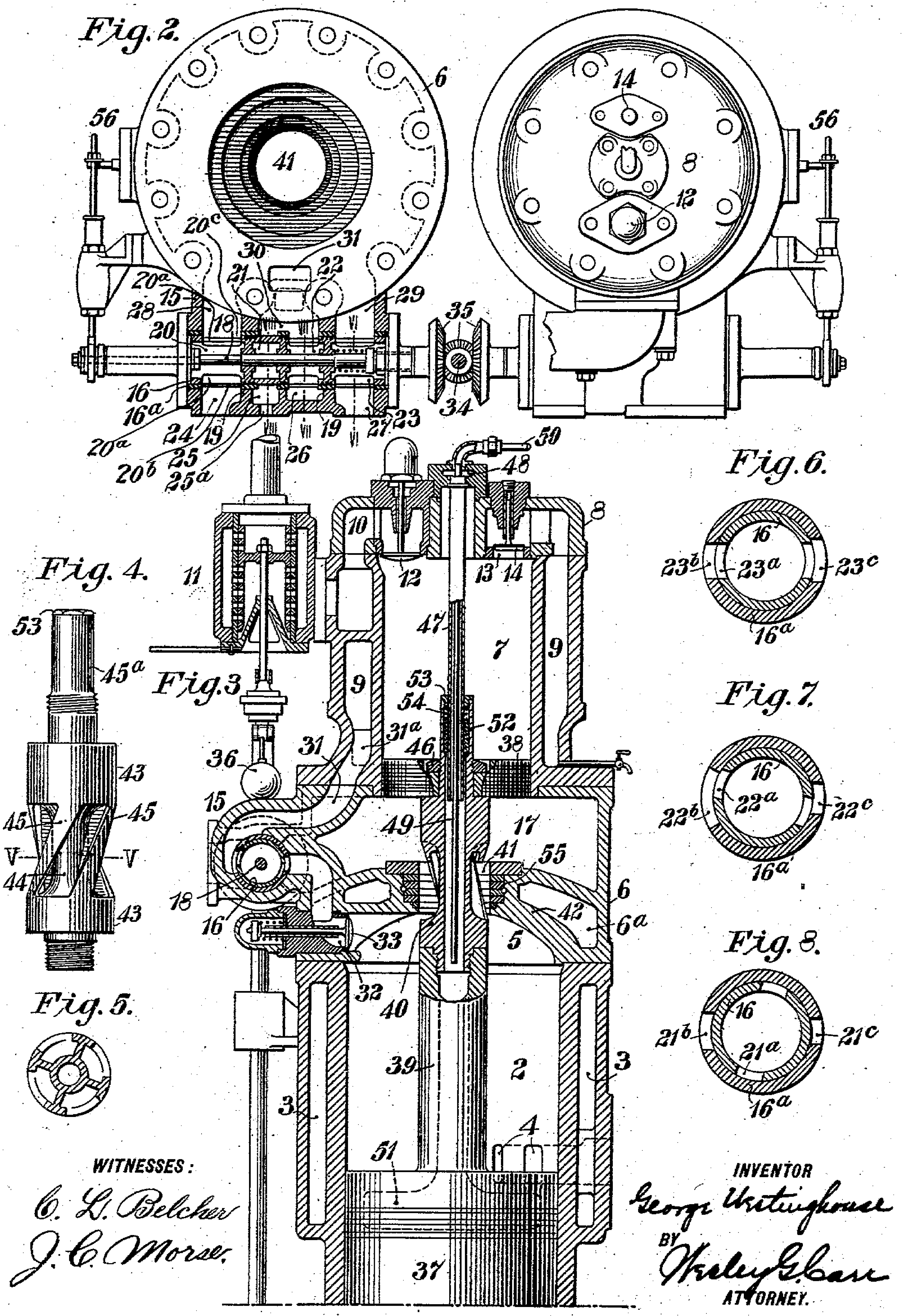

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UNITED STATES PATENT OFFICE.

GEORGE WESTINGHOUSE, OF PITTSBURG, PENNSYLVANIA.

GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 745,704, dated December 1, 1903.

Application filed April 30, 1901. Serial No. 58,192. (No model.)

To all whom it may concern:

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

My invention relates to internal-combustion gas-engines; and it has for its object to provide a two-cycle engine of this character at a minimum cost of construction which shall be compact and symmetrical in structure and the operation of which shall involve a satisfactory scavenging of the explosion-cylinder and substantial immunity from premature explosions.

With these ends in view I have devised the engine and its attachments shown in the accompanying drawings, in which—

Figure 1 is a front elevation of a two-cylinder engine, the parts below the cylinders, except a portion of the base-casting, being omitted. Fig. 2 is a view, partially in plan and partially in section, of the engine shown in Fig. 1. Fig. 3 is a vertical sectional view of so much of the engine as is shown in Fig. 1. Fig. 4 is a detail side elevation of the valve for controlling the air-supply to the explosion-cylinder. Fig. 5 is a sectional detail view taken on line V V of Fig. 4. Figs. 6, 7, and 8 are sectional detail views taken, respectively, on lines VI VI, VII VII, and VIII VIII of Fig. 2.

The invention is illustrated as embodied in engines of the vertical type, and for convenience it will be described as pertaining to such engines. I desire it to be understood, however, that the invention is not limited to vertical engines and that wherever terms are employed in the description which so define the relative location or the movements of parts as to apparently limit the same to such engines such use of terms is for convenience of description only and is not to be so construed as to limit the invention to engines of that type.

The two explosion-cylinders of the engine and the parts contained therein and supported thereby are substantial duplicates of each other as regards both structure and mode of operation, except that one of the pistons is so connected to the main shaft (not shown) as to move upward while the other is moving downward, as is usual in two-cylinder engines, and I shall, therefore, describe one of the cylinders and the parts contained in and supported by it with the understanding that such description applies to the other cylinder and the parts contained in and supported by it. It will be further understood that the illustration of a two-cylinder engine is not intended to exclude from the scope of my invention either single-cylinder engines or those having a greater number of cylinders than two.

The casting 1, constituting the base of the engine, only a portion of which is shown, may constitute a crank-case and be provided at its ends with bearings for a main crank-shaft, as is usual.

As has been already stated, engines constructed in accordance with my invention may embody one explosion-cylinder and coöperating apparatus contained in and supported thereby or a plurality of such cylinders and coöperating apparatus. Since in general the cylinders, if there be more than one, are of the same construction and are provided with the same coöperating apparatus, I shall for convenience describe one cylinder and the coöperating parts located in and supported thereby with the understanding that such description is intended to apply either to a single-cylinder engine or to a plural-cylinder engine.

In the form of engine shown in the drawings the explosion-cylinder 2 is mounted vertically upon the crank-case 1 and is provided with chambers or passages 3 in its walls for the circulation of a cooling liquid, as is usual in gas-engines, and is also provided with one or more exhaust-ports 4, that may communicate with a suitable exhaust-pipe. (Not shown.)

The ignition-chamber 5 at the upper end of the explosion-cylinder constitutes a continuation of said cylinder, but is formed in a separate casting 6, that is also provided with certain chambers, passages, and valves that will be hereinafter described.

Mounted upon the casting 6 is a cylinder 7, that is preferably in axial alinement with the cylinder 2, but of smaller diameter and has a head 8 attached in the usual manner. The walls of this cylinder are provided with a chamber 9 for receiving and temporarily storing a compressed non-explosive mixture of air and gas, as will be hereinafter more fully described. The cylinder 7 and casting 6 might constitute a single unitary structure so far as the operation is concerned; but for convenience of casting I prefer to make the structure in two parts, as indicated. The cylinder 7 is essentially a pump-cylinder, and it is provided, partially in its side wall and partially in the head 8, with a chamber 10 for receiving a non-explosive mixture of air and gas. This chamber 10 communicates with a mixing supply-valve 11, which is indicated as constructed substantially in accordance with Patent No. 483,585, granted to Edwin Ruud and myself June 1, 1897, and serves to properly regulate the mixture of air and gas supplied to the chamber 10 in the manner substantially set forth in said patent. The chamber 10 communicates with the upper end of the cylinder 7 through a port that is normally closed by a spring-seated inwardly-opening valve 12. A plurality of ports and corresponding valves may obviously be employed for admitting gas from chamber 10 to the cylinder 7, but ordinarily one such port and valve will probably be found sufficient in engines of moderate size. The upper end of the cylinder 7 communicates with the storage-chamber 9 through a port 13, that is provided with an outwardly-opening valve 14.

No limitation is intended to be placed upon the construction as regards the number, size, or form of passages, chambers, and valves thus far described, since these parts may be varied as regards number, form, location, and dimensions to suit specific conditions of service without departing from the invention.

The casting 6 is provided at one side with an extension 15, in which is located a rotatable cylindrical valve 16. This valve is employed to control the admission of air to a chamber 17 in the casting 6, which constitutes an extension of the cylinder 7, the passage of the air and gas mixture from the chamber 9, and a supply of compressed air for starting the engine. The valve 16 is mounted upon a shaft 18 and is divided by partitions 19 into four sections 20, 21, 22, and 23, that are respectively provided with ports 20^a, 21^a, 22^a, and 23^a. The valve is surrounded by a bushing 16^a, that has ports 20^b, 21^b, 22^b, and 23^b at one side and similar ports 20^c, 21^c, 22^c, and 23^c at the other side, with which the valve-ports coöperate as the valve is rotated.

The two valve-sections 20 and 23 are substantially alike both as regards their structure and the service performed, and consequently detailed illustration and description of one of them will suffice for both.

The extension 15 is provided at the outer side of the valve with chambers 24, 25, 26, and 27, corresponding to the valve-sections and bushing-ports, and at the inner side with two end chambers 28 and 29 and a single middle chamber 30. The chamber 26 is connected with the storage-chamber 9 by a passage 31, and chambers 24 and 27 are open to the atmosphere. A partition-wall 31^a is located at each side of the inlet from chamber 9 to passage 31, so that water which may leak from the cooling-pipes into the cylinder 7 and be carried with the mixture into chamber 9 may be prevented from entering said passage. The water may be withdrawn from the bottom of chamber 9 by means of an ordinary stop-cock. The chamber 30 extends to a port 32 in the ignition-chamber 5, that is provided with an inwardly-opening valve 33, and the chambers 28 and 29 communicate directly with the air-chamber 17. The chamber 25 is provided with a port 25^a, through which compressed air may be supplied from a suitable source for starting the engine.

The valve-shaft 18 is rotated by the governor-shaft 34 and bevel-gears 35, the gear-wheels being so proportioned and the valve so adjusted as to control the admission of air to chamber 17 and the non-explosive mixture from chamber 9 to the port 32 in accordance with the stroke of the engine-pistons and also the supply of compressed air to the port 32 for starting the engine.

The valve mechanism for controlling the supplies of air and non-explosive mixture to the chamber 17 and the cylinder 2, respectively, may be varied within widely-separated limits without departing from my invention, provided it is so constructed and arranged as to effect the desired results.

The shaft 34 is provided with a suitable governor 36, that operates in the usual manner to automatically adjust the mixing supply-valve 11.

In the two-cylinder engine shown a right and left hand arrangement of ports is indicated, and the two valves 16 are indicated as actuated by a single bevel-pinion on the governor-shaft. Other types and arrangements of gearing may obviously be employed whatever may be the number of cylinders and valves.

The piston 37, that is located and operates in the explosion-cylinder 2, is actuated by explosions in the cylinder to drive the main shaft through suitable connecting mechanism and is rigidly connected to the piston 38, which is located in cylinder 7, by means of a hollow stem 39, that is provided with or embodies a valve device 40. This valve device operates in a cylindrical opening 41, formed in the head or partition-wall 42, which separates the chamber 17 from the ignition-chamber 5 and, as shown, constitutes an integral part of the casting 6.

The valve device 40 comprises two heads 43, a tubular stem 44, and a plurality of spirally-inclined wings 45, the outer surfaces of which constitute parts of a cylinder of which the heads 43 are the ends. The inclined arrangement of wings affords the same result as regards wear upon the cylinder 41, through which the valve moves as would a solid cylindrical valve and at the same time provides spaces between the wings for the passage of air. The valve device 40 has a tubular extension 45^a, that projects through and above the piston 38, to which it is rigidly fastened by means of a nut 46. The extension 45 is provided in order to insure ready accessibility to the packing devices which surround a stationary pipe 47, that projects through and terminates slightly below the piston 38. The pipe 47 is supported by the head 8 of the cylinder 7 and communicates with a chamber 48 in the said head. This chamber 48 may communicate with cooling-chambers 3 in the walls of the cylinder and also with the chamber 6^a in the casting 6, and the water for cooling purposes may be either introduced into one of these chambers or withdrawn therefrom, as may be desired. In order to complete the circulatory system, I provide a pipe 49 of relatively small diameter, that is also supported in the head 8 and projects through the pipe 47 and to some distance beyond its lower extremity. The upper end of this pipe 49 is connected to a pipe 50, through which cooling-water is supplied to the circulatory system or withdrawn therefrom, according to the direction of circulation.

The tubular stem 39 is shown as communicating at its lower end with a chamber 51 in the top of the piston 37. This chamber may be made larger than is indicated or it may be omitted altogether, according to the size of the engine and the consequent necessity of cooling the piston.

Any suitable packing means may be employed between the pipe 47 and the extension 45^a; but I have shown a satisfactory means which comprises a plurality of metal packing-rings 52, interposed between the pipe and the valve extension, a nut 53, and a coiled spring 54. The cylindrical opening 41, through which the valve device 40 operates, may be provided with suitable packing-rings 55, seated in corresponding grooves, to which a suitable liquid may be supplied for lubricating purposes, if desired.

The igniting devices 56, which may be of any suitable construction, are here shown as operated by cams on the valve-shafts 18.

In describing the operation of the engine we will assume for convenience that the pistons 37 and 38 have reached the limit of their downward stroke as the result of an explosion in the cylinder 2, and that consequently the corresponding crank of the main shaft is substantially on its dead-center, this position of parts being indicated in Fig. 3. The downward movement of the piston 38 has served to draw into the cylinder 7 a charge of non-explosive mixture, and the air admitted to the cylinder 2 from the chamber 17 through the valve device 40 has driven out the greater portion of the products of combustion resulting from the preceding explosion. When the pressure in the cylinder 2 is reduced by the exhaust through the posts 4 to a point below the pressure of the non-explosive mixture in the chamber 9, such difference of pressure will unseat the valve 33, and the explosive mixture will therefore flow into the ignition-chamber 5, the mixture-ports in the valve 16 and its bushing 16^a being in such relative position as to admit this inflow of mixture. The inflow of non-explosive mixture will be timed to begin at about the time or shortly after the pistons begin their upward stroke and shortly after the flow of air through the valve device 40 has been cut off. The inflow of mixture will begin prior to the closing of the exhaust-ports 4 by the piston 37 and will therefore aid in completing the scavenging of the cylinder 2, the regulation being such that enough air will be left in the cylinder 2 to combine with the non-explosive mixture in such proportions as to form a suitable explosive mixture. As the pistons move upward a partial vacuum will be formed in the cylinder 7 below the piston 38 and in the chamber 17, and air will therefore flow in through the sections 20 and 23 of valve 16, the latter being so timed in its operation as to permit the inflow of air during substantially the entire time that the piston 38 is making its upward stroke. The upward movement of the piston 38 also compresses the non-explosive mixture in the cylinder 7 and forces it through the port 13 into the storage-chamber 9, thus providing a fresh charge for admission to the cylinder 2 at the proper time. During this upward movement of the pistons the inflow of non-explosive mixture to the cylinder 2 will continue until the pressures on the two sides of the valve 33 are approximately equal and be then stopped. It follows that the charge of mixture and air in the cylinder 2 will become intimately mixed and also compressed, so as to be ready for ignition when the pistons reach the limit of their upward stroke.

It will be both feasible and desirable to take air into the chamber 17 at a comparatively low temperature, and since the cylinder 2 and the parts operated therein are necessarily maintained at a high temperature the compressed air of comparatively low temperature which is admitted into the cylinder 2 by the valve device 40 will be heated to such a degree as will effect its expansion, so as to approximately fill the cylinder 2, and thus expel the burned gases, notwithstanding the comparatively low degree of compression to which the scavenging-air is subjected.

While the cylinder 2 and the parts operating therein necessarily operate at a high temperature, as above stated, I am enabled to keep the temperature down within safe limits by the cooling means hereinbefore described.

The type of engines here illustrated and described provides for wide variations in the quality of gas used. In the case of natural and illuminating gas the proportion of gas to air is about one to eight. In producer-gas and blast-furnace gas, however, about equal quantities of air and gas are required, while with other gases the proportion may be one of gas to two or three of air. In the arrangement shown it will be observed that a predetermined amount of air is supplied to the explosion-cylinder at each revolution of the engine. In the cylinder 7, above the piston 38, however, the proportion will vary according to the character of the gas, and this variation will be effected in the manner described in Patent No. 583,585, hereinbefore mentioned.

It will be observed that this type of engine differs materially from the ordinary explosion-engines in which the required explosive mixture of air and gas is drawn into the explosion-cylinder, and is thus in a condition to be exploded by heat of compression or otherwise. In the engine here illustrated and described air is admitted to the explosion-cylinder after each explosion for scavenging purposes, and a non-explosive mixture of air and gas is subsequently supplied from the storage-chamber, so that the air and non-explosive mixture are gradually commingled during the return stroke of the piston. By this separate and subsequent admission of a non-explosive mixture to form the explosive mixture by combining with air previously admitted I am enabled to operate the engine with less than the usual clearance between the piston and the cylinder-head, and thereby secure a greater degree of compression and a greater resultant economy in the use of gas, since what is generally termed a "premature explosion" will rarely occur in an engine of this type, even with high compression, whereas premature explosions would be so frequent in the ordinary type of engine as to make high compression practically impossible.

I am aware that variations from what is specifically shown and described may be made not only in form, but in relative dimensions and in the arrangement and location of parts without departing from the spirit of the invention or materially varying the results obtained, and I therefore desire it to be understood that my invention is not limited to structural details any further than limitations may be imposed by the state of the art.

I claim as my invention—

1. In a gas-engine, the combination with a compressing-cylinder and an explosion-cylinder, of pistons in the respective cylinders and a rigid connection between them which embodies a relatively immovable valve device for controlling a supply of compressed air to the explosion-cylinder.

2. In a gas-engine, the combination with a compressing-cylinder and an explosion-cylinder having their axes in alinement with each other, of pistons for the respective cylinders and a rigid connection between the same which embodies a relatively immovable valve device for controlling a supply of compressed air to the explosion-cylinder.

3. In a gas-engine, the combination with an air and gas compressing cylinder and its piston, of an explosion-cylinder and its piston, and a valve device operatively connected to the two pistons but immovable with reference thereto and serving to control a supply of compressed air from the compressing-cylinder to the explosion-cylinder.

4. In a gas-engine, the combination with an explosion-cylinder having exhaust-ports at or adjacent to one end and inlet-ports at the other end, of a compressing-cylinder having communication from each end to the explosion-cylinder, a valved inlet at one end, connected pistons for the respective cylinders and a valve device operated thereby to control a supply of compressed air to the explosion-cylinder.

5. In a gas-engine, the combination with a compressing-cylinder and an explosion-cylinder, of pistons for the respective cylinders connected to operate in unison and a relatively immovable valve device which is operated thereby to admit compressed air from the compressing-cylinder to the explosion-cylinder to drive out the products of combustion resulting from explosions.

6. In a gas-engine, the combination with an explosion-cylinder having an exhaust-port and a piston serving as the valve for said port, of a compressing-cylinder in line with the explosion-cylinder and having a valved air-inlet at the end adjacent to the explosion-cylinder, a valved gas or mixture inlet and a valved outlet at the opposite end, a storage-chamber with which said valved outlet communicates, a compressing-piston and a valve device connected to and operated by the pistons to admit compressed air from the compressing-cylinder to the explosion-cylinder when the exhaust-port is uncovered.

7. In a gas-engine, the combination with a compressing-cylinder and its piston, of an explosion-cylinder and its piston, a stem connecting the two pistons and embodying a relatively immovable valve device for controlling the admission of compressed air to the explosion-cylinder and means for circulating a cooling liquid through said stem and valve device during the operation of the engine.

8. In a gas-engine having compressing and explosion cylinders and connected pistons operating therein, a valve device forming a connection between the pistons and embodying a central, tubular part, cylindrical heads and inclined wings connecting the two heads.

9. In a gas-engine having a compressing-cylinder and an explosion-cylinder respectively provided with pistons rigidly connected by means of a hollow stem, of a valve device incorporated in said stem, said device having cylindrical heads and being cut away between said heads to form inclined wings for engagement with the cylinder in which the valve device operates.

10. In a gas-engine, the combination with a compressing-cylinder and an explosion-cylinder each provided with suitable inlet and exhaust ports, of pistons for said cylinders and a hollow stem rigidly connecting said pistons

and embodying a piston valve device the sides of which are cut away to form inclined or spirally-disposed wings to guide and direct the currents of air through the cut-away portions and to engage with the walls of the cylinder in which the device operates.

11. In a gas-engine, the combination with an explosion-cylinder having exhaust-ports and a piston serving as the valve for said ports, and a compressing-cylinder having valved inlet and outlet ports at one end and a storage-chamber with which the outlet-port communicates, means for controlling the admission of air to the other end of the compressing-cylinder, a piston in said cylinder, and a stem which connects said piston to the explosion-cylinder piston and has a valve device for controlling the supply of air to the explosion-cylinder.

12. In an internal-combustion engine, the combination with an explosion-cylinder and a compressing-cylinder in line therewith, of rigidly-connected pistons in the respective cylinders, the piston in the compressing-cylinder being double-acting and serving on one side to supply the requisite amount of air for scavenging the explosion-cylinder and on the other side to supply a mixture of air and gas to form, by combination with a portion of said supply of air, the required explosive mixture, at each revolution of the engine-shaft.

13. In an internal-combustion engine, the combination with an explosion-cylinder and a compressing-cylinder having their axes in alinement, of rigidly-connected pistons for the respective cylinders, the compressing-piston being double-acting, means for supplying air from one end and a mixture of air and gas from the other end of the compressing-cylinder to the explosion-cylinder during each double stroke of the pistons.

14. In an internal-combustion engine, the combination, with an explosion-cylinder having inlet-ports at one end and exhaust-ports at the other end and a compressing-cylinder in axial alinement with the explosion-cylinder and having inlet and outlet ports at each end, the latter of which constitute or are connected with inlet-ports for the explosion-cylinder, of rigidly-connected pistons in the respective cylinders, the compressing-piston being double-acting and means for admitting a mixture of air and gas to one end of the compressing-cylinder prior to the introduction of air into the explosion-cylinder from its other end.

15. In an internal-combustion engine, the combination with an explosion-cylinder and a compressing-cylinder in axial alinement with each other, of rigidly-connected pistons in the respective cylinders, the compressing-piston being double-acting, and mixture and air connections between the respective ends of the compression-cylinder and the ignition end of the explosion-cylinder whereby air is admitted to the explosion-cylinder to drive out the products of combustion and thereafter a mixture is introduced to combine with a portion of such air to form an explosive mixture at approximately the time the piston reaches the ignition end of its cylinder.

16. In an internal-combustion engine, the combination with an explosion-cylinder and a compressing-cylinder in axial alinement, of rigidly-connected pistons in said cylinders, the compressing-piston being double-acting, valves for admitting air and a mixture of air and gas to the respective ends of the compressing-cylinder, means for admitting a scavenging charge of air from the compressing-cylinder to the explosion-cylinder when the pistons approach their limit of stroke in one direction and means for subsequently admitting a mixture charge as the pistons are beginning their return stroke.

17. In an internal-combustion engine, a power-piston having a hollow extension, in combination with two liquid-conducting pipes located the one within the other and projecting into said extension.

18. In an internal-combustion engine, the combination with an explosion-cylinder and a piston therein having a hollow extension, of two liquid-conducting pipes projecting, the one within the other, into said hollow extension, one of said pipes being of greater length than the other.

19. In an internal-combustion engine, the combination with an explosion-cylinder and a piston therefor, having a hollow extension, of two liquid-conducting pipes located, the one within the other, and projecting different distances into said extension and a packing means between the free end of the extension and the outer pipe.

20. In an internal-combustion engine, the combination with an explosion-cylinder and a compressing-cylinder in axial alinement, of pistons in the respective cylinders, a hollow stem projecting from the explosion-piston through the compressing-piston and two concentric pipes of different length projecting into said hollow stem.

21. In an internal-combustion engine, the combination with an explosion-cylinder and a compressing-cylinder in axial alinement, of pistons in the respective cylinders, a hollow stem projecting from the explosion-piston through the compressing-piston and a removable packing between the free end of the hollow stem and the outer pipe.

22. In an internal-combustion engine, the combination with an explosion-cylinder and a compressing-cylinder in axial alinement, of pistons in the respective cylinders, a hollow stem connecting said pistons and embodying a valve device for controlling the flow of compressed air from the compressing-cylinder to the explosion-cylinder, two concentric pipes projecting into said hollow stem and a removable packing between the free end of the stem and the outer pipe.

23. In a gas-engine, the combination with a compressing-cylinder and an explosion-cylin-

der, of pistons in the respective cylinders, the compressing-piston being double-acting and means for so regulating the supply of air and non-explosive mixtures to the explosion-cylinder that the resulting mixture does not attain explosive condition until the main piston reaches approximately the limit of its compressing stroke.

24. In a gas-engine, the combination with a compressing-cylinder and an explosion-cylinder, of pistons in the respective cylinders, the compressing-piston being double-acting, a rigid connection between said pistons embodying a valve device for controlling the supply of compressed air to the explosion-cylinder and means for so regulating the supply of non-explosive mixture from the compressing-cylinder to the explosion-cylinder that the mixture thereof with air in the explosion-cylinder does not reach explosive condition until the main piston has reached substantially the limit of its compressing stroke.

25. In a gas-engine, the combination with a compressing-cylinder and an explosion-cylinder, of pistons in the respective cylinders and a rigid connection between them, means for admitting a non-explosive mixture of air and gas to the compressing-cylinder, a storage-chamber into which the mixture is forced by the compressing-piston, valves for successively admitting air and mixture into the explosion-cylinder as the pistons begin their return stroke, and means for igniting the resulting mixture when said return stroke is completed.

In testimony whereof I have hereunto subscribed my name this 23d day of April, 1901.

GEO. WESTINGHOUSE.

Witnesses:

A. M. Gow,

Wm. H. Capel.