No. 863,922. PATENTED AUG. 20, 1907.

C. HOUSUM & F. E. NORTON.

GAS ENGINE INLET VALVE.

APPLICATION FILED APR. 11, 1906.

4 SHEETS—SHEET 1.

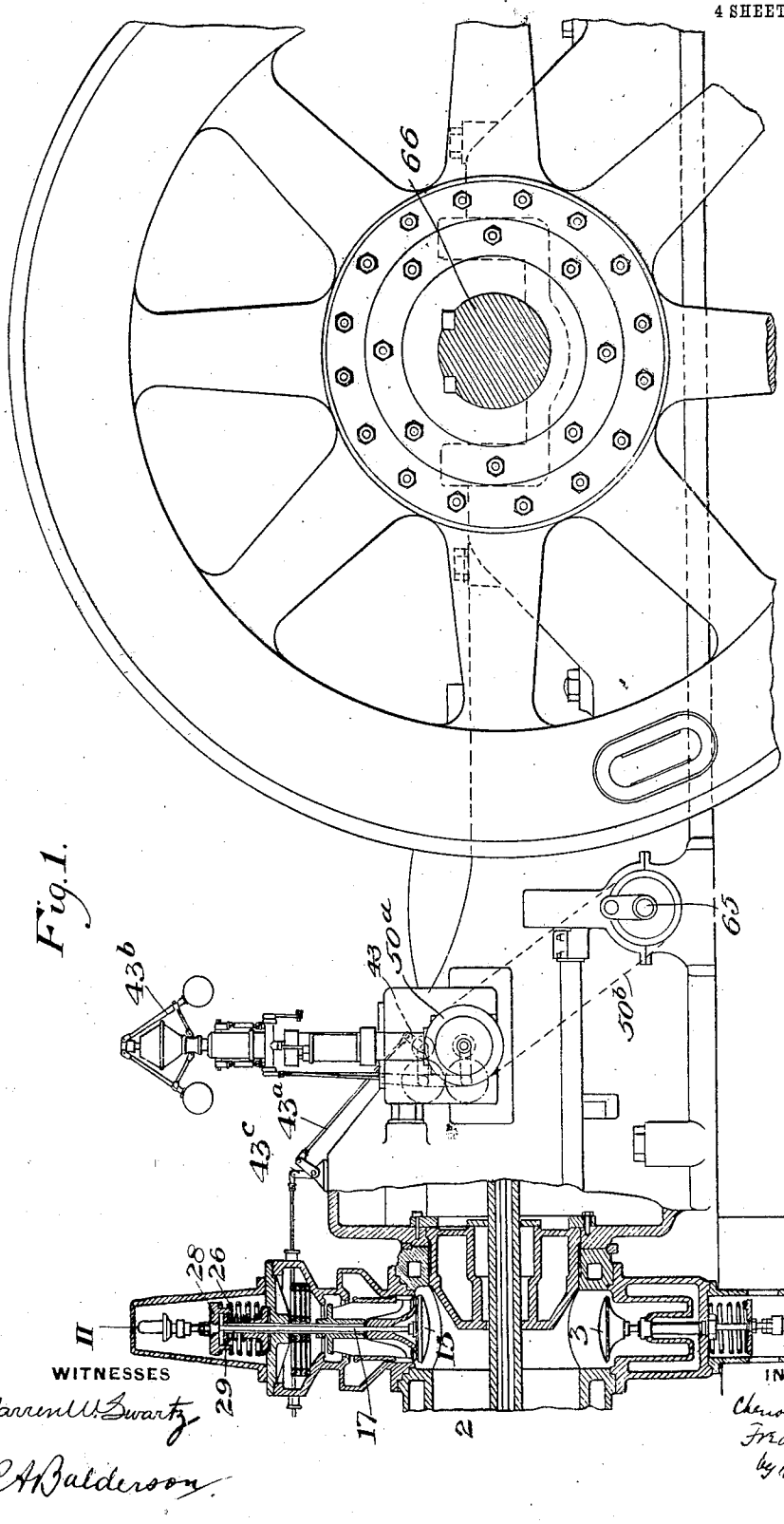

Fig. 1.

WITNESSES

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4 SHEETS—SHEET 2.

Fig. 2.

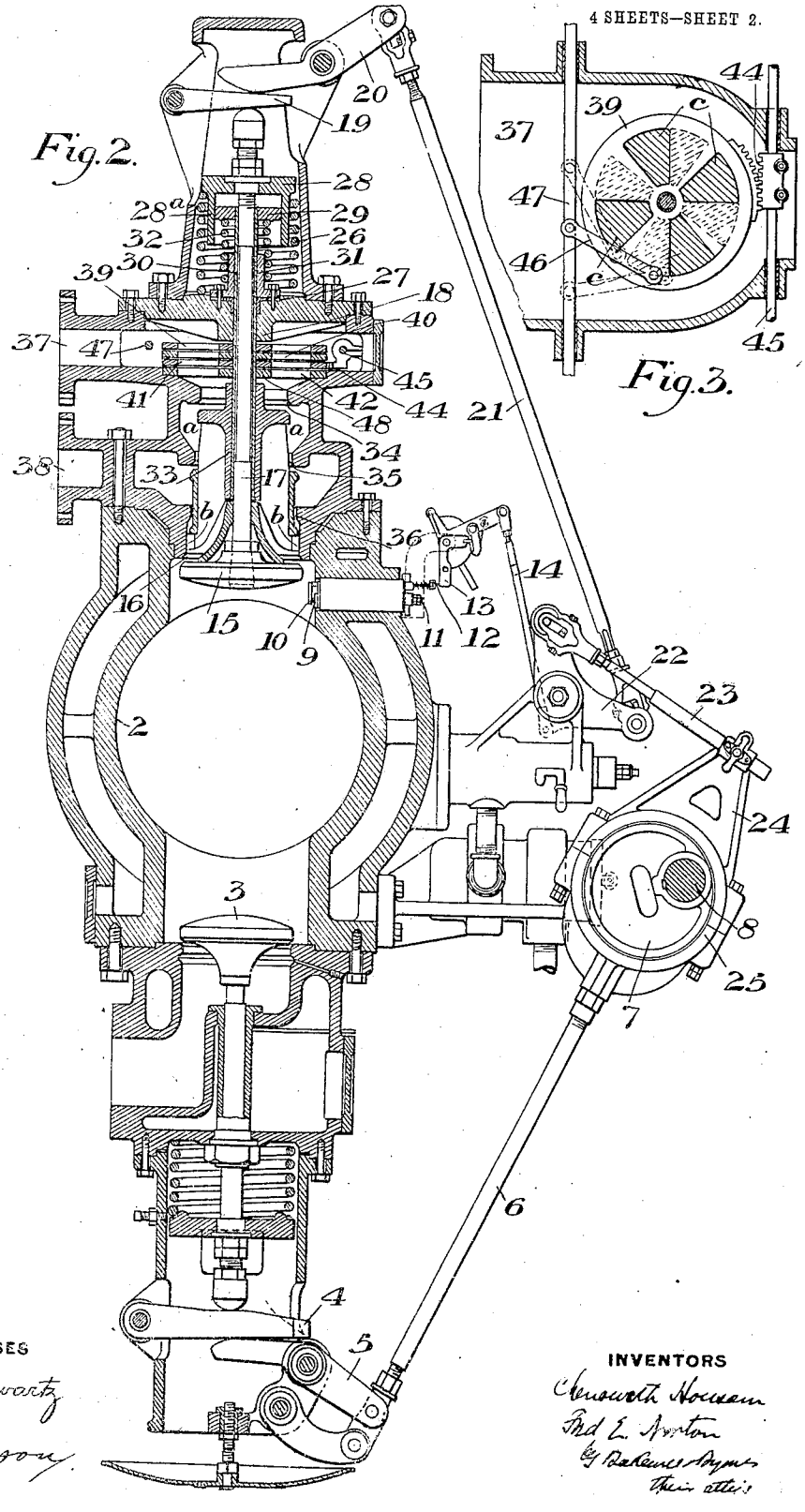

Fig. 3.

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4 SHEETS—SHEET 3.

Fig. 4.

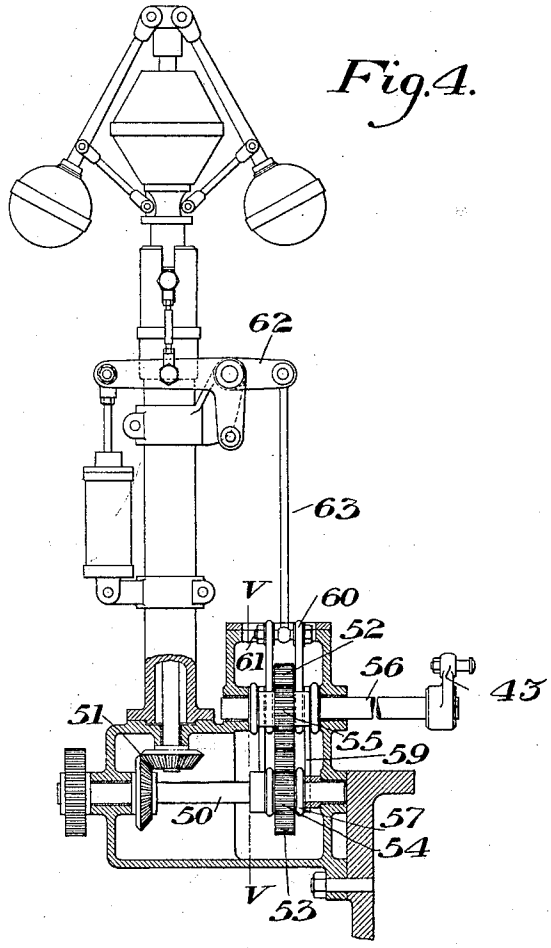
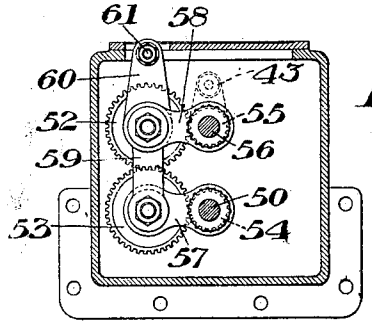


Fig. 5.



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4 SHEETS—SHEET 4.

Fig. 6.

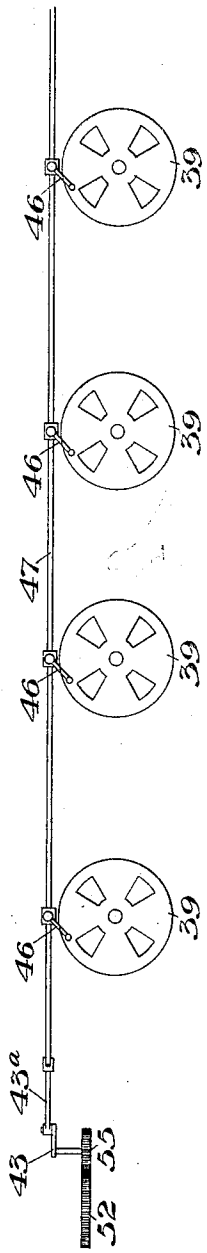
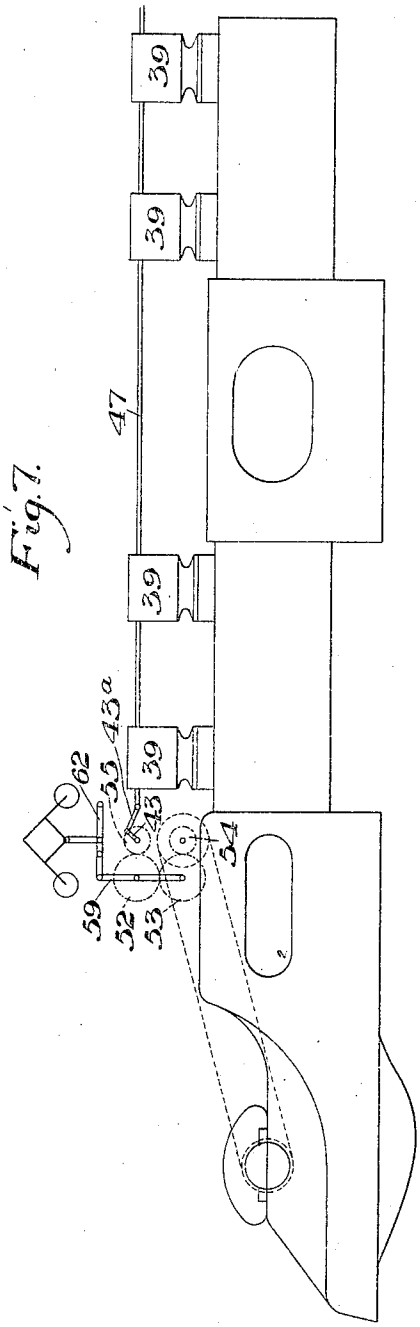


Fig. 7.



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UNITED STATES PATENT OFFICE.

CHENOWETH HOUSUM AND FRED E. NORTON, OF YOUNGSTOWN, OHIO.

GAS-ENGINE INLET-VALVE.

No. 863,922. Specification of Letters Patent. Patented Aug. 20, 1907.

Application filed April 11, 1906. Serial No. 311,037.

To all whom it may concern:

Be it known that we, CHENOWETH HOUSUM and FRED E. NORTON, both of Youngstown, Mahoning county, Ohio, have invented a new and useful Gas-Engine Inlet-Valve, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming part of this specification, in which—

Figure 1 is a sectional view showing our improved valve applied to one form of gas engine; Fig. 2 is a section on the line II—II of Fig. 1; and Fig. 3 is a view showing means for operating the gas admission valve. Fig. 4 is a side view, partly in section, showing one form of governor and its connections for operating one of the valve members; and Fig. 5 is a section on line V—V of Fig. 4. Figs. 6 and 7 are respectively plan and side views, largely diagrammatic, showing the application of our invention to a four-cycle, double-acting, tandem gas engine.

Our invention is applicable to gas engines of any form in which it is desirable to introduce the gas and air in predetermined proportions; and it consists in the novel construction and arrangement of valves and valve mechanism all substantially as hereinafter described and pointed out in the appended claims.

In the drawings, the numeral 2 designates the cylinder of a gas engine, 3 an exhaust valve of any suitable type which is operated by means of the compound lever mechanism 4, 5 and 6 from an eccentric 7 on a shaft 8, operated from the engine shaft by the usual half-speed gearing.

9 and 10 designate the sparking points, the point 9 being carried by a relatively fixed spindle 11, while the point 10 is carried by a longitudinally movable spindle 12, which is actuated by a hammer device 13, operated by a lever movement 14 connected to a lever of the inlet valve operating mechanism presently to be described. This igniting device forms, however, no part of our present invention, but is fully described and claimed in the co-pending application of Fred E. Norton, Serial No. 311,034, one of the applicants herein.

15 designates the inlet valve, which controls the admission port 16. The valve 15 is of the mushroom form, and is secured to a stem 17 having a guide at 18, and whose free end is engaged by a lever 19 of a compound lever-operating movement 19, 20, 21, 22 and 23 operated by an arm 24 of the strap 25 of the eccentric 7 before referred to.

The valve-operating mechanism shown and thus briefly described forms the subject-matter of a second application of the said Fred E. Norton, Serial No. 311,032, and is shown herewith for the purpose only of illustrating means for the operation of the inlet valve.

The valve stem 17 is disconnected from the lever 19, so that the valve and spindle are separate from all other parts and the valve is free to adjust itself to its seat against the peripheral wall of the admission port 16 under all conditions. The valve is seated by means of a spring 26 which has a bearing at one end against the engine frame at 27, and at its other end against the movable cap 28 which is secured to the spindle 17. The cap 28 is provided with a hollow cylindrical portion 28^a, in which is seated a piston 29 secured to a sleeve 30. Seated between the piston 29 and a boss 31 of the frame is a second spring 32. Secured to the sleeve 31 is a valve body 33, which is of cylindrical form, and which has the circumferential ports *a* and *b*. This valve 33 has the three seats 34, 35 and 36.

37 is the gas inlet and 38 the air inlet port. Seated around the sleeve 30 behind the valve 33 is a compound valve for controlling the admission of gas in the port 37 to the valve 33 and its chamber. This compound valve consists of four disks 39, 40, 41 and 42 placed adjacent to each other, and formed each with a series of segmental openings *c*. The disks 40 and 42 are stationary, while the disks 39 and 41 are capable of a rotary movement in order to vary the effective area of the openings through the series of disks. Various means may be provided for operating these movable disks. Thus, the disk 41 may be operated by hand, while the disk 39 can be operated by any suitable connection with the engine governor, the preferable method being, as shown in Fig. 1 to move said disk by means of a suitable crank or eccentric 43 having a fixed throw, but a variable time of motion relatively to the engine crank. This relative change in time may be accomplished in any of the ways usual for steam and other engines, and is not claimed as part of our invention.

In the drawing, 1 have shown the disk 41 as connected by gear 44 with a longitudinally movable rod 45 which may be operated by hand, or by any other suitable means, while the disk 39 is connected by a link 46 with a rod 47 which is connected through the levers 43^c and rod 43^a to the crank or eccentric 43, as shown in Fig. 1, and which is actuated by a connection 43^a to a governor 43^b.

Figs. 4 and 5 illustrate in detail one arrangement by which the governor is caused to act in the manner described. This governor is the usual fly-ball governor, driven from the engine shaft through the shaft 50 and bevel-gearing 51.

52, 53, 54 and 55 designate the gear wheels of an epicycloidal gear train, the gear wheel 54 being keyed to the shaft 50, and the wheel 55 to a shaft 56. The wheels 52 and 53 are intermediate gears, held in mesh by the links 57, 58, and 59, and the wheel 52 being supported by the links 60 which carry a pin 61 connected to the governor arm 62 by a link 63. On the end of the shaft 56 is the crank arm 43, to which the connection 43^a leading to the levers 43^c is attached. The ratio of the gears 52, 53, 54 and 55 is such that the crank 43 is driven at the same number of revolutions as the engine shaft. As the governor moves up

or down, it moves the gears 52 and 53 with it, and consequently causes the rotation of the crank 43 either clockwise or counter-clockwise, independently of the rotary motion given to it by the rotation of the engine. In other words, the action of the governor is to change the phase relation of the crank 43 with respect to the main engine crank.

In setting the valve plates, with the engine crank on center and the governor in its down position, the valve plate 39 will be on the point of opening, or "cutting-on". The down position of the governor, or the lowest extreme of its travel, is, of course, the full-load position. With the engine running at half load and the governor in its mid position, the crank 10 has been retarded by about ninety degrees of its travel and consequently the governor valve is not opened until about mid-stroke of the engine piston. The same result may obviously be obtained by using a shaft governor instead of a fly-ball governor.

The shaft 50 is shown as driven by a sprocket wheel 50^a and chain 50^b, (see Fig. 1), from a shaft 65 driven in any suitable manner from the main engine shaft 66.

By driving the gas governor valve at the same speed as the main engine shaft, we avoid a complication of shafts and driving mechanisms. This will be understood by considering a four-cycle double-acting tandem gas engine, with one cylinder behind the other. Designate the end of the cylinder next the bed-plate as A, the other end as B, the forward end of the second cylinder as C, and its other end as D, the inlet valve bonnets are all the same, and the rod 47 runs through all four bonnets. The governor valve plates of A and C will open clockwise, while by connecting the links 46 to opposite sides of the valve plates, the other valves may be made to open counter-clockwise. The rod 47 is reciprocated by the crank 43, so that the valves of A and C open on the forward stroke and B and D on the return stroke. The main valve 15, for A is the only main valve, however, which opens on the forward stroke, so that the opening of the governor valve for C is an idle movement, no gas being admitted. From this, the advantage of driving the gas valve at the same speed as the engine shaft will be clear, since otherwise a complication of mechanism would be required. In order to secure free movement of these disks, they may be separated from the adjacent fixed disks by means of small washers 48, as shown in Fig. 2. The gas is admitted through this compound valve, thence through the ports 34 and *a* into the interior of the valve 33, and thence into the cylinder by way of the ports *b* and 16. The air from the port 38 also passes into the valve 33 by way of the ports *a*, and thence to the cylinder, mixed with the gas, by way of the ports *b* and 16, the interior of the valve 33 forming a mixing chamber.

Fig. 1 of the drawing shows the position of the parts when the engine crank is on the dead point and is just about to start the piston forward on the inlet stroke. The valve 15 is slightly open, and the air in the cylinder 28^a back of the piston 29 is beginning to be compressed, thereby tending to open the valve 33. As soon as the engine piston moves forward, the pressure in the cylinder 2 falls, and the valves 15 and 33 move forward, admitting air through the port 38. The valve disk 39, which is controlled by the governor, will not at this time have opened unless the engine is under maximum load, and consequently no gas will be admitted until the crank is moved through an angle determined by the governor. At some point in the forward stroke of the engine piston, the valve 39 will open, and for the remainder of the suction stroke air and gas will be admitted in a constant proportion, as determined by the effective areas of the ports 34 and 35, or by the throttling through the fixed disks 40 and 42 by the movement of the disk 41. The movement of the disk 39 may be controlled in such a manner that it will admit gas during the entire stroke, when the governor is in its position corresponding to the greatest load, or it may admit gas during the latter portion only of the suction stroke, when the governor is at its other extreme of motion. In the latter case, only enough gas will be admitted to overcome the friction of the engine.

In order to provide for the economical and reliable operation of the engine, it is desirable that the valve disk 39 should be full-open at the end of the suction stroke, when working at part load, so as to insure a good mixture of gas and air during the latter part of the inlet stroke. It is also desirable that the disk 39 shall move very quickly to its wide open position, so as to secure the so-called stratification effect as much as possible, air only being admitted during the first part of the suction stroke, while a proper mixture of gas and air is admitted during the remainder of that stroke. For this reason, it is preferable to actuate this disk from an eccentric or crank, such as 43 which rotates at the same speed as the engine. In the arrangement shown in Figs. 1 and 3, wherein both the inlet valve 15 and exhaust valve 3 derive their motion from the shaft 8, which is a half-speed shaft in a four-cycle type engine, these valves are open every alternate stroke only, while the valve disk 39 is open at each stroke. In this manner, a quick motion of the cut-off valve is secured without unnecessary complication, and all the valves in the tandem engine may be driven from a single crank or eccentric which may have its stroke varied by the governor, either in extent, or in phase relation to the engine crank.

The gas engine inlet valve, as herein described, is designed to work on the principle of the "stratification of gases". To illustrate, suppose the engine is running on half load and the corresponding position of the governor is in mid-travel. By our arrangement of inlet valve, the main valve 15 will commence to open just before the beginning of the suction stroke and the triple-seated puppet valve will move with it, while the governor valve 39 remains closed. As the piston travels forward, air will be sucked into the cylinder through the air passage 38 and the port 35, the area of the port 35 determining the amount of air entering the cylinder. By the time the piston has reached about mid-stroke, the crank 43 will have been turned through a sufficient angle to cause the governor valve 39 to commence to open. The area through the governor valve is in excess of the amount required to furnish a proper proportion of gas to air, and has a large amount of over-travel. This is done so as to give a more rapid port opening. The opening between the valve seat 34 and the top valve of the triple-seated puppet valve 33 is proportioned to

give the proper mixture of gas to air. As it takes a definite length of time for the governor valve to open and consequently the piston has moved a definite amount, a large amount of air and a small amount of gas will be sucked into the cylinder. After further movement of the piston and consequently further movement of the governor crank 43. The governor valve 39 will have opened an excessive amount, but the correct area of the gas port is determined by the top valve of the triple-seated puppet valve 33 and its top seat 34. When the main puppet valve 15 is closed, triple-seated puppet valve 33 is also closed, and closes off the air port and the gas port even though the governor valve may still be open. The action of the governor valve may be described as "cutting-on" instead of "cutting-off". By admitting the good mixture during the latter part of the suction stroke, it stays around the igniter, and consequently we will have a most rapid combustion in the cylinder.

If the engine were running at full load, the governor would be at full load position (in this case at the lower extreme of its travel), and the crank 43 would be advanced relatively to the engine crank by an angle of about 90°, consequently the governor valve would open at the beginning of the suction stroke and the entire cylinder would be filled with a good mixture. For quarter load position, the governor would be 3/4 up and the governor valve would be retarded about 135° from full load position, or gas would be admitted for only the last quarter of the suction stroke; during the first three-quarters of the suction stroke, only air would be admitted to the cylinder.

The essential difference of governing on the principle of the "stratification of gases" and by the usual throttling of the mixture admitted to the cylinder is that, by the first named method, no matter what the load on the engine, the cylinder is filled full of air and a mixture of gas and air at practically atmospheric pressure; therefore, with a given clearance volume in the cylinder, the compression of the mixture taken into the cylinder is constant. By the throttling method of governing, the admission valve is opened more or less, and the cylinder contains the mixture in a more or less rarefied condition. Therefore, with a given clearance volume in the cylinder, the amount of compression in the cylinder is variable. The actual result from constant compression is an increase in the efficiency of the engine when running at light loads.

The valve arrangement described is of particular advantage in the regulation of gas engines using dusty or dirty gas, as the valve members are all formed in such a way that there are no pockets to collect dust or other foreign matter, and a perfect mixture and proportion of the gas and air is secured.

It will be further noted that there are no sliding surfaces of a character subject to wear, and that the governor valve is arranged to move with perfect freedom under all conditions of dirty or sticky gas. We thereby obviate the defects and objections which have heretofore been present due to excessive wear in, and sticking of the moving parts, and which have in part defeated the object sought by variable admission of gas.

A further object of our invention is the simplicity of construction, and the minimum number of working parts which are employed.

It will be readily understood that our invention is not limited to the particular type of engine which we have shown and described, but that it may be applied to engines of various types. Instead of locating the compound damper valve in the manner shown, it is obvious that such valve may be placed in a separate chamber suitably connected with the chamber of the valve 33; also various other changes may be made in the construction and arrangement of the parts without departing from the spirit and scope of our invention.

What we claim is:—

1. In an inlet valve for gas engines, a main mushroom valve, a triple-seated puppet valve, and a compound damper valve composed of separate circular plates having openings therein, together with means for rotating one or more of said plates, to thereby secure admission of gas in a definite relative volume to that of the air admitted, for varying periods of the inlet stroke; substantially as described.

2. In a gas engine, the combination with air and gas inlet ports, and a main admission port, of a main admission valve, a triple-seated air and gas admission valve movable with the main valve, and a compound gas admission valve composed of a plurality of separate disks, one or more of which are movable relatively to the others; substantially as described.

3. In a gas engine, the combination with a main admission port and air and gas ports, of a compound valve, comprising a main puppet admission valve, a triple-seated puppet mixing valve, and a governor valve consisting of a relatively fixed member having openings therein, and a relatively movable member also having openings therein, together with means for actuating said movable member by an eccentric or crank whose phase relation to the engine crank is determined by a governor; substantially as described.

4. In a gas engine, a gas governing valve, comprising a plurality of flat circular disks having openings therein, one or more of said disks being arranged to be rotated by an eccentric or crank which moves in definite phase relation to the engine crank but has a variable stroke controlled by a governor; substantially as described.

5. In a gas governing valve for gas engines, a movable valve member having segmental openings therein, a governor, and means for actuating said valve member to vary the time of admission of gas under control of the governor, a second movable valve member having segmental openings, means for actuating said valve manually, and a triple-seated puppet mixing valve; substantially as described.

6. In a gas engine, the combination with a main admission port, and a main puppet valve controlling the same, of air and gas ports, a triple-seated puppet valve controlling the air port, and also controlling a gas port, and a compound gas-controlling valve which controls the admission of gas to the last named port; substantially as described.

7. In a four-cycle gas engine, a main admission valve; a puppet mixing valve driven from a half-speed shaft, and a gas governing valve, together with means for actuating the last named valve at the same speed as the engine; substantially as described.

In testimony whereof, we have hereunto set our hands.

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