No. 740,571. PATENTED OCT. 6, 1903.

G. JORANSON.

GAS ENGINE.

APPLICATION FILED FEB. 15, 1900.

NO MODEL. 2 SHEETS—SHEET 1.

Fig. 1.

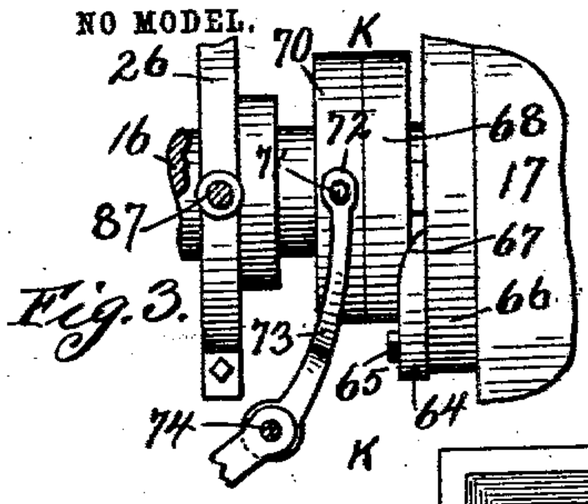

Fig. 3.

Fig. 2.

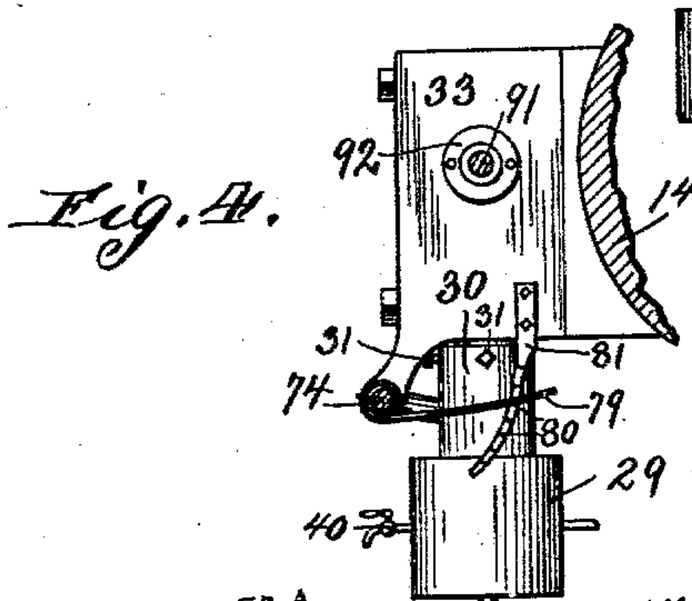

Fig. 4.

Witnesses:
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NO MODEL. 2 SHEETS—SHEET 2.

Fig. 5.

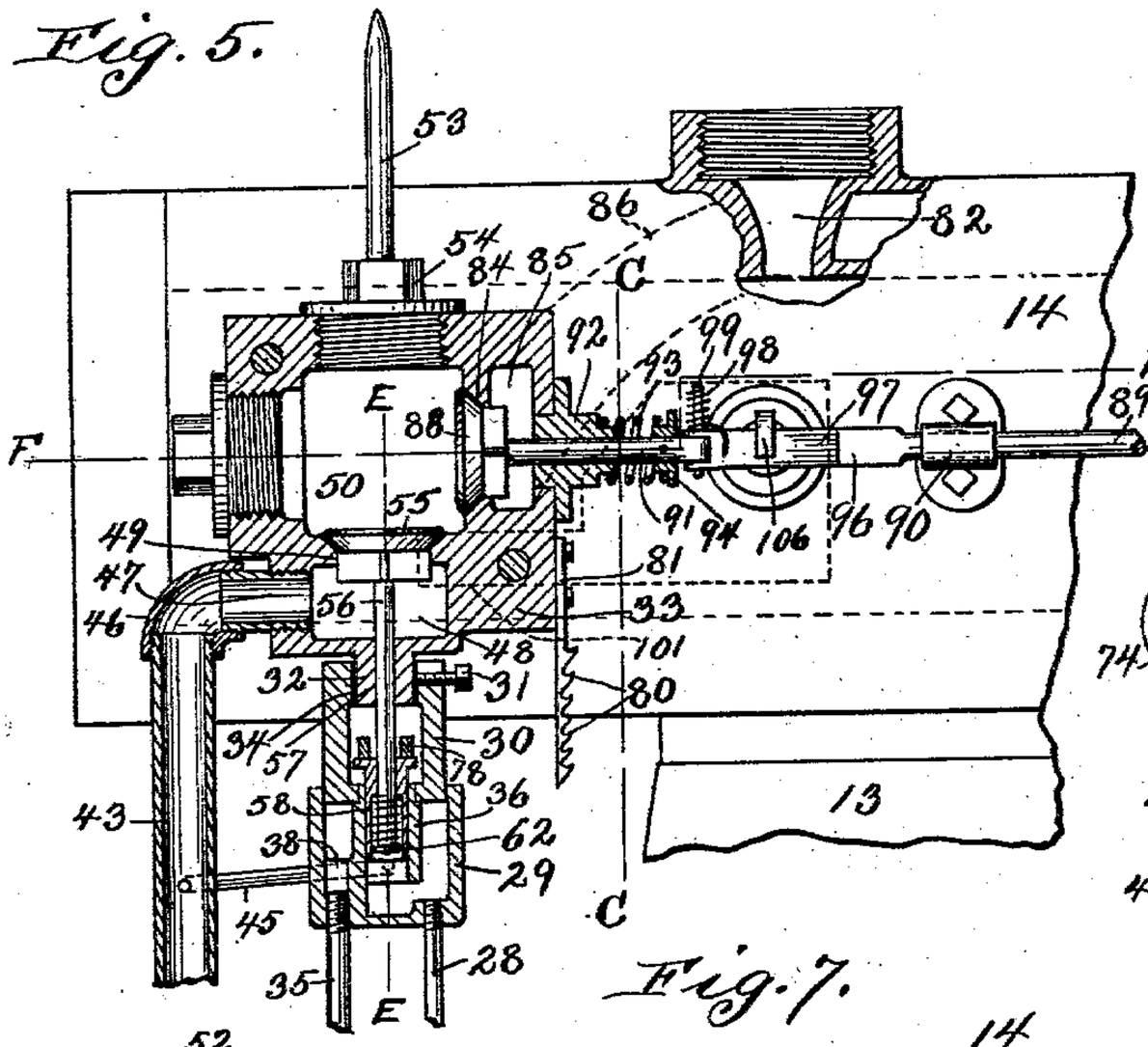


Fig. 7.

Fig. 6.

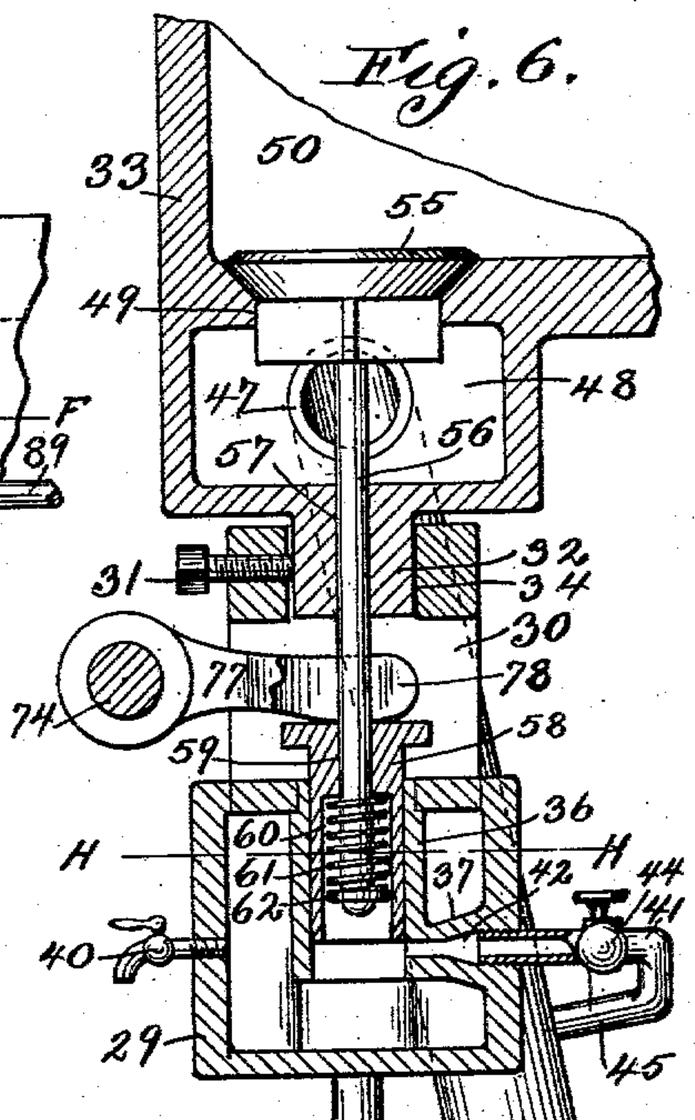
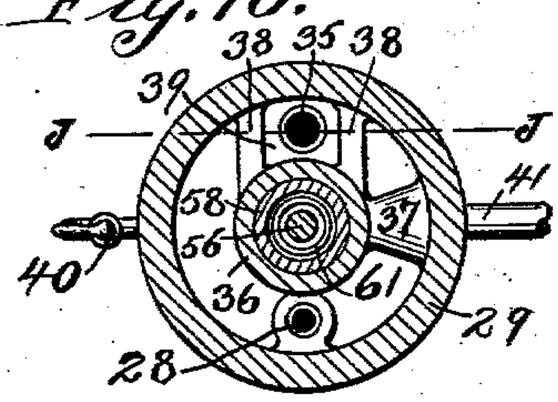


Fig. 10.



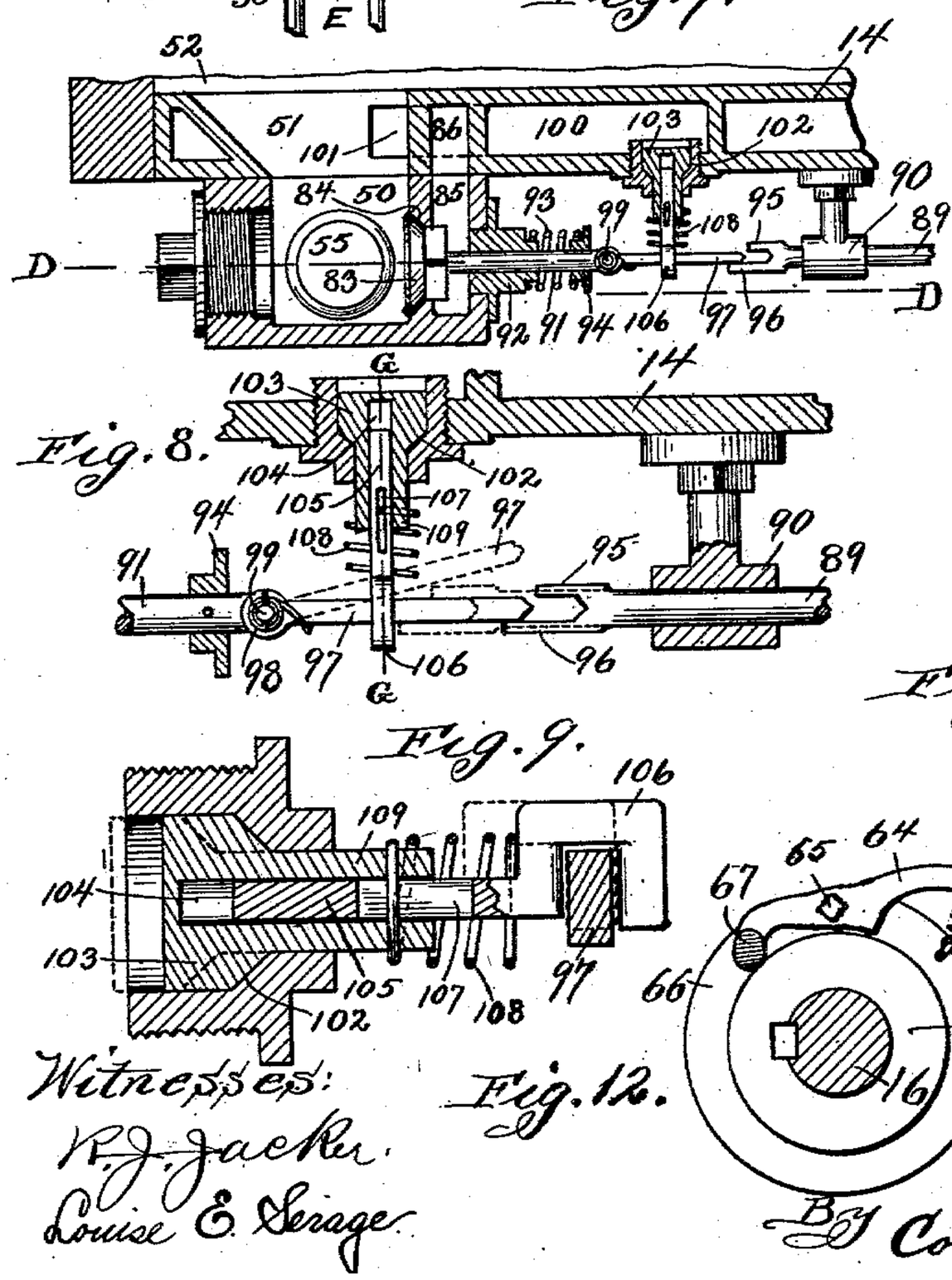


Fig. 8.

Fig. 9.

Fig. 11.

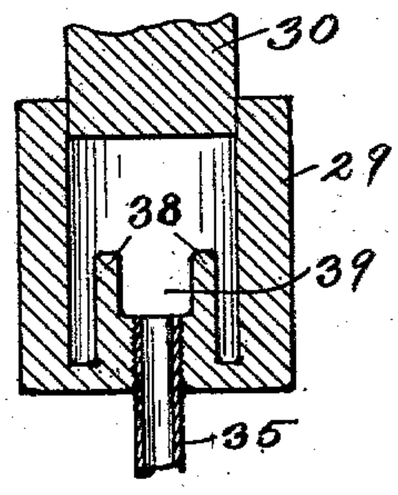


Fig. 12.

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No. 740,571. Patented October 6, 1903.

UNITED STATES PATENT OFFICE.

GUSTAF JORANSON, OF CHICAGO, ILLINOIS, ASSIGNOR TO THE CARL ANDERSON COMPANY, OF CHICAGO, ILLINOIS, A CORPORATION OF ILLINOIS.

GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 740,571, dated October 6, 1903.

Application filed February 15, 1900. Serial No. 5,247. (No model.)

To all whom it may concern:

Be it known that I, GUSTAF JORANSON, a resident of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Fuel-Governors for Explosive-Engines, of which the following is a specification.

My invention relates to certain improvements in gas-engines of the type shown in the Letters Patent of the United States granted to me January 5, 1897, No. 574,610.

In my prior patent I employed a cam upon the shaft of the engine which by means of certain connections operated the exhaust-valve every second rotation, as is necessary in this type of engines; but the connections therein employed necessitated the use of spring-pressure to hold the two members of the exhaust-valve rod in operative engagement, which was objectionable, as they should be held positively together during their time of operation to prevent any possible disengagement. In my improved construction I employ an eccentric upon the shaft instead of the objectionable cam and also radically-different connections between the eccentric and the exhaust-valve, which serve to lock the two members of the exhaust-valve rod positively together instead of depending upon spring-pressure to preserve their connection. Moreover, in my prior patent I employed an exhaust-chamber whose connection with the cylinder was controlled entirely by the exhaust-valve, while in my present construction I employ an exhaust-aperture opening directly from the cylinder into the atmosphere and coöperating with the piston to permit of the discharge of the compressed products of combustion at the end of the operative stroke of the cylinder, thus leaving only the contents of the cylinder at atmospheric pressure to be discharged through the exhaust-valve when the piston returns to its initial position preparatory to the second forward stroke, which serves to draw in the supply of fresh air and gas. This novel construction serves to reduce materially the resistance to be overcome in the operation of the engine and is a valuable feature.

Another improvement over the structure of my prior patent consists in the employment of a novel fuel-feed operating by the action of gravity from the reservoir instead of being positively pumped therefrom, as in my aforesaid prior patent.

My invention is also concerned with a novel speed-governing mechanism in which any undue increase in the speed of the engine serves to wholly or partially shut off the supply of oil instead of preventing its entry to the ignition-chamber, as in my prior patent, thus preventing the waste of oil which would necessarily follow in my prior construction when the speed-governing mechanism came into action. Connected also with this feature of my invention is the novel mechanism for determining at what increase of speed the governing mechanism shall be brought into action to slow the engine down.

Another feature of my speed-governing mechanism is embodied in a construction in which as the supply of oil or gas is decreased the amount of air admitted to the cylinder is also proportionately diminished, so that the proportion of air and gas will always remain constant and at the highest point of efficiency for explosive purposes.

Finally, my invention is concerned with certain details of construction, as will be fully described in the specification and set out specifically in the claims.

Referring now to the accompanying sheets of drawings, in which the same numerals of reference are used to designate identical parts in all the figures, Figure 1 is a plan view of an engine embodying my improvements. Fig. 2 is a side elevation of the same, with the shaft in section on the line A A of Fig. 1. Fig. 3 is an enlarged detail in section on the line B B of Fig. 2. Fig. 4 is another detail in section on the line C C of Fig. 5. Fig. 5 is a side elevation of the cylinder, on an enlarged scale, with the ignition-chamber and fuel reservoir in section on the line D D of Fig. 7. Fig. 6 is a detail, on a still larger scale, in section on the line E E of Fig. 5. Fig. 7 is a detail in section on the line F F of Fig. 5. Fig. 8 is a detail from Fig. 7, but on a larger scale. Fig. 9 is a section on the line G G of Fig. 8, but on a still larger scale. Fig. 10 is a sec-

tion through the fuel-reservoir on the line H H of Fig. 6. Fig. 11 is a vertical section of the same on the line J J of Fig. 10, and Fig. 12 is a section on the line K K of Fig. 3.

As shown, I employ a base 13 of any desired construction, which supports at one end thereof the cylinder 14, which is incased by a water-jacket, as is customary in this class of engines. At the other end of the base are located the bearings 15 15 for the shaft 16, which carries at its outer ends the fly-wheels 17 17. The shaft 16 is provided with the crank-arms 18, between which is mounted the piston-rod 19 upon the customary wrist-pin connecting the crank-arms, the inner end of the piston-rod 19 being pivotally connected to the cylindrical piston 20, the position of which is indicated by the dotted lines in Fig. 1 and which is hollow and open at one end, as is customary in this class of engines.

The oil-supply in case gasolene or some similar vaporizing fluid is employed is obtained from the tank 21, which may be located at any desired position and from which the oil is drawn by the pipe 22 to a small pump 23, which I preferably secure upon the side of the base 13 directly beneath the shaft 16 and actuate its piston-rod 24 by a link 25, pivotally connected to an eccentric-strap 26, surrounding the eccentric 27, secured upon the shaft 16. The operation of this pump is not the primary function of this eccentric, which is also employed by the mechanism to be subsequently described for opening the exhaust-valve. The oil drawn to the pump 23, which is of course suitably provided with check-valves on either side thereof, is forced through the pipe 28 to the oil-reservoir 29, (best illustrated in Figs. 5, 6, 10, and 11,) which consists of a cylindrical cup pinned or otherwise secured to a yoke 30, which is adjustably secured by the set-screws 31 in any desired position upon the lug 32, projecting downward from the bottom of the ignition-chamber block 33 and into a correspondingly-shaped aperture 34, formed in the upper end of the yoke 30. The pipe 28 opens into the bottom of the reservoir 29 at one side thereof, and opening into the bottom of said reservoir at any convenient point, such as at the opposite side thereof, is the return-pipe 35, which carries the overflow of the oil back to the tank 21. Located in the center of the reservoir 29 is the cylinder 36, which is open at both ends and which is supported by the neck 37, leading from one side at the lower end to the adjacent side of the reservoir 29, and also by the webs 38, extending from the bottom of the reservoir upwardly and connecting the lower end of the cylinder 36 with the adjacent sides of the reservoir 29, so as to form a cup 39, into which the return-pipe 35 opens, so that by this means the oil in the reservoir 29 will always be held at a certain level. A stop-cock 40 may be employed opening into the reservoir at this level, the principal use of which is to determine in starting the engine when the oil in the reservoir has been pumped up by hand to the proper level, so that the feed will operate in starting the engine. It also serves to drain off the surplus oil if for any reason the return-pipe 35 should become stopped up or otherwise incapacitated for work. The feed-pipe 41 for the oil opens into the reservoir 29 through a channel 42, formed in the neck 37, and the channel 42 has its inner end opening just at the level to which the oil in the reservoir is held by the employment of the cup 39, so that a small portion of the contents of the reservoir will be free to flow by the action of gravity from the cup and through the feed-pipe 41 into the air-pipe 43, the open end of which I preferably locate in the hollow portion of the base 13, so as to prevent the entrance of any foreign substances with the air as far as possible. A stop-cock 44 may be employed to shut off or control the amount of feed from the reservoir, if desired. The lower portion 45 of the pipe 41 is inclined downwardly, as will be readily apparent, so that the flow of the oil from the reservoir to the air-pipe 43 is purely by gravity and will be steady and uninterrupted so long as the pump 23 maintains the oil in the reservoir at the prescribed level. The air-pipe 43 opens by means of the elbow 46 and the section 47 into the channel 48, formed in the lower portion of the ignition-chamber block 33. This channel 48 communicates by the port 49 with the ignition-chamber 50, which is centrally located in the block 33 and opens through the entrance 51 into the interior 52 of the cylinder. The ignition-tube 53, which may be of any desired construction, is connected with the ignition-chamber 50 by the nut 54 in the upper side of the block 33. The port 49 is normally closed by the puppet-valve 55, which is seated upon the customary bearings formed in said port and has the stem 56, extending down through a bearing 57 in the lug 32 and through the sleeve 58, the shape of which is clearly shown in cross-section in Fig. 6 and which is mounted to slide in the cylinder 36, previously described. As will be seen, the upper portion of the sleeve 58 has the aperture 59 therein of just sufficient size to furnish a bearing for the rod 56, while the aperture in its lower portion is enlarged, as at 60, so as to accommodate the helically-coiled expanding-spring 61, which is interposed between the shoulder formed between the apertures 59 and 60 and an enlargement 62, formed or secured upon the lower end of the rod 56. The action of this spring 61, as will be readily apparent, is to hold the puppet-valve 55 down seated upon its bearings except when the outward movement of the piston in the cylinder 14, after the inward movement which forces out the foul air, serves to exhaust the air within the ignition-chamber, and thus cause the atmospheric pressure to open the valve 55 and admit a fresh supply of air through the tube 43, which air is

charged with gas or gasolene vaporized in the tube 43, as previously set out.

As the governor for controlling the speed of the engine acts in connection with the apparatus just described, I will now proceed to the description of that mechanism, which is best shown in Figs. 1 to 4, 6, and 12. The governor-ball, with its immediate connections, is substantially the same as that shown in my prior patent, No. 574,610, and it consists of a ball 63, secured upon one end of a suitably-curved lever 64, which is pivotally mounted, as at 65, to the hub 66 of one of the balance-wheels 17 or to any other suitable part revolving with the shaft 16. The other end of the lever 64 is beveled, as at 67, and is adapted to take in between the hub 66 and the short sleeve or collar 68, which is splined on the shaft 16, so that as the speed of the engine increases the centrifugal force operating on the ball 63 and against the coiled spring 69, connecting the ball and the hub 66, will serve to throw the beveled end 67 inward between the hub 66 and the sleeve 68, so as to force the latter away from the hub. The collar 68 in its movement forces an adjacent collar 70 with it, and this collar 70 is provided with the pins 71, which take into ears 72 on the yoke 73, the inner end of which is rigidly secured to a rock-shaft 74, mounted in the bearings 75 and 76, which are secured to the side of the base 13 and the under side of the ignition-chamber block 33, respectively. The other end of the rock-shaft 74 has secured thereon the arm 77, which terminates in a yoke 78, embracing the rod 56 and resting on top of the sleeve 58. A strong coiled spring 79, which has one end passed through the rock-shaft 74, has its free end extending inwardly and adapted to coöperate with any one of the notches 80 on the plate or bar 81, which is secured to the end of the ignition-chamber. It will be readily seen that if the free end of the spring 79 is placed in the lowermost notch 80 it will be under less tension than if it is placed in any of the higher notches, and by means of this adjustment I am enabled to regulate the force with which the yoke 78 shall normally press upon the sleeve 58. If the engine is set for a low rate of speed, the spring 79 will be set in one of the lowermost notches 80; but if it is set for a high rate of speed it will be placed in one of the uppermost notches. The operation of this governing device will be apparent. As the engine passes the rate of speed at which it is desired that it should be run the centrifugal force acting upon the governor-ball 63 against the stress of the springs 69 and 79 will force the sleeves 68 and 70 outward, rocking the shaft 74, so as to force the arm 78 downward, carrying with it the sleeve 58 against the stress of the spring 61, which in its downward movement will partially or entirely cut off the opening from the channel 42 into the cylinder 36, thus reducing or cutting off the supply of oil, thus necessarily decreasing the speed of the engine until it reaches the normal speed, after which, the governor being drawn to its normal position by the spring 69 and the yoke 78 being raised by the spring 79, the spring 61 will be free to raise the sleeve 58, thus opening the channel 42 and again permitting the flow of the gasolene to the tube 43. As the sleeve 58 is forced down the spring 61 is put under increased tension, and this serves to hold the valve 55 more firmly on its seat, so that it will take a greater pressure to unseat it, and consequently so large a quantity of air cannot be drawn into the ignition-chamber by the suction, and thus as the supply of gas is diminished the amount of air is correspondingly diminished, and the proper proportion of gas and air is still retained, although the amount of both furnished to the ignition-chamber is diminished. It will be apparent that by the adjustment of the spring 79 upon the teeth 80 of the plate 81 I am enabled to quickly and accurately adjust the engine to run normally at any desired rate of speed.

In the customary operation of these engines starting at the time of the explosion the piston is driven out to the limit of its movement, after which it returns, and some means must be provided for opening an exhaust-valve to permit the escape of the products of combustion, so that a fresh supply of air and vapor may be drawn into the chamber as the piston travels outward the second time in its cycle of movements, its second inward travel being used to compress the fresh air and the vapor preparatory to their being ignited at the moment the piston has reached the limit of its second inward stroke, thus completing its cycle of movements. As these engines have been previously built, so far as I am aware, the entire discharge of the products of combustion and the dead air are dependent upon the opening of the exhaust-valve during the first inward movement of the piston. In my improved construction I place a port or discharge-aperture 82 in the upper side of the cylinder 14, it of course passing through the water-jacket and into the body of the cylinder and being so located that it is normally closed by the piston 20, except just at the limit of its outward stroke, at which time the port is open to allow the escape of the products of combustion and dead air sufficiently to bring the pressure in the cylinder down to atmospheric pressure. As the piston now returns for the first time in its cycle of movements and tends to compress the remaining products of combustion and foul air in the cylinder the exhaust-valve has only to be opened against atmospheric pressure instead of against a greater pressure, as is the case where the discharge-port 82 is not employed.

The exhaust-valve 83, which is of the customary puppet-valve construction, coöperates with a valve-seat formed in the port 84, leading from the ignition-chamber into the

channel 85, which is preferably cored out through the ignition-chamber and along the pathway 86, (indicated by dotted lines in Fig. 5,) through the space occupied by the water-jacket and opening into the exhaust-port 82, previously described.

My novel apparatus for unseating the exhaust-valve 83 during the return of the piston for the first time in its cycle of operations is as follows: Secured upon the shaft 16 is the eccentric 27, previously mentioned, which is surrounded by the eccentric-strap 26, which has the eccentric-rod 87 extending therefrom and pivotally connected by the offset 88 to the outer member 89 of the exhaust-valve slide-rod, which outer member 89 is mounted in the bearings 90, secured to the side of the cylinder. The inner member 91 of the exhaust-valve slide-rod is secured to the valve 83 and is supported by the bearing-sleeve 92, secured in the end of the ignition-chamber block 33. A helically-coiled expanding-spring 93, confined between the bearing-sleeve 92 and the collar 94, pinned upon the member 91 of the exhaust-valve slide-rod, serves to hold the exhaust-valve normally closed. The inner end of the member 89 is formed with a yoke the inner arm 95 of which is somewhat shorter than the outer arm 96 for reasons to be subsequently explained, and this yoke is designed to coöperate with the locking-piece 97, which is pivotally connected to the outer end of the member 91 and is provided with the coiled spring 98, one end of which is secured to the pivot-pin 99, which is secured to the member 91, and the other end of which coöperates with the locking-piece 97, so as to normally tend to hold said locking-piece in the dotted-line position of Fig. 8, in which position it will not be engaged by the yoke upon the member 89. It will be apparent that if the locking-piece 97 is in the dotted-line position of Fig. 8 when the member 89 passes from its outermost or full-line position of Fig. 8 to its innermost or dotted-line position the member 91 will not be affected by this movement, and this is the relation of the parts as the member 89 passes inward during the second half of the cycle of movements when it is desired to keep the exhaust-valve closed. During the same movement of the member 89 during the first half of the cycle of movements it is necessary to have the locking-piece 97 in the full-line position of Fig. 8, so that as the member 89 advances to its dotted-line position it will carry with it during the second half of its inward movement the member 91, thus opening the exhaust-valve 83, which movement is so timed that the valve is opened during the time that the piston is returning after its explosive stroke, so that the foul air and products of combustion can be discharged through the port 84, channels 85 and 86, and out through the discharge-port 82. To carry the locking-piece 97 to the full-line position at the proper time during the first half of the cycle of movements, the following mechanism is employed.

In the side of the cylinder 14 and in a portion of the space customarily occupied by the water-jacket I form a small compartment 100, the air in which is kept at the same tension as in the ignition-chamber by means of a channel 101, passing from said compartment 100 beneath the channel 86 and opening into the entrance 51 into the ignition-chamber. Secured in the outer side of this compartment is a valve-seat 102, with which coöperates a check-valve 103, the shape and construction of which are clearly shown in Figs. 8 and 9. This valve has formed therein the slot 104, in which is placed the body 105 of a hook 106, which embraces the locking-piece 97, as best shown in Fig. 9. This body portion 105 of the hook 106 has formed therein the slot 107, through which one end of a coiled expanding-spring 108 passes, the said end being secured in the stem 109 of the valve 103. This spring extends between the stem 109 and the hook 106 and tends to normally hold the valve 103 and the hook 106 in the relative positions shown in full lines in Fig. 9. As the atmosphere in the compartment 100 has the same tension as in the ignition-chamber 50, it will be apparent that the valve 103 normally tends to remain open under the stress of the spring 98, which operates through the locking-piece 97, hook 106, and spring 108, except at such times as the pressure in the compartment 100 is above atmospheric pressure, which is only just before and after the explosion and while the piston is moving inward and outward for the first time during its cycle of operations and before it passes the port 82. The eccentric 27 is so placed upon the shaft 16 that just at the instant the compression of the air and gas is completed and the explosion occurs the member 89 of the exhaust-valve slide-rod has actually or substantially reached its intermediate position in moving outward, in which position it will be apparent that the locking-piece 97 cannot move to the full-line position, but will be arrested by its end taking against the arm 95 of the yoke, in which position it will remain, the spring 108 being held under tension until the member 89 reaches its outermost position, (shown in full lines in Fig. 8,) in which the spring 108 snaps the piece 97 into the engaging position shown, in which it is arrested by its end contacting with the longer outer arm 96 of the yoke. As the member 89 now moves inward, the first half of its movement will not affect the member 91, except that shortly after it starts the arm 95 of the yoke will pass over the end of the locking-piece 97 and prevent any possible disengagement thereof if the valve 103 should for any reason be prematurely unseated. During the second half of the movement of the member 89 it will carry with it the locking-piece 97 and the member 91, thus opening the exhaust-valve 83 to release the prod-

ucts of combustion and foul air, which have been compressed and are forced out by the contemporaneous inward movement of the piston 20 during the first half of its cycle of movements. As the member 89 moves backward it will be apparent that the member 91, which moves with it, will not be unlocked until the member 89 has reached substantially the limit of its outward movement, at which time the suction of the air caused by the outward movement of the piston during the second half of its cycle of movements will serve to unseat the valve 103, moving it to the dotted-line position of Fig. 9, in which position the hook 106, moving with the valve, will carry the locking-piece 97 to the dotted-line position of Fig. 8, the movement being assisted by the tension of the spring 98, so that the locking-piece 97 will remain in position so that it cannot be engaged by the member 89 as it moves inward during the second half of the cycle of movements. By employing the construction and timing of the parts described it will be seen that the valve or piston 103 is operated by the compression of the air just prior to the explosion, so that if for any reason the explosion should fail to occur the valve 103 will nevertheless be seated before the member 89 reaches the limit of its outward movement and the locking-piece 97 will be pressed against the arm 95 of the yoke and be ready to be snapped into engaging position as soon as the member 89 reaches the limit of its outward movement, thus securing the necessary opening of the exhaust-valve under all possible circumstances.

From the foregoing description it will be evident that by the construction which I have devised the exhaust-valve 83 will be operated beyond any possibility of failure at each inward movement of the member 89 during the first half of the cycle of movements, but cannot possibly be operated thereby during the second half of the cycle of movements.

While I have in the foregoing specification and drawings shown and described a complete engine including the mechanism for operating the exhaust-valve, I do not herein claim said exhaust-valve mechanism, but reserve the same for a divisional application.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. In a device of the class described, the combination of an oil-reservoir adjacent the air-inlet pipe, with means for keeping the oil in said reservoir at a constant height, a small pipe opening into said reservoir at or slightly below the level at which the oil stands and leading downward at a slight angle to the horizontal and opening into the air-inlet pipe, a governor controlled by the speed of the engine, and a sleeve in said reservoir adapted to be moved by the governor to control the supply of oil admitted to the air-inlet pipe.

2. In a device of the class described, the combination with the ignition-chamber having the lug 32 projecting from the bottom thereof, of the yoke 30 secured to said lug, and the reservoir 29 secured to the bottom of said yoke, substantially as and for the purpose described.

3. In a device of the class described, the combination of the ignition-chamber having the lug 32 projecting therefrom, the yoke 30 secured to said lug, the reservoir 29 secured to said yoke, the sleeve 58 in the top of said reservoir, and the valve 55 having its stem 56 extending through the lug 32 and the sleeve 58.

4. In a device of the class described, the combination of the ignition-chamber having the lug 32 projecting therefrom, the yoke 30 secured to said lug, the reservoir 29 secured to said yoke, the sleeve 58 in the top of said reservoir, the valve 55 having its stem 56 extending through the lug 32 and the sleeve 58, and the spring 61 interposed between the end of the stem and the cylinder 58.

5. In a device of the class described, the combination of the feed-pipe for supplying fuel to the engine, the reservoir into which said pipe opens provided with the cylinder 36 having an aperture therein leading to said pipe, the sleeve 58 sliding in said cylinder and adapted to close said aperture, a spring 61 tending to hold the sleeve above the aperture, the rock-shaft 74, the spring 79 adapted to hold the shaft in its inoperative position, the arm 77 extending from the shaft to the sleeve 58, and a governor operatively connected to said shaft to rock it when a certain speed is attained.

6. In a device of the class described, the combination of the cylinder, an air-suction pipe connected therewith into which the vaporizing fluid is admitted, with a feed device for supplying the vaporizing fluid to said air-suction pipe, governing mechanism controlled by the speed of the engine, and connections between said governing device and the feed device for simultaneously limiting the quantity of vaporizing fluid admitted to the air-suction pipe, and the amount of air admitted to the cylinder, said connections comprising a closure for the vaporizing-fluid device, the valve governing the admission of air to the cylinder, and a spring controlling said valve and closure, and put under tension by the operation of either.

7. In a device of the class described, the combination of the cylinder, a valve controlling the admission of air charged with gas thereto, with a feed device for the vaporizing fluid, means for limiting the operation of said feed device, and connections between said valve and the feed device for simultaneously increasing the tension on said valve and limiting the operation of said feed device.

8. In a device of the class described, the combination of the cylinder, a valve controlling the admission of air charged with gas thereto, with a feed device for the vaporizing fluid, means for limiting the operation of said feed device, and connections between said valve and the feed device for simultaneously

increasing the tension on said valve and limiting the operation of said feed device, said connections comprising a spring interposed between said valve and said feed device and put under tension by the operation of either mechanism.

9. In a device of the class described, the combination of the ignition-chamber, the exhaust-valve 55 located therein and having the stem 56 extending therefrom, the reservoir 29 supported beneath said valve and containing the cylinder 36, the supply-pipe opening into the said cylinder, the sleeve 58 mounted in said cylinder and normally extending above the opening for the supply-pipe, and having the stem 59 extending therethrough, and a spring 61 interposed between the end of said stem and said sleeve 58, substantially as and for the purpose described.

10. In a device of the class described, the combination of the feed-pipe for supplying fuel to the engine, with a closure for the same, a governor controlling said closure, a coiled spring normally resisting the movement of said closure, and graduated means for increasing the tension of the spring to any desired amount consisting of the notched piece 81 with which the extended end 79 of the coiled spring is adapted to coöperate, substantially as and for the purpose described.

11. In a device of the class described, the combination of the cylinder, an air-suction pipe connected therewith into which the vaporizing fluid is admitted, with a feed device for supplying the vaporizing fluid to said air-suction pipe, governing mechanism controlled by the speed of the engine, and connections between said governing device and the feed device for simultaneously limiting the quantity of vaporizing fluid admitted to the air-suction pipe, and the amount of air admitted to the cylinder, said connections comprising a closure for the vaporizing-fluid device, the valve governing the admission of air to the cylinder, and yielding connections between the valve and the closure whereby the closure may be operated to absolutely shut off the vaporizing fluid while the valve is not closed against high pressure.

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