No. 714,352. Patented Nov. 25, 1902.

C. A. ANDERSON, E. A. ERICKSON & J. WICKSTROM.

COMBINED HOT AIR AND GAS ENGINE.

(Application filed Mar. 28, 1900.)

(No Model.) 2 Sheets—Sheet 1.

Fig. 1.

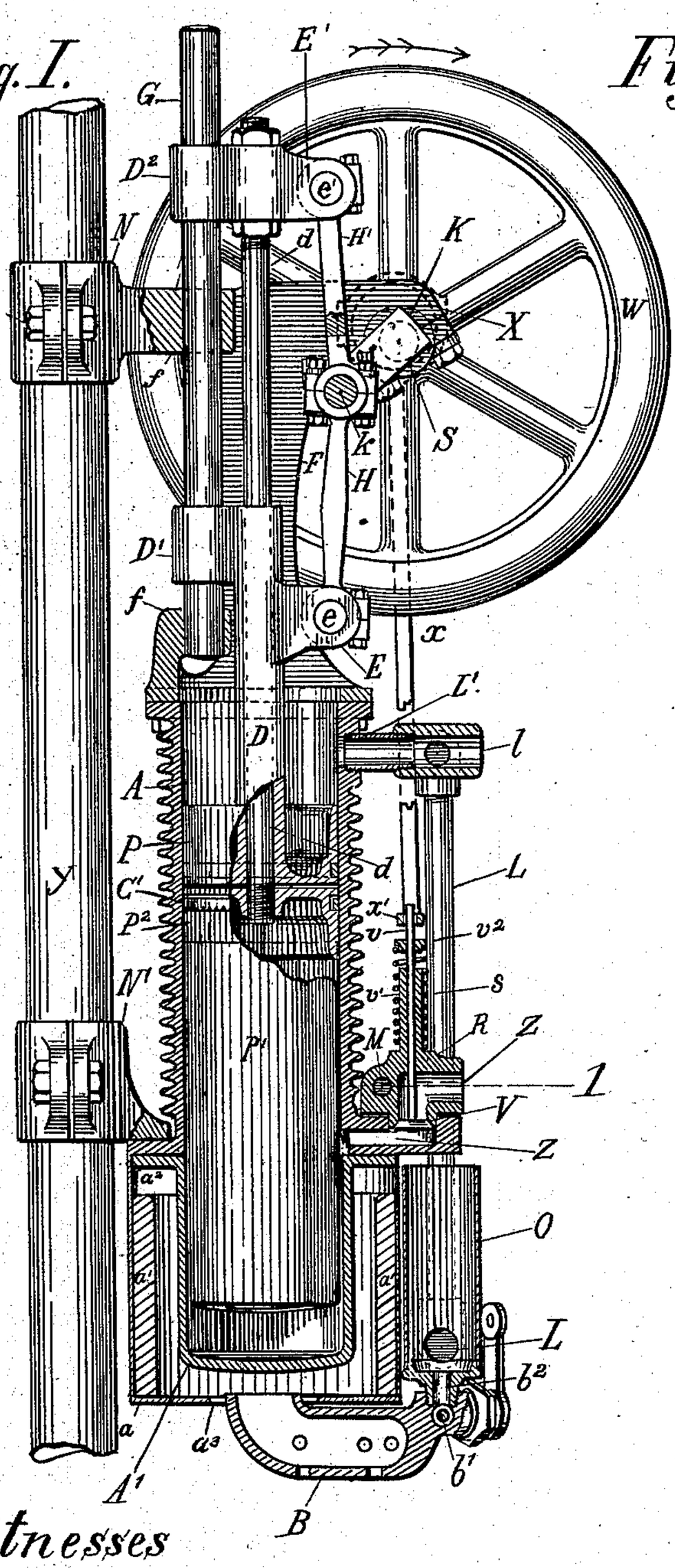

Fig. 2.

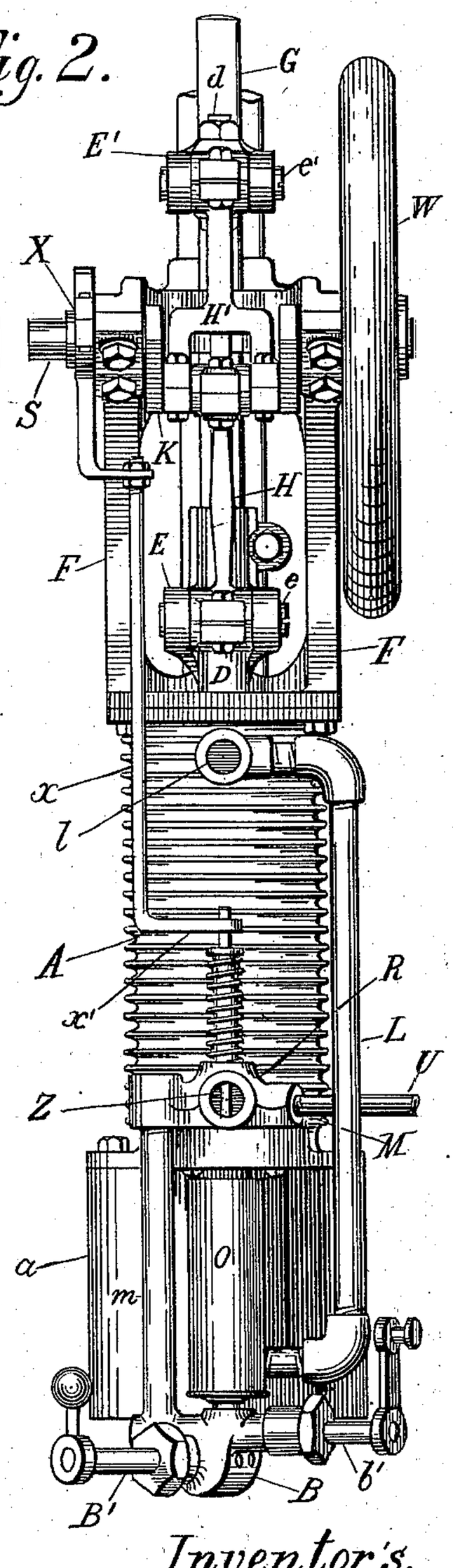

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Fig. 3.

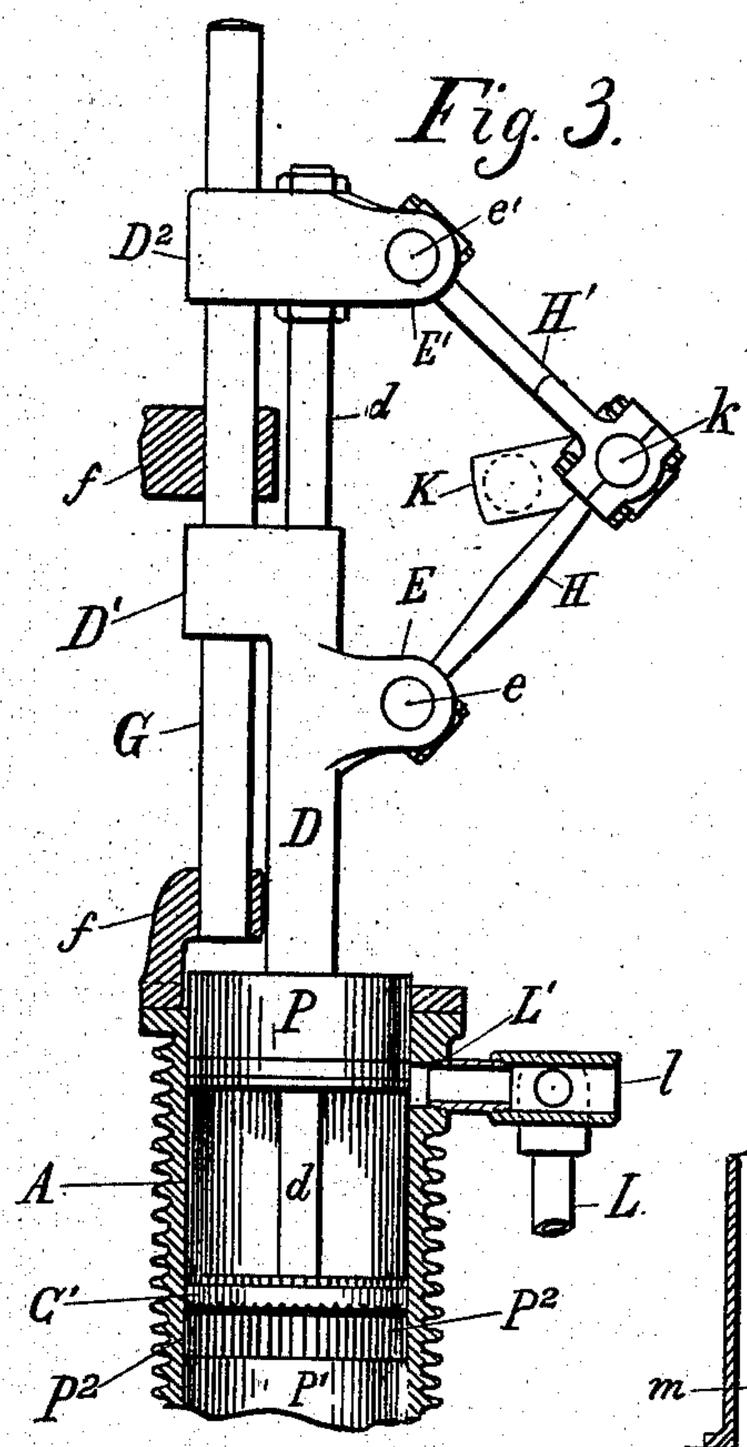


Fig. 5.

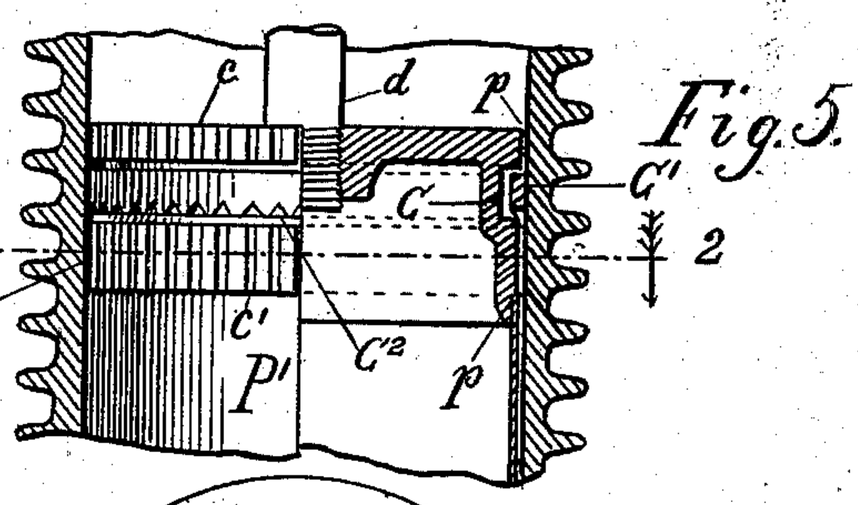


Fig. 6.

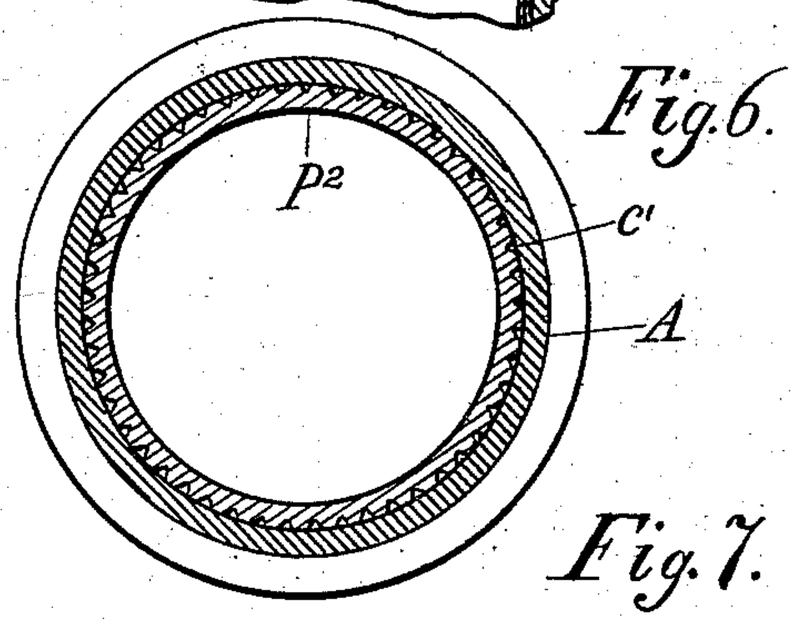


Fig. 7.

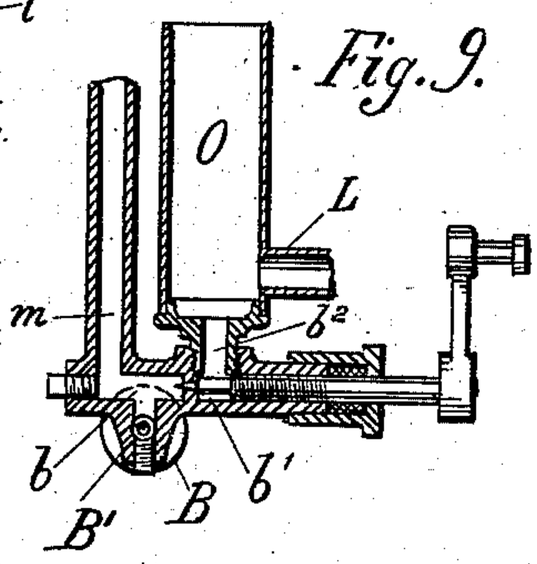


Fig. 9.

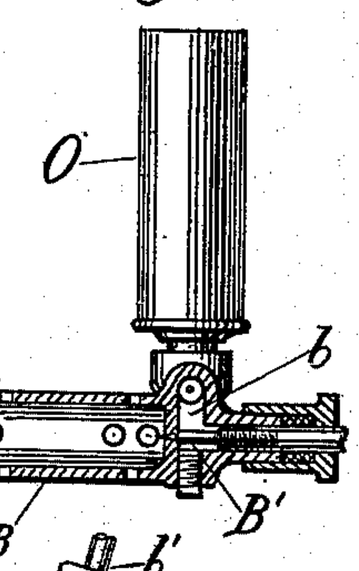


Fig. 4.

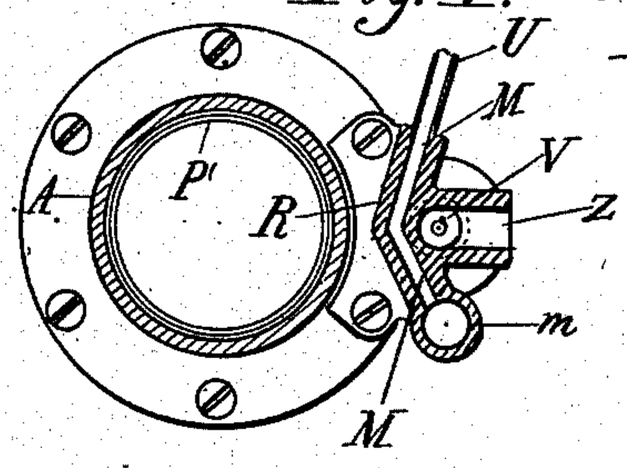
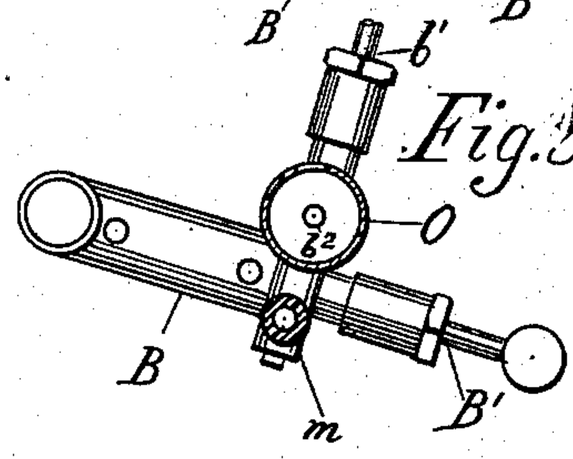


Fig. 8.



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UNITED STATES PATENT OFFICE.

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COMBINED HOT-AIR AND GAS ENGINE.

SPECIFICATION forming part of Letters Patent No. 714,352, dated November 25, 1902.

Application filed March 28, 1900. Serial No. 10,570. (No model.)

To all whom it may concern:

Be it known that we, CHARLES A. ANDERSON, ERICK A. ERICKSON, and JOHN WICKSTROM, citizens of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in a Combined Hot-Air and Gas Engine, of which the following is a specification.

This invention relates to improvements in gas-engines, and refers more specifically to improvements in that type of engines wherein the cycle of the machine includes an explosion or impulse for each reciprocation of the piston, the gas being admitted to one part of the cylinder and transferred to a different part through the medium of a transfer-piston acting in conjunction with a coöperating power-piston.

Among the salient objects of the invention are to provide an engine so constructed that that portion of the cylinder within which the power-piston works will be maintained relatively cool without the use of water-jacketing or the like, while at the same time that part of the cylinder within which the gas or vapor is burned will be maintained at a relatively high temperature, thereby producing a high and efficient expansion-curve; to provide an engine so constructed as to afford a power-stroke for every revolution of the main shaft, while at the same time the burned gases and products of combustion are thoroughly discharged prior to the ingress of the explosive charge; to provide an improved construction and arrangement whereby the ignition of the charges of gas is effected through the heat of a portion of the wall of the chamber within which the gas is exploded, thereby avoiding the complication, uncertainty, and objectionable features incident to the use of special ignition devices; to provide an improved construction in the mechanism whereby the charge of gas is transferred from one side to the other of the transfer-piston; to provide improvements in the mechanical connections whereby the transfer and power pistons are actuated and controlled from the main shaft; to provide improvements in the details of construction of the gas-mixer, forming one feature of the invention, insuring a more thorough and efficient mixing of the air and gas and an improved control of the operation of this mechanism, and in general to provide simplified and improved details of construction contributing to the efficiency and durability of the engine.

To the above ends the invention consists in the matters hereinafter described and more particularly pointed out in the appended claims and will be readily understood from the following description, reference being had to the accompanying drawings, in which—

Figure 1 is a side elevation, with the cylinder and adjacent parts shown in longitudinal vertical section, of an engine embodying our invention. Fig. 2 is a front elevation of the same. Fig. 3 is a side elevation of parts shown in Fig. 1, certain parts being shown in section, showing more particularly a changed position of the piston-rods, links, and connected parts. Fig. 4 is a transverse sectional view taken through the exhaust-valve and adjacent part of the cylinder. Fig. 5 is an enlarged sectional detail of the upper portion of the transfer-piston and inclosing portion of the cylinder. Fig. 6 is a sectional view taken on line 2 2 of Fig. 5 and looking in the direction of the arrow. Fig. 7 is a detail of the burner parts of the latter, being shown in axial section. Fig. 8 is a plan view of the burner with parts in transverse section. Fig. 9 is an axial sectional view showing more particularly the construction of the passages therein.

Referring to said drawings, A designates as a whole the power or working cylinder, the lower portion of which constitutes the combustion-chamber or heater part, (designated A′,) which is shown in the present instance as constructed in a separate part and secured to the main operating or power cylinder A^2. Said heater part A′ is inclosed by a fire-box or outer chamber a, having a lining of refractory material a', a vent a^2, located near the front end of the fire-box, and an inlet-opening a^3, located directly opposite the end of the heater part of the cylinder.

Within the power-cylinder A are arranged a power-piston P and a transfer-piston P′,

the latter being of the type commonly known as a "trunk-piston." The lower portion of said transfer-piston or that toward the end of the cylinder constituting the heater part or combustion-chamber is of somewhat smaller external diameter than the inside of the cylinder, so as to permit the flow of gas past this part of the transfer-piston, as will hereinafter appear. The upper portion of the transfer-piston, as clearly shown in Figs. 5 and 6, is constructed to fit the cylinder closely and is provided adjacent to this end with a circumferential groove C, in which is located a valve-ring C′, the periphery of which fits closely against the inner surface of the cylinder A. In width or axial length and also in radial thickness the dimensions of said valve-ring are less than those of the groove C, so that as the valve-ring is carried back and forth with the piston the ring has a lost-motion movement with reference to said piston, which serves to permit the flow of gas through the groove in a manner hereinafter described. The valve-ring C′ is provided in its lower edge with a plurality of radially-disposed grooves or passages C^2, (see detail Fig. 5,) and that portion of the periphery of the transfer-piston immediately below the lower or rear side of the groove C is provided with a series of longitudinally-extending grooves *c′*, which serve to permit the passage of the gas or vapor downwardly or rearwardly from the groove C to that portion of the transfer-piston which is of reduced diameter. That part of the transfer-piston adjacent to and above the groove C is likewise provided with a series of longitudinally-arranged grooves *c*, which extend from the groove upwardly or forwardly throughout the remaining length of the cylinder, thus affording passages for the ingress of gas to the circumferential groove C. It is to be noted, however, that the upper side of the valve-ring C′ is unprovided with grooves and is constructed to fit closely against the upper side wall of the groove C, so as to close the passages formed by the groove *c* when the said valve-ring rests in contact with this side of the groove C.

The power-piston P is provided with an aperture, through which extends the piston-rod *d* of the transfer-piston, this aperture or passage being formed in the present instance through a hollow extension D, mounted upon or formed integral with the power-piston, as shown clearly in the drawings. At one end the piston-rod *d* is connected with the transfer-piston, while at its opposite end it is rigidly connected with a guide-shoe D^2, which is arranged to reciprocate upon a guide-bar G, mounted to extend parallel with the piston-rod in extensions *f f′* on the main frame F of the engine. The hollow extension D, which is mounted on the power-piston, is likewise provided with a guide-shoe D′, which also engages and reciprocates upon the said guide-rod G.

The frame F, upon which the guide-rod is mounted, is secured to the cylinder A by means of bolts or in any other preferred way. Journaled in the frame F is a main crank-shaft S, provided at a point intermediate its length with a crank K. Upon the hollow extension D of the power-piston P and likewise on the guide-shoe D^2 are pivot-lugs E′, arranged in the present instance in pairs, and with said lugs are respectively connected pitman-bars H and H′, both of which are connected at their opposite ends with the crank K of the main shaft, the pitman H being shown as connected with the central portion of said crank, while the pitman H′ is of forked construction at this end and arranged to embrace the crank at opposite sides of said pitman H. It is noted in this connection that the location of said crank-shaft and the length of the crank-arm thereof is such with relation to the pivotal axes of the connections of the pitmen with the several pistons that in the revolution of the crank-shaft the wrist of the latter intersects a direct line extending between the said pivotal points of connection with the pistons. In other words, the two pitmen, both engaged at one end with the wrist of the crank and at their opposite ends with the respective pistons, form, in effect, a toggle connection between said pistons, and the main shaft is so located with relation to said toggle that the links of the latter will be carried into and beyond a position in direct alinement with each other upon each revolution of the main shaft, the object of this construction being to impart a peculiar approaching and receding movement of the two pistons relatively to each other for a purpose which will hereinafter appear in the description of the operation of the engine.

W designates a fly-wheel mounted upon the main shaft S, in the present instance at one end of the latter.

In the lower portion of the cylinder A is arranged an exhaust-port Z, which communicates with an exhaust-valve chamber R, formed in a casting secured to the exterior of the cylinder. Within the exhaust-valve chamber R is arranged a valve V, having a stem *v* arranged to extend out through a hollow extension *v′* parallel with the axis of the cylinder. Surrounding the extension *v′* is a spring *s*, engaging at one end a shoulder formed at the junction of the extension *s* with the main body of the valve-chamber and at its opposite end engaging a collar v^2, secured on the valve-stem, so as to tend to hold the valve against its seat.

x designates a tappet-rod operatively connected at one end with an eccentric X on the main shaft S and arranged to engage at its opposite end the end of the valve-stem *v*, as indicated at *x′*, the engaging end portion being shown in the present instance as consisting of an arm bent to extend at right angles to the main body of the tappet-rod and apertured to receive the end of the piston-rod and being so located with reference to the

collar v^2 thereon as to engage the latter and open the valve upon each revolution of the main shaft.

M designates a passage extending through the wall of the exhaust-valve chamber R, but not communicating with said chamber, for conducting the oil or vapor from the fuel-supply pipe U to a pipe m, which leads thence rearwardly or downwardly to the burner B. Said burner B is provided with a valve B′, (best shown in Fig. 7,) which controls the inlet from the pipe m to the combustion-chamber B^2 of the burner, and a passage b, controlled by a second valve b' and leading to a mixing-chamber O through a communicating passage b^3, as best shown in Fig. 9. Communicating with the mixing-chamber O is a pipe L, which extends thence to and is connected with an inlet-port L′, communicating with the cylinder A near the upper or forward end of the latter. The point of communication of the pipe L with the mixing-chamber O is so located relatively to the gas-inlet passage b^3 that under the exhaust or suction action of the engine upon the pipe L the latter will draw in a certain proportion of gas or vapor from the passage b^3 and at the same time a certain proportion of air through the open outer end of the mixing-chamber O. The supply-pipe L is provided at a point adjacent to the port L′ with an inlet-opening l, communicating with the outer atmosphere, the arrangement being such that the flow of gas through the said supply-pipe under the exhaust or suction action of the engine serves to entrain an additional supply of air from the atmosphere.

In the present embodiment of the engine, the latter is shown in upright position and is secured in this position conveniently by means of an upright bar or post Y, with which the frame of the engine is rigidly connected by means of suitable extensions, terminating in clips, which are arranged to embrace said bar.

The operation of the engine constructed and arranged as described is as follows: The burner B will first be initially heated in any suitable manner, so as to inaugurate the production of gas as the oil is admitted thereto, after which, the burner being lighted, the products of combustion from the combustion-chamber thereof will pass inwardly through the opening a^3 of the fire-box and impinge upon the heater part of the cylinder, rapidly heating the latter to a temperature sufficient to ignite a charge of gas introduced within this part of the cylinder. The heater part having been thus brought to the requisite heat, the engine may be started in any suitable manner, as by turning it through its first revolution manually, it being understood that the valve b' will be suitably opened and adjusted to supply vapor to the engine. Upon turning the main shaft of the engine the power-piston and transfer-piston will first be caused to separate, the parts assuming the position shown in Fig. 3, and as they thus separate a charge of vapor will be drawn in between the cylinders through the supply-pipe L in the manner hereinbefore described. During this part of the movement of the pistons the exhaust-valve V is kept open, thereby permitting the burned gases of the preceding charge contained within the heater part A′ to be forced out into the atmosphere by the descent of the transfer-piston. The expulsion of the burned gases is rendered positive by reason of the fact that as the transfer-piston starts in its descent or rearward movement the check-valve C′ is shifted up into engagement with the upper side of the groove C of said piston, thereby forming an air-tight seal with the latter and preventing the escape of gases past the piston. The transfer-piston P′ having completed its down or in stroke, the exhaust-valve V closes, the power-piston P is now caused to move rapidly inward, thereby compressing the mixture of air and gas which has been drawn in between said pistons, the transfer-piston P′ in the meantime remaining almost stationary while its pitman is being carried past the inner dead-center. The power-piston P having almost completed its instroke, the transfer-piston is caused, by means of its connection to the crank of the main shaft, to approach the power-piston very rapidly, causing the volume of compressed air and gas between the two pistons to force the valve-ring C′ away from the upper side of the groove C, thereby permitting the gas to flow downwardly into said groove and from the latter through the radial passages C^2 of the valve-ring and thence through the longitudinal passages c' and past the transfer-piston into the heater part or combustion-chamber of the cylinder. As the charge of gas flows into the heater part of the cylinder the heat of the latter ignites the gas, whereupon it expands and acting upon the transfer-piston drives the two pistons upwardly or outwardly, the valve-ring being held in bearing with the upper side of the grooves C in position to prevent the escape of the gas past the piston by the explosive action of the gas. The connections of the power and transfer pistons with the crank of the main shaft bear such relation to the axis of the latter that the two pistons are caused to move outwardly at a substantially uniform speed during the principal part of the outstroke, thereby permitting the burning gas and air to act most efficiently upon the pistons. The driving power imparted to the main shaft upon the outstroke of the pistons causes the momentum of the fly-wheel W to complete the revolution and return the cylinders, thereby drawing in a new charge of gas and compressing and transferring the same, as hereinbefore described. As the transfer-piston approaches the limit of its outstroke the exhaust-valve V is open, permitting the exhausted gases to escape into the atmosphere, and the foregoing cycle of operations is repeated over and

over again as long as gas is admitted to the cylinder.

It will be obvious from the foregoing description that an engine constructed in accordance with our invention will work for an indefinite length of time without any special cooling mechanism for the cylinder, for the reason that the heat from the burning vapor is not transmitted to the upper portion of the cylinder, wherein the packed parts of the pistons work, to an extent sufficient to destroy such packings or interfere with the operation of the engine; but, on the contrary, each new charge of relatively cool vapor serves to cool this part of the cylinder and maintain it at a relatively low temperature. At the same time the burning of the gas within the lower end of the cylinder and the action of the burner thereon serve to maintain the heater part of the cylinder hot enough to ignite the gas as soon as it is admitted thereto, so that the explosion is rendered certain and uniform, and is, moreover, more in the nature of a prolonged combustion than an abrupt explosion, as is the case where a sparking or analogous ignition device is used. This last feature is a feature of importance, for the reason that the bursting strain upon the cylinder is thereby materially reduced.

The exhaust-gas passing out through the exhaust-chamber Z obviously serves to maintain the latter at a relatively high temperature, so that the fuel-oil passing into the burner through the passage M, extending through the walls of said valve-chamber, is heated to a considerable degree before it reaches the burner and its vaporization thereby materially aided. It is to be further noted in this connection that by reason of the fact that the supply of vapor is first intermingled with a supply of air in the mixing-chamber O, thereafter circulated through the supply-pipe L throughout the length of the latter, and then mixed with an additional supply of air insures the production of a vapor of high efficiency, it having been found that the intermingling of the requisite quantity of air by introducing the latter in successive charges contributes to the thorough intermingling of the gas and air, and consequently to the efficiency of the vapor thus produced.

It is to be further noted that the construction and arrangement of the several parts are such that the desired results are secured with a minimum number of parts, which parts are of extremely simple and strong construction. The novel construction and arrangement of the parts whereby the peculiar movement described is imparted to the pistons is a feature of importance and is obviously capable of embodiment in analogous mechanisms, the general construction and operation of which may be entirely different from the construction of the particular engine shown herein. We wish, therefore, to claim that feature broadly as well as specifically in combination with the coöperating features of construction set forth herein. It will be further obvious that the details of construction of the other features of the engine may be modified without departing from the spirit of the invention, and we do not, therefore, wish to be limited to the precise details shown except as they may be made the subject of specific claims.

We claim as our invention—

1. In combination with a cylinder and a pair of pistons arranged to work therein, means for controlling said pistons to impart a synchronous but differential movement thereto comprising a pitman-support upon each piston, one of which is in the form of an extension whereby the pitman is adapted to be connected with the piston at a point remote from the latter, a pitman pivotally connected with each pitman-support, a main shaft located out of alinement laterally with a line extending between the points of connection of the pitmen with their respective pitman-supports and at a point intermediate the distance separating said points, and crank connections between said main shaft and pitmen, the axis of said main shaft being located at one side of said line extending between the points of connection of the pitmen with their respective supports a distance less than the length of the crank-arm.

2. In combination with a cylinder and a pair of pistons arranged to work therein, means for controlling said pistons to impart a synchronous but differential movement thereto, comprising a pair of pitman-supports connected with, or upon, the respective pistons, one of said supports being in the form of an extension whereby the pitman may be connected therewith at a point longitudinally remote from the pitman connection to the other piston, a main shaft located at one side of a direct line extending between the points of connection of the respective pitmen with said supports and at a point intermediate the distance separating said points, a crank upon said main shaft and a pair of pitmen connected with said crank and with the respective pitman-supports, the location of the main shaft being such that the path of the pitman-wrist of its crank intersects said direct line extending between the points of connection of the pitmen with their respective supports.

3. In combination with a cylinder and a pair of pistons arranged to work therein, means for controlling said pistons to impart a synchronous but differential movement thereto, comprising two piston-rods severally connected with the respective pistons and arranged to extend therefrom parallel with each other and in the same direction, one piston-rod having longitudinally-sliding engagement with the other, a pair of pitman-rods severally connected with said piston-rods at points longitudinally separated from each other, a main shaft with which both of said pitman-rods have cranked connection located

at one side of a direct line extending between the pivotal point of the connection with the several pitman-rods with their respective piston-rods, the axis of said main shaft being located at one side of said direct line a distance less than the length of its crank-arm, as and for the purpose set forth.

4. In combination with a cylinder and a pair of pistons arranged to work therein, means for controlling said pistons to impart a synchronous but relatively differential movement thereto, comprising a hollow extension connected with one of said pistons and forming a piston-rod, a piston-rod connected with the other piston and extending through said hollow extension, a guide arranged parallel with said latter piston-rod, a guide-shoe connected with said piston-rod and engaging said guide, a pair of pitmen respectively connected with the hollow extension and the piston-rod at longitudinally-separated points, a main shaft located at one side of a direct line extending between the pivotal axes of the points of connection of said pitmen with their respective driving members, a crank upon said main shaft with which each one of said pitmen directly is connected, whereby said pitmen are flexed into direct alinement with each other during each revolution of the main shaft, as and for the purpose set forth.

5. In a gas-engine, the combination, of a cylinder provided at one end with a heater-part portion, means for maintaining said heater-part portion at a temperature sufficient to ignite the charge therein, power and transfer pistons working in said cylinder, said transfer-piston being of trunk form and having one end arranged to extend within the heater-part portion, inlet and exhaust ports located near the respective ends of said cylinder, a check-valve mechanism located in said transfer-piston constructed to permit the flow of a combustible charge from the space between said pistons to the heater part of the cylinder, and means for imparting a synchronous but relatively different movement to said pistons, whereby the combustible charge admitted between the pistons is first compressed and then transferred to the heater part of the cylinder, substantially as described.

6. In a gas-engine, the combination, of a power-cylinder, a power-piston and a transfer-piston, in said cylinder, inlet and exhaust ports in said cylinder, a hollow extension on said power-piston carrying a bearing or pivot *e*, a transfer-piston rod secured to one end of said transfer-piston and extending through and sliding in said hollow extension and at its other end carrying a bearing or pivot *e'* said pivots *e* and *e'* being arranged to move in unison and in a parallel line with said power and transfer pistons; two links journaled at one of their ends to said pivots and at their other end to a crank on a drive-shaft journaled outside of a straight line traced between the centers of said pivots *e* and *e'*, the center of said crank-pin intersecting the same line twice during the outstroke of said power and transfer pistons, substantially as described.

7. In a gas-engine, the combination, of the cylinder comprising the parts A, A', the latter inclosed in the combustion-chamber *a*, the burner B arranged to discharge into said combustion-chamber, a mixing-chamber O, the fuel-supply pipe *m* communicating with said burner and said mixing-chamber, the vapor-supply pipe L communicating with the mixing-chamber and the inlet-port L', the exhaust-port Z and the valve V arranged to control said port, the power-piston P having the extension D, the transfer-piston P' and its piston-rod *d* arranged to extend out through the said hollow extension, the pitman-rods H, H' respectively connected with said hollow extension and with the piston-rod *d*, the main shaft K having the crank-wrist *k* with which said pitmen are both connected, the fly-wheel mounted upon said main shaft, the eccentric or equivalent upon said main shaft operatively connected with said exhaust-valve, and the gas-passages extending from one end of the trunk-piston to the other and controlled by the valve-ring C arranged within the circumferential groove C', combined and operating substantially as described.

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