3 Sheets—Sheet 1.

J. WERTHEIM.

ATMOSPHERIC GAS ENGINE.

No. 185,709. Patented Dec. 26, 1876.

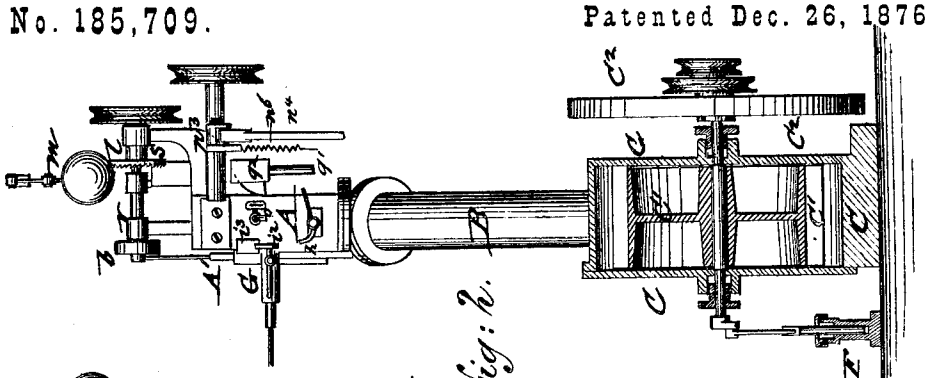

Fig: 2.

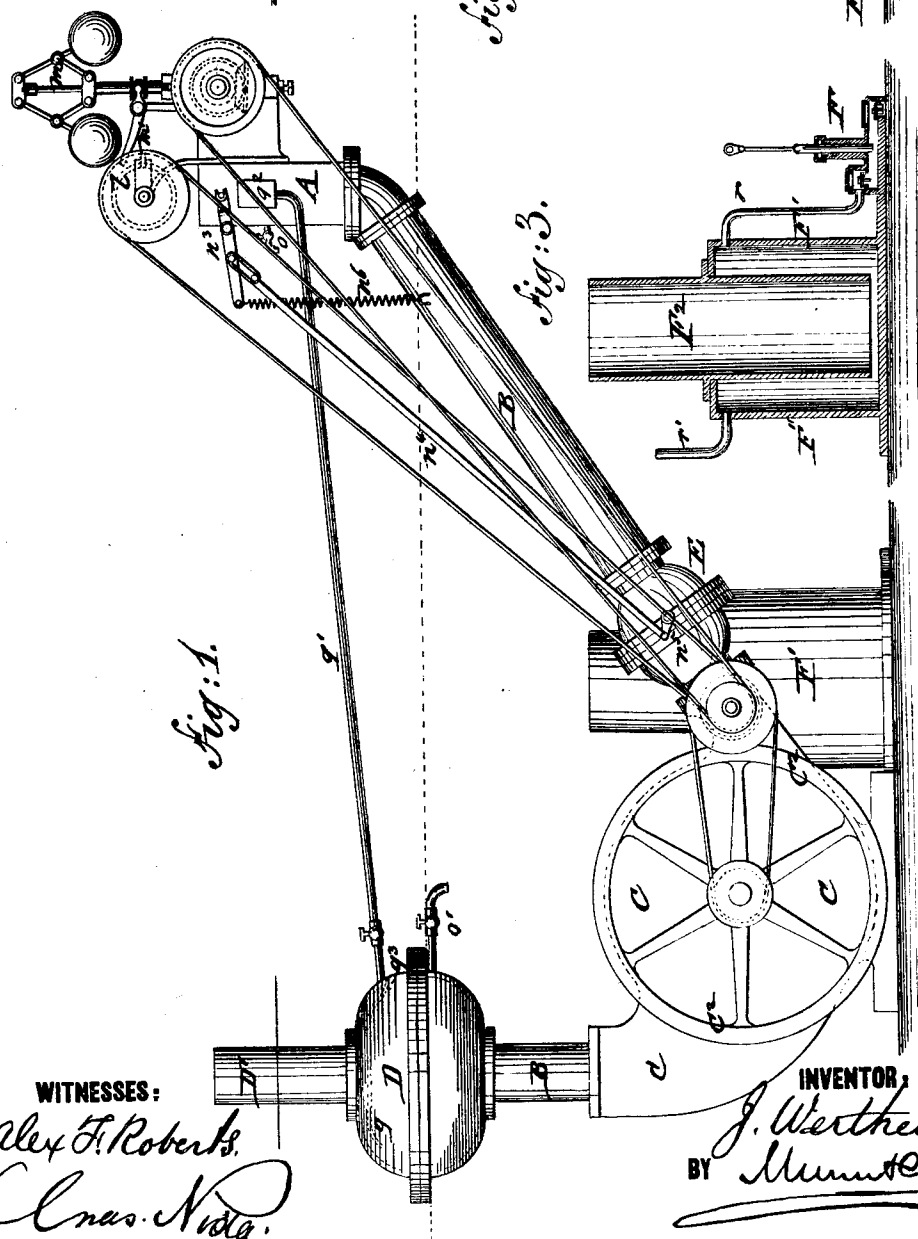

Fig: 3.

Fig: 1.

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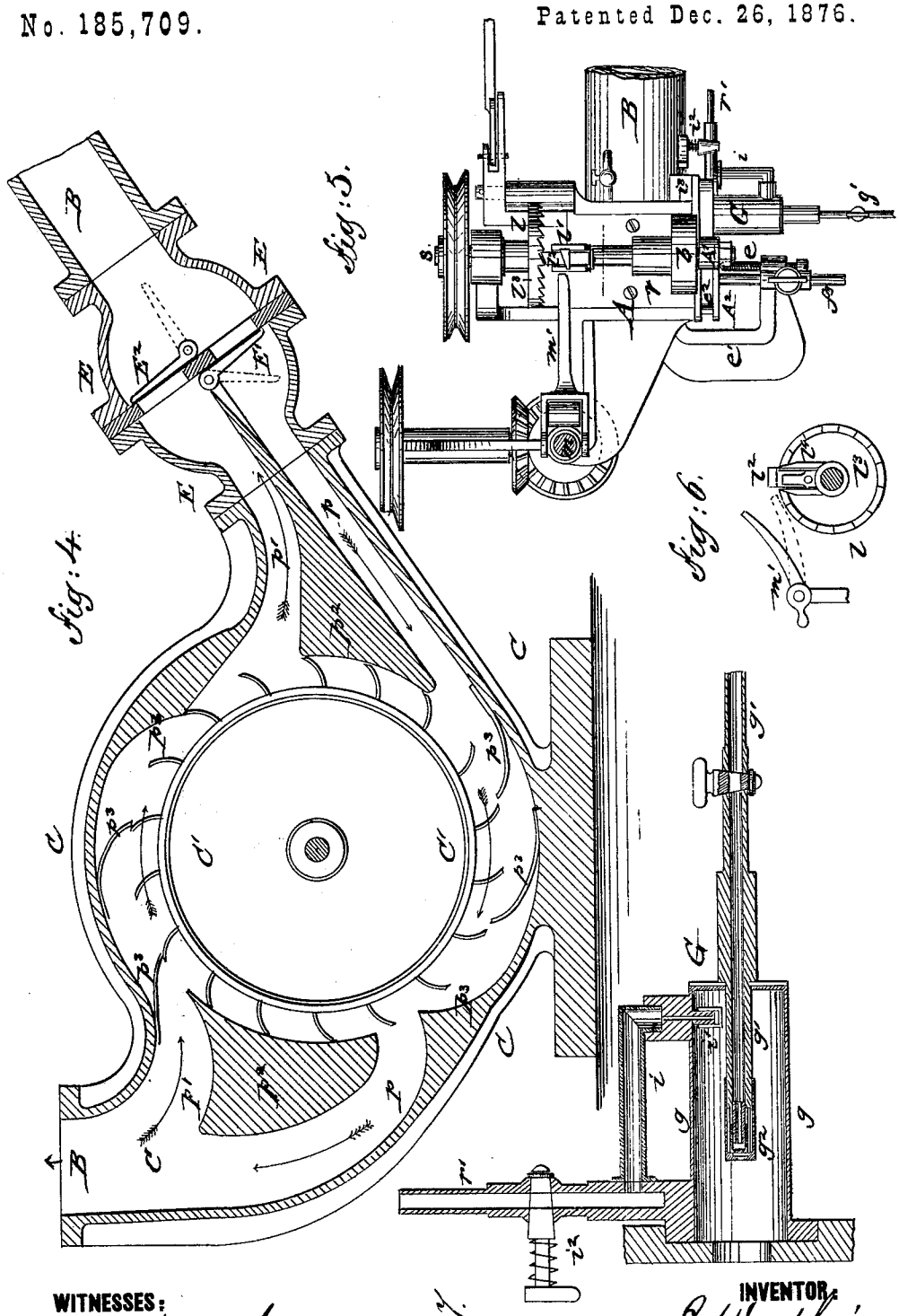

Fig: 4.

Fig: 5.

Fig: 6.

Fig: 7.

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3 Sheets—Sheet 3.

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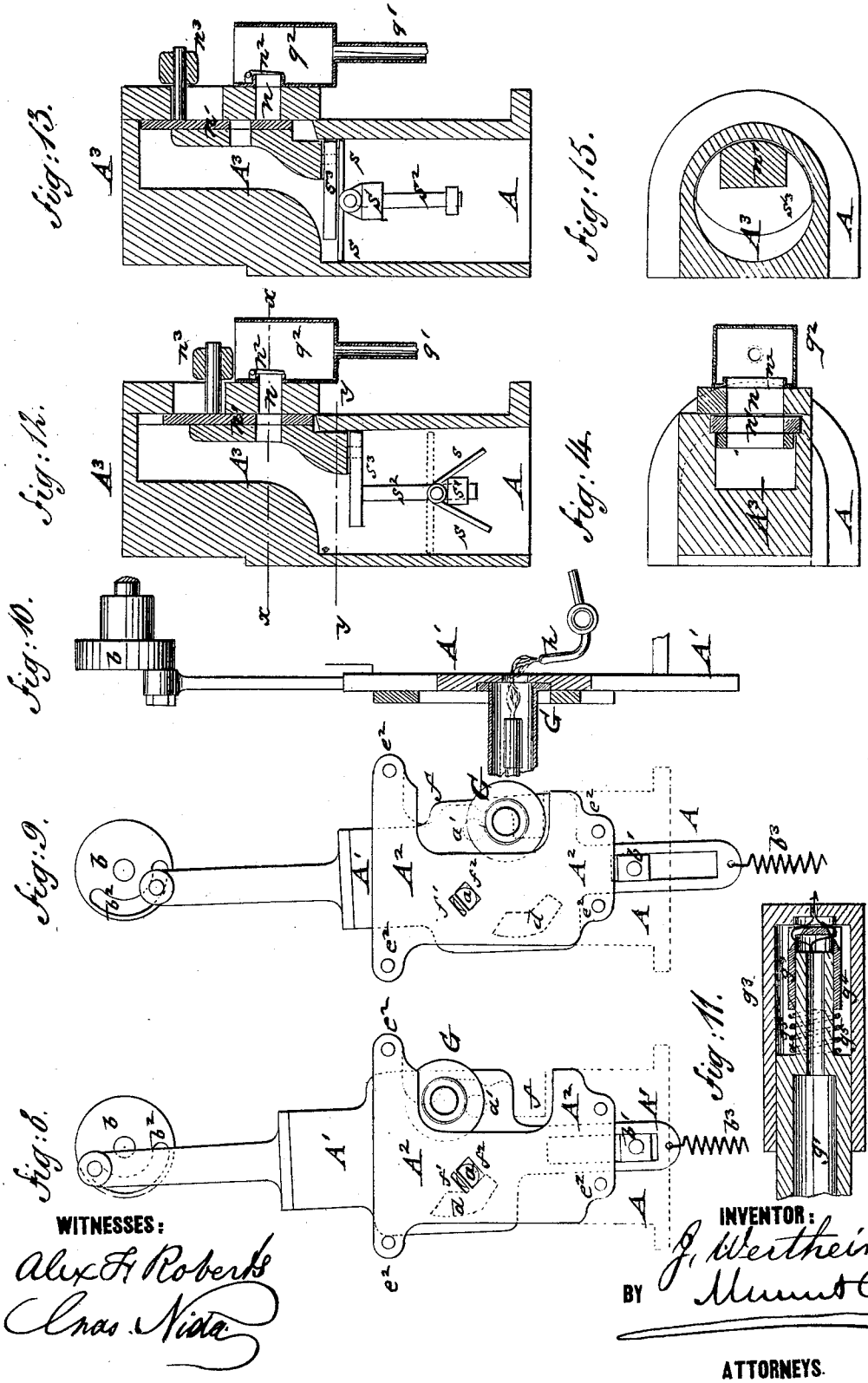

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UNITED STATES PATENT OFFICE.

JOSEPH WERTHEIM, OF BORNHEIM, PRUSSIA.

IMPROVEMENT IN ATMOSPHERIC-GAS ENGINES.

Specification forming part of Letters Patent No. **185,709**, dated December 26, 1876; application filed October 9, 1876.

To all whom it may concern:

Be it known that I, JOSEPH WERTHEIM, of Bornheim, near Frankfort-on-the-Main, Germany, have invented a new and Improved Atmospheric-Gas Engine, of which the following is a specification:

The invention relates to an improved combined atmospheric-gas engine, in which the explosive force of a suitable gas-and-air mixture and the atmospheric pressure are utilized as motive powers; and it consists, mainly, of a cylindrical explosion-dome, connected by a siphon-pipe with a reservoir. In this pipe, but at its lower part, is a paddle-wheel, arranged in a casing with curved chutes, on which the power of the explosion in the dome and of the atmospheric pressure created by the vacuum therein is exerted by means of water or other liquid.

The explosion may be produced by a suitable mixture of illuminating-gas and air that is admitted into the explosion-dome, and ignited by a slide-valve with an igniting mechanism. The explosion forces the liquid, through a double-valve arrangement of the siphon-pipe, paddle-wheel, casing, and connecting channels, into the liquid-reservoir at the end of the siphon-pipe, and back again by the vacuum formed in the dome and pipe, imparting, by the forward and return motion, a continuous rotary motion to the paddle wheel. The liquid-valves control the escape of the gases from the explosion-chamber, in connection with the return of the liquid, by means of a slide-valve and interior pendent float-valves, any mechanically-escaping liquid being returned by a small collecting-chamber and pipe to the liquid-reservoir.

The regulating device is operated in connection with the fly-wheel of the paddle-wheel shaft, interrupting temporarily the explosions in the dome when the speed is too fast; the special construction of the explosion-dome, with its slide-valve, air and gas admitting devices, and igniting apparatus, together with the valve arrangement for the escape of the gases of combustion, the governor, the liquid-valve chamber, paddle-wheel and casing, liquid-reservoir, and air-supply pump, being more fully described hereafter, and then pointed out in the claims.

By reference to the accompanying drawings, illustrating my invention, Figure 1 represents a side elevation of my improved combined atmospheric-gas engine; Fig. 2, an end view, partly in section, through the paddle-wheel casing; Fig. 3, a vertical central section of the air-supply pump; Fig. 4, a vertical longitudinal section of the paddle-wheel, casing, and liquid-valves on enlarged scale; Fig. 5, a top view of the explosion-dome with regulator; Fig. 6, a detail side view of the clutch-connection of governor and shaft of slide-valve, illustrating working of regulating mechanism; Fig. 7, a detail horizontal section of igniting apparatus. Figs. 8 and 9 are side views of explosion-dome and slide-valve, showing the same, respectively, in position for receiving the supply of air and gas, and for being ignited. Fig. 10 is a detail vertical transverse section of slide-valve and igniter, showing method of lighting the igniter after each explosion; Fig. 11, a detail section of the burner of the igniting apparatus. Figs. 12 and 13 are vertical transverse sections of the upper chamber of explosion-dome, with the slide and pendent valves for the escape of explosion gases, shown, respectively, in open and closed position; and Figs. 14 and 15 are horizontal sections of the explosion-dome, respectively on lines *x x* and *y y*, Fig. 12.

Similar letters of reference indicate corresponding parts.

In describing my combined atmospheric-gas engine, I will first describe the main parts of the same—namely, the explosion-dome, with its main slide-valve and igniting apparatus; then the siphon-pipe, with its valve-chamber, the paddle-wheel and casing, the liquid-reservoir, and air-supplying apparatus; and, finally, the governor and extension-chamber of the explosion-dome, with its valves for the expansion of the gases of combustion.

In the drawing, A, Fig. 1, represents the explosion-dome, which is a cylindrically-turned body, closed at the upper end, and provided with one straight side, along which the main slide-valve A^1 is guided in suitable manner. The dome A has an entrance-opening, *a*, for the explosive mixture of air and illuminating-gas, and near to it an opening, *a'*, serving as place of ignition. (Both shown in Figs. 8 and

9.) The slide-valve A^1 moves along the straight face of the dome A in an elliptical line, the motion being imparted by a revolving disk, *b*, to which the upper end of the slide-valve is pivoted, and by a square pivoted guide-piece, b^1, along which the lower slotted end of the slide-valve moves. The revolving disk *b* has a segmental slot, b^2, in which the connecting-pivot of the slide-valve moves freely, and by which the slide-valve is raised until, after the disk has passed its upper dead-point, the slide-valve is quickly drawn downward by the action of a spring, b^3, at its lower end, the slot serving to guide the slide-valve until its pivot arrives at the lowest point of the slot. During the upward motion of the slide-valve, as produced by the crank-disk *b*, a segmental slot, *d*, of the slide-valve A^1 forms communication with the entrance-opening *a* of the dome, while the ignition-opening *a'* remains closed by the slide-valve. By the downward motion of the slide-valve the opening *a* will be closed, while the igniting apparatus G, fixed to the slide-valve, slides over the ignition-opening *a'*, so as to communicate therewith for an instant, and cause the ignition of the explosive gas-and-air mixture therein. The slide-valve A^1 is covered by a plate, A^2, which is firmly held in position on the dome, but so as to be readily detachable, by a clamping-screw, *e*, turning in a fixed arm, e^1, and by fastening pins e^2, as shown in Figs. 5, 8, and 9. The covering-plate A^2 is provided with a side recess, *f*, of sufficient size to admit the unobstructed motion of the igniter G of the slide-valve. It has also two small oblong openings, f^1 and f^2, of which one is larger than the other, and which correspond with the entrance-opening *a* of the dome. Through the larger opening f^2 the atmospheric air is admitted to the dome, while the illuminating-gas enters through the smaller opening f^1, and gas-pipe connected therewith. The quantity of gas required is regulated by means of a cock, so that the exact proportions of air and gas for the explosive mixture are obtained. The square entrance-openings $f^1 f^2$ of the covering-plate are arranged at suitable inclination to the vertical axis, and intended to produce, in connection with the arc-shaped or segmental opening *d* of the slide-valve, a regular supply of gas and air to the dome during the up and downward motion of the slide-valve, together with the simultaneous opening and closing of the corresponding openings.

The igniting apparatus G consists of a cylindrical inclosing-casing, *g*, that is attached to the slide-valve, as shown in Figs. 2, 7, 8, and 9, being open at the point of attachment, to communicate with the ignition-opening *a'* of the dome. A gas-pipe, g^1, enters through the end of the casing *g*, and may be opened or closed by a stop-cock. The igniter G is applied to the slide-valve in such a manner that when the same arrives at its lowermost point, and just before it begins to move upward, the casing *g* communicates with the atmosphere; but as soon as the slide-valve has passed the highest point and begins its rapid downward movement, the opening of the igniter communicates with the ignition-opening of the dome.

A burner, g^2, at the end of gas-pipe g^1 in the interior of casing *g*, produces the ignition of the explosive mixture in the dome at the moment when the opening of casing passes over the igniter-opening *a'*, the burner g^2 communicating again with the atmosphere on the arrival of the slide-valve at its lowest position. The burner g^2 is so constructed that the explosion extinguishes its flame, which is lighted again by a small gas-flame of a pipe, *h*, at the side of the dome at the moment when the igniter communicates with the air, as shown in Figs. 2 and 10.

The construction of the burner g^2 is shown in detail in Fig. 11, and consists of a fixed outer tube, g^3, attached to the gas-pipe g^1, and provided with one small outlet-opening for the gas. A sliding sleeve, g^4, moves along the thinner end of the gas-pipe, at the inside of the tube g^3, and communicates therewith by small openings near the circumference of the front end of the sleeve. A spiral spring, g^5, is interposed between the shoulder of the gas-pipe and the rear end of sleeve g^4, and serves to push the sleeve instantly forward after the force of the explosive gases has thrown the same back. The solid central part of the front end of the sleeve g^4 closes, at the moment of the explosion, the end of the gas-pipe, and extinguishes thereby the flame, which, however, is lighted again by the forward motion of the sleeve as the gas is allowed to pass out through the perforations of the sleeve and outer burner-tube, to be relighted by the nearly simultaneous connection with the continually-burning flame of gas-pipe *h* at the end of the stroke of the slide-valve.

The gases of combustion, which have filled the entire casing *g* of the igniter, are expelled by fresh air, which enters through a pipe, *i*, so that the gas is lighted without difficulty. The air-pipe *i* is arranged parallel to the casing *g*, and allowed to enter at the rear end of the same by being bent at a right angle. The inner end of pipe *i*, in the same manner as the end of the gas-pipe g^1, is surrounded by a sliding and spring-acted sleeve or cover, i^1, to prevent the entrance of the gases of combustion.

The air-pipe *i* is provided with a spring-acted cock, i^2, which is closed by contact with a face, i^3, of the dome, Figs. 2 and 5, during the time when the opening of the igniter is closed, by passing along the side of the dome. At the moment when the igniter arrives at the opening *a'* the handle of the cock i^2 leaves the contact-face i^3, and is opened by the action of the spring, so as to supply fresh air to the interior of the igniter at the moment of the ignition.

The temporary closing of the cock i^2 is necessary for the purpose of preventing the

admission of air into the casing g at the time when the igniter is closed by the side of the dome, as the free entrance and pressure of air would extinguish the flame before the igniter arrives at the ignition-opening, so as to prevent the explosion.

The explosion-dome A communicates, by a siphon-pipe, B, secured by an angular joint to the bottom part of the same, with a paddle-wheel box or casing, C, at the lowermost part of the siphon-pipe, and with a liquid-reservoir, D, at the other end of the same. The engine is filled with any suitable liquid—as water, mercury, &c.—through the reservoir D, until, by passing through the siphon-pipe, wheel-casing, and dome, it arrives at a level at suitable height above the reservoir, as indicated in Fig. 1 by a line drawn across the air-pipe D′ of the reservoir.

After the liquid has filled the dome, which is indicated by its running out of a stop-cock, O, of the same, this stop-cock is closed and the level of the liquid in the reservoir reduced to about the middle line of the same by a stop-cock, o'. The engine is now ready for the action of the explosions in the dome, the liquid serving as a kind of movable piston, which forms a continuous air-tight connection with the parts of the engine. This liquid-piston is, by the force of the explosion, compelled to move downward in the siphon-pipe B, and through a valve chamber, E, of the same, near the connection of the pipe B with the paddle-wheel casing C, onto the paddle-wheel C^1, so as to revolve the same, passing out of the same through a channel at the opposite side of the wheel into the vertical section of the siphon-pipe, and into the liquid-reservoir. The vacuum produced by the explosion in the dome and upper part of inclined siphon-pipe forces, by the atmospheric pressure, the liquid immediately back through an upper channel of the wheel-casing onto the upper part of the paddle-wheel, passing back through the valve-chamber into the siphon-pipe and dome, to be acted on again in the same manner by the successive explosions of the air-and-gas mixture.

The valve-chamber E is provided with two swinging valves, E^1 and E^2, which admit the passage of the liquid in either direction, the valve E^1 swinging downward to allow the downward motion of the liquid, the other upward to admit the return motion of the same. The lower half of chamber E is separated into two channels by a central partition, of which one channel communicates with the lower channel p, the other with the upper channel p^1, of the wheel-casing. In the ordinary pendent position of the valve E the liquid may be forced out of the dome by the pressure of the entering air. The force of the explosion forces the liquid down and presses the valve E^2 tightly to its seat, while the valve E^1 is pushed into a recess at the lower side of the partition, to allow the unobstructed passage of the liquid through the lower channel p. When the liquid is forced back the atmospheric pressure closes the valve E^1, and causes the liquid to flow through the upper channel p^1, pushing the valve E^2 open for the passage of the liquid to the dome.

The wheel-casing C fits sufficiently to the sides of the paddle wheel C^1 to admit the ready turning of the same by the action of the liquid. The buckets or paddles are fitted to move close to the solid partition-sections p^2, between the channels p and p^1, and also to the chutes or guides p^3 of the wheel-casing. The liquid is forced by the chutes on the paddles, and produces the continuous rotary motion of the wheel by the alternating action of the liquid on the lower and upper paddles, as caused by the explosion and the vacuum in the dome.

The shaft of the paddle-wheel turns in suitable bearings of the casing C, and extends at both sides to the outside of the same, having a fly-wheel, C^2, at one end, and connecting, by a crank at the opposite end, with a small air-pump, F, that supplies, by means of a reservoir, F^1, fresh air to the igniting apparatus of the slide-valve. The fly-wheel C^2 transmits the power, by belt-and-pulley connection, to the slide-valve, governor, and other contrivances.

The liquid-reservoir D receives the liquid driven out of dome A and the siphon-pipe B, and communicates with the atmosphere by its tube D′. Below this tube is arranged, at the inside of the reservoir, a tin or iron covering-plate, q, (indicated in dotted lines in Fig. 1,) that prevents the liquid from being thrown out of tube D′.

The reservoir D connects, by a pipe, q^1, with a small water-exit chamber, q^2, of the explosion-dome, for conducting any liquid that may be carried along by the escaping gases of combustion back into the reservoir D. The discharge-opening of pipe q^1 is above the cover q, and protected by an extension, q^3, of the same against the entrance of the liquid into the pipe q^1.

The cock of the reservoir is opened for obtaining the required level in the same for starting the engine, while the cock of the dome is opened to let out the air until the engine is entirely filled with liquid.

The air-pump F forces air into the vessel F^1, which has a central tubular part, F^2, open at the top and bottom, and is filled with water, for keeping the air in the vessel F^1 compressed. The air enters the vessel F^1 at the upper part by a pipe, r, connecting with the pump, and supplies the casing g of the igniter by a pipe, r'. The surplus of air escapes through the central part F^2. The gearing of the fly-wheel C^2 operates the disk-shaft r of the slide-valve A^1, turning in supports at the top of the explosion-dome. A clutch mechanism, l, throws the disk-shaft r and pulley-shaft s into or out of gear. The clutch l consists of a catch, l^1, of the disk-shaft, that connects, by a sliding and spring-acted tooth, l^2,

with a toothed disk, l^3, keyed to the pulley-shaft, as shown in Fig. 5.

The sliding tooth and disk couple the disk-shaft and pulley-shaft until separated by the governor m, which is revolved, in the customary manner, from the fly-wheel of the engine, and actuates a fulcrumed lever, m', that is thrown down when the engine runs at too great speed, so as to engage a projection of sliding tooth l^2, as shown in Fig. 6, withdraw the tooth from the disk, and interrupt their connection, throwing thereby instantly the disk-shaft out of gear. The motion of the slide-valve A^1 is thereby temporarily interrupted when at its lowest position, and thus a cessation of the explosions produced until the speed of the engine is sufficiently diminished, so that the lever will be raised and released from the tooth, and thereby, by the action of the spring on the tooth, the clutch-connection of the disk and pulley shafts will be re-established, and the operation of the slide-valve and explosion-dome resumed. The gases of combustion are expelled from the upper part of the dome after explosion by means of an extension chamber or casing, A^3. (Shown in section in Figs. 12, 13, 14, and 15.) The chamber A^3 has an exit-opening, n, which is closed by a slide-valve, n^1, guided at the interior of the chamber, and operated by crank-lever connection with the valve E^2 of the valve-chamber E. The exit-opening n is further provided with a pendent valve, n^2, at the outside, for the purpose of preventing the entering of the atmospheric air.

The pendent valve n^2 is opened by the pressure of the combustion gases, when the slide-valve n^1 establishes communication with the exit-opening n, and is immediately closed after the expulsion of the gases is completed. The slide-valve n^1 is opened by the downward motion imparted by a fulcrumed lever-arm, n^3, pivoted to a pin of the valve at one end, and to a crank-rod, n^4, at the other end, the crank-rod n^4 connecting with an outside crank, n^5, of valve E^2. (See Fig. 1.) The return motion of the liquid opens thus, simultaneously with the valve E^2, the slide-valve n^1, for the escape of the gases.

A spiral spring, n^6, attached to the outermost end of the lever-arm n^3, closes the exit-opening n of the extension-chamber A^3 by carrying the slide-valve in upward direction, and assists also to close, at the same time, the liquid-valve E^2. The closing motion of the slide-valve n^1 is, however, not accomplished by the spring n^6 alone, but assisted by the direct force of the returning liquid, which rises in the explosion-dome and drives out the gases of combustion. The *vis viva* of the ascending liquid, forced up by the atmospheric pressure, acts on two pendent flap-valves, s, that are hinged to a sleeve, s^1, sliding on a pin or stud, s^2, that extends downward from a plate, s^3, secured by a connecting-bracket to the slide-valve n^1. The plate s^3 bears with the greater part of its circumference on the inside of the dome, but leaves at one side a space of sufficient width for the escape of the gases of combustion. The pendent valves s are fitted to the interior of the dome, and close, on being spread open, entirely the inner periphery of the same.

The slide-valve n^1 is closed when the explosion takes place, at which moment the sliding sleeve and pendent valves are seated on the enlarged lower end of the guide-pin s^2, and allow the gases to escape; but as soon as the liquid rises in the dome sufficiently to reach the pendent valves, it will swing them open and carry them upward against the plate s^3, so as to accelerate the forcing out of the gases and close the slide-valve n^1 by their pressure against plate s^3. In Figs. 12 and 13 the positions of the slide and pendent valves are shown at the moment when the liquid begins to flow back, and when the dome is free of gases and filled with liquid. The liquid, having passed by its *vis viva* above the level of the reservoir, will readily recede, on the entrance of a fresh quantity of mixed gas and air, down to the siphon-pipe, the pendent valves following the receding motion along its guide-pin until they arrive again at the lowermost position thereon, ready for the next rising of the liquid and expulsion of the gases. The engine may be constructed in large and small scale, having, by the motion of the liquid-piston, but little friction, being, therefore, adapted for driving sewing and other machines requiring cheap motors of small power, as well as for larger machines.

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

1. An atmospheric-gas engine, constructed mainly of an explosion-dome and appendages, of a siphon-pipe with paddle-wheel and liquid-reservoir, and of a liquid actuated by the explosive force of a suitable gas-and-air mixture in the dome by atmospheric pressure, all combined and substantially in the manner and for the purpose set forth.

2. The combination of the explosion-dome A, having entrance-opening a and ignition-opening a', with the slide-valve A^1, reciprocated as shown, having segment-opening d, and igniter G, substantially as shown and described.

3. The combination of explosion-dome with entrance-opening a, slide-valve A^1, reciprocated as shown, with segment-opening d, and covering-plate A^2, with corresponding gas and air openings f^1 f^2, substantially as described.

4. The combination of the spring-pressed slide-valve A^1, having pivot at upper and guide-slot at lower end, with the dome and the revolving segmentally-slotted disk at top of dome, and a square pivot-guide at lower part of dome, as and for the purpose specified.

5. The combination of covering-plate A^2, fastening-pins e^2, and clamp-screw e with dome A and the slide-valve A^1, to secure cov-

ering-plate in rigid but detachable manner, substantially as set forth.

6. The combination, with slide-valve and explosion-dome, of igniting apparatus G, composed of an outer casing, g, inner burner g^2, and air-supply pipe i, substantially as set forth.

7. The combination, with slide-valve and explosion-dome, of burner g^2 of igniter G, constructed of gas-pipe g^1, fixed tube g^3, with central exit perforation, and of sliding and spring-acted interior sleeve g^4, with side exit perforations, to extinguish flame at each explosion, substantially as set forth.

8. The combination, with the slide-valve and air-pipe i, of the spring-acted air-supply cock i^2 of igniter G, with contact-face i^3 of dome, to close air-supply during upward motion of slide-valve to prevent extinction of igniting flame, substantially as set forth.

9. The combination of slide-valve, explosion-dome, and igniter with an air-pipe, i, spring-acted cock i^2, and an air-pumping apparatus, to supply air to the igniter instantly after the explosion, for expelling the gases of combustion and relighting the burner, substantially as specified.

10. The combination, with the explosion-dome and siphon, of wheel-casing C, having liquid-channels p p^1 and chutes p^3, with the paddle-wheel C^1, substantially as set forth.

11. The combination, with the explosion-dome and siphon, of liquid-valves E^1 E^2, with the wheel-casing C and paddle-wheel C^1, to govern the flow of liquid in forward and return direction, substantially as set forth.

12. In a gas-engine, constructed substantially as shown, the combination, with paddle-wheel casing C, of the liquid-reservoir D, having central open tube D′, for admission of atmospheric air, substantially as set forth.

13. In a gas-engine, constructed substantially as shown, the combination, with paddle-wheel casing C, of the liquid-reservoir D, having interior guard-cover q, with extension q^1, substantially as described.

14. In a gas-engine, constructed substantially as shown, the combination, with paddle-wheel casing C, of liquid-reservoir D by pipe q^1, with drip-receptacle q^2 of explosion-dome, to conduct liquid escaping from dome to reservoir, substantially as set forth.

15. The explosion-dome, having top extension-chamber A^3, with exit-opening n for gases of combustion, in combination with slide-valve n^1 and outer swinging valve n^2, substantially as described.

16. The combination of extension-chamber A^3 of explosion-dome, having exit-opening n, with slide-valve n^1 and pendent valves s, sliding along inside of dome, to assist expulsion of gases and closing of exit-opening n, substantially as described.

17. The combination, with the explosion-dome, of slide-valve n^1 of extension-chamber A^3, with fulcrumed and spring-acted lever n^3, rod n^4, and crank n^5 of valve E^2 of siphon-pipe, substantially as set forth.

18. The combination, with explosion-dome and chamber A^3, of horizontal plate s^3, attached to slide-valve n^1, and having central pin s^2, with sliding and pendent valves s, substantially as set forth.

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