No. 855,726. PATENTED JUNE 4, 1907.

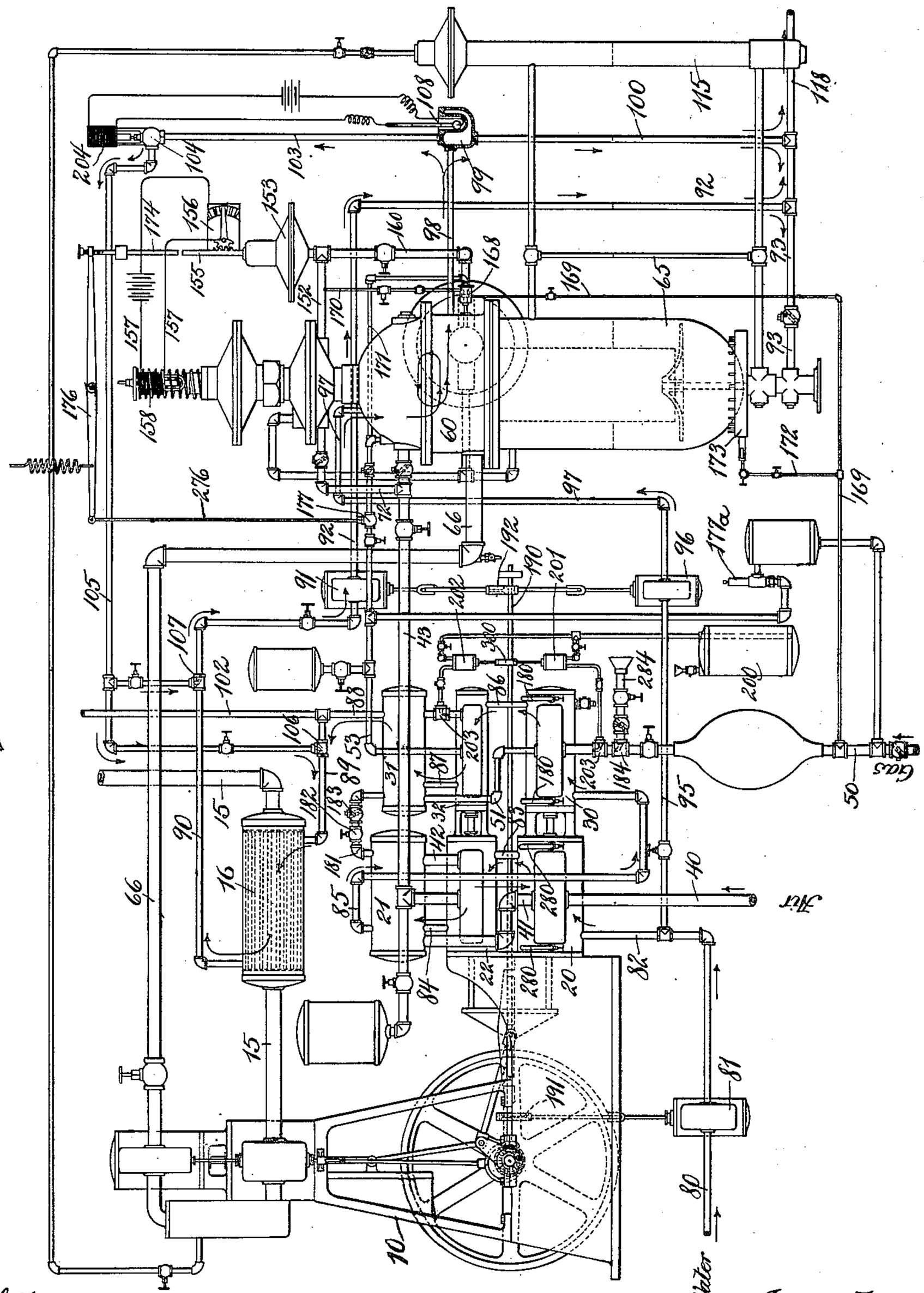
E. P. NOYES.

CONTINUOUS COMBUSTION GENERATING APPARATUS.

APPLICATION FILED MAR. 30, 1904.

2 SHEETS—SHEET 1.

Fig: 1.



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2 SHEETS—SHEET 2.

Fig. 5.

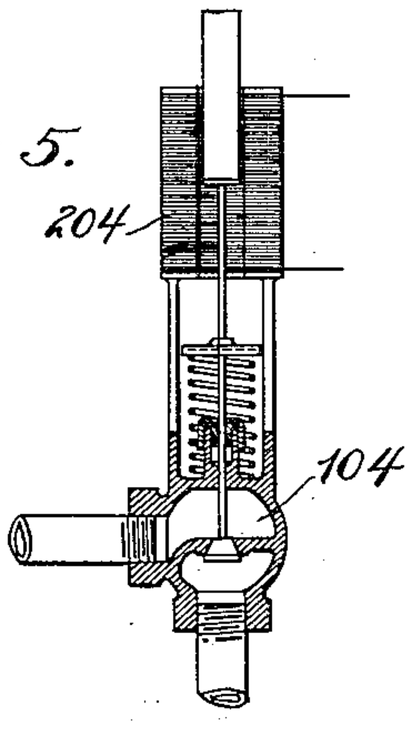


Fig. 6.

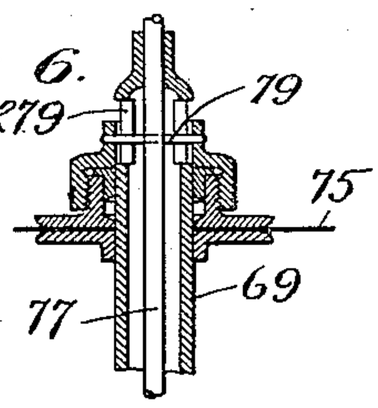


Fig. 4.

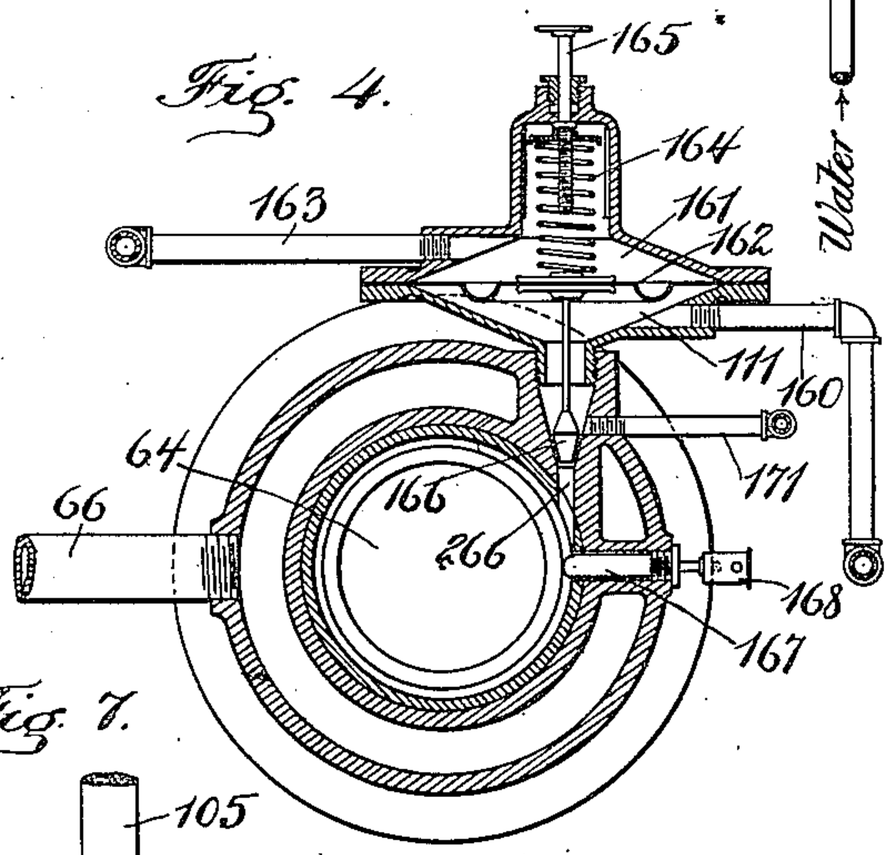


Fig. 7.

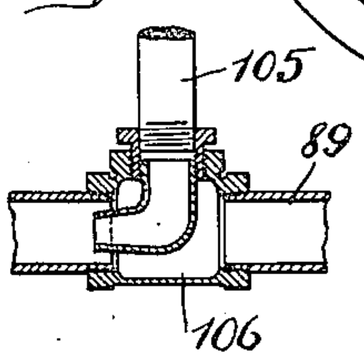


Fig. 3.

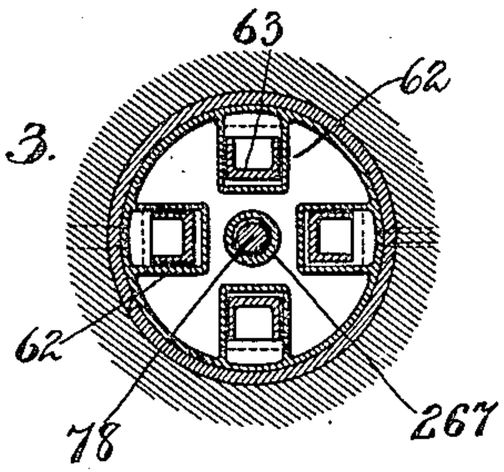
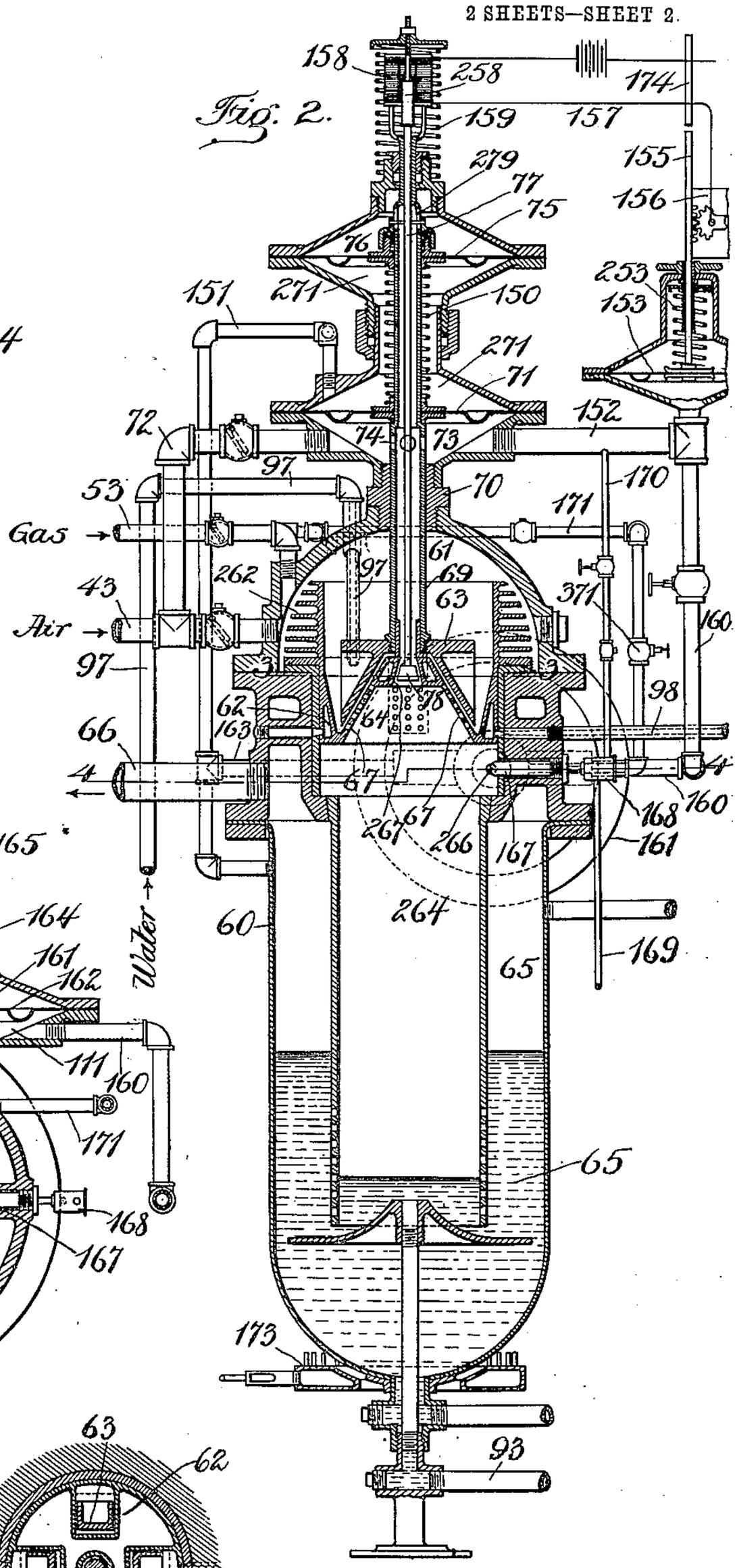


Fig. 2.



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UNITED STATES PATENT OFFICE.

EDWARD P. NOYES, OF WINCHESTER, MASSACHUSETTS.

CONTINUOUS-COMBUSTION GENERATING APPARATUS.

No. 855,726. Specification of Letters Patent. Patented June 4, 1907.

Application filed March 30, 1904. Serial No. 200,700.

To all whom it may concern:

Be it known that I, EDWARD P. NOYES, of Winchester, in the county of Middlesex and State of Massachusetts, have invented certain new and useful Improvements in Continuous-Combustion Generating Apparatus, of which the following is a specification.

This invention relates to heat-engines for developing power by continuous combustion at constant pressure, such for example, as described in patents to S. A. Reeve, Nos. 588,178 and 588,293. It has been customary heretofore in the operation of apparatus of this kind to keep the air and fuel separate before reaching the entrance to the combustion-chamber, this procedure being deemed necessary as a guard against explosion. Premature inflammation of the fluids, besides endangering the apparatus, dilutes the combustible fluids, impairs their readiness to unite, and delays and renders incomplete their ignition when flowing rapidly in a closed chamber and in dense condition. If the fluids are fully physically commingled before reaching the combustion-chamber, the gases tend to all burn back to the commingling point which is disastrous to the apparatus and destructive of efficiency. If on the contrary the fluids are held completely separate up to their entrance into the combustion-chamber, the task of at once and completely commingling them is great and partly due to the increased density which the fluids assume under pressure. To the end of effecting this complete mixture of previously-unmixed fluids when they enter the combustion-chamber special expedients are required or else an enlarged combustion-chamber will be found necessary in order to secure complete combustion.

My present invention embodies the previous mixture of air and fuel in continuous-combustion-at-constant-pressure apparatus, together with means to prevent the burning back of the fluids, and, in addition, certain novel expedients in connection with such means whereby the several devices are made to mutually contribute to the efficiency and utility of the apparatus. It is known that passage of an inflammable mixture through metal perforations prevents back-burning of the mixture because the metal abstracts the heat of the several small flows on account of the large aggregate of metal surface presented by the perforations. This action, however, depends on considerable temperature difference between the fluids and the metal, which I have discovered it is difficult to maintain when the heat is very much in quantity and generated within a limited space, as in apparatus of the kind to which this invention relates. On this account special means are provided to maintain the desired temperature difference, as will hereinafter appear.

My invention further takes cognizance of the velocity of flow into the combustion-chamber. An increase of temperature and pressure increases the rate of backward propagation of flame, against which provision should be made by an increase of velocity. For a given quantity of combustion-fluids flowing into the combustion chamber per unit of time, the velocity of flow will decrease as the pressure rises. Velocity is also diminished at times by special influences, such as negative load, all of which factors and influences are taken account of by the devices hereinafter described, whereby velocity is maintained in the face of all disturbing influences, which velocity coöperating with the temperature-drop of the subdivisional flows through the cooled metal at the entrance to the combustion-chamber, decreases the tendency to back-burn. A feature likewise contributing to the results aimed at lies in creating the above-named velocity-flows continuously and in crossed directions, and controlling the same by the above-mentioned velocity-causing influences.

In providing a previous mixture I may cause a part of the mixing to take place at the compressors, but in such case prefer to sub-divide the mixing so that the mixture does not become explosive until the last, thus avoiding any chance of explosion in the compressors, which would be disastrous. Such explosion, however, if occurring only in the ante-chamber to the combustion-chamber is not so objectionable, and therefore without risk the mixture may be made practically complete in this ante-chamber. Moreover, successive commingling of the air and fuel with a lapse of time between promotes complete mixture. A final entrance of air into the combustion-chamber contributes to the turmoil of the fluids and aids complete combustion within a limited area.

Cooling of the foraminous metal at the en-

trance to the combustion-chamber is preferably effected both by gaseous and water flows. The cooling air employed is thereby heated as an aid to combustion and may be accompanied by fuel, the mixture of the air and fuel being promoted by their impingement upon the heat-radiating surfaces. The cooling water employed may afterward be used in the cooling-pot of the combustion-chamber, thus returning the abstracted heat to the system. The jacket-water of the compressors may be in like manner employed in the cooling chamber and the heating of the water increased by heat acquired from the exhaust of the motor. In the above connection special expedients are employed for the control and direction of the water, as more fully hereinafter explained.

Of the accompanying drawings,—Figure 1 represents a diagrammatic elevation of power-developing apparatus embodying and adapted to carry out my invention. Fig. 2 represents a vertical section of the generator. Fig. 3 represents a horizontal section thereof on line 3—3, showing the valve-seats at the entrance to the combustion-chamber. Fig. 4 represents a section on line 4—4 of Fig. 2. Fig. 5 represents a detail section of the thermostatically-controlled solenoid for diverting partition-jacket-water. Fig. 6 represents a detail section, showing the connection of the upper diaphragm with its valve-stem. Fig. 7 represents a detail section of one of the ejector-like devices hereinafter described.

The same reference characters indicate the same parts in all the figures.

In the drawings, 10 indicates an engine or motor supplied from a generator 60 and having an exhaust-pipe 15 enlarged into an exhaust heated chamber 16 through which the cooling chamber water is passed as hereinafter described. The engine drives a stage air-compressor including low-pressure and high-pressure cylinders 20 22, an intercooler 21, and a stage gas-compressor including low and high-pressure cylinders 30 32, and intercooler 31, the fluids from these compressors being mixed and supplied to the combustion-chamber, burning continuously under constant pressure therein, and afterward being cooled in the cooling chamber and creating a body of steam which passes on with the products of combustion through pipe 66 into the cylinders of the engine 10.

Generator construction and fluid regulation.—The generator 60 embodies a combustion chamber 64 whose lower part is a combustion-tube 264 discharging into the upper part of cooling chamber 65 to which water is supplied through pipe 93. 61 is an ante-chamber to which air is supplied from the air-compressor by a pipe 43, and gas from the gas-compressor by pipe 53, these pipes entering at right angles so that their streams cross and thereby become intermixed. Between the chambers is located a foraminous four-sectioned metallic partition 67 below which the air-and-gas mixture is inflamed and whose office is to prevent back-burning. This partition forms substantially an inclosure or annulus through whose perforations a hollow stream of air-and-gas mixture flows from the ante-chamber 61. This partition is formed with a water-jacket 62 having portions at the bases of the perforated plates, as seen in Fig. 2, and a portion at the upper ends of the plates surrounding a female valve-seat 267 with which coöperates an upwardly-seating cone-shaped or male valve 78. The exterior of the perforated partition constitutes a male valve-seat for a downwardly-seating four-pronged female valve 63 which controls the flow of air-and-gas mixture through the foraminous partition from ante-chamber 61 to combustion-chamber 64. 262 is a flanged or ribbed extension of the perforated partition 67 occupying the ante-chamber 61 and located in the path of the flow from air and gas pipes 43 53 so that their combined flows impinge upon the fins and become thoroughly intermixed.

Water enters the jacket 62 through pipe 97 and leaves through pipe 98, circulation being established by means hereinafter described. Valve 63 is provided with a hollow stem 69 having a sliding fit in a sleeve 70 and attached to a diaphragm 71. Initial air pressure is piped to the chamber 73 on the under side of said diaphragm by a branch 72 from the air-conduit 43. This hollow stem is continued upwardly through a stuffing-box carried by the hub portion of a second diaphragm 75 and is further extended through the top of the diaphragm chamber to carry a solenoid as hereinafter described. The chamber 76 above the upper diaphragm receives initial air-pressure through the interior of hollow stem 69 and ports 74 279. The upper diaphragm is connected with the valve-stem 77 of valve 78 by a pin 79 passing through the slots 279. Between the diaphragms is inclosed a chamber 271 which receives the terminal pressure of the system from the chamber above the cooling-pot by way of a pipe 151 and is occupied by a spring 150 interposed between the diaphragms and tending to press them apart and hence press the valves 63 78 to their seats. In other words, this spring aids the terminal pressure in chamber 271. A spring 159 acting on the hollow stem 69 tends to neutralize the weight of parts connected with said stem and by proper adjustment the arrangement is such that the two valves are acted on equally and oppositely by similar pressure influences. It will be observed that each valve is controlled differentially by the pressures initial and terminal to it and the terminal pressure is aided by the spring 150 so that at all times the two

valves 63 78 impose a pressure-drop on the fluids entering the combustion-chamber and tend to maintain a velocity of flow which not only aids in the proper mixture of the fluids, but is an influence added to that of the foraminous partition tending to prevent back-burning of the fluids.

The air from diaphragm-chamber 73 flows through the interior of valve-stem 69 and past valve 78 in a divergent hollow stream which crosses the convergent stream flowing through the perforations of the partition 67. This arrangement tends to an immediate and thorough mixture of the original air-and-gas mixture with further air coming through the branch-pipe 72. Below these inlets is a tangential inlet 266 controlled by a cone-valve 166 attached to a diaphragm 162. In the chamber 111 on one side of this diaphragm, initial air-pressure is received by a branch 160 from the chamber 73, and in the chamber 161 on the opposite side, terminal pressure is received by a branch 163 from the pipe 151. A spring 164 aids the terminal pressure and adjustment is preferably such as to give a controlling action to the valve 166 the same as that given to the valves 63 and 78 by the pressure and spring influences above described. The mechanical influence of the air-stream entering through tangential-inlet 266 is to cause a whirl of the fluids entering past valves 63 and 78 and of its own flow, and the result is to localize and complete combustion within a comparatively-small zone.

The tangential-inlet 266 enters on a hot-tube or incandescence igniter 167 in the form of a hollow thimble having a salient presentation to the interior of the combustion-chamber. This tube is heated exteriorly by a burner 168 entering its cavity and supplied with compressed air through pipe 170 and gas through a pipe 169. An additional function of the tangential-inlet 266 will now appear. Back of the valve 166 enters a pipe 171 branching from the compressed-gas pipe 53 and provided with stop-valve 371. In starting the apparatus a mixture of air and gas is passed through the tangential-inlet 266, and impinging on the end of the hot-tube 167, it becomes ignited and causes ignition of the primary fluid-flow occurring past valves 63 78. When ignition has been effected, the gas-supply to the tangential inlet is shut off by means of valve 371 and the end of the igniter is then bathed by a pure-air flow which tends to keep it cool and prevent its destruction by the heat of the combustion-chamber, the air and gas supply to the burner 168 being at this time shut off.

At the upper end of the hollow stem 69 is secured a solenoid helix or coil 158 and to the upper end of valve-stem 77 is secured the armature-core 258 of said solenoid. The pressure of the system from pipe 160 acts on the under side of a diaphragm 153, and a spring 253 and the pressure of the atmosphere act on the opposite side thereof. The stem 155 of this diaphragm acts on the arm of a rheostat 156, best seen in Fig. 1, which controls the resistance in the actuating circuit 157 of solenoid 158. The result is that as pressures accumulate and give rise to greater densities and hence a less velocity of fluid flow for a given quantity flow of the combustible fluids, the suction of the solenoid 158 will increase and augment the pressure tending to move the valves 63 78 to their seats. The consequence is that the velocity flow into the combustion-chamber is maintained during the higher pressures, with the result of maintaining a uniform mixing power of the flow and a uniform tendency to prevent back-burning into the ante-chamber 61. At an extreme increase of pressure in the system, the stem 155 acts through a rod 174, lever 176, and rod 276 upon a stop-valve 177 in the fuel-pipe 53 with the result of shutting off the entire gas-supply to the generator.

Air circuit.—Air from the suction-pipe 40 passes through L. P. air-compressor cylinder 20, pipe 41, intercooler 21, pipe 42, H. P. cylinder 22 and compressed air pipe 43 to the ante-chamber 61 of the generator, and by branch 72 to the diaphragm-chamber 73. As hereinbefore indicated, part of the air is piped from the diaphragm-chamber through 152 160 to one side of the solenoid-controlling diaphragm 153 and tangential-valve diaphragm 162, a part also going through pipe 170 to the igniter-burner 168, and further parts up through stem 69 to diaphragm-chamber 76 and down through said stem past valve 78 to the combustion-chamber.

Gas circuit.—Gas from suction-pipe 50 passes through L. P. gas-compressor cylinder 30, pipe 51, intercooler 31, pipe 87, H. P. cylinder 32 and compressed-gas pipe 53 to the ante-chamber 61. A portion is branched through pipe 171 to supply the tangential-inlet 266 at starting, and a portion of the street main gas supply passes by pipe 169 to the burner 168 and by pipe 172 to a Bunsen burner 173 for initially heating the water pot 65, to effect a start or for other reason.

Air-and-gas circuit.—A part of the partially-compressed air is mixed with the partially-compressed gas in the gas-intercooler 31 by passage through a pipe 181 connecting the latter with the air-intercooler and containing stop-valve 182 and check-valve 183. As the low-pressure cylinders of the two compressors both receive their supplies at substantially atmospheric pressure, they constitute meters for the fluids taken in, and under such circumstances the intercooler pressures depend upon the ratios between the capacities of the low-pressure and high-pressure cylinders of the respective compressors. It is easily arranged to have a pressure in the air-intercooler 21 superior to

that in the gas-intercooler 31, so that a flow becomes established through pipe 181 and a partial mixture of air and gas thus effected. The ratio of intercooler pressures may be changed by varying the relative capacities of the low-pressure air and gas cylinders or either of them by means of the clearance-controlling chambers 180 280. If the preponderance of air-intercooler pressure is greater than desired, the flow may be throttled by means of valve 182. In branch connection with the compressed-gas pipe 53 is a safety-valve 177ª releasing to the suction-pipe 50 upon the attainment of a predetermined pressure in the system. When the gas-compressor is supplying a mixture of air and gas through pipe 53, the circuit established by release-device 177ª causes a cumulative dilution of the mixture passing through pipe 53 to the generator, and hence imposes a check upon the intensity of combustion and the further rise of pressures. Air may also be mixed with the gas on the suction side of the L. P. gas-cylinder 30 by an atmospheric air-pipe 284 and a nozzle-device 184.

At times it may be desired to employ liquid fuel either in conjunction with the gas, as for instance when the latter needs enriching, or alone as the only fuel. I have shown oil-pumps 201 202 drawing from an oil-tank 200 and operated by an eccentric 300 actuated from the engine-driven shaft 190, the output from said pumps entering the gas circuit on the suction sides of both L. P. and H. P. cylinders through nozzle-devices 203 203. By this means a stage mixture of the liquid fuel with the gaseous fluid passing through the compressor is effected. When liquid fuel alone is used, the gas-compressor is then preferably employed as an air-compressor in addition to the regular air-compressor, and the result is an increased capacity or power of the apparatus.

Water circuit.—The air and gas compressor cylinders are provided with water-jackets of well-known construction, and the water-circuit therethrough and further is as follows, namely, through pump suction 80, pump 81 operated by engine-driven eccentric 191, pipe 82, jacket of L. P. air cylinder 20, pipe 83, jacket of H. P. air-cylinder 22, pipe 84, water-space of air intercooler 21, pipe 85, jacket of L. P. gas cylinder 30, pipe 86, jacket of H. P. cylinder 32, pipe 87, water-space of gas-intercooler 31, pipe 88, water-space of exhaust-heater 16, and pipe 90 to the suction side of a force-pump 91. By this pump the water is forced through pipes 92 and 93 to the cooling-chamber 65 of the generator or out through a waste-pipe 118 under the control of a suitable feed-water regulator 115. In this way, a greater or less quantity of the heat of compression is conserved in the water passing to the cooling-chamber.

102 is an overflow-pipe branching from the pipe leading to exhaust-heater 16, and designed to dispose of any excess of the water from the compressor-jackets not demanded by pump 91. This pipe also furnishes a head to prime the said pump. In parallel with this compressor-jacket and cooling-chamber circuit is the circuit of the foraminous partition-jacket 62, which is by way of pipe 95, pump 96, pipe 97, jacket 62, pipe 98, chamber 99, and pipes 100 and 93 to the cooling-chamber 65, whereby is conserved more or less of the heat of combustion abstracted by the partition-jacket 62. Such of this flow as is not demanded by the cooling-chamber may pass off through the waste-outlet 118 under control of the feed-water regulator. A branch 103 from the chamber 99 is adapted to divert more or less of the output from the partition-jacket when this output reaches a predetermined temperature. A mercury-thermostat 108 in connection with the chamber 99 controls the circuit of the solenoid 204 which operates a valve 104 controlling the flow through branch-pipe 105. The water thus diverted passes through pipe 105 to the suction side of pump 91, either directly through a nozzle-device 107 or through the exhaust-heater 16 by way of a nozzle-device 106. The construction of nozzle-device 106 is illustrated in Fig. 7, and represents that of the other nozzle-devices herein mentioned. The direct flow through 107 is chosen when the water in 105 is hotter than the engine-exhaust and hence should not be used to heat up this exhaust, and the avenue through 106 is used when the water is cooler than the exhaust. The partition-jacket water diverted by the action of thermostat 108 displaces some or all of the compressor-jacket water from the suction of pump 91 which is a useful result when the partition-jacket water has a superior heat. The displaced compressor-water overflows automatically through pipe 102. The pumps 91 96 are shown as driven from the eccentric 192 on shaft 190.

It should be observed that my invention belongs principally to that class of heat-engine cycles broadly designated as internal-combustion-at-constant-pressure cycles, this term signifying that the development of the heat-energy takes place without a necessary rise in pressure, such as is characteristic, for instance, of the combustion in the ordinary Otto cycle. The term does not exclude fluctuations in pressure, which may even be very considerable in amount, but which are due to conditions of use and are not inherent in the cycle. The combustion in this cycle also preferably takes place continuously, that is, there is no inherent limitation to intermittent periods of combustion such as is observed for instance in the Brayton cycle.

I claim:—

1. In a continuous-combustion power-gen-

erating apparatus, the combination of a combustion-chamber, an ante-chamber, means to supply air and fuel under pressure to said ante-chamber, a perforated partition separating said chambers, and a jacket for said partition adapted to contain a cooling fluid.

2. In continuous-combustion power-generating apparatus, the combination of a pressure-chamber for conducting combustion, an ante-chamber, means for supplying air and fuel under pressure to said ante-chamber, a foraminous partition separating said chambers, a cooling-chamber jacketing said partition, and means to circulate a cooling fluid through said chamber.

3. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, a perforated partition separating the same and having a replicate heat-dissipating extension, and a conduit for supplying combustion fluid to said ante-chamber arranged to impinge its flow upon said extension.

4. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, a foraminous partition separating the two and having a replicate heat-dissipating extension, and conduits for supplying air and fuel to the ante-chamber so directed as to mix their flows and impinge the mixture upon said extension.

5. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, an ante-chamber communicating therewith, conduits to supply air and gas to said ante-chamber so directed as to cross and mix their streams of fluid, and sources of air and gas pressure supplying said conduits.

6. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, and means for supplying crossed streams of air and gas thereto.

7. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, means to supply a stream of mixed air and gas thereto, and means to supply a stream of air to said chamber crossing the first-said stream.

8. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, means to supply a convergent hollow stream of combustion fluid thereto, and means to supply a divergent hollow stream of combustion fluid from within the first-said stream and crossing the latter.

9. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, means to supply air and gas to said ante-chamber, a foraminous partition separating said chambers, and means to direct a stream of combustion fluid into said combustion-chamber across the stream from the foraminous partition.

10. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, a foraminous partition structure separating said chambers and making substantially an inclosure, means to supply air and fuel to the ante-chamber, and means to supply a combustion fluid to the combustion-chamber from within the inclosure formed by said partition structure.

11. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, a foraminous partition structure separating said chambers and making substantially an inclosure arranged to direct a convergent hollow stream of mixed fluid into the combustion-chamber, and means for supplying a divergent stream of combustion-fluid to the combustion-chamber from within the said inclosure.

12. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, a foraminous partition separating the two and having a valve-seat, a valve coöperating with said seat, and means to supply air and fuel to said ante-chamber.

13. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, means to supply air and fuel under pressure to said ante-chamber, a foraminous partition separating said chambers, a valve coöperating with said partition, and means for automatically regulating said valve by the pressure of the system.

14. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, means for supplying air and fuel to said ante-chamber, a foraminous partition separating said chambers, a valve coöperating with said partition, and means for automatically regulating said valve differentially by the pressures initial and terminal thereto.

15. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, means to supply air and fuel to said ante-chamber, a foraminous partition separating said chambers and having a valve-seat, and a valve movable toward and from said seat.

16. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, means to supply air and fuel to said ante-chamber, a foraminous partition separating said chambers and having a valve-seat, a valve movable toward and from said seat, a movable partition connected with said valve and having chambers on its opposite sides, and means to supply said chambers respectively with the pressures initial and terminal to said valve.

17. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, a partition separating said chambers and having a male valve-seat, and a female valve movable toward and from said seat.

18. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, means to supply air and fuel to said ante-chamber, a foraminous partition separating said chambers and having a male valve-seat, and a female valve movable toward and from said seat.

19. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, means to supply air and fuel to said ante-chamber, a foraminous partition separating said chambers and having a sectional male valve-seat, and a multi-sectioned female valve movable toward and from said seat.

20. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, means to supply air and fuel to said ante-chamber, a foraminous partition separating said chambers and having a male valve-seat, a female valve movable toward and from said seat, and means to automatically control said valve differentially by the pressures initial and terminal thereto.

21. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, means to supply air and fuel to said ante-chamber, a foraminous partition separating said chambers, a cooling jacket for said partition adapted for the circulation of a cooling fluid, and a valve coöperating with said partition.

22. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber having coöperating inlets for combustion fluid, valves controlling said inlets, and means controlled by the pressure of the system for simultaneously moving said valves in opposite directions.

23. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber having coöperating inlets for the admission of combustion fluid, said inlets being provided respectively with male and female valve-seats, female and male valves coöperating with the respective seats, and pressure-controlled means for simultaneously moving said valves in opposite directions.

24. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, inlets so arranged as to direct crossed streams of combustion fluid into said chamber, and valves automatically controlled by the pressure of the system for controlling said inlets.

25. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, means to supply air and fuel to said ante-chamber, an inlet to the combustion-chamber from said ante-chamber, a second inlet for combustion fluid to the combustion-chamber so arranged as to direct its stream of fluid across the stream from the first-said inlet, and valves controlling said inlets.

26. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, means to supply air and fuel to said combustion-chamber, a foraminous partition separating said chambers and having a male valve-seat, an inlet for combustion fluid to the combustion-chamber having a female valve-seat embraced by the first-said valve-seat, oppositely-moving valves coöperating with said seat, and means for controlling said valves differentially by the pressures initial and terminal to the valves.

27. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, means to supply air and fuel to said ante-chamber, a foraminous partition separating the chambers and having a male valve-seat, a female valve-seat embraced by the first-said seat, a cooling jacket structure having portions respectively at the base of said partition and at the crest thereof embracing the female valve-seat, and oppositely-seating valves coöperating with said valve-seats.

28. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, means to supply air and fuel to said ante-chamber, coöperating inlets to the combustion-chamber, one of which leads from the ante-chamber, so directed as to cross their flows, said inlets having valve-seats, valves coöperating with said seats, and a cooling jacket structure having portions surrounding the respective seats.

29. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber having inlets provided with valve-seats, one within the other, means connected with said inlets for supplying combustion fluids thereto, oppositely-seating valves coöperating with said seats, and means controlled by the pressure of the system for simultaneously moving said valves in opposite directions.

30. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, means to supply combustion fluid thereto, oppositely-movable valves controlling the fluid flow, one of which is provided with a hollow stem, the other having a stem occupying said hollow stem, and diaphragms connected with said stems and subject to the pressure of the system.

31. In continuous-combustion power-gen-

erating apparatus, the combination of a pressure combustion-chamber, a pair of oppositely-seating valves controlling the flow of combustion fluid thereto and having stems, one of which is hollow and incloses the other stem, diaphragms connected with the respective valves and inclosing a chamber between them, a spring interposed between the diaphragms, means to establish in said chamber the pressure of the system terminal to the valves, chambers on the remote sides of the diaphragms, and means to establish in the latter chambers the pressure of the system initial to the valves.

32. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, a valve controlling communication between the two and having a hollow stem, means to supply combustion fluid to the chamber through said stem, and a second valve controlling said fluid supply.

33. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, a valve controlling communication between the two and having a hollow stem, means to supply combustion fluid to the chamber through said stem, a second valve controlling said fluid supply and having a stem passing through said hollow stem, diaphragms connected with the respective stems, means to establish the system-pressure terminal to the valves on one side of each diaphragm, and initial-pressure chambers on the opposite sides of the diaphragms communicating with each other through said hollow stem.

34. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, means to supply combustion fluid thereto, a valve controlling said fluid, means to control said valve differentially by the pressures initial and terminal thereto, yieldingly-acting means to establish a differential pressure on the valve, and means controlled by the pressure of the system for automatically varying the force of said differential.

35. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, means to supply combustion fluid thereto, a valve controlling said fluid and differentially controlled by the pressures initial and terminal to the valve, means yieldingly aiding the terminal pressure, and means controlled by the pressure of the system for automatically augmenting said aid as the pressure increases.

36. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, means to supply combustion fluid thereto continuously under pressure, a valve for maintaining a velocity flow of said fluid, and electro-magnetic means controlled by the pressure of the system for varying the force exerted on said valve.

37. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, a valve controlling the flow of combustion fluid thereto, an electro-magnet controlling said valve, and a movable partition subject on one side to the pressure of the system and on the other side to a substantially-constant pressure for varying the resistance of the magnet circuit.

38. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, means to supply combustion fluid thereto, a valve controlling the fluid flow and differentially controlled by the pressures initial and terminal to the valve, means exerting a yielding pressure on the valve in aid of the terminal pressure, a device for augmenting said aid, and a movable partition subject on one side to the pressure of the system and on the other side to a substantially-constant pressure for controlling said device.

39. In continuous combustion power-generating apparatus, the combination of a pressure combustion-chamber having inlets for combustion fluids, oppositely-seating valves controlling said inlets, an electro-magnet having its coil attached to one of said valves and its armature to the other, and means actuated by the pressure of the system for controlling the circuit of said magnet.

40. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, oppositely-seating valves controlling the flow of combustion fluids thereto, one of said valves having a hollow stem, the other having a stem inclosed thereby, diaphragms connected with said stems and subject on opposite sides to the pressures initial and terminal to the valves, a solenoid having its coil attached to the hollow valve-stem and its core to the other valve-stem, and means controlled by the pressure of the system for varying the resistance of the solenoid circuit.

41. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber having an inlet, means to supply air and fuel through said inlet, an independent tangential-inlet to said combustion-chamber, and means to supply a combustion fluid through said tangential-inlet, whereby a whirl of the two flows is established.

42. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, means for supplying a combustion fluid continuously under pressure thereto, and means for introducing said fluid tangentially into the chamber.

43. In continuous-combustion power-generating apparatus, the combination of a pres-

sure combustion-chamber having a tangential-inlet, means for supplying a combustion fluid through said inlet, a valve controlling said inlet, and means for controlling said valve differentially by the pressures initial and terminal thereto.

44. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber having a tangential-inlet, a conduit to supply combustion fluid through said inlet, a valve controlling the inlet, a movable partition connected with the valve and having on one side a chamber connected with said conduit and on the other side a chamber receiving the pressure terminal to the valve, and means yieldingly aiding the terminal pressure on the valve.

45. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, inlets for the supply of combustion fluids thereto so arranged as to cross their flows, and a tangential-inlet for the supply of combustion fluid to said chamber.

46. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, means to supply air and fuel to said ante-chamber, an inlet from the ante-chamber to the combustion-chamber, a second inlet arranged to direct its stream across that of the first-said inlet, means to supply combustion fluid through said second inlet, a tangential-inlet to the combustion-chamber, and means to supply a combustion fluid through said tangential-inlet.

47. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber having two inlets supplying crossed streams, a tangential-inlet, means to supply combustion fluid through said inlets, three valves controlling the respective inlets, and means controlled differentially by the pressures initial and terminal to said valves for controlling all three valves.

48. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber having a primary inlet, means to supply air-and-fuel mixture through said inlet, a secondary inlet to the combustion-chamber, and means to supply a single combustion fluid or a mixture of combustion fluids through said secondary inlet at will.

49. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, means to supply air and fuel thereto, a tangential-inlet to said chamber, a source of compressed-fuel supply connected with said tangential-inlet, and means to shut off said fuel supply at will.

50. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, means to supply a primary flow of air and fuel thereto, an incandescence igniter for said chamber, and means to supply to said chamber a secondary current of combustion fluid whose path intercepts the igniter.

51. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, means to supply a primary flow of air and fuel thereto, an ignition-thimble having a salient presentation to the interior of said chamber, means for externally heating said thimble, and means to supply to said combustion-chamber a secondary stream of combustion fluid whose path intercepts the ignition thimble and joins the flow of the primary fluids.

52. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, means to supply a primary flow of air and fuel thereto, an incandescence igniter for said chamber, a tangential-inlet to the chamber entering on the igniter, and means to supply combustion fluid through said tangential-inlet.

53. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, means to supply a primary flow of air and fuel thereto, an incandescence igniter for said chamber, a secondary inlet to the chamber entering on said igniter, and means to supply at will through said inlet air or air-and-fuel mixture.

54. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, a foraminous partition separating the two, means to supply air and fuel to said ante-chamber, a cooling-chamber succeeding the combustion-chamber, a water-jacket for said partition, and means to circulate water in succession through said jacket and cooling-chamber.

55. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, a foraminous partition separating the two and having a water-jacket, a cooling chamber succeeding the combustion-chamber, a conduit connecting said jacket with the cooling-chamber, and means controlled by the temperature of the output from said jacket for diverting the output from said conduit.

56. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, a foraminous partition separating the two and having a water-jacket, a cooling chamber succeeding said combustion-chamber, a compressor to supply combustion fluid to said combustion-chamber and having a water-jacket, and means to supply water to said jackets and from said jackets to the cooling-chamber.

57. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, a foraminous partition separating the two and having a water-jacket, a chamber succeeding the com-

bustion-chamber, a compressor to supply combustion fluid to said combustion-chamber having a water-jacket, and means to conduct a water-supply through said jackets in parallel and into the cooling-chamber.

58. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, a foraminous partition separating the two and having a water-jacket, a cooling chamber succeeding the combustion-chamber, a compressor to supply combustion fluid to the combustion-chamber having a water-jacket connected with the cooling-chamber, means to conduct the output of the partition water-jacket to the cooling-chamber, a pump to force the compressor jacket-water into the cooling-chamber, and means controlled by the temperature of the output from the partition jacket for diverting said output to the suction of said pump.

59. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, a cooling-chamber succeeding the same, a compressor to supply combustion fluid to said combustion-chamber having a water-jacket, means to conduct the water from said jacket into the cooling-chamber, and an overflow for the disposal of surplus water from said jacket.

60. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, a foraminous partition separating the two and having a water-jacket, a cooling chamber succeeding the combustion-chamber, a compressor to supply combustion fluid to the combustion-chamber having a water-jacket, pumps for independently forcing the two jacket supplies into the cooling-chamber, an overflow for the compressor-jacket-water, a branch conduit connecting the outlet of the partition jacket with the suction side of the compressor-jacket pump, and means controlled by the temperature of the water in said conduit for controlling the flow therethrough.

61. In continuous-combustion power-generating apparatus, the combination of a combustion-chamber having an inlet, a water-jacket for said inlet, a cooling-chamber, a pump supplied from said jacket for supplying the cooling-chamber and also having an independent supply, means to automatically divert said second supply from the suction of the pump, and means controlled by the temperature of the jacket-water for automatically controlling the supply thereof to the pump.

62. In continuous-combustion power-generating apparatus, the combination of combustion and cooling-chambers, a compressor for supplying combustion fluid to the combustion-chamber having a water-jacket, a chamber heated by the exhaust of the motor, and means to conduct a water-supply in succession through said jacket and chamber to the cooling-chamber.

63. In continuous-combustion power-generating apparatus, the combination of combustion and ante-chambers, a foraminous partition separating the two and having a water-jacket, a cooling chamber, a motor supplied by the combustion-chamber, a chamber heated by the exhaust of the motor, means to conduct a water supply through said chamber to the cooling-chamber, and means to conduct the water from said jacket to the cooling-chamber either directly or through said exhaust-heated chamber.

64. In continuous-combustion power-generating apparatus, the combination of a combustion-chamber, air and gas compressors to supply the same, means to effect a mixture of the air and gas before entering the combustion-chamber, means to automatically release an excess of the mixture, and means to return said excess to the suction side of one of the compressors.

65. In continuous-combustion power-generating apparatus, the combination of a combustion-chamber, air and gas compressors for supplying the same, means to effect a mixture of the air and gas prior to the combustion-chamber, means to automatically release an excess of the mixture upon attainment of a predetermined pressure thereof, and means to return the excess to the suction side of the gas-compressor.

66. In continuous-combustion power-generating apparatus, the combination of a combustion-chamber, means to supply fuel and compressed air thereto, means to mix said fluids prior to the combustion-chamber, and means for automatically diluting the fuel-supply with the mixture upon the attainment of a predetermined pressure of said mixture.

67. In continuous-combustion power-generating apparatus, the combination of a combustion-chamber, stage compressors for supplying air and gas thereto having intercoolers, and means for establishing a flow from the air-intercooler to the gas-intercooler.

68. In continuous-combustion power-generating apparatus, the combination of a combustion-chamber, stage compressors for supplying air and gas thereto having intercoolers, means for establishing a flow from the air-intercooler to the gas-intercooler, means to automatically release the excess of mixed fluids, and means to return said excess to the suction side of the gas-compressor.

69. In continuous-combustion power-generating apparatus, the combination of a combustion-chamber, stage compressors for supplying air and gas thereto having intercoolers, means for establishing a flow from the air-intercooler to the gas-intercooler, a

branch conduit connecting with the compressed-gas conduit having a device for releasing gas upon the attainment of a predetermined pressure in said branch conduit, and means to conduct the fluid released by said device to the suction side of the gas-compressor.

70. In continuous combustion power-generating apparatus, the combination of a combustion-chamber, stage compressors for supplying air and gas thereto having intercoolers, a conduit connection between said intercoolers, means for releasing fluid from the compressed-gas conduit to the suction side of the gas-compressor upon the attainment of a predetermined pressure in said conduit, and means for varying the relative capacities of the compressing units of the respective compressors.

71. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber having an inlet, means for supplying a mixture of air and fuel through said inlet, means for artificially cooling said inlet by an extraneous fluid-flow, and a resistance-valve controlling said inlet and differentially controlled by the pressures initial and terminal to itself.

72. In continuous-combustion power-generating apparatus, the combination of a pressure combustion-chamber, a plurality of independently-movable resistance-valves controlling the flow of combustible toward said chamber, means for controlling said valves differentially by the pressures initial and terminal thereto, and yielding means conjointly affecting the two valves in aid of the terminal pressure.

In testimony whereof I have affixed my signature, in presence of two witnesses.

EDWARD P. NOYES.

Witnesses:
R. M. PIERSON,
A. C. RATIGAN.