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COMBUSTION PRODUCTS GENERATOR HAVING OPPOSED RESONATING CHAMBERS

Filed July 11, 1944 | | 2 Sheets-Sheet 1

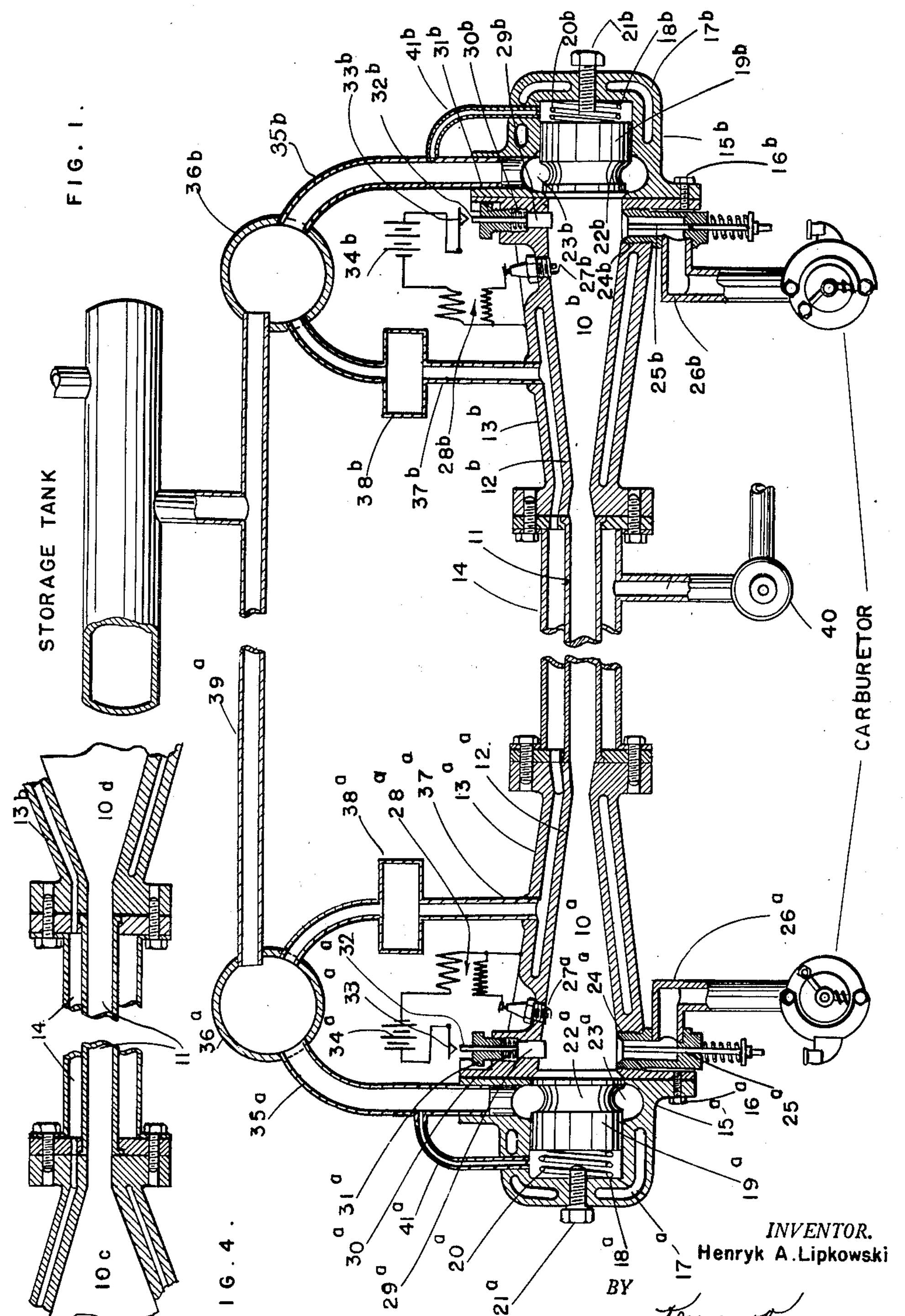

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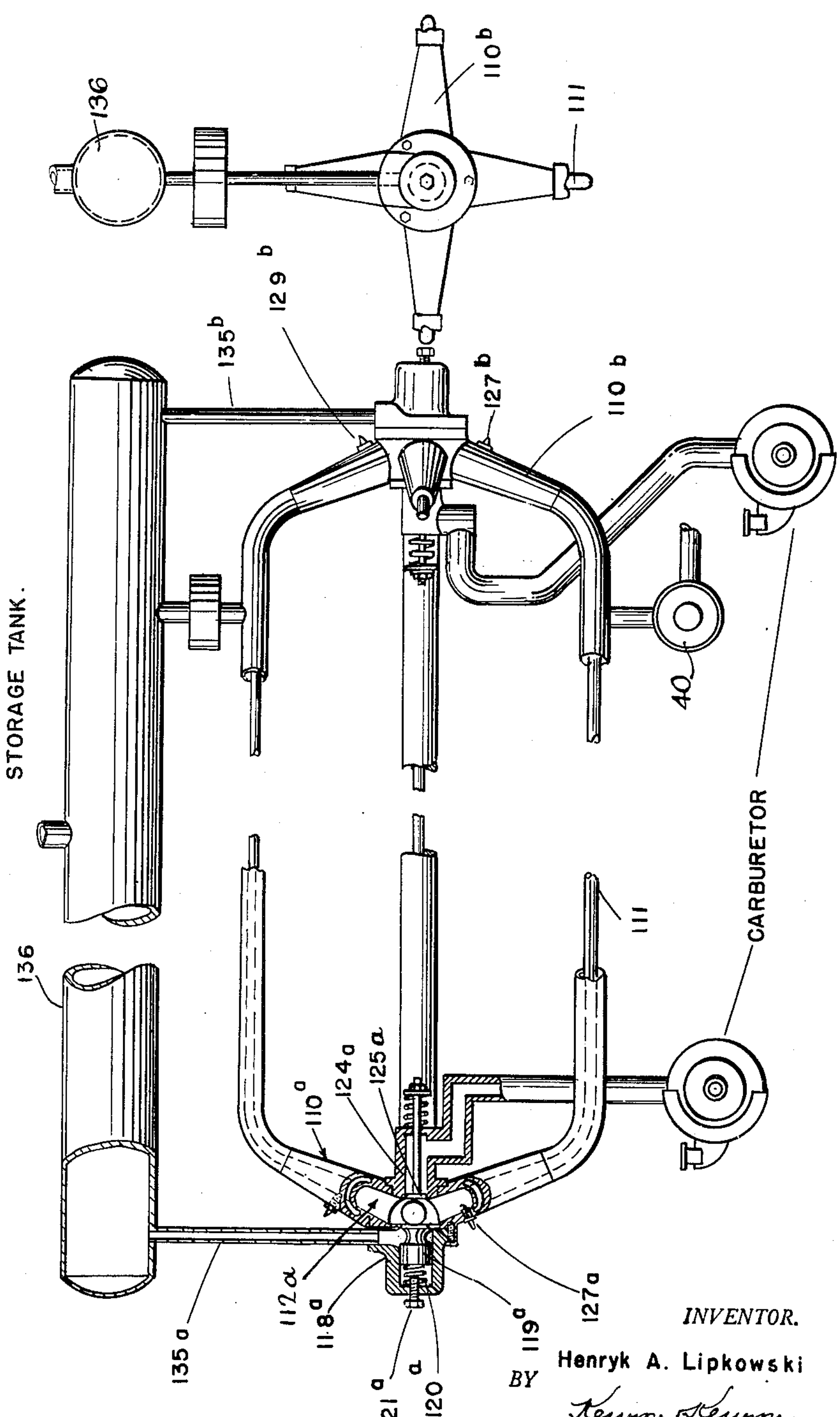
FIG. 3.

FIG. 2.



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COMBUSTION PRODUCTS GENERATOR HAVING OPPOSED RESONATING CHAMBERS

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8 Claims. (Cl. 60—44)

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This invention relates generally to gaseous pressure and more particularly to a novel and useful thermodynamic power generator.

Among the objects of the present invention lies the provision of a machine or a generator of the class described which is capable of producing high pressure by combustion of combustible material, for example, gas; liquid hydrocarbons such as gasoline; oil, carbon powder, and so forth.

In accordance with the present invention a suitable fuel is burned in one of a plurality of chambers and the product gas (or gases) at greater pressure resulting from the combustion is conducted through a plurality of conduits. One portion of the resultant gas is used to accomplish useful work or to be stored for a future use while another portion of the resultant gas is used to compress the charge in another chamber preparatory to the firing of said charge in said chamber. A still further portion of the resultant gas may be used to introduce a new charge of unburned gas into the first chamber.

An object of the invention lies in the provision of a thermodynamic power generator which may have a high ratio of power output to weight and in which relatively few moving parts are utilized, the moving parts principally being in the nature of valves which are preferably automatically gaseously pressure operated rather than mechanically driven.

A feature of the present invention lies in the fact that compression of the unburned gases in a combustion chamber about to be fired, is accomplished by use of the kinetic energy of a part of the gases formed by combustion in another chamber previously fired.

Another object herein lies in the provision of a device of the character described in which the supply of combustible mixture to form a charge in a given chamber is transported to said chamber by use of the kinetic energy of a part of the combustion gases from a previous burning or explosion.

Another object herein lies in the provision of a thermodynamic generator in which the supply of the combustible mixture within the chamber is made by the use of the relative reduction of pressure within said combustion chamber subsequent to the explosion by the evacuation of a part of the burned gases through an elongated conduit.

Other objects, novel features and advantages of this invention will become apparent from the following specification and accompanying drawings, wherein:

Fig. 1 is a vertical section through one embodiment of the invention;

Fig. 2 is a section through a second embodiment of the invention;

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Fig. 3 is an end view of Fig. 2, and

Fig. 4 is a fragmentary view of a modification of Figure 1.

The thermodynamic power generator of this invention consists of two combustion chambers designated generally **10**a and **10**b interconnected by a tube **11**. The two combustion chambers are of identical construction and the specific description of such structure will be limited to the combustion chamber **10**a and the corresponding elements of the combustion chamber **10**b will be designated by reference numerals corresponding to those used for the combustion chamber **10**a with the substitution of b for a. The combustion chamber **10**a consists essentially of a convergent-divergent nozzle **12**a commonly known as the DeLaval nozzle and the nozzle is surrounded by a water jacket **13**a. The angle of deviation for each section of the nozzle is the same and lies in the range of 7° to 12°. It will be observed that the combustion chambers **10**a and **10**b each have a throat portion that is of smaller cross-section than the respective outer and inner ends thereof. The inner or smaller end of the nozzle **12**a communicates through the pipe **11** with the inner or smaller end of the nozzle **12**b. The pipe **11** is provided with a water jacket **14** communicating both with the water jacket **13**a and the water jacket **13**b.

A cap **15**a is attached to the outer or larger end of the nozzle **12**a by bolts **16**a and is provided with a water jacket **17**a communicating with the water jacket **13**a. In a suitable recess **18**a in the cap **15**a there is arranged a reciprocable valve **19**a arranged to close the large end of the nozzle **12**a in one position of the valve and being movable from such position to open the large end of the nozzle **12**a. A spring **20**a biases the valve toward its nozzle-closing position and an adjustable bolt **21**a provides a stop for limiting the extent of movement of the valve **19**a from its nozzle-closing position. The valve **19**a is provided with an annular semi-circular recess **22**a which in the closed position of the valve faces an annular groove **23**a in the cap **15**a, the groove **23**a being of larger radius than the groove **22**a. The valve **19**a permits only egress of fluids from the nozzle **12**a through the large end of the nozzle and constitutes an outlet port for the combustion chamber **10**a.

In the conical wall of the nozzle **12**a is provided an inlet port **24**a equipped with a spring-pressed self-closing valve **25**a of the tappet type arranged to permit only ingress of fluids into the combustion chamber **10**a. A delivery pipe **26**a leads to the port **24**a from a carburetor or other suitable source of combustible mixture. Also, in the conical wall of the nozzle **12**a there is provided a spark plug **27**a connected to one terminal of the secondary of a transformer **28**a, the remaining terminal of which is electrically connected to the combustion chamber 10a. A piston 29a is slidably mounted in a bore in the conical wall of the nozzle 12a and is biased inwardly by a spring 30a, the outer end of which is engaged by the inner end of a bushing 31a threaded into the wall of the nozzle 12a. The piston 29a carries a plunger 32a passing through the bushing 31a and having its outer end normally slightly spaced from a contact 33a connected through a battery 34a to one terminal of the primary of the transformer 28a, the remaining terminal of which is electrically connected to the combustion chamber 10a. The spring 30a normally maintains the plunger 32a out of engagement with the contact 33a but yields to permit outward movement of the piston 29a to engage the plunger with the contact upon sufficient increase of pressure in the nozzle 12a.

A conduit 35a leads outwardly from the groove 23a to a chamber 36a. A pipe 37a leads upwardly from the water jacket 13a through a steam separator 38a to the chamber 36a. A pipe 39a leads from the chambers 36a and 36b to a storage tank. A pump 40 supplies water to the water jacket 14. A pipe 41a leads from the outer end of the recess in the cap 15a to the pipe 35a.

In the operation of the thermodynamic power generator above described, a charge of combustible mixture is introduced into each of the combustion chambers 10a and 10b at substantially atmospheric pressure or slightly above by manually opening the valves 25a and 25b and flowing the mixture thereinto by the use of any suitable means. Next, the piston 29a is operated manually to close the circuit through the primary of the transformer 28a thus producing a spark at the spark plug by means of which the charge in the combustion chamber 10a is ignited, thereby generating considerable pressure in the combustion chamber to cause outward movement of the valve 19a to put the open end of the nozzle 12a in communication with the groove 23a and conduit 35a and permit a part of the gases to escape therethrough to the chamber 36a. The remainder of the gases pass out the inner end of the nozzle 12a and through the pipe 11 into the nozzle 12b. Because of the nozzle form of the combustion chamber 10a, the combustion gases travel with greater speed than the speed of sound traveling through air and effect compression of the combustible mixture in the combustion chamber 12b. The flow of gas to the chamber 12b creates a pressure reduction in the chamber 12a resulting in the ingress of a fresh charge of combustible mixture through the part 24a. Upon increase of the pressure in the combustion chamber 10b up to the strength of the spring 30b, the piston 29b is moved outwardly to bring the plunger 32b into engagement with the contact 33b thereby closing the circuit through the transformer 28b and causing the spark plug 27b to produce a spark igniting the combustible mixture in the combustion chamber 10b whereupon the reverse of the operation just described occurs.

The length of the pipe 11 is so calculated that considerable relative pressure reduction occurs in the combustion chamber 10a upon flow of gas therefrom toward the chamber 10b and a new portion of combustible mixture is introduced thereinto through the port 24a, the valve 25a moving inwardly by reason of the pressure differential to permit ingress of the mixture. When the pressure in the combustion chamber 10b reaches the value for which the piston 29b has been set, the electrical circuit is closed and ignition of the combustible mixture therein takes place. The valve 19b opens when a predetermined pressure is reached and the compressed combustion gases begin to escape.

Owing to the particular design of each combustion chamber in the form of a convergent-divergent nozzle, not all gases in the chamber are under the same pressure. The maximum pressure occurs at the outer or large end of the nozzle where the combustible mixture burns. As the combustible mixture burns, the pressure increases and the exhaust valve opens. When the burning stops, the pressure decreases and the exhaust valve closes. The rest of the gas travels through the pipe 11 to the opposite combustion chamber to compress combustible mixture therein, causing at the same time relative pressure reduction in the first chamber and introducing into it a new portion of combustible mixture through the inlet port. The rush of gas to each chamber from the other effects compression of the new charge of combustible mixture therein which is ignited by automatic operation of the spark circuit. Then the action travels in quick cycles as above described.

After a period of operation, the generator heats up and circulation of water through the water jackets prevents excess heating thereof. The design of the cooling system is such that steam is generated in the various water jackets and is conducted therefrom through the pipes 37a and 37b to the chambers 36a and 36b. Accidental flow of water through the pipes 37a and 37b is prevented by the separators 38a and 38b. The steam is generated under the same pressure as the gases generated in the apparatus and may be utilized therewith for any desired purpose.

In Figs. 2 and 3 there is illustrated a multiple arrangement generator. A plurality of radially-arranged combustion chambers 110a are connected through pipes 111 with a like number of combustion chambers 110b. Each chamber 110a and 110b includes a convergent-divergent nozzle but only the nozzle 112a is shown. The chambers 110a are embodied in a single unit having a common inlet port 124a controlled by a valve 125a for supplying combustible mixture to the combustion chambers 110a and a common exhaust port controlled by a valve 119a slidably arranged in a cap 118a and provided with a biasing spring 120a and an adjustable limit bolt 121a. Conduits 135a, 135b conduct exhaust gases from the combustion chambers 110a and 110b to a chamber 136. Each set of chambers 110a is provided with a spark plug 127a. The same details of water-cooling, firing and timing as are shown in Fig. 1 are embodied in the construction of Fig. 2, although not therein shown in detail. The operation of the embodiment of Figs. 2 and 3 is identical with that of the embodiment of Fig. 1 except that the device of Fig. 2 embodies a plurality of devices each individually a substantial duplicate of Fig. 1.

In the modification of Fig. 4, the combustion chambers 10c and 10d are of conical shape and the smaller ends are interconnected by a tube 11 of the same cross-section as the smaller ends themselves. The angle of deviation of each chamber cone is the same and lies in the range of 7° to 12°. The two cones in combination with the pipe 11 together constitute a convergent-divergent nozzle. The combustion chambers and interconnecting pipe are provided with a water jacket as previously described together with inlet and outlet valve-controlled ports and means for effecting ignition of combustible material contained in the chambers. The operation of this modification is believed to be evident from the previous description of operation.

Because of the use of the convergent-divergent nozzle form of combustion chamber, a well-known device described in any treatment of thermodynamic generators, the velocity of the gases passing through the tube 11 exceeds several times the velocity of sound. The desired compression and efficiency in proportion to this compression can be obtained. The expansion of gases in the above-described generator can theoretically be obtained to any desired degree and a practical expansion of 1 to 20 is not unusual. Thus, the velocity of the gases in the pipe 11 can be several times higher than that of sound and high compression can be obtained before the ignition of the combustible mixture occurs at the larger end of the combustion chamber. The efficiency of the herein-described generator on the basis of the modest expansion ratio of 1 to 8 is 56.5%. By utilization of the energy of the steam from the water jacket the total efficiency may be very materially increased.

The design of the combustion chambers is such as to develop maximum efficiency by reason of the high expansion ratio and high compression which can be accomplished. Combustion chambers of different design than herein shown have more limited expansion ratios and more limited compression of the gases. Such devices, therefore, cannot compare with the device herein disclosed in respect of efficiency. Devices of other design are limited to the so-called critical speed (speed of sound) and the expansion of the gases in the connecting pipe is limited to approximately 1:0.53 as is known from the laws of thermodynamics. A device having substantially spherical combustion chambers, for example, would, therefore, be very inefficient and impractical and would be of no commercial value.

Although the apparatus as above specifically described is equipped with spark-producing means, it is to be understood that the invention contemplates that such means may be omitted in the event that the compression produced in the chambers exceeds the ignition point of the fuel used. In such event, ignition would occur spontaneously and spark-producing means would be unnecessary.

I claim:

1. A thermodynamic power generator comprising a pair of identical combustion chambers each consisting of a convergent-divergent nozzle having a throat portion of smaller cross-section than either of the ends of said nozzle, a pipe connecting corresponding ends of said nozzles, a water jacket surrounding said chambers and pipe, each nozzle having an outlet port at one end and an inlet port in its conical wall, a loaded check

valve controlling flow through each port, and means associated with each chamber responsive to pressure therein for producing a spark in said chamber.

2. A thermodynamic power generator according to claim 1 in which the angle of both the converging and diverging sections of deviation of each nozzle lies in the range of 7 to 12°.

3. A thermodynamic power generator according to claim 1 in which the pipe interconnecting the nozzles is of larger cross-section than the throats of the nozzles and of the same cross-section as the nozzle ends to which it is connected.

4. A thermodynamic power generator according to claim 1 characterized by a storage tank, means connecting the exhaust ports to said storage tank, and connections for conducting steam from said water jacket to said tank.

5. A thermodynamic power generator according to claim 1 characterized by a storage tank, means connecting the exhaust ports to said storage tank, connections from said water jacket to said tank, and steam-separating means in said connections.

6. A thermodynamic power generator comprising a first and a second set of combustion chambers with each set having a common exhaust port and a common inlet port, each chamber comprising a convergent-divergent nozzle, a pipe connecting each nozzle of the first set with the corresponding nozzle of the second set, a water jacket surrounding each combination of two combustion chambers and interconnecting pipe, a loaded check valve for each port, and means individual to each set of chambers responsive to the pressure therein for effecting ignition of combustible material contained therein.

7. A thermodynamic power generator according to claim 6 characterized by a tank connected to said exhaust ports, and a connection for conducting steam from said water jacket to said tank.

8. A thermodynamic power generator according to claim 6 characterized by a tank connected to said exhaust ports, connections from said water jacket to said tank, and steam-separating means in said connections.

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