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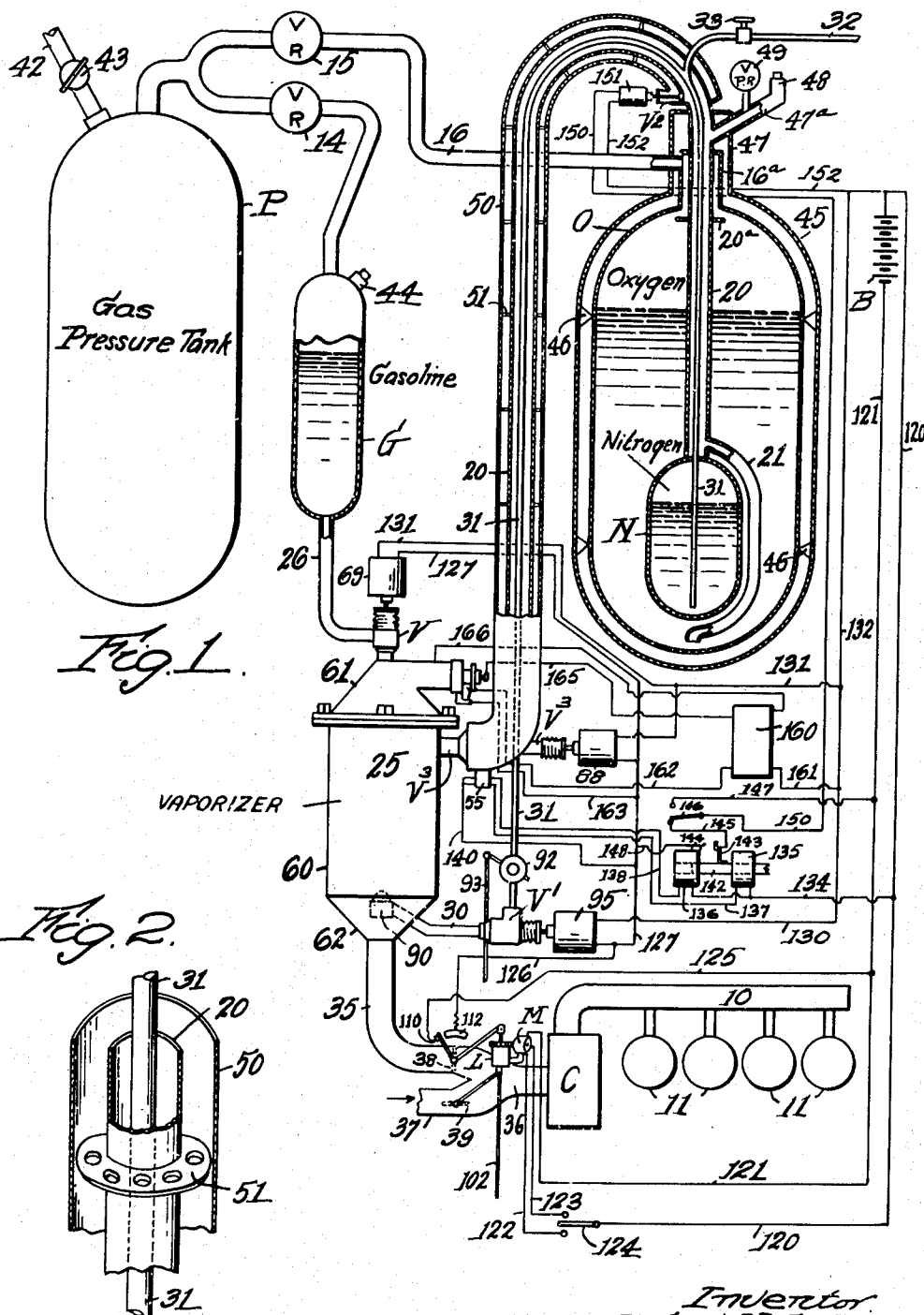
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GAS PRODUCING APPARATUS AND METHOD

Filed Feb. 9, 1942

3 Sheets-Sheet 1



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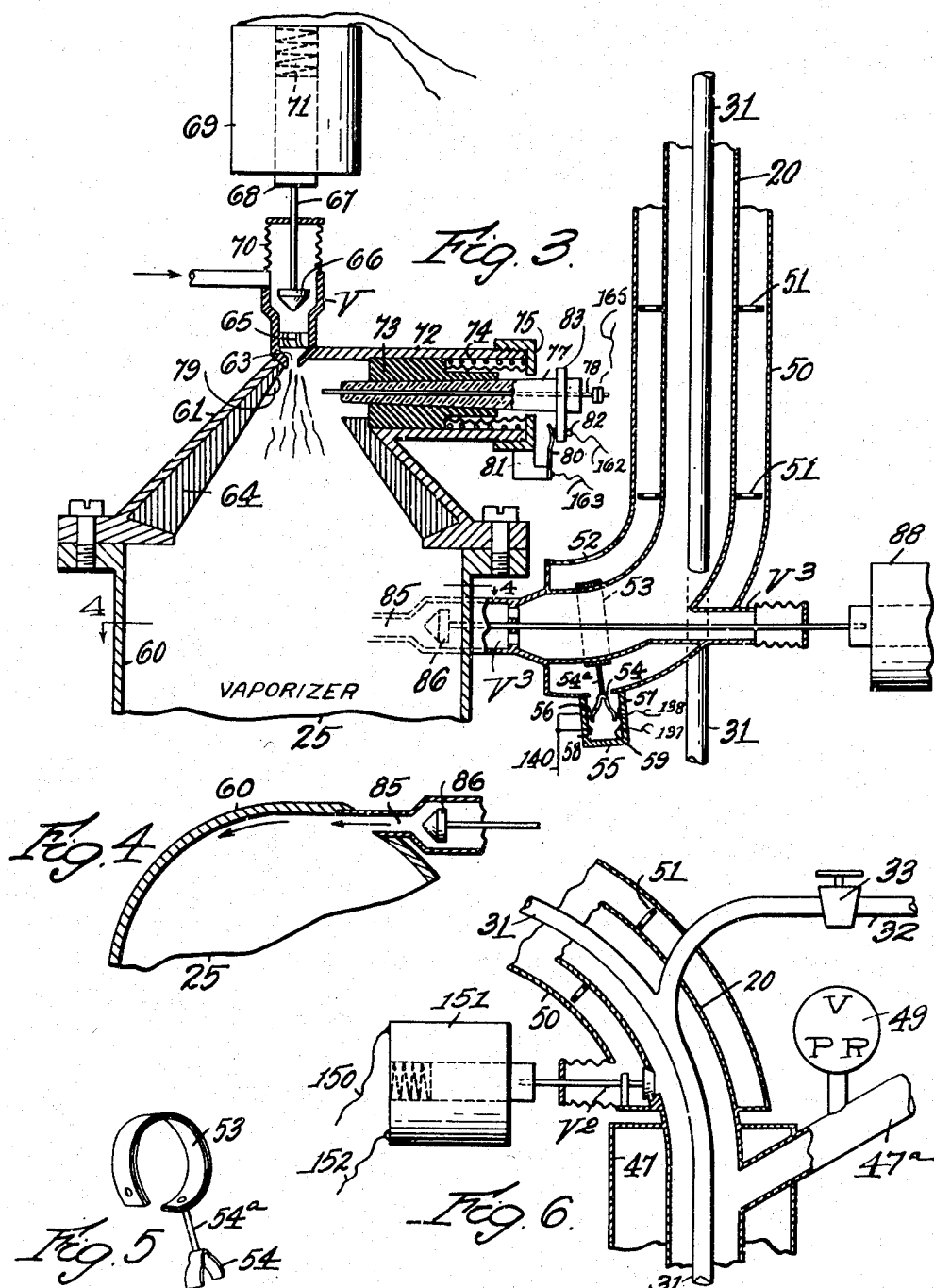
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GAS PRODUCING APPARATUS AND METHOD

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3 Sheets-Sheet 2



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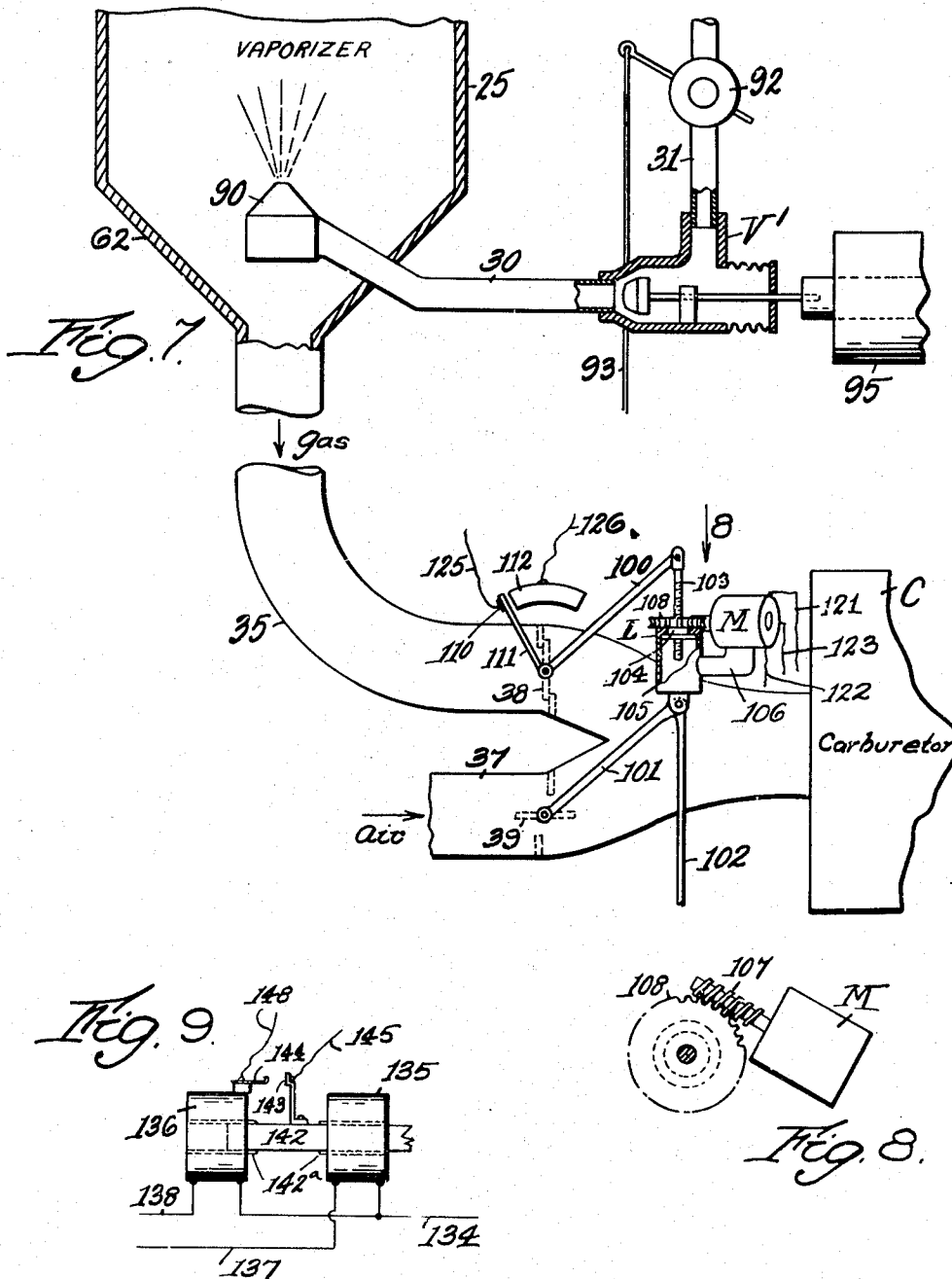
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GAS PRODUCING APPARATUS AND METHOD

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

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GAS-PRODUCING APPARATUS AND METHOD

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6 Claims. (Cl. 48—61)

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This invention relates to the production of an oxidizing gas by the evaporation of a liquid, and particularly to production of gas from a very cold liquid, such as liquid oxygen. This invention has special utility and importance in connection with the operation of internal combustion engines at very high altitudes, as in aircraft or rocket craft, the oxidizing gas being used to replace the greatly rarefied surrounding atmosphere, in whole or in part.

It is the general object of my invention to provide improved apparatus by which an oxidizing gas may be rapidly produced by evaporation of an oxidizing liquid, preferably in a generator in which limited combustion is sustained to accelerate evaporation.

I also provide improved devices for controlling the delivery of such an oxidizing gas to a carburetor or similar apparatus, and for varying the proportion of oxidizing gas and atmospheric air delivered to said carburetor.

Another feature of the invention relates to the provision of means for modifying or diluting the oxidizing gas before it is delivered to the carburetor. This may preferably be accomplished by the introduction of a limited amount of an inert gas, such as nitrogen, which inert gas may also be produced by evaporation.

My invention further relates to arrangements and combinations of parts which will be hereinafter described and more particularly pointed out in the appended claims.

Preferred forms of the invention are shown in the accompanying drawings, in which

Fig. 1 is a side elevation, partly in section, of my improved gas producing apparatus, with certain associated mechanism and electrical circuits shown more or less diagrammatically;

Fig. 2 is an enlarged detail sectional elevation of a portion of a jacketed pipe structure;

Fig. 3 is an enlarged sectional elevation of the upper portion of a gas generator and certain associated parts;

Fig. 4 is a partial transverse section of the gas generator, taken along the line 4—4 in Fig. 3;

Fig. 5 is a perspective view of a thermostatic circuit-closing device shown in Fig. 3;

Fig. 6 is an enlarged side elevation, partly in section, showing certain operative connections to the oxygen storage tank;

Fig. 7 is an enlarged side elevation, partly in section, showing the lower end of the gas generator, together with certain control valves and connections;

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Fig. 8 is a detail plan view, looking in the direction of the arrow 8 in Fig. 7; and

Fig. 9 is a side elevation of a solenoid-operated circuit-closing device to be described.

Referring particularly to Fig. 1, I have shown my gas producing apparatus as connected to supply an artificial oxidizing gas, such as oxygen, to the carburetor C of an internal combustion engine having a gas manifold 10 and a plurality of cylinders 11. The engine and carburetor are illustrative only, as my improved apparatus may be used to produce gas for many different purposes.

As shown in Fig. 1, my improved gas producing apparatus comprises a gasoline tank G, an oxygen tank O, a nitrogen tank N, and a pressure tank P. The pressure tank P is connected to the gasoline tank through a reducing valve 14, and is similarly connected through a reducing valve 15 and pipe 16 to the oxygen tank O, the connection being made through the sleeve 16^a. The lower end of an oxygen discharge pipe 20 provides a support for the nitrogen tank N and has an offset branch 21 extending around and below the tank N and open at its lower end. A baffle ring 20^a on the pipe 20 prevents the pressure gas entering through the sleeve 16^a from agitating the liquid oxygen in the oxygen tank O.

I also provide a vaporizer 25 to which the gasoline tank G is connected through a pipe 26 and a solenoid-operated valve V. The generator 25 is connected to receive oxygen from the lower end of the oxygen discharge pipe 20, and the lower part of the generator 25 is connected through a pipe 30, solenoid-operated valve V' and pipe 31 to receive nitrogen gas from the nitrogen tank N. The pipe 31 is carried through the oxygen discharge pipe 20 and is extended nearly to the bottom of the tank N, with the lower end of the pipe open. A branch pipe 32 (Fig. 1) is provided for filling the tank N and this pipe is provided with a shut-off valve 33.

The lower end of the vaporizer 25 is connected by a discharge pipe 35 to the upper branch of a gas connection 36 for the carburetor C. A corresponding lower branch 37 provides for the admission of atmospheric air. The pipes 35 and 37 are provided with butterfly valves 38 and 39, the special operating apparatus for which will be hereinafter described.

The details of construction of my improved gas producing apparatus may be more readily understood if the general purpose and method of operation is first described.

The general intent is to provide an oxidizing

gas, such as oxygen more or less modified by an inert gas, to replace the rarified atmosphere found at very high altitudes. To accomplish this purpose, liquid oxygen from the tank O is forced into the generator 25 by gas pressure provided from the pressure tank P through the regulating valve 15. Gasoline in limited amount is similarly forced into the generator 25 from the gasoline tank G, and ignition is provided by a spark-plug. Combustion of a comparatively small amount of gasoline provides sufficient heat to vaporize a relatively large amount of liquid oxygen.

The resultant oxygen gas then passes through the discharge pipe 35 to the carburetor C, provided the valve 38 is not closed. The oxygen gas may be modified to reduce its detonating effect by admitting a controlled small amount of nitrogen to the generator 25.

The relative setting of the valves 38 and 39 is controlled manually, and the proportions of atmospheric air and oxidizing gas may thus be varied as desired and as conditions indicate. The valves 38 and 39 operate reversely, so that as one valve is moved toward closed position, the other valve receives an opening movement. By proper movement and relative adjustment of the control valves 38 and 39, the carburetor C may be provided with a suitable oxidizing gas under any atmospheric condition.

Having made this brief statement of general operation, I will now describe the details of construction of the several parts of my apparatus.

The pressure tank P and the gasoline tank G may be of any usual construction, the tank P having a filler pipe 42 and shut-off valve 43 and the tank G having a filler plug 44.

The oxygen tank O is provided with an outer casing or jacket 45 to reduce evaporation, and the space between the tank and the jacket may be filled with a suitable heat-insulating material or may be exhausted to provide a partial vacuum. In the latter case, spacing cones or plugs 46 may be used to prevent collapse of the jacket. These plugs should be of heat-insulating material, such as Bakelite, and should normally slightly clear the outer surface of the tank O.

The jacket 45 has an upward extension at 47 which supports a filler pipe 47^a connected into the discharge pipe 20. The pipe 47^a is provided with a filler plug 48 and with a safety valve 49 which prevents any undue rise in pressure in the oxygen tank.

The oxygen discharge pipe 20 is also jacketed as indicated at 50 (Figs. 1 and 2) and is provided with a series of perforated discs or baffles 51 (Fig. 2) which are mounted on the discharge pipe 20 and within the outer casing or jacket 50. These baffles 51 extend close to, but do not touch, the outer casing 50. The baffles thus cool the inner tube 20 effectively, and at the same time do not lead heat inward from the outer casing.

Liquid oxygen is admitted to the jacket space by a solenoid-operated valve V² (Figs. 1 and 6), the construction and operation of which will be hereinafter described.

The jacket 50 (Fig. 3) extends downward to a point adjacent the connection of the pipe 20 to the vaporizer 25 and is provided with a vent or opening 52 at its lower end. The discs or baffles 51 in the jacket 50 retard the down flow of liquid oxygen, so that only oxygen gas can reach the vent 52.

As it is desired to use no more liquid oxygen than necessary for cooling the space inside the jacket 50, I provide a thermostat control device

at the lower end of the discharge pipe jacket and adjacent the vent 52. This device comprises a bi-metallic curved band 53 (Figs. 3 and 5), one end of which is fixed to the pipe 20 and the other end of which is free to move toward or away from the pipe 20 in response to temperature changes.

A contact element 54 (Fig. 5) is supported by a non-conducting rod 54^a mounted on the band 53, and the element 54 is positioned in a small contact chamber 55 fixed at the lower end of the jacket 50. When the bi-metallic band 53 contracts, the element 54 connects an inner pair of contacts 56 and 57. When the band 53 expands, the element 54 connects an outer pair of contacts 58 and 59. These contacts control electrical circuits to be described, by which the solenoid operated valve V² is actuated to shut off the supply of liquid oxygen from the jacket 50 as soon as the lower or vented end of the jacket is sufficiently cooled.

The vaporizer 25 is shown as having a cylindrical side wall 60, a conical head 61 and a conical bottom portion 62. The solenoid-operated gasoline feed valve V is mounted above the conical head 61 and when the valve V is opened, gasoline is projected through an inlet opening 63 in the form of a spray. The head 61 is provided with a protective copper lining 64 of substantial thickness. Curved vanes 65 in the gasoline intake give a whirling motion to the gasoline as it approaches the inlet 63 and thus produce a more effective spray.

The plug 66 (Fig. 3) of the valve V is connected by a rod 67 to a plunger 68 slidable in a solenoid 69. A bellows packing 70 surrounds the rod 67 and prevents leakage. A spring 71 normally closes the valve V when the solenoid 69 is not excited.

The head 61 has an offset tube 72 in which a cylindrical spark-plug support 73 is slidable. The inner end of the support 73 engages a shoulder in the tube 72 and the support is normally held against the shoulder by a coil spring 74, the outer end of which abuts a cap 75 on the end of the tube 72.

The spark-plug 77 is firmly mounted in the support 73 and is slidable therewith. The usual spark rod 78 extends through the porcelain sleeve of the spark-plug, and the spark is formed between the inner end of the rod 78 and a grounded projection 79 on the copper lining 64.

A contact arm 80 is mounted on a bracket 81 supported by the cap 75 and this arm 80 is normally engaged by a contact pin 82 on an arm 83 mounted on the porcelain sleeve of the spark-plug 77. The circuits to the spark rod 78, the arm 80 and the contact pin 82 will be hereinafter described. For the present it is sufficient to state that when the pressure rises in the generator 25, the spark-plug support 73 is moved outward and the contact between the arm 80 and the pin 82 is thus broken. This also withdraws the plug from extreme heat.

Liquid oxygen from the discharge pipe 20 enters the cylindrical side wall 60 of the generator 25 through a reduced inlet 85 (Fig. 4) controlled by the plug 86 of a solenoid-operated valve V³ (Fig. 3).

The solenoid-operated valve V³ is of the same construction as the valve V previously described and is operated by a solenoid 88. The inlet 85 is tangentially arranged, so that the liquid oxygen enters tangentially and forms a circumferential film on the inside of the vaporizer wall 60.

As the oxygen begins to evaporate, a small amount of oxygen vapor rises and mingles with

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the gasoline spray and the mixture thus formed is ignited by the spark-plug 77. This produces a sufficient amount of hot combustion gases to evaporate a relatively large amount of liquid oxygen into oxygen gas.

The oxidizing gas produced in the vaporizer 25 is thus a mixture of a large amount of oxygen gas with a small amount of carbon dioxide and a small amount of water. The mixture is thus available for breathing at high altitude in an enclosed aircraft cabin.

It is usually found desirable to additionally dilute the oxidizing gas for carbureting purposes, as otherwise a detonating mixture may be formed. For this purpose I connect the nitrogen feed pipe 30 (Fig. 7) to a nozzle member 90 supported within the vaporizer 25 and near the conical lower end portion 62 thereof.

The flow of nitrogen through the pipe 31, valve V' and pipe 30 to the nozzle 90 is controlled by a shut-off valve 92 having an operating rod 93 by which it may be manually controlled. By opening or closing the valve 92, any desired amount of liquid nitrogen may be released through the nozzle device 90, thus providing a corresponding amount of nitrogen gas to dilute the oxidizing gas as it passes downward to the discharge pipe 35. The valve V' is of the same construction as the valves V and V³ shown in Fig. 3 and is similarly controlled by a solenoid 95.

The butterfly valves 38 and 39 (Fig. 7) in the branch pipes 35 and 37 are provided with operating arms 100 and 101. The arm 101 is pivotally connected to a rod 102 by which the position of the arm 101 may be manually controlled to open or close the atmospheric valve 39.

The arm 100 is connected to the arm 101 and rod 102 through an adjustable link L comprising a threaded rod 103, a nut 104 and a support 105 on which the nut is rotatably mounted. If the nut 104 is rotated, the effective length of the link L connecting the arms 100 and 101 will obviously be changed.

A small motor M (Figs. 7 and 8) is mounted on a bracket 106 on the side of the support 105 and is provided with a worm 107 engaging a worm wheel 108 rotatable with the nut 104. The motor M is reversible and when rotated in either direction will correspondingly rotate the worm wheel 108 and nut 104 and thus increase or decrease the length of the link L which connects the arms 100 and 101.

By changing the effective length of the link L, the relative position of the oxygen valve 38 for any position of the atmospheric valve 39 may be determined. The valves open reversely, so that opening movement of either is accompanied by a closing movement of the other valve.

The arm 100 of the oxygen valve 38 supports an insulated contact member 110 on an arm 111. The member 110 engages a fixed segmental contact plate 112 whenever the valve 38 is moved from the fully closed position shown in Fig. 7.

The electrical circuits for control of various devices in my improved gas producing apparatus are shown diagrammatically in Fig. 1. A battery B or other suitable source of electricity is connected to wires 120 and 121. The wire 120 is connected to the reversing motor M through branch wires 122 and 123 and a reversing switch 124. The wire 121 is also connected to the motor M as a return wire. The switch 124 is normally open but the motor may be operated in either direction to vary the length of the link L by

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manually shifting the switch to close either of the branch connections 122 or 123.

A wire 125 connects the battery wire 121 to the contact member 110 which is movable with the valves 38 and 39. The segmental contact plate 112 is connected through wires 126 and 127 to one side of each of the solenoids 95, 98 and 99 which control the valves V', V³ and V respectively. The other sides of these solenoids are connected to the battery through branch wires 130 and 131 and a return wire 132. When the contact member 110 engages the segmental plate 112, these solenoid circuits are closed and the valves V, V' and V³ are simultaneously opened.

The battery wire 120 is additionally connected through a wire 134 to one side of each of two solenoid coils 135 and 136 (Figs. 1 and 9). Return wires 137 and 138 from these coils are connected to the previously described contacts 59 and 57 (Fig. 3) respectively, which contacts are engageable by the movable contact element 54 which is thermostatically controlled. These solenoid circuits are selectively completed through the contacts 59 and 56, which contacts are connected by a common return wire 140 to the wire 127 previously described.

A plunger 142 (Figs. 1 and 9) is slidable in the coils 135 and 136 and supports an insulated contact member 143 which is positioned to engage an insulated contact plate 144 when the plunger 142 is moved to the left as viewed in Fig. 9.

The member 143 is connected by a wire 145 (Fig. 1) to one terminal of a reversing switch 146. The other terminal is connected by a wire 147 to the battery wire 121. The contact plate 144 is connected by a wire 148 to the wire 127 and the reversing member of the switch 146 is connected by a wire 150 (Fig. 1) to one side of a solenoid 151 (Fig. 6) which operates the valve V² which controls the admission of oxygen to the discharge jacket 50. The other side of the solenoid 151 is connected by a wire 152 to the battery B.

The primary of the spark-coil 160 (Fig. 1) is connected by a wire 161 to the return wire 132 and by a wire 162 to the contact pin 82 (Fig. 3) which is movable with the spark-plug 77. The associated contact plate 80 is connected by a wire 163 to the wire 127 which is energized by engagement of the contact member 110 with the segmental plate 112.

The spark rod 78 (Fig. 3) in the spark-plug 77 is connected by a wire 165 (Fig. 1) to one side of the secondary in the spark-coil 160, and the other side of the secondary is grounded through a wire 166 connected to the generator head 61.

Having described the details of construction of my improved gas producing apparatus, the method of operation and advantages thereof are as follows:

The gasoline tank G, oxygen tank O and nitrogen tank N are first filled with gasoline, liquid oxygen and liquid nitrogen respectively, and the pressure tank P is similarly filled with air, nitrogen, helium or other suitable gas under pressure through the filler pipe 42 and valve 43. This gas then exerts controlled pressure through the reducing valves 14 and 15 on the gasoline in the tank G and on the oxygen in the tank O.

The valves 38 and 39 which control admission of atmospheric air or oxidizing gas to the carburetor C are shown in Fig. 1 in normal position for operation with atmospheric air, the valve 38 being closed and the valve 39 being open. If it now is desired to supply an oxidizing gas to

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replace the atmospheric air in whole or in part, the rod 102 is pulled downward manually and such movement will partially close the atmospheric valve 39 and correspondingly open the valve 38. Such movement will at the same time close a control circuit through the member 110 and plate 112.

When this control circuit is closed, the gasoline valve V, the oxygen valve V³ and the nitrogen valve V' will be simultaneously opened to admit gasoline, oxygen and nitrogen respectively to the vaporizer 25. At the same time, a circuit is closed through the primary of the spark coil 160, thus energizing the secondary and providing a spark to ignite the mixture of gasoline vapor and oxygen gas which will now form in the upper part of the vaporizer.

As the pressure rises in the vaporizer 25, the spark-plug support 73 will be pushed back against the pressure of the spring 74 and the contact pin 82 will be separated from the contact arm 80, thus breaking the ignition circuit which is no longer necessary after combustion has been well established.

At the beginning of operations, the discharge pipe 20 and the lower part of the jacket 50 will be substantially at atmospheric temperature, with the thermostatic band 53 contracted and the contact element 54 connecting the terminals or contact points 56 and 57. A circuit is thus completed through the left-hand solenoid 136, drawing the plunger 42 to the left and connecting the contact elements 143 and 144. Felt friction sleeves 142^a in the solenoids 135 and 136 cause the plunger to maintain any position to which it is shifted until it is positively moved therefrom.

Closing of the circuit between the contacts 143 and 144 energizes the solenoid 151 for the valve V² (Fig. 6) and causes oxygen to be admitted to the space between the discharge pipe and the jacket 50. When the lower end of the jacket 50 is sufficiently cooled, expansion of the band 53 will connect the contacts 58 and 59, energizing the solenoid 135 (Fig. 9) and separating the contact members 143 and 144, thus breaking the operating circuit of the solenoid 151 and allowing the valve V² to close. The contact members 143 and 144 are normally separated as shown in Fig. 1 when the apparatus is not in operation.

If it is desired to admit oxygen to the jacket 50 to precool the discharge pipe 20 and associated parts before starting the apparatus in operation, the switch 146 may be shifted to make contact with the terminal of the wire 147, thus bypassing the thermostatic control and providing direct manual control for the valve V².

The opening and closing movements of the valves 38 and 39 respectively by the rod 102 may be continued to provide any desired proportions of atmospheric air and oxidizing gas for the carburetor C. These proportions may be further varied by changing the length of the link L through operation of the motor M in one direction or the other under the manual control of the switch 124.

From the preceding description it will be seen that I have provided a very compact and effective apparatus for producing an oxidizing gas in large volume from a relatively small amount of gasoline and liquid oxygen, and that I have also provided for modifying or diluting this gas by the evaporation of a controlled amount of liquid nitrogen.

It will be further seen that the entire opera-

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tion of the apparatus is substantially automatic and takes place without attention by the operator except for initial movement of the pull rod 102 and for manipulation of the rod 93 if a different nitrogen content is desired, or the switch 144 if a different proportion of atmospheric air and oxidizing gas is desired.

Having thus described my invention and the advantages thereof, I do not wish to be limited to the details herein disclosed, otherwise than as set forth in the claims, but what I claim is:

1. In a gas producing apparatus, a vaporizer, said vaporizer having an inlet means for supplying a fluid thereto, having a second inlet means for supplying another fluid thereto, and having an ignition means associated therewith, said latter means including a sparkplug in said vaporizer, a movably mounted support for said sparkplug, and yieldable means arranged to hold said sparkplug and said support in operative sparking position in said vaporizer but so as to allow outward movement of said sparkplug and support to an inoperative non-sparking position on increase in gas pressure in said vaporizer above a predetermined maximum.

2. The combination in gas producing apparatus set forth in claim 1, in which means operatively associated with the sparkplug is provided to break the ignition circuit of said sparkplug when said plug and support are moved outward by a rise in gas pressure in said vaporizer.

3. Combustion apparatus comprising a carburetor having a conduit for supplying a first combustion supporting fluid thereto, a valve in said conduit arranged to control the flow of said fluid, having a conduit for supplying a second combustion supporting fluid thereto, a valve in said last named conduit arranged to control the fluid of said second fluid, an adjustable link operatively connecting said two valves and arranged to simultaneously and reversely shift said valves towards full-open and full-closed positions respectively upon movement thereof, means for effecting movement of said link, a means operable independently of said last named means associated with said link and arranged to vary the length of said link when operated.

4. Combustion apparatus comprising a vaporizer having a conduit for supplying a fluid thereto, having a second conduit for supplying another fluid thereto, valves arranged in said conduits for controlling the flow of fluids there-through, a conduit connection extending from said vaporizer to a carburetor, a valve in said conduit connection arranged to control the flow of fluid therethrough, said carburetor having a conduit for supplying another fluid thereto, a valve arranged in the last named conduit for controlling the flow of fluid therethrough, means arranged for simultaneously and oppositely shifting the last named valve and the valve in the conduit connection, and connections operatively associating the valve in the conduit connection with the first named valves arranged to close said first named valves upon movement of the valve in the conduit connection to a closed position.

5. A process of producing oxygen gas which comprises injecting liquid oxygen tangentially to the wall of a chamber to cool said wall, simultaneously injecting a relatively small amount of liquid fuel into said chamber, effecting combustion of the mixture, the proportions of fuel and oxygen being such as to cause the combustion of only such portion of the liquid oxygen as will

generate sufficient heat to quickly vaporize the remaining oxygen, and discharging the vaporized mixture from the chamber.

6. In a gas producing apparatus, a vaporizer, a tank for a cold liquid, a connection from said tank to said vaporizer, jacket devices for said tank and connection, a tank for a second and colder liquid mounted within said first tank but spaced therefrom, and a discharge connection from said second tank to said vaporizer, which latter connection is enclosed within said first connection and whereby said second liquid is protected from evaporation by said first liquid.

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