United States Patent [19]

Croker

[11] **3,903,692**

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[54] **HOT GAS GENERATOR**

[75] Inventor: **David M. Croker**, San Diego, Calif.

[73] Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, D.C.

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[21] Appl. No.: **430,959**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 274,786, July 24, 1972, abandoned.

[52] **U.S. Cl.** ..... **60/39.71**; 60/39.74 R; 431/173; 431/242; 431/243

[51] **Int. Cl.**[2] **F23D 11/24**; F23D 11/44

[58] **Field of Search** ..... 60/39.69, 39.71, 260, 267, 60/39.14, 39.48, 39.7, 39.13, 39.74 R; 431/173, 242, 243

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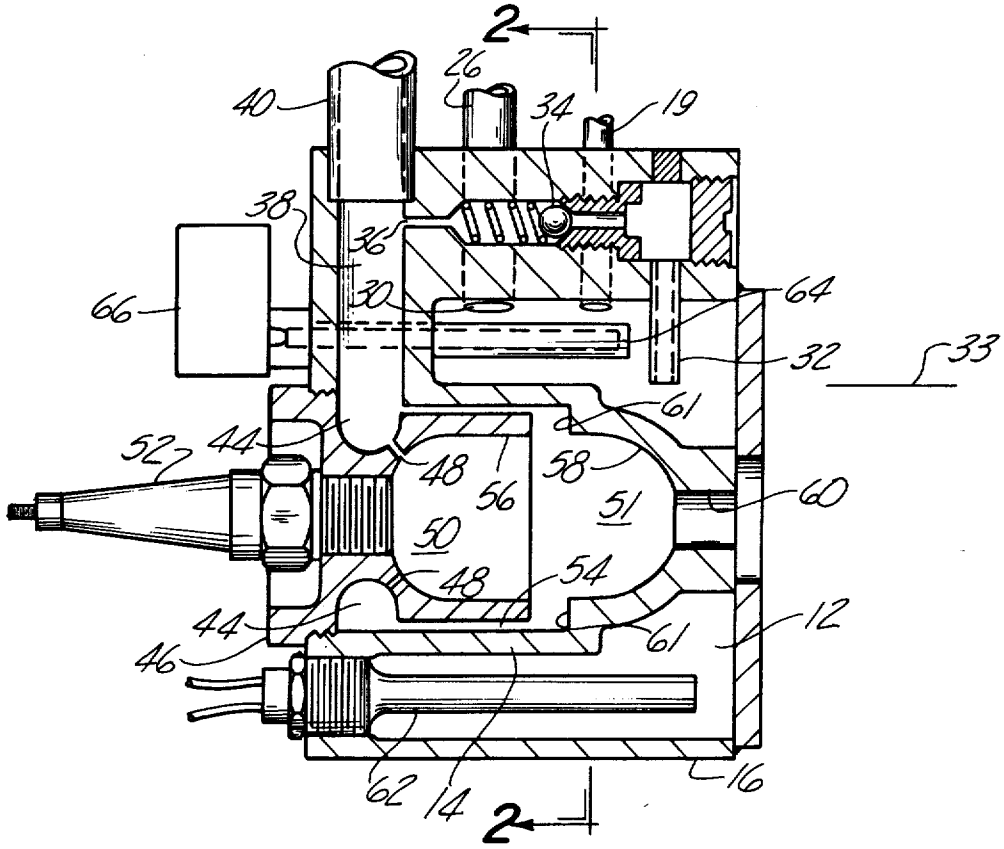
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[57] **ABSTRACT**

A hot gas generator wherein liquid fuel is supplied to an annular heated reservoir surrounding the burner, whereby the heated fuel heats the walls of the combustion chamber, thereby enabling the generator to attain relatively high output temperatures in very short periods of time. The generator is useful in starting gas turbine engines, i.e. by discharging high temperature, high pressure gas through a nozzle into the blades of the turbine to initiate turbine rotation.

5 Claims, 2 Drawing Figures



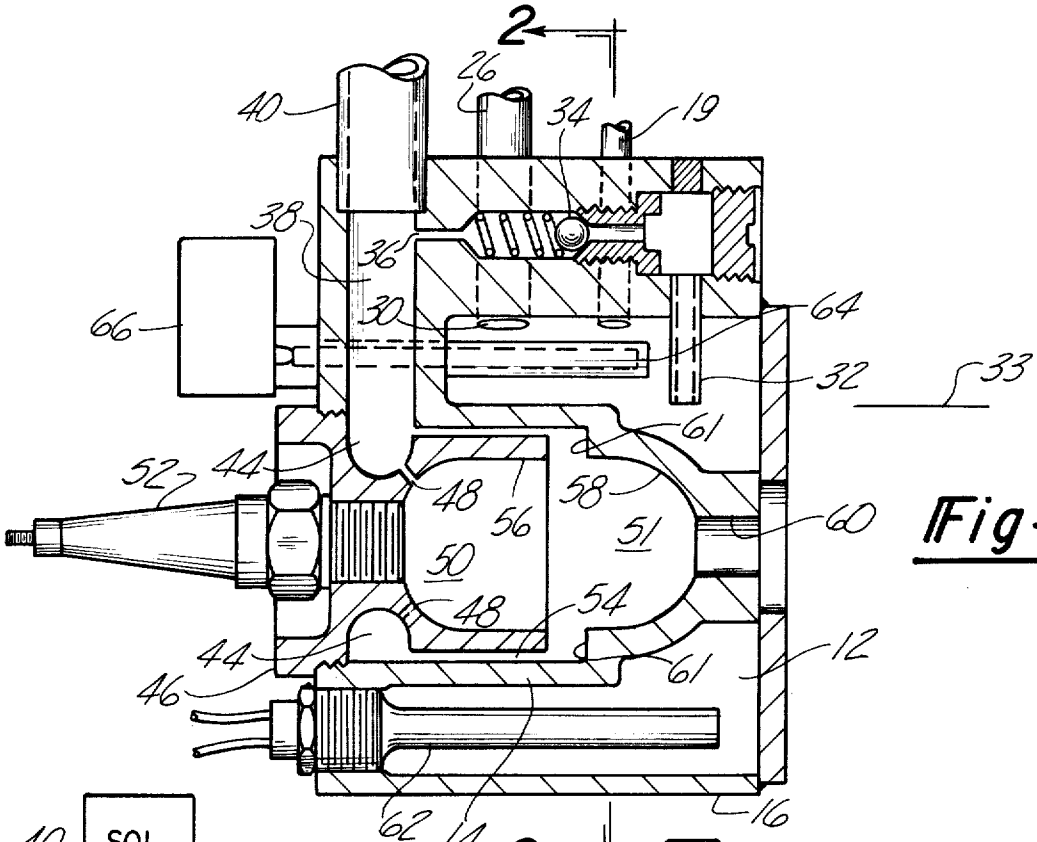

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Fig-1

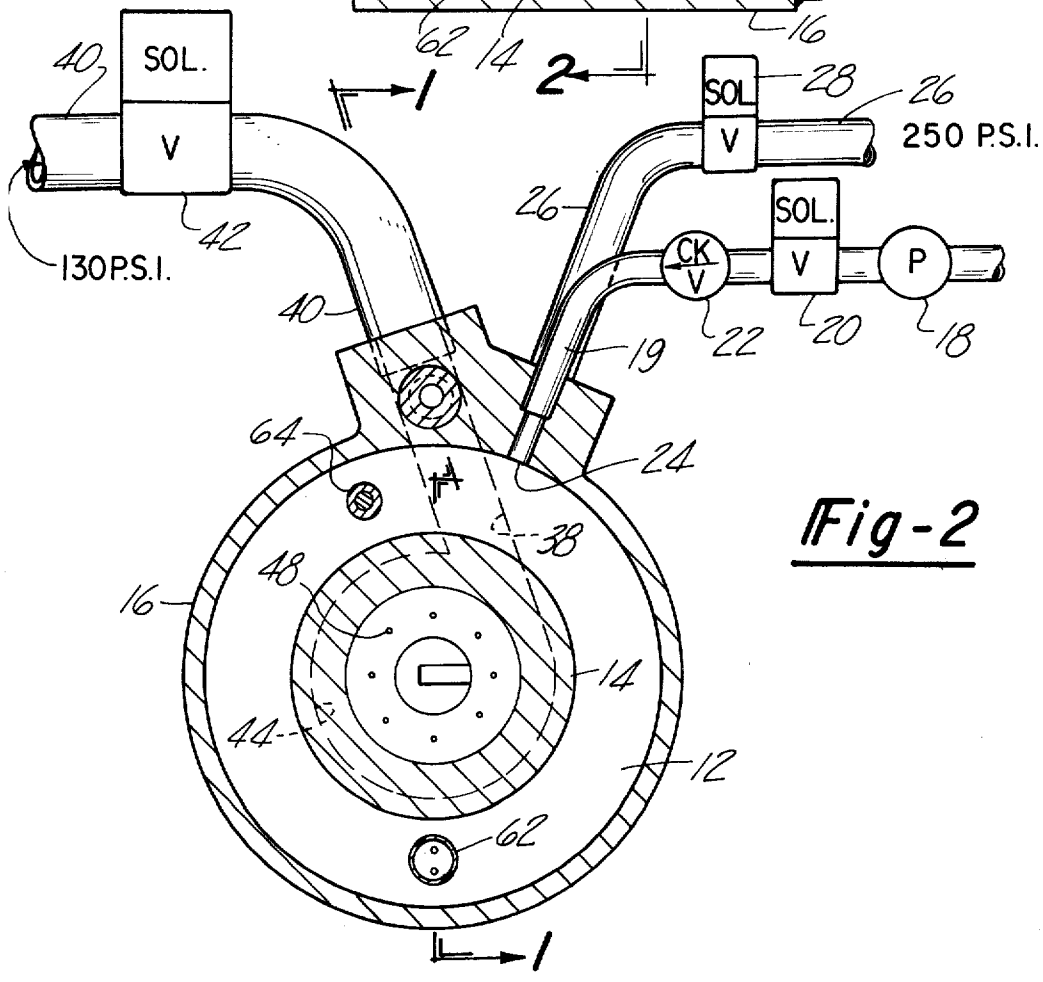

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Fig-2

HOT GAS GENERATOR

RELATION TO OTHER PATENT APPLICATION

This is a continuation-in-part of an earlier filed Pat. application, Ser. No. **274,786** filed on July **24, 1972,** now abandoned in the name of the present inventor, and assigned to the United States Government.

BACKGROUND OF THE INVENTION

Previously it has been proposed to use hot gas generators for initiating rotation of turbine engines. For example, see U.S. Pat. **2,775,866** issued to K. B. Randall; U.S. Pat. **2,921,431** issued to A. C. Sampietro; U.S. Pat. **2,925,713** issued to R. M. Stevens; U.S. Pat. **2,968,152** issued to E. K. Moore; U.S. Pat. **3,004,387** issued to M. P. Woodward; and U.S. Pat. **3,707,074** issued to M. I. Meyer et al.

THE PRESENT INVENTION

The present invention proposes a hot gas generator especially designed to include a small burner capable of rapidly heating high pressure air or other gas to a relatively high temperature on the order of **1500°** F. The heated gas can be discharged from the burner through a high pressure nozzle to impinge on the blades of a turbine engine, thereby initiating engine start-up. The burner is located to extend through an annular fuel supply reservoir that is maintained in a heated condition, e.g. at **100°** F, whereby the fuel in the reservoir heats the burner surfaces; the aim is to enable the burner to rapidly heat the supply air to a high temperature, even when the apparatus is located in artic atmosphere. The annular fuel reservoir is pressurized prior to burner ignition; at burner ignition the pressurized fuel is injected into a stream of high pressure oxidizer gas (compressed air) to form a combustible mixture. This mixture passes through a narrow annular passage that is radially interposed between the combustion chamber and the heated fuel reservoir. The mixture is therefore heated when it enters the combustion chamber. The chamber arrangement promotes the rapid attainment of a high temperature, high pressure condition at the burner outlet without flame flashback or useless back pressure effects.

THE DRAWINGS

FIG. **1** is a sectional view through one embodiment of the invention, taken generally on line **1—1** in FIG. **2.**

FIG. **2** is a sectional view taken on line **2—2** in FIG. **1.**

FIGS. **1** and **2** illustrate a hot gas generator comprising an annular fuel reservoir **12** having an inner wall **14** and an outer wall **16.** Liquid fuel is initially supplied to reservoir **12** by means of a fuel pump **18** located in a line **19** containing a solenoid valve **20** and check valve **22.** The liquid fuel enters chamber **12** through a port **24.**

After chamber **12** is completely filled with liquid fuel the fuel space may be pressurized by means of a high pressure air line **26** containing an electrically operated valve **28.** The line connects with reservoir **12** through a port **30.** Valve **28** is opened to pressurize the fuel only during periods when the burner is in operation; during non-operating periods valve **28** is closed.

Pressurized fuel is delivered upwardly through a vertical tube **32** to a pressure-responsive control valve **34**

that has a spring operating force sufficient to keep the valve closed against the pressure developed by fuel pump **18.** The pump pressure is effective to fill reservoir **12** and the space to the right of ball valve **34** when the reservoir is depressurized.

When reservoir **12** is filled and pressurized (by opening valve **28**) fuel flows leftwardly past valve **34** through a nozzle opening **36** and into an air supply passage **38** for the burner; nozzle opening **36** forms a fuel intake connection to air supply passage **38.** The supply air is initially taken from a high pressure source through a line **40** containing an electricallyoperated valve **42.** During non-operating periods valve **42** is closed. During burner-operating periods the air-fuel mixture flows downwardly through passage **38** into an annular passage **44** formed by a peripheral groove in a combustion cup element **46.** Some of the airfuel mixture is forced through a number of ports **48** into the cup interior space **50** near the sparking end of spark plug igniter **52.** Some of the mixture flows in a spinning fashion through a narrow annular inlet space **54** formed by the inner surface of reservoir wall **14** and the outer surface of combustion cup side wall **56;** space **54** forms a peripheral inlet for the combustion chamber. Circumferential spin is imparted to the incoming gaseous mixture because passage **38** has a tangential connection to annular passage **44** (as seen in FIG. **2**).

The combustion chamber is defined in part by a spherical wall **58** leading to a discharge nozzle wall **60.** A nozzle (not shown) connects wall **60** to the vanes of a gas turbine engine, whereby hot combustion gases are discharged at high pressure against the turbine vanes to initiate turbine start-up in the manner described in the previously mentioned patents.

Burner start-up is initiated by switch energization of an immersion heater **62** located in the lower portion of reservoir **12.** When the liquid fuel has reached an elevated temperature, e.g. **100°** F, a thermostatic operator **64** in the upper portion of the reservoir operates a snap switch **66** to start the burner operation. Operator **64** and switch **66** can be standard shelf items. As shown in FIG. **1** operator **64** is a tube-rod device wherein the tube has a low coefficient of thermal expansion, and the rod has a high coefficient of thermal expansion; switch actuation results from differential expansion.

Switch **66** is preferably arranged to control heater **62,** pump **18,** spark plug **52** and the three valves **20, 28** and **42.** At the actuation temperature of **100°** F the switch deenergizes heater **62** and pump **18,** closes valve **20,** opens valves **28** and **42,** and energizes spark plug **52.** Suitable relays and transformers may be employed to accomplish the program.

Valve **28** opens to pressurize the fuel in reservoir **12.** The fuel is thereby forced past valve **34** into passage **38** where it mixes with the combustion air flowing from the now-opened line **40.** Fuel-air mixtures flowing through ports **48** are ignited by spark plug **52.** The rightwardly advancing flame front in chamber **50** ignites the mixture flowing from annular space **54** into the combustion zone **51.** The hot combustion gases are exhausted at high pressure through a nozzle connected to wall **60.**

The combustion process may be continued until the fuel level in reservoir **12** drops below the lower end of tube **32;** i.e. below imaginary line **33.** After that time the continued pressurization of reservoir **12** by air line

26 is ineffective to deliver fuel to passage 38. By that time the turbine should be operating.

The illustrated structure is believed to be advantageous in that the preheated fuel in reservoir 12 heats the fuel and also inner wall 14; the result is believed to be improved fuel volatilization, better fuelair homogenity, and improved combustion, even when the apparatus is located in sub-zero temperatures.

The spin given to the mixture in groove 44 and space 54 is believed to be advantageous in converting flow energy to pressure energy, in a fashion somewhat similar to that taking place in centrifugal fans. Space 54 is relatively narrow in the radial direction; e.g. about 0.06 inch, so that pressures generated by the combustion process presumably have minimum tendency to exert shock forces backwardly through space 54. Combustion pressures would presumably have to completely disrupt the spin imparted to the entering gases before such pressures could generate a useless backward shock force; the spin energy presumably acts to preclude such action. The narrowness of space 54 would appear to offer a restriction to flame flashback while still permitting large fuel entry into the combustion zone.

Sperherical combustion surfaces 58 probably reflects combustion pressures to establish a high pressure condition in space 51. Surface 58 also acts as a throat to accelerate the gases as they are discharged through the opening at 60.

Peripheral inlet space 54 is offset slightly from space 51 by reason of the inwardly extending surface 61; hopefully this will partially shield the inlet passage from shock so that high pressures are usefully directed through opening 60 rather than backwardly into the peripheral inlet.

I claim:

1. A hot gas generator comprising an annular liquid fuel storage reservoir defined partly by a first imperforate inner annular wall and a second imperforate outer annular wall; means for heating the fuel in the fuel storage reservoir to thereby preheat the inner annular wall; the inner surface of said inner wall serving to define a combustion chamber; a hollow combustion cup extending into the combustion chamber, said cup including an end wall and a third annular side wall spaced inwardly from the first inner annular wall to cooperate therewith in defining an annular fuel-air inlet space for the combustion cup interior; an air supply passage having a tangential connection with the annular inlet space at a point near the cup end wall; means for injecting preheated liquid fuel from the reservoir into the air supply passage; said fuel injecting means being connected to the air supply passage at a point upstream from the aforementioned tangential connection, whereby fuel and air are mixed during movement thereof through the passage and annular inlet space, said tangential connection serving to impart a circumferential spin to the fuel-air mixture as it flows through the annular inlet space; and an igniter extending through the end wall of the cup to ignite the fuel-air mixture therewithin.

2. The generator of claim 1: said fuel injection means comprising a pressure-responsive control valve effective to admit fuel to the air supply passage only when the reservoir is pressurized.

3. The generator of claim 2: said fuel reservoir being pressurized by a gas pressure means having a pressure connection in the ceiling area of the reservoir; said reservoir being connected to the pressure-responsive control valve through reservoir outlet opening located between the ceiling and floor areas of the reservoir, whereby pressurized fuel flow is discontinued upon the delivery of a predetermined quantity of fuel.

4. The generator of claim 1: said cup side wall and the inner annular wall of the reservoir being sufficiently close to one another as to prevent flame flashback from the combustion space.

5. The generator of claim 1: the combustion cup having ports therethrough for conveying fuel air-mixtures from the annular inlet space into the cup space immediately adjacent to the ignitor ignition point.

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