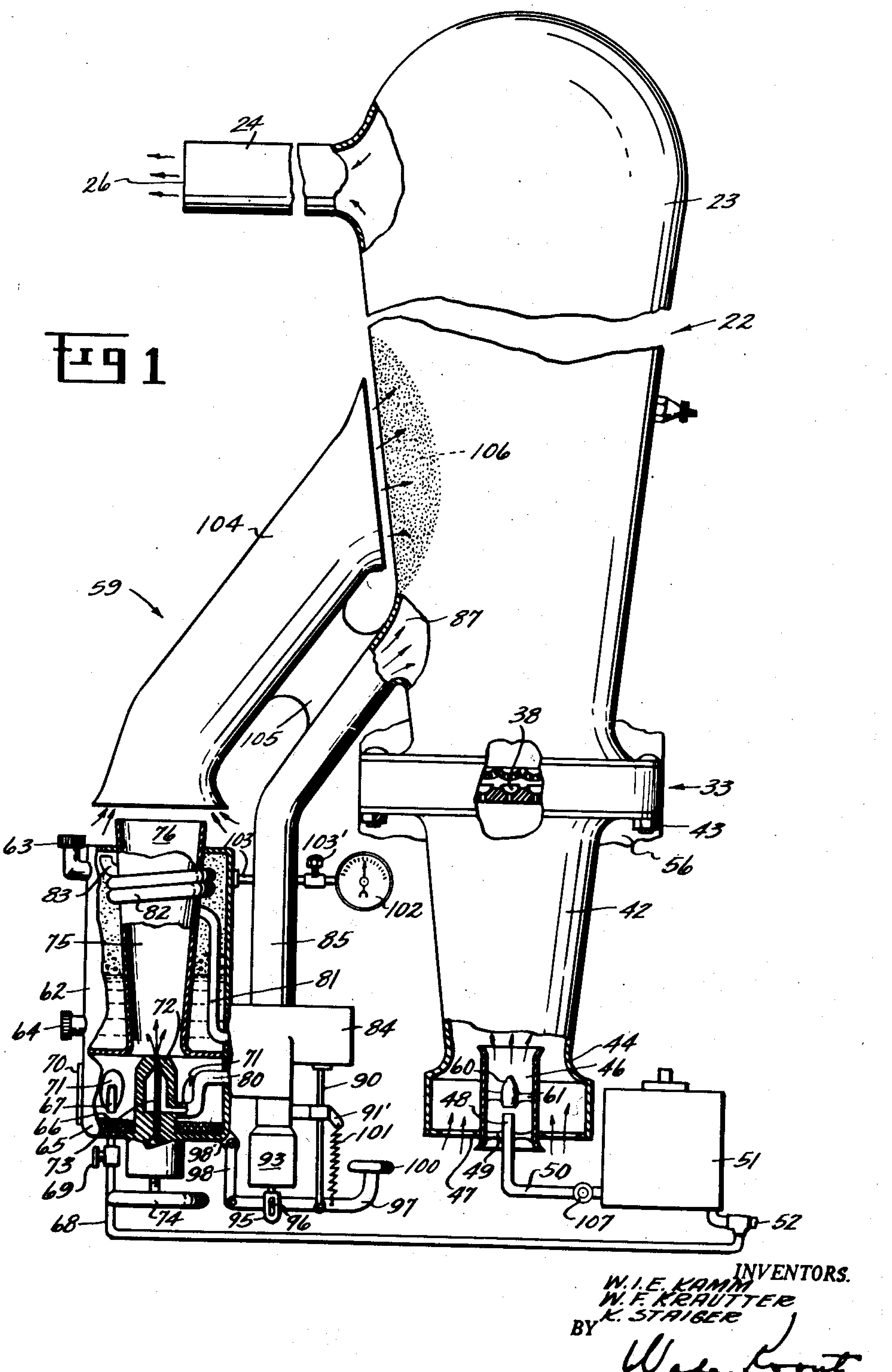
GAS STARTER FOR RESONANT PULSE JET BURNERS

Filed Feb. 16, 1950 2 Sheets-Sheet 1

FIG. 1



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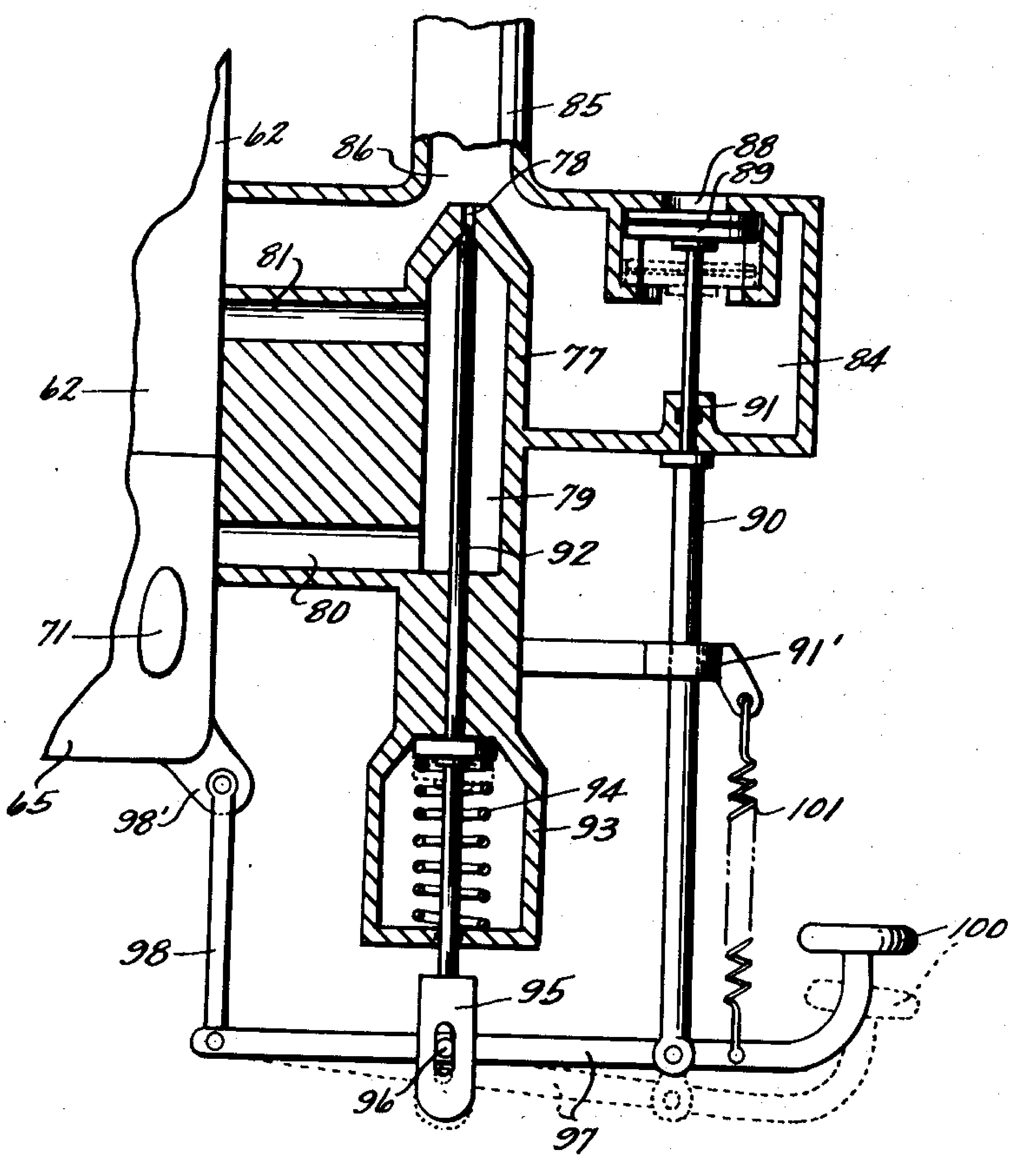
Filed Feb. 16, 1950 2 Sheets-Sheet 2

Fig 2



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GAS STARTER FOR RESONANT PULSE JET BURNERS

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Application February 16, 1950, Serial No. 144,556

8 Claims. (Cl. 158—28)

(Granted under Title 35, U. S. Code (1952), sec. 266)

1

The invention described herein may be manufactured and used by or for the Government for governmental purposes without payment to us of any royalty thereon.

This invention relates generally to acoustically tuned resonant pulse jet burners which are used to produce and propel a supply of hot combustion gases for use as a heating or power medium and more particularly to gas starters for resonant pulse jet burners, having for an object the provision of a pulse jet starter device which is independent of any outside energy, and is therefore self contained and can be easily and conveniently started, for instance, by a common match.

Another object of the invention is to utilize the pulse jet burner fuel for supplying all of the necessary energy and heat for initially supplying a fuel and air mixture in a dry state to the pulse jet combustion chamber under considerable pressure, and for heating the combustion chamber to produce the initial explosion therein to initiate the pulse jet resonant cycle and combustion process within the combustion chamber.

A further object is the provision of a self contained starter device for pulse jet burners which includes means for preheating the burner combustion chamber to provide a hot spot including means for injecting superheated gaseous fuel under pressure with the combustion supporting air into the heated combustion chamber under a considerable pressure to initiate the resonant pulse jet cycle.

A further object is the provision of manually controllable means for initiating the injection of the heated gaseous fuel and air mixture into the combustion chamber, and for interrupting the introduction of the gaseous heated fuel and air mixture supply to the combustion chamber when desired for instance after the pulse jet cycle has started.

A further object is the provision of a gaseous starting fuel supply jet and air aspirator tube therefor in communication with the interior of the combustion chamber for supplying a heated gaseous fuel mixture to the combustion chamber in which the length and diameter of the aspirator tube is such as to offer a sufficiently high flow resistance to maintain the necessary pulsating pressures within the combustion chamber, representing a secondary oscillating system, in which the column within the tube oscillates at a natural frequency, even after starting, when supplied with combustible fuel mixture, which is common with the pulse jet cycle frequency so as to vibrate in unison with the pulse jet frequency.

2

A further object is the provision of improved check valve means for controlling the admission of air into the air aspirator tube which is connected into the pulse jet combustion chamber and resisting the outward movement of air so introduced, including means for positively closing the check valve means to discontinue the supply of mixing air to the aspirator tube to thereby increase the pressure output from the combustion chamber, independently of the starting device, including means for simultaneously interrupting the supply of superheated starting fuel into the pulse jet combustion chamber as the check valve means is thus closed.

Other objects and advantages will become apparent from the following description when considered in connection with the accompanying drawings in which like reference characters refer to like parts in the several figures.

Figure 1 is a somewhat diagrammatic side elevation of a resonant pulse jet burner device incorporating our invention, parts disclosed therein being broken away and shown in section.

Figure 2 is a somewhat enlarged fragmentary vertical sectional view of the lower end portion of the aspirator tube and mixing air supply chamber, illustrating the check valve controlled air supply port check valve means, and spring means for normally closing the port, together with the manually controllable means for releasing the starting fuel mixture into the combustion chamber.

Referring more particularly to Figure 1 of the drawings, the reference numeral **22** denotes a resonant pulse jet unit having a combustion chamber **23** with an elongated discharge conduit or tail pipe **24** leading therefrom having a discharge outlet **26**, and being acoustically tuned to a desired resonant frequency by determining the length and area of the tail pipe relative to the combustion chamber area.

The combustion chamber **23** tapers downwardly from its head or dome and a check valve unit **33** is secured across the lower end or fuel mixture inlet for admitting the combustible fuel mixture into the combustion chamber during the normal operation of the device.

We prefer to use free floating cup shaped fuel inlet check valves with complemental seats and stop means. Since these form a part of a separate application of W. I. E. Kamm, W. F. Krautter and K. Staiger, Serial No. 129,862, filed November 28, 1949, for pulse jet motor fuel inlet valve constructions, they are not referred in detail herein, except that they are denoted by the reference numeral **38** as shown in Fig. 1.

A downwardly tapered fuel and air supply tube **42** is secured at **43** below the valve unit **33**, terminating in a flared mouth or aspirator inlet port **44**, disposed in communication with a fresh air intake chamber. A central air and fuel mixing inlet tube **46** is provided, supported within the aspirator **44** at **47** by an apertured closure plate or spider. Concentrically located in the mixing tube **44** is a fuel jet **48** which is carried by a supporting spider **49**, the jet **48** being supplied with liquid or gaseous fuel through a conduit **50** from a carburetor or fuel supply device **51**, the carburetor being supplied through a conduit **52** from a suitable fuel source or fuel tank, not shown.

The pulse jet unit may be supported, or fixed in position as desired, by any convenient supporting means, such as a bracket member **56**, connecting the same to any main supporting frame, also not shown.

Our improved automatic, self contained starting unit or set for initiating a resonant pulse jet burner device such as set forth above into operation is denoted generally by the reference numeral **59**.

The use of this starting unit **59** eliminates the use of pumps, air pressure supply tanks, conduits, valves, etc., also eliminating the use of batteries, high tension coils, switches, spark plugs, etc., and provides other advantages later to be pointed out.

Once the pulse jet burner is set into operation there will be a vertically vibrating column of air and fuel within the intake nozzle **42** and the central fuel and air mixing intake tube **46** and in order to prevent "back pressure" at the fuel nozzle **48** as the check valves **38** close at the time of explosion within the combustion chambers **23**, an uwardly tapered baffle member **60** is provided which is supported on a "spider" **61** directly above the nozzle **48**, best seen in Fig. 1, directing the downwardly moving column of the fuel mixture at this time outwardly away from the fuel inlet jet **48**.

The starting unit or set **59**, as best seen in Fig. 1 comprises a combined fuel heating tank and pressure boiler **62** having a filler and deaerating opening and closure cap **63** and a drain passage and closure cap **64** which may be used alternately. Located directly below the boiler **62** is a suitably ventilated heating torch and wick compartment **65** having an asbestos wick **66** in the bottom thereof. A suitably valved fuel supply nozzle or tap **67** is preferably connected to the main fuel tank, or to the carburetor supply pipe **52** by a conduit **68** having a shut-off control valve **69** therein. A door **70** provides free access to the torch compartment for lighting the wick **66**, suitable vents or apertures **71** being provided which supply the necessary air for the burning of the fuel in the heating wick compartment and for supporting combustion in the heating retort tube **75**.

Located concentrically within the wick compartment **65** is a fuel jet nozzle **72** having a needle valve **73** which is controlled by a hand wheel **74**. Extending upwardly from a port in the bottom of the fuel heating and vaporizing boiler **62** is a central upwardly flared Venturi and retort heating tube **75** having its inlet end directly above and concentric to the fuel jet **72** and its outlet end at **76**, above the top end closure of the boiler **62**. Adjacent the side of the boiler **62** and the wick and torch chamber **65** is a gaseous fuel nozzle **77** as seen in Fig. 2, having a fuel jet **78** and

an elongated gaseous fuel pressure chamber **79**, the chamber **79** being connected at its lower end by a conduit **80** to a chamber in the interior of the main fuel retort nozzle **72** and connected at its upper end by a fuel supply pipe **81** which passes through and is sealed in the wall of the boiler, extending upwardly therein and wrapped around the upper portion of the retort tube **75** within the boiler as indicated at **82**, a gaseous fuel inlet port **83** being formed at its upper end just under the top end of the boiler **62**.

The boiler **62** carries a laterally offset closed chamber **84** which surrounds the fuel jet **77**. A gaseous fuel and air mixing or mixture supply tube **85** projects upwardly from a port in the top of the offset chamber **84** and is formed with a flared lower end or mouth **86** connecting the chamber, the upper end of the mixing tube **85** being in communication through a port at **87** with the interior of the combustion chamber **23**. The tube **85** is welded or otherwise secured to periphery of the port just mentioned and forms a supporting arm for the starting unit **59**.

The laterally offset chamber **84** is provided with a fresh air inlet port **88** in the top thereof which is controlled by a loose disk or check valve **89**, suitable guides therefor being provided. A vertical push rod **90** is slidable in a suitable guide passage **91** for the purpose of forcing the check or disk valve **89** closed to prevent fresh air from entering the offset chamber **84**.

The fuel nozzle **78** is controlled by a spring tensioned needle valve **92** slidable in a suitable guide passage formed in the lower portion of the nozzle structure below the elongated gaseous fuel chamber **79**. A tubular extension **93** is formed on the lower end of the nozzle **78** having a spring seat at its lower end, housing a compression spring **94** which exerts valve closing thrust against a spring seat flange formed on the needle valve **92**. The lower end of the needle valve **92** carries a bifurcated head **95** thereon which is formed with a vertical slot for receiving an actuating pin **96** that is fixed on an actuating lever **97**. The lever **97** is pivoted at its inner end to a link **98**, which in turn is pivoted to a bracket or ear **98'** projecting from the heating torch wick compartment **65**. The lever **97**, as shown in Fig. 1, extends laterally beyond the lower end of the flap valve closing push rod **90** and is loosely connected to the push rod at **99** so that when the lever **97** is swung downwardly it will first lower the push rod **90** to release or free the check or disk valve **89** and then continued downward movement will withdraw the needle valve **92**. The extremity of the lever **97** carries a manual actuator or push button **100** for actuation thereof. A tension spring **101** is connected between the push rod guide **91** and the lever **97** for yieldably urging the lever upward to its closing position.

A pressure gauge **102** is preferably provided which is connected to the interior of the boiler **62** by a suitable conduit **103**, so as to determine the starting or fuel vapor pressure within the boiler **62**. A safety valve **103'** is connected to the conduit **103**.

A heat and flame conducting and air mixing tube **104** is supported, as shown in the drawings, by a web **105**, from the fuel and air mixture introducing or supply pipe **85**, the tube being flared outwardly above the retort tube outlet **76** and also flared at its upper end with the upper end located closely adjacent to the side of the pulse jet combustion chamber **23**. The tube **104** in-

clines upwardly toward the combustion chamber so as to direct all of the heat from the starting unit against the side of the combustion chamber **23** to form a hot spot **106**.

Operation

In starting the pulse jet heating unit the shut off valve **69** is first opened to saturate the wick **66** with fuel and is then closed. The door **70** is opened and the saturated wick is ignited in any convenient manner, such as by a match. Air entering the apertures **71** supports the combustion and the flame passes upwardly through the central heating retort tube **75**, heating the same to cause some evaporation of fuel and a low pressure within the boiler **62**. The heat also ascends the tube **104** and warms the pulse jet combustion chamber **23**. After a short interval of time the hand wheel **74** is turned to open the needle valve **73** and nozzle jet **72** starting the retort. Fuel in the boiler is boiled, evaporated, and thus superheated by the coil **82**. The gaseous fuel then passes down pipe **81**, through the elongated chamber **79** and pipe **80** and through the fuel jet nozzle **72**. Air is drawn through apertures **71** in the wick chamber **65** and the superheated gaseous fuel from the nozzle burns with intense heat which is directed upwardly through the tubes **75** and **104** against the side of the combustion chamber **23** heating the same to provide a very hot or igniting spot thereon as indicated diagrammatically at **106**.

In the meantime, due to the intense heat passing through the boiler **62**, pressure within the boiler will build up rapidly and the gauge **102** should be noted to determine when a desired pulse jet starting pressure is reached, preferably in excess of 80 pounds. When the starting pressure is reached and the glowing spot is hot enough the push button **100** is depressed, releasing the check valve **89** and withdrawing the needle valve **77**, causing an explosive mixture of super heated fuel and air to be injected through the supporting conductor pipe **85** and into the combustion chamber **23** building up an explosive mixture therein under some pressure. This mixture finally reaches the "hot spot" **106**, which is still being heated by the starting device **59**, and the mixture explodes, initiating the resonant pulse jet cycle. So long as the push button **100** remains depressed, fuel and air will be injected and sucked through the pipe **85** and into the combustion chamber, and when exploded the mixture column in pipe **85** will also explode, but the check valve **89** will close, preventing escape of the combustion products through the port **88**. When the push button **100** is released the needle valve **92** closes and the check valve **89** is forced upwardly shutting off the air supply and interrupting fuel injection in the offset chamber **84** and the column of air in the pipe **85** becomes "dead" and only vibrates vertically in resonant frequency with the rapid explosions of the pulse jet cycle within the combustion chamber **23**. The hand wheel **74** can now be turned to close the needle valve **73** and shut off the starting unit **59**. The hand wheel **74** is of course now rotated to raise the needle valve **73** to close the retort fuel supply jet **72** since further heating of the pulse jet combustion chamber is no longer necessary. Once the resonant pulse jet cycle is initiated it will continue at its tuned resonant frequency until the supply of fuel to the carburetor **51** is exhausted, or the shut off valve **107** is closed.

The important advantages are that the starting device is entirely self contained and is always ready for operation if there is fuel available to operate the main resonant pulse jet structure.

While the check valve **89** is released and permitted to open to admit air into the chamber **84** when the push rod **90** is lowered by depression of the push button **100** the check valve **89** is also free to automatically close and prevent escape of gas or fuel from the offset chamber **84** into the surrounding atmosphere if the pressure in the chamber **84** effective against the lower surface of the check valve **89** exceeds the pressure outside of the chamber **84** effective on the opposite or upper face of the check valve **89**.

The length and diameter of the tube **85** is somewhat important and preferably such as to provide a tuned natural resonant frequency with the combustion chamber **23** after the pulse jet cycle has started. When the push button **100** is released the spring **101** raises and holds the check valve **89** closed and also closes and holds the needle valve **92** closed, no fuel or air then being admitted into the tube **85**, the gaseous column in the tube **85** then vibrating vertically in unison with the resonant pulse jet cycle frequency.

The drawings disclose and the specification describes one embodiment of the pulse jet starting apparatus for exemplary purposes, it being obvious that minor changes of the apparatus as depicted in the drawings may be made without departing from the spirit of the invention as defined in the accompanying claims.

What we claim is:

1. In a resonant pulse jet burner having a wall forming a combustion chamber, a discharge pipe leading from said combustion chamber and forming therewith a resonant passage, and check valve controlled fuel and air mixture supply means in communication with the combustion chamber for supplying an explosive fuel and air mixture to the combustion chamber incident to a higher differential pressure exteriorly of the combustion chamber than the pressure within the combustion chamber; pulse jet starter means for said burner comprising a fuel and air mixture supply tube in communication with the combustion chamber; fuel heating and vaporizing pressure supply means in communication with the fuel and air mixture supply tube, having means for injecting heated vaporized fuel and air through said fuel and air mixture supply tube into said combustion chamber to form a heated explosive mixture within the combustion chamber, including normally closed manually openable valve means in the injection means for controlling said vaporized heated fuel injection; and common heating means for simultaneously heating said fuel heating and vaporizing pressure supply means for heating and vaporizing fuel therein and heating a spot on the combustion chamber wall for effecting ignition of the heated fuel and air mixture injected into the combustive chamber through said fuel and air mixture supply tube to start the resonant pulse jet burner, and means for supplying fuel to the common heating means.

2. In combination with a resonant pulse jet burner having a wall forming a combustion chamber, a starting device comprising a closed fuel vaporizing boiler having a central retort heating tube extending therethrough, a torch heating chamber positioned directly below the retort heating tube having an air aspirator opening therein formed by the lower end of the retort tube, a wick in said chamber, means for supplying the

wick with a fuel, a fuel jet located in the torch heating chamber below the retort tube for injecting fuel through the aspirator opening into the retort heating tube, a fuel supply conduit in communication with said fuel jet and in communication with the top portion of the interior of the boiler for supplying vaporized gaseous fuel from the top of the boiler to the jet under pressure when the boiler is heated and fuel therein is vaporized, a closed fuel and air mixing chamber adjacent said torch chamber having an air inlet port, a gaseous fuel and air mixture supply tube in communication at one end with the interior of the closed mixing chamber and connected with the interior of the pulse jet burner combustion chamber at its other end, a check valve for closing the air inlet port in the closed mixing chamber to prevent the exhaust of air and fuel from the mixing chamber through the air inlet port, a gaseous fuel supply jet located in the closed mixing chamber for injecting gaseous fuel into the mixture supply tube, a gaseous fuel supply conduit establishing communication between the gaseous fuel supply conduit in the boiler and the fuel jet, a push rod normally engaging the check valve for maintaining the same closed, a needle valve normally closing the gaseous fuel jet, spring means for normally maintaining the needle valve in closed position, common actuating means connected to the push rod and needle valve for withdrawing said push rod to release the check valve and opening said needle valve to inject gaseous fuel from the boiler through the gaseous fuel and air mixture supply tube into the combustion chamber to introduce a heated explosive fuel and air mixture in the combustion chamber, and a heat conductor tube having one end disposed to receive heat from the retort tube and its other end located in juxtaposed relation to the exterior surface of the combustion chamber wall for heating the same to explode the mixture of vaporized fuel and air introduced therein through the fuel and air mixture supply tube to start the resonant pulse cycle of the resonant pulse jet burner.

3. In a resonant pulse jet burner device having a wall forming a combustion chamber, a discharge pipe leading from the combustion chamber and forming therewith a resonant passage, fuel and air mixture introducing means including check valve means in communication with the combustion chamber for admitting an explosive fuel and air mixture to the combustion chamber following a predetermined pressure reduction therein; a starting device for said resonant pulse jet burner comprising a boiler having a vaporized fuel delivery jet, and an aspirated air delivery conduit surrounding said jet, forming an air and fuel mixture supply tube means having a discharge outlet in communication with the combustion chamber for supplying a heated vaporized fuel and air explosive mixture to the combustion chamber independently of the first mentioned fuel and air mixture introducing means, said conduit including a wall surrounding the jet forming a chamber having communication with the vaporized fuel and air mixture supply tube and formed with an air inlet port for admitting air to the supply tube adjacent the delivery jet, check valve means for the inlet port for admitting air into the chamber, adapted to close to prevent escape of air from the chamber through the air inlet port, common heating means for the boiler and combustion chamber including a retort tube extending through the boiler for heating and vaporizing fuel contained in the boiler and a heat conductor tube disposed to receive heat from

the retort tube, said conductor tube having a discharge end located adjacent the wall of the combustion chamber to concentrate heat from the retort tube on a spot on the combustion chamber wall, to heat the same to cause ignition within the combustion chamber of the vaporized fuel and air mixture introduced therein through said fuel and air mixture supply tube, and conduit means connected to the boiler for supplying fuel from the boiler to the retort tube to be burned therein.

4. Apparatus as claimed in claim 3 in which a needle valve is provided at the jet for controlling vaporized fuel delivery from the jet, and includes spring means engaging the needle for yieldably retaining the needle valve in closed position, and spring returned manual actuating means connected to the needle valve for opening the same, said actuating means including check valve closing means interconnected thereto normally engaging and closing the air inlet port check valve means, and movable by the manual actuating means to disengage and free the check valve means to permit the same to open.

5. In a resonant pulse jet burner having a wall forming a combustion chamber, a discharge pipe leading from said combustion chamber and forming therewith a resonant passage, check valve controlled fuel and air mixture supply means in communication with the combustion chamber for supplying an explosive fuel and air mixture to the combustion chamber; pulse jet cycle starter means for said burner comprising a fuel and air mixture supply tube in communication with the combustion chamber; fuel heating and vaporizing pressure supply means for injecting vaporized fuel under pressure through said fuel and air mixture supply tube into the combustion chamber, said last means including a closed chamber in communication with the supply tube and formed with an air inlet port in communication with the interior of the chamber, air inlet check valve means for said inlet port for admitting air through the inlet port to form an explosive fuel and air mixture with the vaporized fuel injected into the supply tube from the fuel heating and vaporizing pressure supply means, normally closed needle valve means for controlling the injection of said vaporized heated fuel into said supply tube, including manual actuating means normally closing the air inlet check valve means and interconnected with the needle valve means for opening the needle valve means; said fuel heating and vaporizing pressure supply means including a retort heating means for simultaneously heating and vaporizing fuel in the fuel heating and vaporizing fuel pressure supply means and directing heat on a spot on the combustion chamber wall for effecting ignition of the heated fuel and air mixture injected into the combustion chamber through said fuel and air mixture supply tube to start the resonant pulse jet burner, and vaporized fuel conduit means connected to the fuel heating and vaporizing supply means for supplying vaporized fuel to the retort heating means.

6. In a starter for resonant pulse jet burners as claimed in claim 5, resilient means for moving the manually operable needle valve means to closed position and simultaneously closing the air inlet check valve means.

7. In a resonant pulse jet burner having a wall forming a combustion chamber, a discharge pipe leading from the combustion chamber and forming therewith a resonant passage, check valve

controlled fuel and air mixture supply means in communication with the combustion chamber for supplying an explosive fuel and air mixture to the combustion chamber; pulse jet starter means for said burner comprising a fuel and air mixture supply tube in communication with the combustion chamber, fuel heating and vaporizing pressure supply means, vaporized fuel injection jet means for injecting vaporized fuel under pressure through said supply tube into the combustion chamber, a closed chamber surrounding the vaporized fuel injection jet means and formed with an air inlet port therein for admitting air into said closed chamber to the mixture supply tube, check valve means for closing said air inlet port opening inwardly toward the closed chamber, normally closed needle valve means for the injection jet means for admitting vaporized fuel through the jet means into the mixture supply tube when open, manually actuating means for opening the needle valve means and the releasing of the check valve means, said manual actuating means having an actuating connection thereon for closing the check valve means and closing the needle valve means when the same is moved in one direction, and releasing the check valve means and opening the needle valve means when moved in another direction, a vaporized fuel delivery conduit connected between the fuel heating and vaporizing pressure supply means and said vaporized fuel injection jet means, retort heating means for heating the said fuel heating and vaporizing pressure supply means to vaporize fuel therein, including means for directing heat therefrom against the wall of the combustion chamber to produce a fuel ignition hot spot thereon, and valved fuel supply means connected between the fuel heating and vaporizing pressure supply means and the retort heating means for supplying fuel to the retort heating means.

8. In a resonant pulse jet burner having a wall forming a combustion chamber, a discharge pipe leading from said combustion chamber and forming therewith a resonant passage therewith, and check valve controlled fuel and air mixture supply means in communication with the combustion chamber for introducing an explosive fuel and air mixture into the combustion chamber in-

cident to a higher differential pressure exterior of the combustion chamber than the pressure within the combustion chamber; a pulse jet cycle starting means comprising a fuel and air mixture supply tube in communication with the combustion chamber, a closed fuel heating and vaporizing chamber, vaporized fuel and air mixture injection means connected to the vaporizing chamber for injecting a fuel and air mixture through said fuel and air mixture supply tube into said combustion chamber, normally closed valve means in said last mentioned injection means for interrupting the said injection of vaporized fuel into said fuel and air mixture supply tube, manually operable means for opening said valve means to admit fuel into said fuel and air mixture supply tube, and retort means having heating conduit means disposed for simultaneously heating said fuel heating and vaporizing chamber means and heating a spot on the wall of the combustion chamber, thereby vaporizing the fuel in the closed fuel heating and vaporizing chamber means and heating the combustion chamber wall to effect ignition of the heated vaporized fuel mixture injected into the combustion chamber through said fuel and air mixture supply tube from the fuel heating and vaporizing chamber means, and a fuel supply conduit connected between said heating and vaporizing means and said retort means for supplying fuel to the retort means.

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