March 28, 1950 H. J. DE N. McCOLLUM 2,502,332

ASPIRATOR COMPRESSOR TYPE JET PROPULSION APPARATUS

Filed April 12, 1945 4 Sheets-Sheet 1

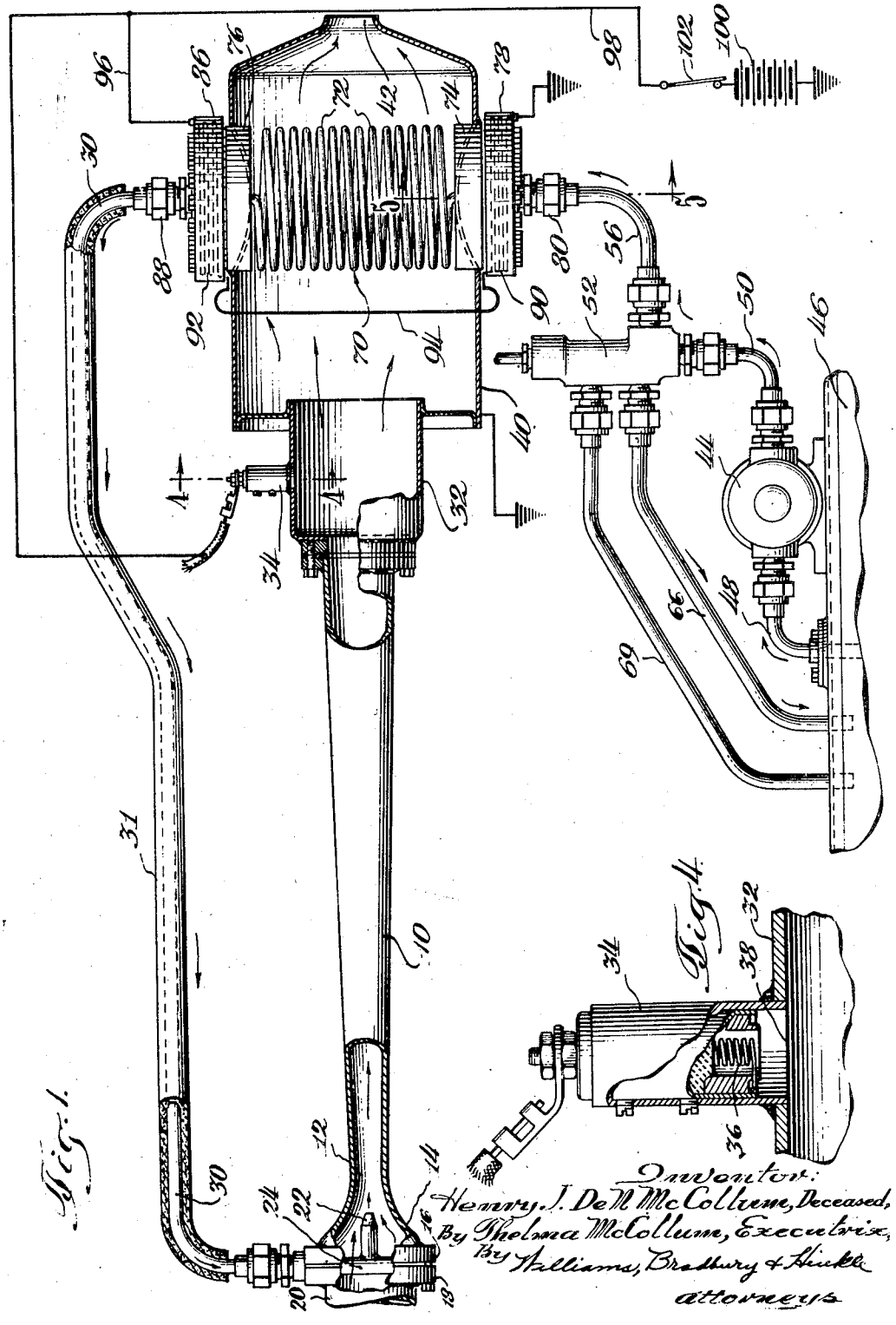


Fig. 1.

Fig. 4.

Inventor:
Henry J. De N. McCollum, Deceased,
By Thelma McCollum, Executrix,
By Williams, Bradbury & Hinkle
Attorneys

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Fig. 3.

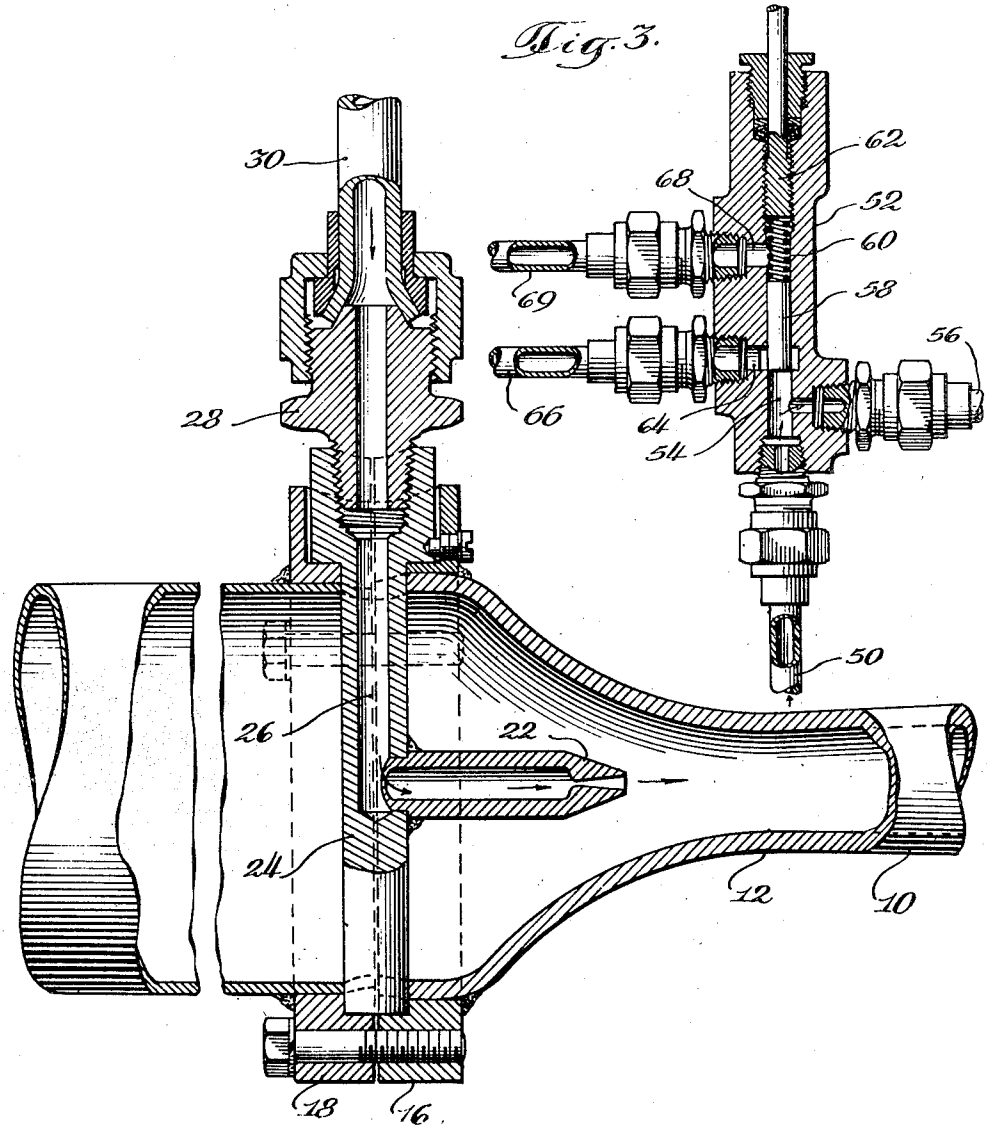


Fig. 2.

Inventor:
Henry J. De N. McCollum, Deceased,
By Thelma McCollum, Executrix,
By Williams, Bradbury & Hinkle
Attorneys.

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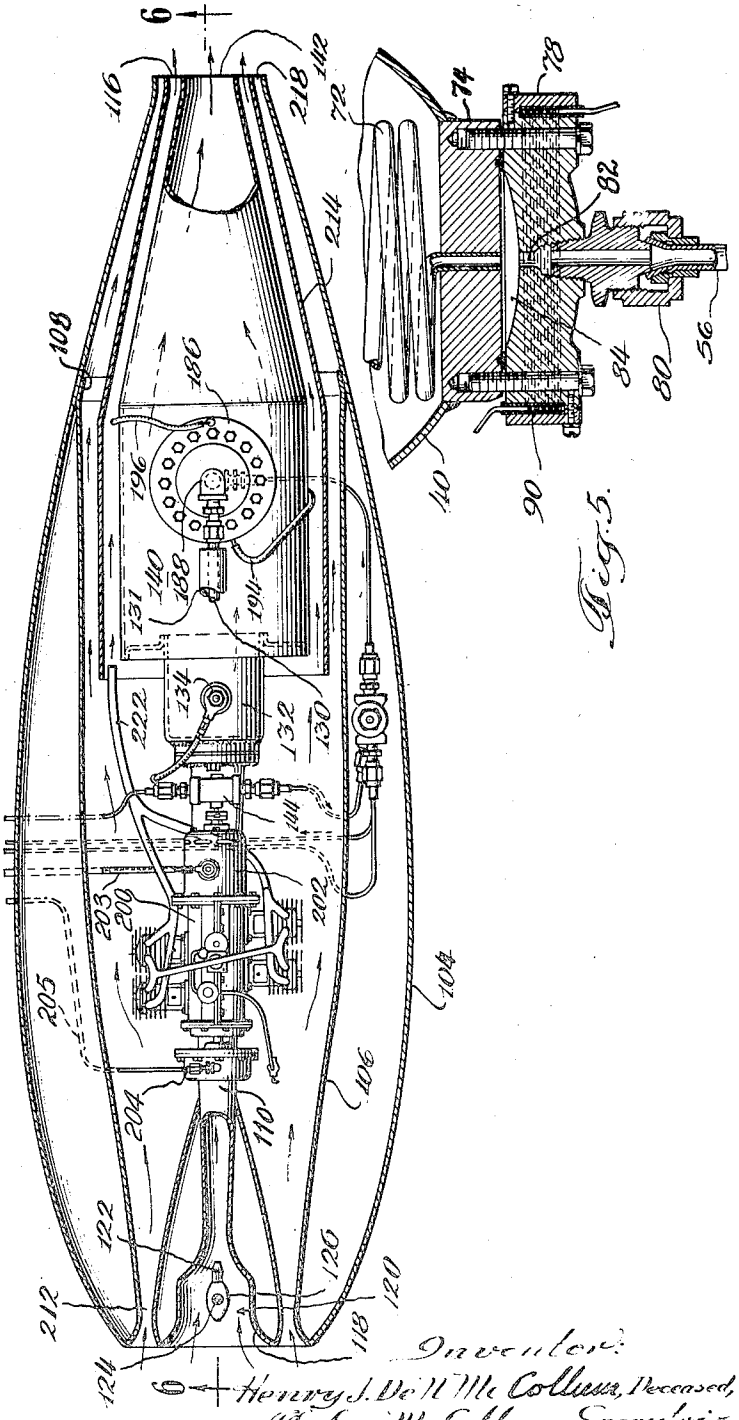


Fig. 5.

Fig. 8.

Inventor:
Henry J. De N. McCollum, Deceased,
By Thelma McCollum, Executrix,
By Williams, Bradbury & Hinkle
Attorneys

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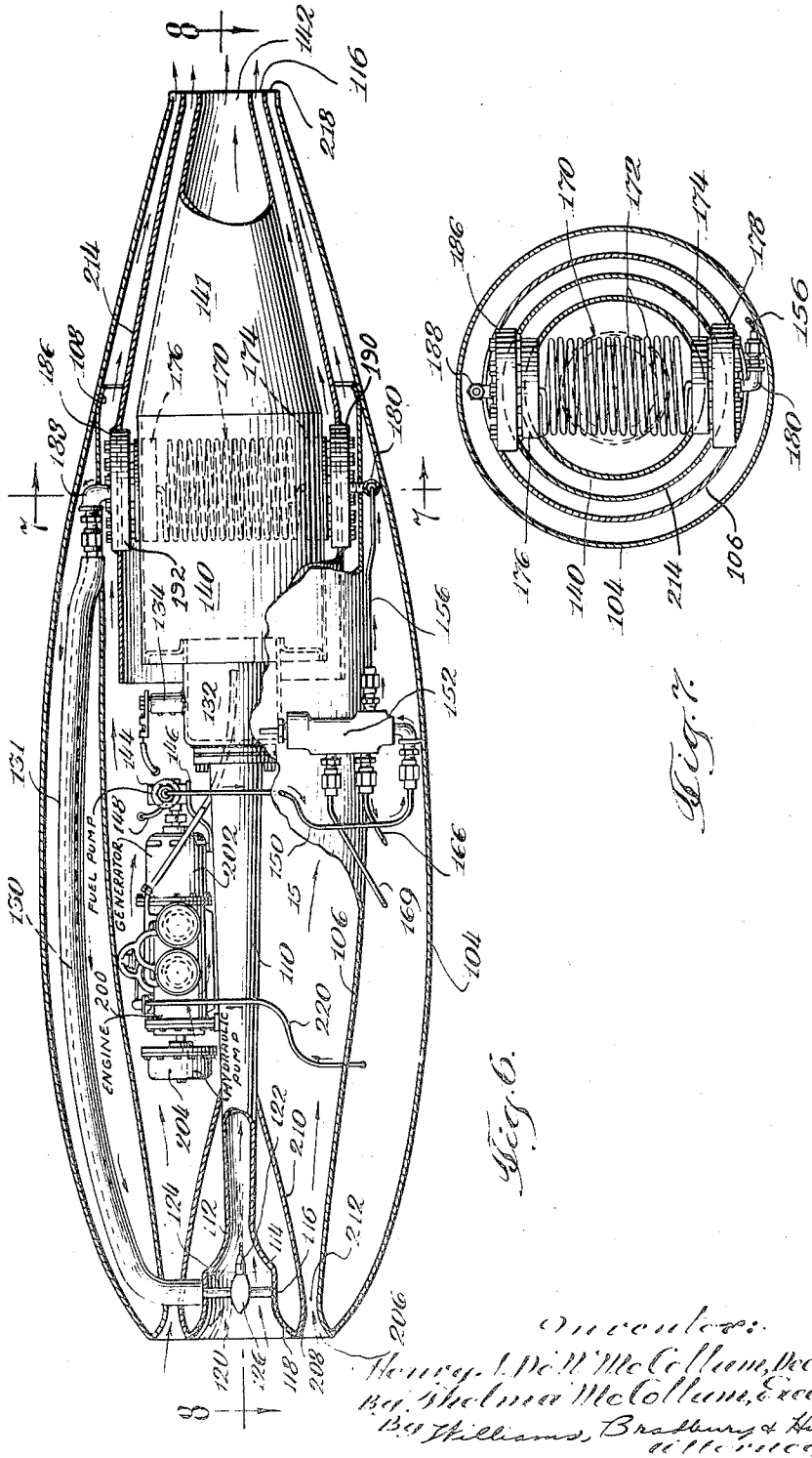


Fig. 6.

Fig. 7.

Inventor:
Henry J. De N. McCollum, Deceased,
By Shelmer McCollum, Executrix
By Williams, Bradbury & Hinkle
Attorneys

Patented Mar. 28, 1950 2,502,332

UNITED STATES PATENT OFFICE

2,502,332

ASPIRATOR COMPRESSOR TYPE JET PROPULSION APPARATUS

Henry J. De N. McCollum, deceased, late of Chicago, Ill., by Thelma McCollum, executrix, Chicago, Ill., assignor to Stewart-Warner Corporation, Chicago, Ill., a corporation of Virginia

Application April 12, 1945, Serial No. 587,926

2 Claims. (Cl. 60—35.6)

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This invention relates to jet propulsion apparatus, and one object of the invention is to provide a new and improved jet engine which shall not require a mechanical air compressor for supplying air for the jet.

Another object of the invention is to provide a jet propulsion apparatus in which auxiliary devices are driven by a separate power source so as to dispense with the provision of a gas turbine operated by the force of the jet and detracting from the total power output thereof.

It is also an object of the invention to provide a jet propulsion apparatus in which liquid fuel is preheated and vaporized in a heat exchanger adjacent the combustion chamber, and is then discharged into the mixing tube of the apparatus at high pressure so as to aspirate and compress a sufficient quantity of air for the jet and dispense with conventional means for supplying compressed air for this purpose.

The invention also includes the provision of a jet propulsion apparatus particularly designed for use on aircraft and employing instead of a turbine operated by the jet, an aspirator compressor and an auxiliary engine adapted to operate from the same fuel supply as the jet propulsion apparatus and to drive not only the fuel pump for said apparatus but other auxiliaries required for operation of the aircraft, such as an electric current generator and a hydraulic pump.

Other objects and advantages of the invention will appear from the following description taken in connection with the drawings, in which:

Fig. 1 is a side elevation partly in section and partly diagrammatic, showing a jet propulsion apparatus embodying this invention;

Fig. 2 is a vertical sectional view on an enlarged scale, showing the fuel feeding nozzle with adjacent portions of the mixing tube and air induction tube;

Fig. 3 is a vertical sectional view of the pressure regulating device for the liquid fuel supply;

Fig. 4 is an enlarged detail elevation partly in section taken as indicated at line 4—4 of Fig. 1, showing the electrical igniting device;

Fig. 5 is a detail section taken as indicated at line 5—5 of Fig. 1;

Fig. 6 is an axial vertical section at line 6—6 on Fig. 8, taken through the nacelle in which a

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jet propulsion apparatus embodying this invention is shown housed together with an auxiliary engine for use on aircraft;

Fig. 7 is a transverse sectional view, taken as indicated at line 7—7 on Fig. 6;

Fig. 8 is a horizontal section taken as indicated at line 8—8 on Fig. 6.

In jet propulsion devices, it is necessary to supply air for combustion under pressure, and to render the unit self-contained, a gas driven turbine has been arranged to be driven by the products of combustion for operating an air compressor. This not only absorbs a portion of the energy of the jet but frequently involves difficulties arising from the high temperature of the gases fed to the turbine and the consequent danger of disintegration of the turbine wheel itself under centrifugal force at such high temperature. In the present invention, the use of a turbine and mechanical air compressor is avoided by providing for the preheating of the liquid fuel at high pressure to an extent which converts it to gaseous form at high pressure, at which it is introduced to the mixing tube of the apparatus so as to entrain or aspirate and compress an adequate quantity of air for combustion. Since there is no turbine in the circuit, much higher gas temperatures can be used, thus giving better efficiencies.

As shown in Fig. 1, the mixing tube 10 is of elongated tapered form, constituting a venturi with a constricted portion at 12 and with a larger entrance portion 14 having a flange 16 securely bolted to the flange 18 of an air induction tube 20. The fuel feed nozzle 22 is mounted to discharge toward the constriction 12 of the venturi and is formed as the stem portion of a T-shaped fitting 24 shown on an enlarged scale in Fig. 2. The fitting is disposed diametrically across the air intake passage at the plane of junction of the flanges 16 and 18 with the nozzle portion 22 extending at right angles from the main portion and disposed axially in the mixing tube 10. A bore 26 in the fitting 24 connects with the bore of a coupling 28 and with that of the feed pipe 30, and leads to the bore of the nozzle 22 for discharge of fuel into the Venturi constriction at 12. The feed pipe 30 is preferably enclosed in a heat insulating jacket 31 for reasons which will presently appear.

The air and fuel become quite thoroughly intermingled and compressed in the elongated and gradually enlarging mixing tube 10, and are delivered therefrom into a combustion chamber 32 provided with an electrical igniter 34 which may be of any suitable type as, for example, that shown in Fig. 4, having an electrically heated wire coil 36 which is mounted in a housing opening at 38 into the chamber 32 and thus exposing the heated coil 36 to the gaseous mixture in the combustion chamber. The ignited and expanding gas flows from the chamber 32 into the heat exchanger chamber 40, which is of somewhat larger diameter than the chamber 32, and which has an exhaust opening 42 at its opposite end from which the products of combustion are expelled in a powerful jet which provides the propulsive force which the apparatus is designed to generate. The particular design of the exhaust opening or jet nozzle 42 will be varied in accordance with several factors, and the form shown in Fig. 1 is merely diagrammatic.

Liquid fuel for operating the apparatus is supplied by a high pressure pump 44 which may be driven independently of the jet propulsion device, and which draws its fuel from a tank indicated at 46 and through an intake pipe 48. The feed pipe 50 extending from the pump 44 leads to a pressure regulating device 52, one type of which is shown in detail in Fig. 3. The pipe 50 leads to a bore 54 of the device which connects with the outlet pipe 56 and is normally otherwise closed by a plunger 58 backed by a spring 60. The tension of the spring 60 may be adjusted by means of a threaded plug 62 against which the spring reacts. Whenever the pressure in the pipe 50 exceeds the predetermined value for which the spring 60 is adjusted, it will force back the plunger 58 thus admitting some of the incoming fuel to the port 64 from which a return pipe 66 leads back to the tank 46. Any fuel which leaks past the plunger 58 will escape by way of a port 68 and return pipe 69 which also leads back to the tank 46, thus the pressure of the outgoing fuel in the pipe 56 is limited to a predetermined value and the pump will normally run at a rate sufficient to slightly exceed this pressure so as to insure the maintenance thereof.

The pipe 56 leads to a heat exchanger indicated generally by the numeral 70 and located in the chamber 40, and for purposes of illustration, this heat exchanger is shown as comprising a single continuous coil of tubing 72 connecting at its lower and upper ends into headers 74 and 76, respectively. The header 74 is fitted with a cap 78 into which is secured the coupling 80 by which the pipe 56 is connected into the bore 82 of the cap 78. The inner surface of the cap 78 is recessed to form a shallow chamber 84 for the purpose to be hereinafter explained, and from this chamber the liquid fuel passes directly into the lower end of the coil 72. The upper header 76 is provided with a cap 86 which may be exactly similar to the cap 78, and into which the coupling 88 connects the feed pipe 30 leading to the nozzle 22 in the mixing tube 10. As it passes through the coil 72 of the heat exchanger, the liquid fuel, being subjected to the intense heat of combustion in the chamber 40, is vaporized and its tendency to expand as it assumes gaseous form enormously increases its velocity in the pipe 30 so that the fuel is discharged from the nozzle 22 in gaseous form with great velocity, which serves to entrain or aspirate the air supplied through

the tube 20. The decrease in velocity of the heated gas and air flowing in the mixing tube 10 builds up sufficient pressure in the combustion chamber to operate the device efficiently and to maintain a steady supply of combustible mixture which is ignited initially by the electrical igniter 34, but which will be subsequently ignited instantly upon contact with the flaming gas in the chamber 32. Therefore, if desired, the energizing current may be cut off from the igniter 34 after operation of the apparatus is under way.

Since it is necessary for the liquid fuel to be preheated and vaporized in order that it shall be discharged from the nozzle 22 with sufficient velocity to aspirate the air from the induction tube 20, the cycle can be started by providing supplemental heating means for the fuel for starting purposes. This is shown in the form of electric heating coils 90 and 92 embedded, respectively, in the cap members 78 and 86, connected together by a conductor wire 94 and connected by a wire 96 to the feed wire 98 which extends to the igniter 34 from a battery 100 or other suitable source of electrical energy. Both the igniter circuit and the heating coils are indicated as grounded. Thus, when the switch 102 is closed to energize the igniter, it also energizes the heating coils 90 and 92 so that as the liquid fuel supplied by the pump 44 enters the chamber 84 in the cap 78 and the similar chamber in the cap 86, it is exposed to a substantial area of heated metal by which it is rapidly voltalized and converted into gas under pressure sufficient to operate effectively at the nozzle 22. As soon as combustion has been established, the hot gases flowing through the chamber 40 in contact with the heat exchanger 70 will serve to volatilize and preheat the fuel therein and the switch 102 can then be opened.

A propulsion unit of the type just described is well adapted for use in driving aircraft and one application for this purpose is illustrated in Figs. 6, 7, and 8. In these views the propulsion unit is shown housed in a shell or nacelle 104 of streamlined design. An inner shell 106 is formed at its rear end with a flange 108 secured to the inner surface of the nacelle 104. The shell 106 immediately encloses the propulsion unit which includes the elongated mixing tube 110 having its constricted portion at 112 and having its enlarged outer end 114 continued outwardly in a cylindrical portion 116 and a flaring mouth 118 forming an air intake passage designated generally by the numeral 120. The fuel nozzle 122 is supported in this passage by the diametrically extending portion 124 of the nozzle fitting and the outer end portion of the nozzle may be formed with a streamlined body portion 126 to reduce its air resistance. The fuel feed pipe 130 with its heat insulating jacket 131 is connected to the nozzle fitting 124 and is accommodated mainly in the space between the nacelle 104 and the inner shell 106.

The mixing tube 110 is of the same design as that shown in Fig. 1, and is connected to a combustion chamber 132 provided with an igniter 134 which is arranged to be electrically energized from any suitable source. The heat exchanger chamber is shown at 140 adjoining the combustion chamber 132, but at its opposite end said chamber has an elongated tapering portion 141 which terminates in an exhaust nozzle 142 through which the jet of gases constituting the products of combustion is expelled for propelling the aircraft.

The fuel pump 144 is shown mounted on a bracket 146 secured to the upper side of the mixing tube 110, and the fuel inlet pipe 148 of the pump may be understood as extending from a fuel tank which may be conveniently located in the wing or fuselage of the aircraft, but which is not shown in the drawing. The pipe 150 leading from the pump 144 enters the pressure regulating device 152 which may be understood as similar in all respects to the device 52 shown in Figs. 1 and 3. The fuel leaves the regulator 152 by way of the pipe 156 and any excess quantity supplied by the pump is returned to the tank by pipes 166 and 169.

The heat exchanger designated generally by the numeral 170 is disposed in the chamber 140 and comprises a single coil of tubing 172 extending between headers 174 and 176 with their respective end caps 178 and 186, the pipe 56 being connected to the heat exchanger by a coupling 180, and the fuel feed pipe 130 being coupled to an elbow 188 extending from the upper cap 186. It may be understood that the caps 178 and 186 are equipped with electrical heating means 190 and 192 similar to those shown in Fig. 5 and arranged for connection with a source of electrical energy by way of conductor wires 194, 196, of which fragments are shown in Fig. 8 the wire 194 serving to connect the two heater coils in series.

An auxiliary power plant is shown in the form of a four cylinder engine 200 of the internal combustion type mounted on the upper side of the mixing tube 110 and connected to drive a generator 202 which will supply current by means of a conductor 203 for the airplane generally as well as for the igniter 134 and for the heating elements 190 and 192. The engine 200 is also coupled to the fuel pump 144 for actuating it and if desired a hydraulic pump 204 may be connected to the engine 200 for supplying hydraulic pressure through conduits 205 to actuate various elements of the aircraft, such as rudders, ailerons, landing wheels, etc.

The engine 200 is shown as of the air cooled type having its cylinders provided with cooling fins and to supply cooling air the inner shell 106 is provided with an annular air intake opening 206 formed between the outwardly flaring forward end of the shell 106 and the inwardly curved portion 208 of a partition 210 which tapers rearwardly from the inlet 206 and is joined to the mixing tube 110. The annular throat extending from the opening 206 is thus of Venturi form in cross section with a constricted portion at 212 and a substantial air blast is maintained through the space in which the engine 200 is housed, particularly when the aircraft is in motion. The air flowing through this space and carrying away this waste heat of the engine 200 moves rearwardly through an annular space formed between the shell 106 and an inner shield 214 which is of the same general contour as the combustion chamber 140 and its tapering portion 141, and is mounted in spaced relation thereto as shown in Figs. 6 and 8. A portion of the air within the shell 105 flows rearwardly through the space between the shield 214 and the wall of the chamber 140, so that the two rearwardly moving annular streams of air emerge from the rear end of the nacelle through annular outlets 216 and 218 serving to cool the chamber 140 and the outer wall of the nacelle 104 which is heated by radiation.

The fuel line for the engine 200 is shown at 220 and if desired it may lead from the same tank as that from which fuel is drawn by the pump 144 for the jet propulsion apparatus. The exhaust pipe of the engine is shown at 222 discharging into the space between the shield 214 and the chamber 140. Before the jet propulsion apparatus can be placed in operation, its fuel must be heated; therefore, the first step is to start the engine 200 whereupon the generator 202 will supply current for the heating elements 190 and 192 and the pump 144 will commence to feed liquid fuel through the heat exchanger 170. The operation of the engine 200 and the generator 202 will also provide electrical energy for the igniter 134 so that the first mixture of fuel with air flowing from the mixing tube 110 into the combustion chamber 132 will be ignited and combustion will proceed through the chamber 140. Thereupon, the heat exchanger 170 will assume the function of vaporizing and preheating the fuel so that the current supplied to the electrical heaters 190 and 192 may be switched off if desired and combustion will continue to maintain itself without aid from the electrical igniter 134. The engine 200 will continue to operate, however, for performing auxiliary functions in connection with the aircraft, as well as for driving the fuel pump.

While there is shown and described herein certain structure illustrating the invention, it is to be understood that the invention is not limited thereto or thereby but may assume numerous other forms, and includes all modifications, variations, and equivalents coming within the scope of the following claims:

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. In combination with a jet propulsion apparatus, a streamlined nacelle for housing the same having an air intake opening at its front end, said apparatus including an elongated mixing tube extending from said opening, means forming a combustion chamber having said mixing tube connected thereto at one end and tapered at its opposite end to a jet outlet in the rear end of the nacelle, a fuel nozzle discharging into the mixing tube to aspirate air from said intake opening to form a combustible mixture, means to ignite said mixture, and means for supplying fuel to said nozzle in gaseous form, including a heat exchanger in the combustion chamber, a pump arranged to fed liquid fuel to said heat exchanger under pressure, and a conduit for the fuel vaporized in the heat exchanger leading therefrom to the fuel nozzle in the mixing tube, together with an engine housed in the nacelle, a generator driven thereby for energizing the igniting means and a drive connection from said engine to the fuel pump, said nacelle having an additional air intake opening of annular form surrounding the aforesaid air intake and an annular air outlet at the rear end surrounding the jet outlet to provide a stream of air through the nacelle for cooling the mechanism in said nacelle.

2. In combination with a jet propulsion apparatus, a streamlined structure for housing the same having an air intake opening at its front end, said apparatus including an elongated mixing tube extending from said opening, means forming a combustion chamber having said mixing tube connected thereto at one end and tapering at its opposite end to a jet outlet in the rear end of said structure, a fuel nozzle discharging into the mixing tube to aspirate air from said

intake opening to form a combustible mixture, means to ignite said mixture, and means for supplying fuel to said nozzle in gaseous form, including a heat exchanger in the combustion chamber, a pump arranged to feed liquid fuel to said heat exchanger under pressure, a conduit for the fuel vaporized in the heat exchanger leading therefrom to the fuel nozzle in the mixing tube, together with an engine housed in the structure, and a drive connection from said engine to the fuel pump, said structure having an additional air intake opening adjacent the front end of said structure and an air outlet opening at the rear of said structure to provide a stream of air through said structure for cooling the mechanism therein.

THELMA McCOLLUM,
Executrix of the Last Will and Testament of Henry J. De N. McCollum, Deceased.

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