March 17, 1964 LE ROY STRAM, JR., ETAL 3,124,933

STARTING SYSTEM

Filed March 9, 1959 3 Sheets-Sheet 1

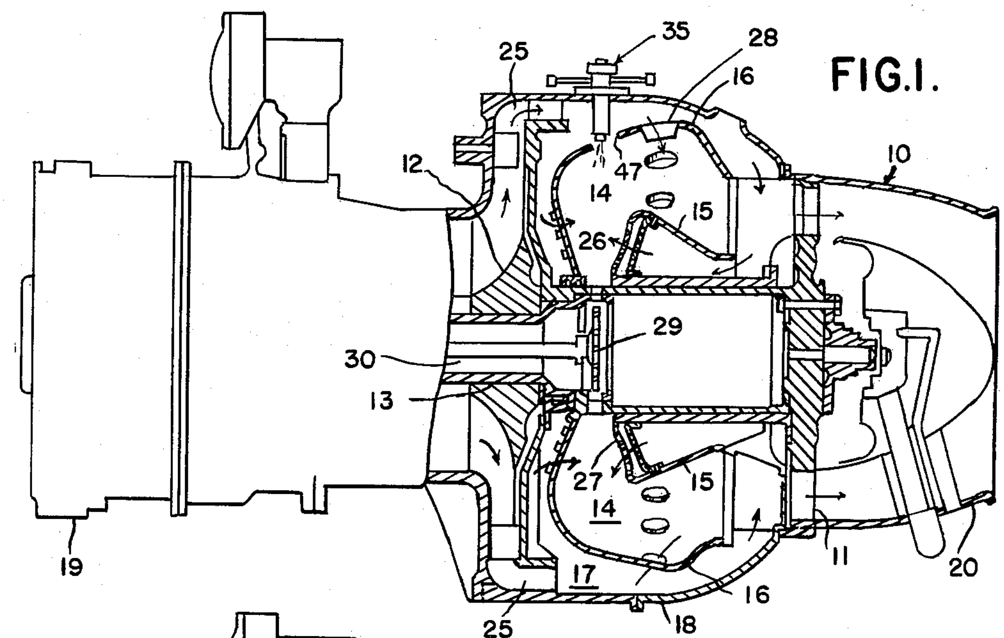


FIG. 1.

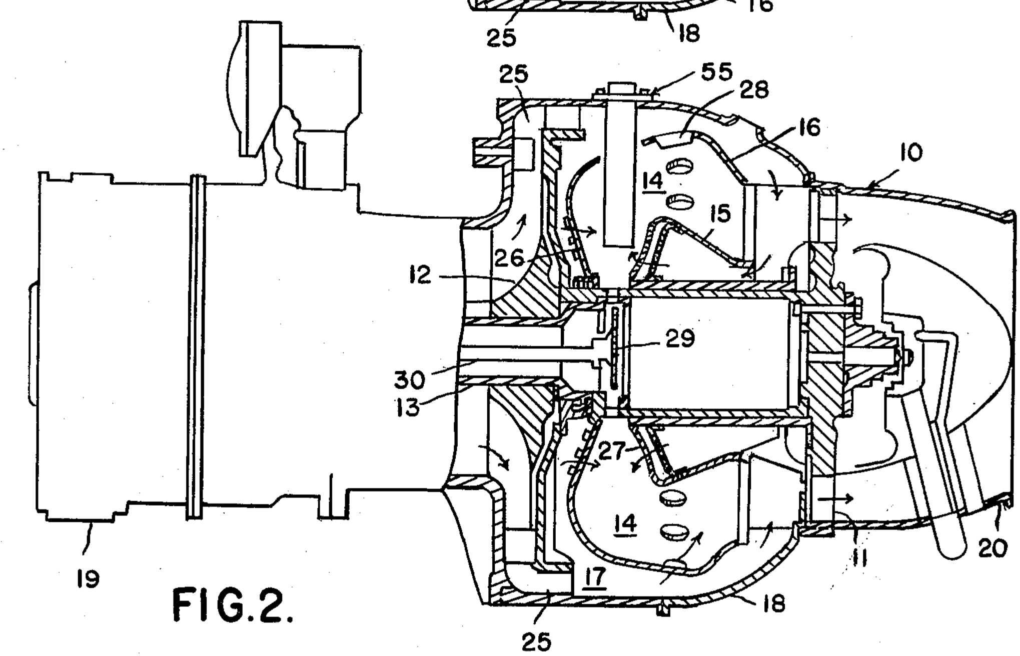


FIG. 2.

INVENTORS
HENRY C. MASKEY
LeROY STRAM, JR.
SEYMOUR A. GENDEN
BY Hauke & Hardesty
ATTORNEYS

March 17, 1964 LE ROY STRAM, JR., ETAL 3,124,933

STARTING SYSTEM

Filed March 9, 1959 3 Sheets-Sheet 2

FIG.3.

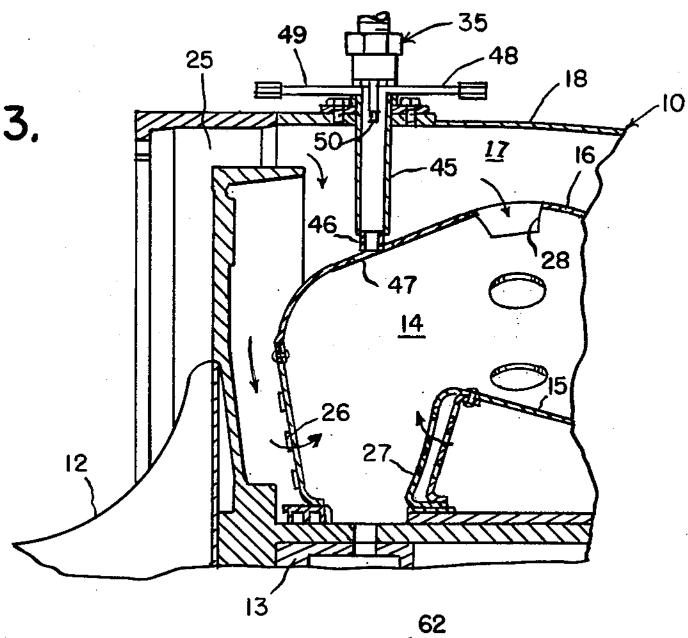
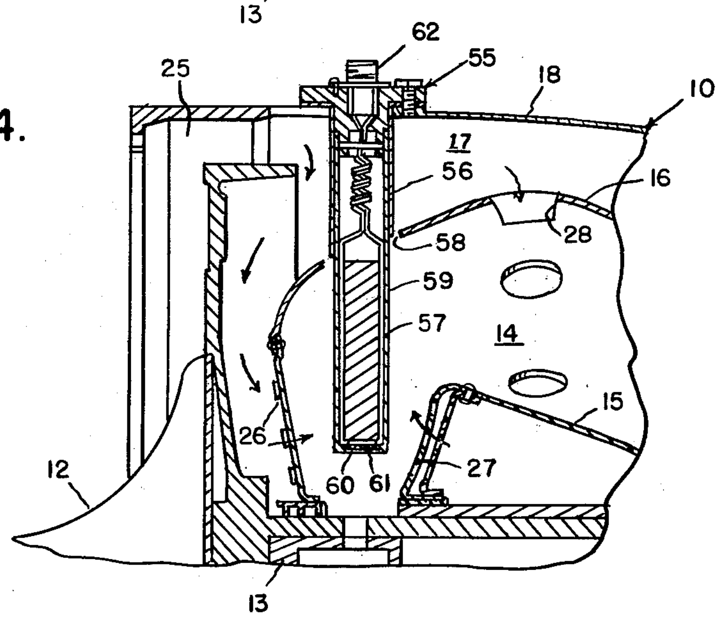


FIG.4.



INVENTORS
HENRY C. MASKEY
LeROY STRAM, JR.
SEYMOUR A. GENDEN

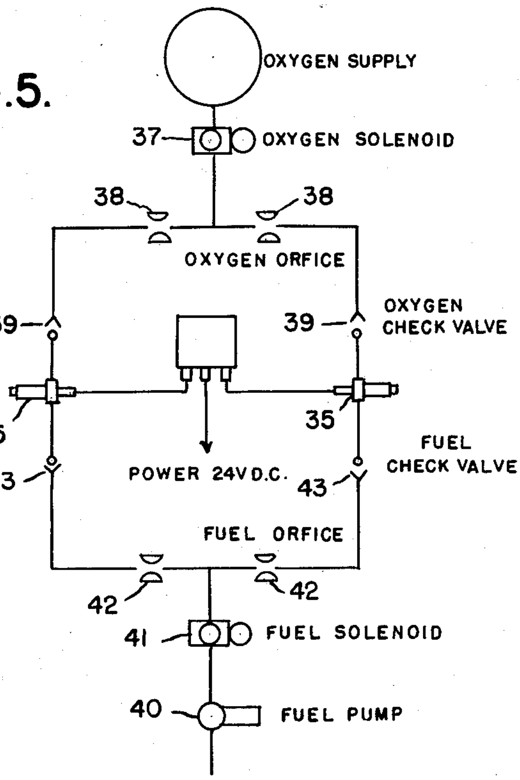
BY Harke & Hardesty
ATTORNEYS

March 17, 1964 LE ROY STRAM, JR., ETAL 3,124,933

STARTING SYSTEM

Filed March 9, 1959 3 Sheets-Sheet 3

FIG.5.



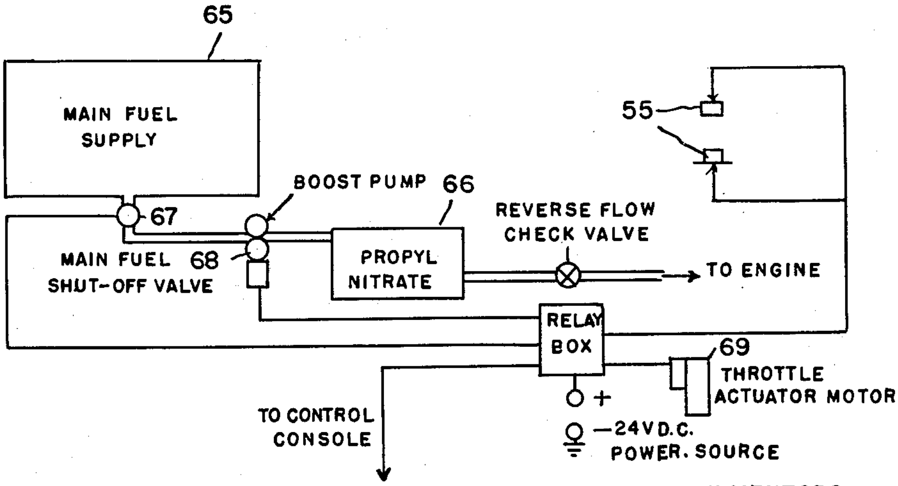


FIG.6.

INVENTORS

HENRY C. MASKEY

Le ROY STRAM, JR.

SEYMOUR A. GENDEN

BY

Hauke & Hardesty

ATTORNEYS

United States Patent Office

3,124,933

Patented Mar. 17, 1964

1

3,124,933

STARTING SYSTEM

Le Roy Stram, Jr., Royal Oak, Seymour A. Genden, Oak Park, and Henry C. Maskey, Grosse Pointe Farms, Mich., assignors to Continental Aviation and Engineering Corporation, Detroit, Mich., a corporation of Virginia

Filed Mar. 9, 1959, Ser. No. 798,218
2 Claims. (Cl. 60—39.82)

Our invention relates to high altitude starting systems for turbojet engines and more particularly to a system for producing a high energy flame within a turbojet combustion chamber to ignite engine fuel for high altitude air starting.

Originally, small turbojet engines for which the present system was devised, could only be started by using high vapor pressure fuels, such as aviation gasoline, and at ambient conditions approximating sea level static operation. Once the engine was over its idling speed, the fuel supply could be switched to the JP type of fuels, and the engine would operate satisfactorily over a wide range of ambient temperatures, inlet ram pressure ratios and altitudes.

However, installation of these engines in target drones and the like required an ignition system capable of starting the engine at certain minimum altitudes and higher true air speeds. Various ignition systems have been investigated involving use of high energy electric coils and primer fuel sprayed into the air induction system, the primer fuel being ignited and carried into the combustor primary combustion zone where fuel spraying from the fuel slinger became ignited. These systems only proved satisfactory up to about 25,000 feet altitude, and 300 m.p.h. true air speed at a temperature of about −45° F. At higher altitudes and speeds and lower ambient temperatures, combustion instability during starting grows more severe and the energy required for ignition proves to be far too great for practical uses of such systems, and even the most advantageous configurations of igniter coils, igniter plugs, and primary fuel spray nozzles could not solve the problems, particularly when it became desirable to effect air starting at altitudes from 40,000 to 75,000 feet at speeds of about Mach .5 to .9.

Another difficulty encountered in starting these small turbojet engines when used in air-dropped target drones is that the starting procedure calls for an experienced operator in the launch aircraft, who must properly accelerate the engine by means of some type of throttle actuator while maintaining a maximum exhaust temperature.

Basically, an object of the present invention is to solve high altitude and high speed starting problems by providing sustained high energies within the combustion chamber for igniting the fuel delivered thereto.

Another object of the invention is to make possible turbojet engine starting at high altitudes and high true air speeds by devising an ignition system capable of introducing an initial high energy flame within the combustion chamber for igniting engine fuel.

A further object of the invention is to provide a reliable high altitude and high speed starting system for turbojet engines by constructing a combustion chamber having means for producing a sustained high energy flame during the critical starting and initial acceleration period, said high energy flame being independent of the primary fuel and induction air conditions.

For a more complete understanding of the invention, reference may be had to the accompanying drawings illustrating preferred embodiments of the invention in which like reference characters refer to like parts throughout the several views and in which

2

FIG. 1 is a partially sectioned illustration of a preferred turbojet engine embodying the present invention.

FIG. 2 is a partially sectioned illustration of a preferred turbojet engine embodying another modification of the invention.

FIG. 3 is an enlarged cross-sectioned view of a portion of the engine of FIG. 1.

FIG. 4 is an enlarged cross-sectioned view of a portion of the engine of FIG. 2.

FIG. 5 is a diagrammatic illustration of the starting system of the engine of FIG. 1, and

FIG. 6 is a diagrammatic illustration of the starting system of the engine of FIG. 2.

Referring to FIGS. 1 and 3, a preferred type of small turbojet engine **10** is illustrated as having a turbine **11** drivingly connected with a single stage compressor **12** through a drive shaft **13**, an annular combustion chamber **14** defined generally by an inner combustor shell **15** and an outer combustor shell **16**, an annular compressed air chamber **17** defined generally by the outer combustor shell **16** and an engine housing structure **18**, the engine housing structure **18** including an air intake structure **19** and an exhaust nozzle structure **20**.

Compressed air is delivered by the compressor **12** as indicated by the arrows through an annular intake passage **25** to the compressed air chamber **17** and thence radially inward and rearward through a swirl vane structure **26** into what is termed the primary combustion zone; axially rearward, radially inward and forward to inside the inner combustor shell **15** and through ports **27** into the rear side of the primary combustion zone; and radially inward through ports **28** in the outer combustor shell **16** into what is termed the secondary combustion zone.

A fuel slinger **29** is carried in the drive shaft **13** and operates by centrifugal force to spray fuel radially outwardly into the primary combustion zone, the fuel being conducted to the slinger **29** through a conduit **30** from the engine supply system (not shown).

The starting system for the engine **10** generally is illustrated in FIG. 5 as preferably comprising a pair of torch igniters **35**, an oxygen supply **36** from which oxygen is delivered through a solenoid shut-off valve **37**, orifices **38**, and check valves **39** to the torches **35**. Fuel from the engine main fuel source is delivered by a fuel pump **40** through a solenoid shut-off valve **41**, orifices **42**, and check valves **43** to the torches **35**. The orifices **39** and **43** are included in the system to respectively govern the flow characteristics of the oxygen and fuel.

One of the torches **35** is illustrated in FIG. 3 as comprising a tube **45** mounted on the engine housing **18** and having a nozzle **46** operable to direct a flame directly into the combustion chamber **14** through a hole **47** in the outer combustor shell **16**. The oxygen and fuel are respectively conducted into the tube **45** through any suitable inlet connections **48** and **49** from their respective sources, and the resulting combustible mixture is ignited by any suitable means such as a spark igniter **50**. It will thus be apparent that the igniter operates independently of conditions in either the air induction system or the engine fuel delivery system.

The high energy flame produced by the torch **35** is directed into the primary combustion zone of the combustion chamber where it will ignite the engine fuel-air mixture and sustain combustion in the combustion chamber for as long as desired, being limited only by the supply of oxygen carried. Combustion can readily be sustained throughout the critical acceleration period of the engine until conditions are reached under which the normal engine fuel and air supply systems will maintain combustion. Depending on the supply of oxygen, this system will also operate to provide for multiple starts if desired.

A modification of the invention is illustrated in FIGS. 2, 4 and 6, in which the same engine **10** is involved, but instead of the torches **35**, pyrotechnic flares **55** are utilized for starting. One such flare **55** is illustrated in FIG. 4 as comprising a metal sleeve **56** mounted on the engine housing **18**, a combustible plastic tube **57** carried in the sleeve **56** and projecting therefrom through a hole **58** in the outer combustion shell **16** into the primary combustion zone of the combustion chamber **14**. The tube **57** is packed with a charge **59** of a suitable composite type rocket propellant including its own oxydizer, such as polysulfide-ammonium nitrate. The tube **57** has an open end **60** and preferably carries a glow wire **61** in contact with the rocket propellant charge **59** and suitably connected by means of an electrical plug connection **62** to any suitable electrical system operable to heat the glow wire **61** for initially igniting the propellant charge **59**.

FIG. 6 illustrates a preferred fuel and electrical system for use with the pyrotechnic flare. Between a main engine fuel supply **65** and the engine is a measured supply **66** of a suitable primer fuel such as propyl nitrate, the primer fuel being delivered to the engine first under the pressure of the main fuel delivered through a fuel shut-off valve **67** by a boost pump **68**. The flares **55**, the fuel shut-off valve **67**, the boost pump **68** and a throttle actuator motor **69** are operated through a common electrical system, the throttle actuator motor **69** operating to regulate fuel flow to prevent quenching of the flare flame during the critical acceleration period.

It will be seen that the pyrotechnic flare method of starting will be operable as a one-start system only, and the time of high energy flame supply will be dependent on the size and type of propellant charge **59**. The propyl nitrate primer fuel has been found to be advantageous for starting since it has a much faster flame propagation rate than that of the hydrocarbon fuels, the low pressures and temperatures experienced at high altitudes materially reducing the flame propagation rates of the hydrocarbon fuels. The propylnitrate thus prevents afterburning and combustion instability during starting.

Although we have described only two embodiments of the invention, it will be apparent to one skilled in the art to which the invention pertains that various changes and modifications may be made therein without departing from the spirit of the invention or the scope of the appended claims.

We claim:

1. A high altitude starting system for a turbojet engine and comprising
   (*a*) a housing structure,
   (*b*) a combustor structure disposed within said housing structure and defining a combustion chamber,
   (*c*) a fuel supply means delivering a primary fuel stream to said combustion chamber,
   (*d*) air induction means delivering air to said combustion chamber to provide high energy fuel, and
   (*e*) a flame producer operable to provide a high energy flame within said combustion chamber for initiating combustion of said primary fuel,
   (*f*) said flame producer comprising a pyrotechnic flare supported within said combustion chamber and having a charge of high energy solid rocket fuel including an oxidizer and means igniting said rocket fuel,
   (*g*) said flare comprising a metal sleeve secured to said housing structure and having an open end disposed adjacent said combustor structure and exteriorly of said combustion chamber,
   (*h*) said flare further comprising a combustible tube carrying said charge of rocket fuel and carried within said sleeve and extending from said open end through said combustor structure and into said combustion chamber, whereby said sleeve is disposed substantially entirely exteriorly of said combustion chamber and said combustible tube is disposed substantially entirely inside said combustion chamber.

2. The starting system as in claim 1 and in which said igniting means comprises a glow wire carried by said tube and adjacent said charge of rocket fuel, and an electrical ignition system including means heating said glow wire to initiate combustion of said charge of rocket fuel.

References Cited in the file of this patent

UNITED STATES PATENTS

2,518,882	Goddard	Aug. 15, 1950
2,561,670	Miller	July 24, 1951
2,595,759	Buckland	May 6, 1952
2,760,340	Seglem	Aug. 28, 1956
2,784,553	De Croso	Mar. 12, 1957
2,856,755	Szydlowski	Oct. 21, 1958
2,937,501	Trousse	May 24, 1960

FOREIGN PATENTS

627,722	Great Britain	Aug. 15, 1949
714,800	Great Britain	Sept. 1, 1954