Sept. 18, 1956 J. W. BEAMS ET AL 2,763,155

HIGH ALTITUDE BURNER SIMULATOR

Filed June 15, 1949 2 Sheets-Sheet 1

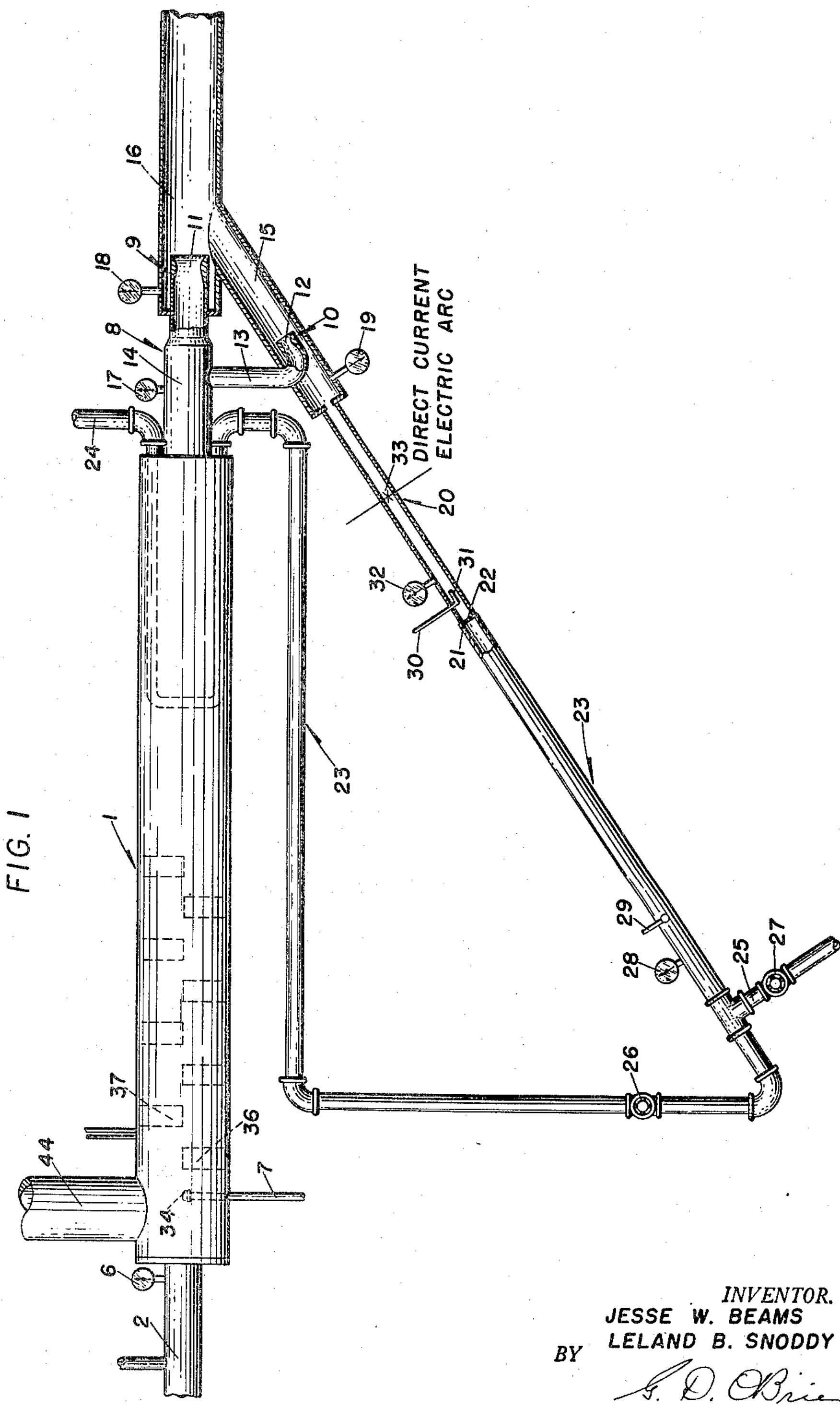

FIG. 1

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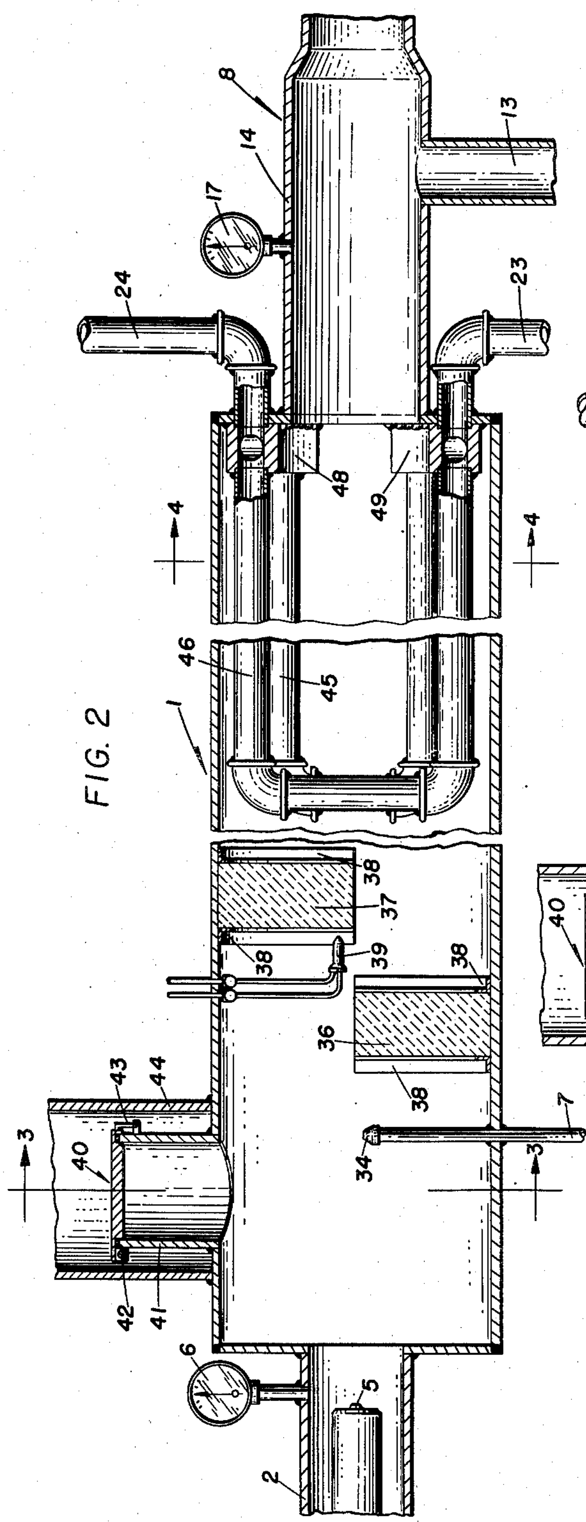

FIG. 2

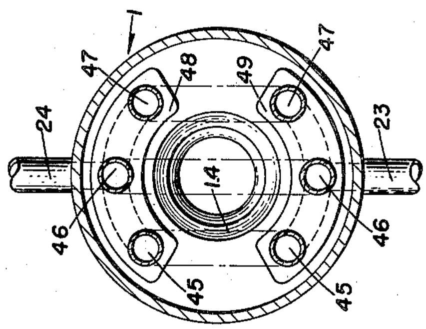

FIG. 4

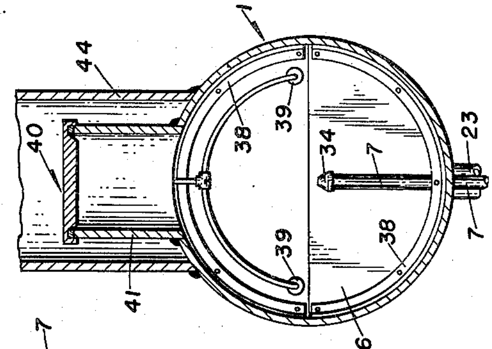

FIG. 3

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HIGH ALTITUDE BURNER SIMULATOR

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Application June 15, 1949, Serial No. 99,258

4 Claims. (Cl. 73—116)

The present invention relates to apparatus and procedures for simulating conditions prevailing in high-altitude regions of the earth's atmosphere, for the purpose of testing ram-jet burners and combustion under such conditions.

The importance of such testing is due to the development of ram-jet vehicles, which operate at high altitudes and wherein combustion of the motor fuel therefor occurs in a low-pressure atmosphere. It will be obvious that combustion will be modified profoundly by such conditions, and that it is not at all certain that fuels and fuel:air mixtures at ratios that are highly satisfactory at or near sea-level, will perform properly, or even burn at all, under low-pressure conditions. It is also possible that similar remarks apply to the burners themselves. Heretofore no suitable procedures or facilities for testing fuels and burners under such conditions have been available.

An object of the present invention is to provide a system free from mechanical pumps and other moving mechanism for maintaining a low pressure atmosphere for combustion experiments and tests.

Another object is to provide a system of this type, wherein a two-stage ejector is utilized to maintain such low pressure atmosphere.

A further object is to provide means having ample air handling capacity, whereby the necessary low pressure may be maintained in spite of a relatively great flow of combustion products resulting from the tests.

An additional object is to provide a system of this type wherein the air supplied to the device being tested may be preheated to a controllable extent.

Other objects and many of the attendant advantages of this invention will be appreciated readily as the same becomes understood by reference to the following detailed description, when considered in connection with the accompanying drawings, wherein:

Fig. 1 is a diagram of the complete apparatus, certain portions being shown in axial section;

Fig. 2 is an axial section, on a larger scale, through the pressure chamber, parts being broken away;

Fig. 3 is a cross section of the pressure chamber in the plane 3—3 of Fig. 2; and

Fig. 4 is a cross section of the pressure chamber in the plane 4—4 of Fig. 2.

Referring first to Fig. 1, the apparatus comprises a pressure chamber **1** wherein a high pressure is produced by the combustion of fuel, such as gasoline, in compressed air. The gasoline may be introduced through a pipe **7**, and the compressed air enters through a pipe **2**, from any suitable source, such as an air compressor, not shown. A pressure gage **6** may be connected to pipe **2**, if desired.

The pressure chamber **1** has two important functions: It supplies a high velocity flow of combustion products, to operate a two-stage ejector, and it preheats the air that is to be supplied to the simulated ram-jet that is being tested. The ejector system is designated as a whole by reference character **8**. It comprises a first stage pump

9, having a relatively large nozzle **11**, preferably in substantial axial alinement with the pressure chamber **1**, and fed from its large outlet conduit **14**, as shown, and a second stage pump **10**, having a smaller nozzle **12**, fed from a branch conduit **13** connected to said conduit **14**.

Assuming that an adequate supply of gaseous combustion products is delivered from the pressure tank **1** through conduit **14**, the ejectors **9** and **10** will operate in a more or less conventional way to exhaust the contents of conduits **15** and **16**. Pressure gages **17**, **18** and **19**, of the Bourdon type, or any other suitable manometers, may be provided as shown, to indicate the pressures prevailing in the various parts of the ejector system.

The ram-jet to be tested is simulated by a conduit **20**. At its intake end there is a plate **21** having an orifice **22**, through which air for combustion is introduced into the conduit **20** from the pipe **23**. This pipe has an inlet pipe **24** at one end, through which atmospheric air enters. Within the chamber **1** there is an air heating section, which will be described later. The pipe **23** thus delivers heated air through the orifice **22**, when valve **26** is open. A branch pipe **25**, with a valve **27**, is connected to pipe **23** as shown, and may be used to admit cold air to the orifice plate, that is, air at atmospheric temperature. By manipulation of both valves, air at controlled temperatures may thus be supplied to the simulated ram-jet. A manometer **28** and a temperature measuring device **29** may be provided to indicate the pressure and temperature of the air supplied through the orifice.

A fuel supply pipe **30**, having a suitable nozzle **31** within the ram-jet **20**, supplies the fuel to be tested. The pressure in the ram-jet is shown by the manometer **32**. Combustion is initiated and maintained by a suitable pilot, an electric arc **33** being here shown for this purpose. The ejector system maintains a suitable low pressure at the outlet end of the ram-jet, simulating atmospheric pressure at high altitude.

The details of the pressure chamber **1** will now be described, with especial reference to Figs. 2, 3 and 4.

Without limiting the dimensions of the chamber thereto, but purely by way of example, it may be said that one pressure chamber now in successful operation is about eighteen inches in inside diameter and thirteen feet long.

At its air intake end, compressed air is introduced through pipe **2** at a suitable pressure, for example 60 lbs. per sq. in., from any conventional source. An oil burner nozzle **5**, such as is commonly used in domestic oil burners, is provided for preheating the chamber **1** and its contents, when it is to be put into operation.

Within the chamber is a gasoline nozzle **34** supplied from the pipe **7**. Refractory baffles **36**, **37**, are mounted within the chamber. These baffles, only two of which are shown, are of semicircular shape, and located alternately on opposite sides of the chamber, with their flat diametrically located surfaces substantially in one plane, so that the hot gases generated by the combustion of the gasoline from nozzle **34** must follow a zig-zag or sinuous course through the baffle region of the chamber.

It will be understood that any desired number of baffles may be provided, preferably at least four. They are made of massive ceramic material and successive baffles are spaced apart a distance approximately equal to the thickness of each baffle, about four inches in the present example. While the baffles are shown alternately above and below the horizontal axial plane in Fig. 2, this was done merely to facilitate the understanding of the structure, and in practice the flat diametrically located surfaces will preferably be vertical instead of horizontal, because it is simpler to support them in the vertical positions mentioned. Any suitable supports for the baffles may be provided. Semicircular angle iron brackets **38** are shown as one possible way.

Igniting means for the gasoline are shown at **39**. These igniters are oxy-hydrogen burners, located near the opposite corners of the first baffle. A flame of this kind is chosen because it is difficult to blow out, in spite of the turbulence and high velocities of gases encountered in the pressure chamber. These pilots or igniters may be themselves ignited in any conventional way, as by an electric spark or the like.

A safety valve **40** is mounted on a spud **41** near the gasoline nozzle **34**. This valve is shown hinged at **42** and releasably latched at **43**, to yield upon excessive pressure in the pressure chamber. A safety shield **44** encloses the whole, and conducts the discharged gases away from the chamber and the personnel operating the latter.

The air heater section comprises an arbitrary number of U-shaped pipes **45**, **46**, **47**, each connected at one end to the intake manifold **48** and at its other end to the discharge manifold **49**. The cold air, at atmospheric temperature and pressure, is introduced into manifold **48** through pipe **24**, and the heated air is discharged from manifold **49** into pipe **23**, already discussed.

For strength, and prevention of leakage, it is preferred to make the pipe connections with the customary threads, wherever feasible, and to provide additional security and tightness by welding around all joints in the entire apparatus, as shown.

The operation will presumably be clear from the description of the structure, but may be summarized briefly as follows:

When the apparatus is to be put into service, the first step is to preheat the pressure chamber, by means of the oil burner **5**. This gradually heats the chamber and its contents, and prevents the sudden thermal shock that would result from starting at once with the large gasoline flame. In this way the life of the ceramic baffles is conserved, and cracking thereof becomes less likely. The preheating is also beneficial in preventing undue strains in the piping and joints.

After the chamber has reached a relatively high temperature from this preheating, the air pressure delivered through conduit **2** may be increased to its full value, and the nozzle **34** may be supplied with gasoline through pipe **7**. This will ignite from the pilots **39** and also will be relit thereby whenever it fails for any reason.

The baffles **36**, **37**, etc. will guide the combustion products in a tortuous course, thoroughly mixing them and equalizing the flow and temperature fluctuations to a certain extent.

The air passing through the pipes **45**, **46**, **47** will become heated, and will supply hot air to the simulated ram-jet **20**, thus simulating the conditions of actual operation of such jet at supersonic speeds, whereby the shock wave at the mouth of the jet provides hot air.

The ejectors **9** and **10** maintain a suitably low pressure at the tail-pipe end of the ram-jet, simulating high altitude atmospheric conditions. The valves and manometers afford a certain degree of control of the operating conditions, as will be obvious.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. Apparatus for simulating the operating conditions of a ramjet in high altitude flight comprising a conduit having an open end exposed to atmospheric air, a section intermediate the ends of said conduit simulating a ramjet, a chamber in which high pressure gases are formed by combustion, a portion of said conduit between said open end and said section extending through said chamber for supplying preheated air to one end of said section of conduit, and exhaust means connected to said chamber and positioned adjacent the other end of said section of conduit for maintaining a reduced pressure at said other end.

2. Apparatus for simulating the operating conditions of a ramjet in high altitude flight comprising a conduit open at one end to atmospheric pressure, a section intermediate the ends of said conduit simulating a ramjet, a chamber in which gases under pressure are formed by combustion, a portion of said conduit between said open end and said section extending through said chamber for supplying preheated air to one end of said section of conduit, and a two stage ejector pump connected to said chamber and arranged adjacent the other end of said section of conduit for maintaining a reduced pressure immediately beyond said other end.

3. Apparatus for simulating the operating conditions of a ramjet in high altitude flight comprising a conduit open at one end to atmospheric pressure, said conduit being provided at a point along its length with an orifice, the section of conduit following said orifice being utilized to simulate a ramjet, a combustion chamber for generating gas under pressure, a portion of the conduit between said open end and said orifice extending through said combustion chamber for supplying preheated air through said orifice to said section of conduit thereby simulating conditions at a ramjet intake, means for supplying fuel to the section of conduit following said orifice for mixing with said preheated air, means for igniting the fuel-air mixture in said section of conduit, and an exhaust pipe connected to said combustion chamber and positioned adjacent the other end of said conduit thereby providing an ejector for maintaining a reduced pressure immediately beyond said section of conduit simulating conditions at the exhaust of a ramjet.

4. An apparatus for simulating the operating conditions of a ramjet in altitude flight, comprising a conduit having one end open to atmospheric pressure, and an outlet at the other end, said conduit being provided with a reduced orifice intermediate its ends, a section of said conduit following said orifice simulating a ramjet, means for supplying fuel to said simulated ramjet section, a combustion chamber, a portion of said conduit between said open end and said simulated ramjet section extending through said chamber and supplying preheated air to said simulated ramjet section, means for igniting the air-fuel mixture contained therein, and exhaust means including an ejector connected to said combustion chamber and positioned adjacent said outlet end of said conduit for removing gases from said simulated ramjet section.

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