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REACTION CHAMBER FOR MONOPROPELLANT OR BIPROPELLANT FUELS

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FIG. 1.

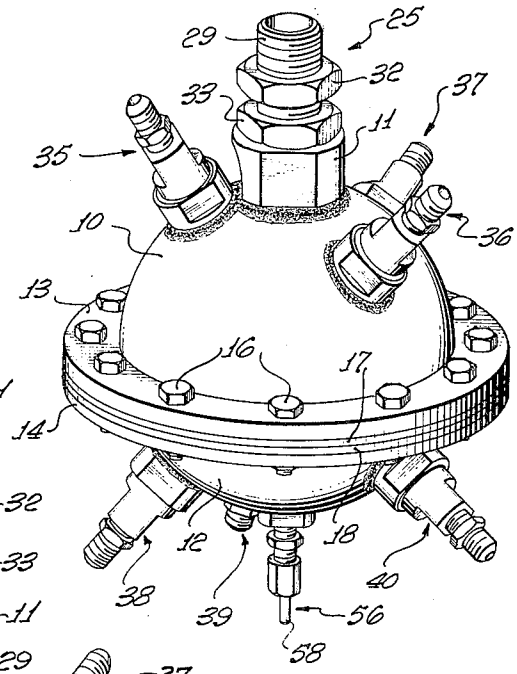


FIG. 2.

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REACTION CHAMBER FOR MONOPROPELLANT OR BIPROPELLANT FUELS

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This invention relates to a reaction chamber for monopropellant fuels, such as ethylene oxide, nitromethane, a mixture of nitromethane and nitroethane and similar monopropellant fuels, or bipropellant fuels, such as liquid or gaseous hydrocarbons reacting with some oxidizer.

The invention will be disclosed as a device for decomposition of monopropellant fuels, but it can be adapted for use with the bipropellant mixtures as will be pointed out at the end of this specification.

It is an object of this invention to provide a homogeneous reaction chamber in which a monopropellant fuel is injected into the chamber in a liquid form as a finely divided spray and this spray is continuously and rapidly mixed with the products of reaction for producing a nearly homogeneous mixture of burning fuel and hot gas throughout the volume of the chamber.

It is an additional object of this invention to provide a reaction chamber in which mixing and rapid heating and ignition of fuel is produced by injecting fuel in a form of a fine spray and directing the flow of hot gases in the direction opposite to the direction of flow of the injected fuel, the hot gases completely surrounding and being mixed with the injected fuel immediately upon its entry into the combustion chamber, for producing rapid heating, ignition, and reaction of the fuel.

It is also an object of this invention to provide a homogeneous reactor of the above type which has a spherical, centrally located reaction chamber and first and second concentrically mounted and spaced from each other metallic spheres surrounding the central spherical chamber, the first sphere being adjacent to and spaced from the inner sphere, the central and the first sphere defining a spherical duct for conveying the burned fuel to an outgoing duct, while the first and the second spheres provide a gas-filled insulation jacket for the reaction chamber.

The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages thereof, will be better understood from the following description considered in connection with the accompanying drawing in which a single embodiment of the invention is illustrated by way of an example. It is to be expressly understood, however, that the drawing is for the purpose of illustration and description only, and is not intended as a definition of the limits of the invention.

Referring to the drawing:

FIGURE 1 is a perspective view of the chamber and FIGURE 2 is a sectional view of the chamber illustrated in FIGURE 1.

Referring to the drawing, the chamber comprises two hemispherical outer shell members **10** and **12**, provided with flanges **13** and **14**. The two hemispheres **10** and **12** of the chamber are held together by means of a plurality of bolts **16** and in order to obtain a gas-tight joint between the two flanges, they are provided with two flange rings **17** and **18**. The flange rings **17** and **18** and flanges **13** and **14** are provided with recesses which are used for accomodating three gaskets **19**, **20** and **21** made of heat-resisting material, such as asbestos, or asbestos impregnated with tallow or silicons.

The outer shell **10—12** preferably is made of stainless steel which is also the metal used for an intermediate shell **22** and an inner shell **24**. The flange rings **17** and **18** extend into the inner chamber, as indicated in FIGURE 2, and are provided with circular seats for mounting the inner shell, composed of two hemispherical members **24***a* and **24***b*, and the intermediate shell, composed of two hemispherical members **22***a* and **22***b*, in concentric relationship with respect to the outer shell **10**. The outer shell is also provided with two locating pins **26** and **27** which are used for proper positioning of the hemispherical members with respect to each other, so that the vents, or the orifices, provided in these members are aligned in proper manner with respect to each other, as shown in FIGURE 2. The outer and the intermediate shells are provided with two aligned openings for accomodating an outgoing duct **25** which includes a boss **11** welded to the outer hemisphere **10**. This boss is provided with a funnel-shaped orifice **28** which opens into the space surrounded by the intermediate and the inner shells **22** and **24**. This space is used as a spherical duct for conveying the products of decomposition reaction to an outgoing duct **25**. A DeLaval nozzle **30** is connected to duct **25**. The DeLaval nozzle is connected to tube **29** and boss **11** by means of threaded joints, including nuts **31**, **32** and **33** and sealing members illustrated in FIGURE 2. The DeLaval nozzle is used in the exhaust duct for obtaining proper pressure in the reaction chamber, the throat of the nozzle being proportioned so as to introduce sufficient resistance to flow of gases for creating that pressure within the reaction chamber which is required for obtaining the proper rate and type of burning desired in the chamber.

The fuel is introduced into the chamber by means of a plurality of nozzles **35** through **40** which are distributed at random on the two hemispheres. Although a symmetrical distribution of the nozzles may also be used, the random distribution is the preferred mounting of these nozzles for obtaining a thorough mixing of the sprayed fuel and of the products of the reaction immediately upon the entry of the sprayed fuel into the inner chamber. In order to insure rapid heating, igniting, reaction and burning of the sprayed fuel within this chamber is provided with orifices **41**, **42**, **43**, **44**, etc., (there are six orifices in the illustrated configuration of the chamber, only four being visible in FIGURE 2) these orifices being axially aligned with the respective longitudinal axis of the respective nozzles. The diameter of these orifices is made larger than the diameter of the tips of the spray nozzles, these tips terminating in the respective planes of the orifices, so as to provide sufficient exits, or exhaust ports, for the exhaust gases. These hot gases flow from the central chamber into the spherical duct formed by the inner sphere **24** and the intermediate sphere **22**. Accordingly, the fuel is injected into the chamber **47** by the nozzles **35** through **40** where heating, ignition, decomposition and burning of the fuel takes place. Mixing of the injected fuel with the burning mixture takes place immediately upon the injection of the fuel into the inner chamber **47**. The hot gases then leave chamber **47** through the orifices **41**, **42**, **43**, etc., and flow through the spherical duct **48** and then into the outgoing duct **29** through the DeLaval nozzle.

The hemispherical members **24***a* and **24***b* are kept at high temperature because they are surrounded by hot gases on both sides.

In order to minimize the heat loss as much as possible, and to provide a hot surface for promoting the combustion processes, the chamber is also provided with the intermediate spherical member **22** which is mounted in space relationship with respect to the outer shell **10—12**. While the outer shell **10—12** must be sufficiently strong to with-

stand the maximum pressure obtainable within the chamber, the inner spheres 22 and 24 are made of thin stainless steel sheet metal since the pressure of gases is the same on both sides of these members. The intermediate sheet 22 is provided with six orifices, such as orifice 50, which permit the free flow of gases from duct 48 into the space between the outer shell 10 and the intermediate shell 22. These orifices are also used to permit the insertion of the nozzles into the chamber 47 through spherical shell 22.

The chamber is also provided with an electric heating element 55 which is connected to a source of electric energy by means of a concentric cable 56 having an inner conductor 57 and an outer conductor 58. The heating element is preheated to a sufficiently high temperature so as to initiate the exothermic reaction.

The chamber is also provided with a tube 60 which is mounted on a boss 61 on the outer shell 12 and can be inserted into the central sphere or into the space between the two inner spheres. This tube serves two purposes. It may be used as a pressure tap for monitoring the pressure within the combustion chamber, or, alternatively, it may be connected to the exhaust from an auxiliary reaction chamber. In this latter application the auxiliary chamber is used to supply heated gas to the reaction chamber 47 in order to pre-heat the inner surfaces of the chamber for the initiation of the combustion reaction. Initiation of the combustion reaction may thus be accomplished by use of either the electrical heating element 55, the exhaust from an auxiliary chamber admitted through tube 60, or by the use of both of these pre-heating devices in combination. A temperature measuring element 65 is mounted on a boss 66 attached to the outer shell 12, and protrudes into the central sphere. This temperature measuring element is used to determine the internal temperature of the reaction chamber. When this temperature has risen sufficiently so as to permit the initiation of the reaction, the fuel is admitted through the plurality of nozzles 35 through 40. Once the reaction has been initiated, operation of the pre-heating devices (heating element 55 and/or exhaust products from the auxiliary chamber admitted through tube 60) is discontinued and the reaction is henceforth self-sustaining.

The advantages of the disclosed chamber are: creation of the reaction throughout the inner volume 47 and the chamber because of the continuous intermixing of the injected fuel with hot gases; reaction chamber 47 has low heat loses because duct 48 and space 62 effectively insulate the inner chamber from the outer wall 10; since the entire volume 47 of the inner chamber is utilized for producing the exothermic reaction, the reactor has a small V_c/A_t ratio which is the ratio of the volume of the chamber (V_c in this case corresponds to volumes 47 and 48 contained within shell 22 and A_t is the minimum cross-sectional area, or Through Area, of nozzle 30. The above ratio V_c/A_t is also known as the L* (L-star) ratio. Low L* ratio is obtained with this chamber because of the utilization of the entire volume 47 for producing the reaction due to the efficient mixing of the propellant with the products of reaction within the core of this volume, because the surface of shell 24 is kept hot by the flow of hot gases on both sides of this shell, and because of the intermixing of the incoming spray of fuel with hot gases achieved by making the sprayed fuel flow in one direction and the hot gases in the opposite direction directly in the vicinity of the sprayed fuel through the orifices 41, 42, etc., which completely surround the hemispherical tips of the nozzles.

The disclosed chamber can also be used with bipropellant fuel systems. In this case the nozzles may be (*a*) premixing injection nozzles (*b*) bipropellant injection nozzles, or (*c*) single propellant injection nozzles.

In (*a*), the fuel and the oxidizers are mixed in the body of the nozzle and injected in the pre-mixed state. In (*b*), each nozzle is designed with two or more orifices through which the two components of the bipropellant system are injected, with mixing, occurring after injection. In (*c*) some of the nozzles are used to inject the fuel while the remainder are used to inject the oxidizer.

Preheating of the injected bipropellant fuels is accomplished as effectively in the three cases cited above as it is in the case of a monopropellant fuel. In each case the incoming fuels are heated by the hot exhaust gases which pass around the injected streams as these gases flow toward the exhaust orifices.

Since the disclosed chamber may be used with monopropellant or bipropellant fuels, the word fuel, as used in the claims, applies to the monopropellant as well as the bipropellant fuels. In the latter case the mixture, strictly speaking, consists of the fuel per se and the oxidizer. For lack of a better term, the word fuel is used in a generic sense in the claims so as to refer to monopropellants as well as bipropellants.

What is claimed as new is:

1. A reaction chamber comprising an outer metallic spherical shell, an intermediate metallic spherical shell, an inner metallic spherical shell, means for supporting said intermediate and said inner shells within and in spaced and concentric relationship with respect to the outer shell, said inner shell being fixedly held by said means in spaced relationship with respect to the intermediate shell, the outer surface of said inner shell and the inner surface of said intermediate shell forming a spherical exhaust duct, said intermediate shell being also held by said means in spaced relationship with respect to said outer shell, the space between the intermediate shell and the outer shell providing a gas-filled insulation jacket for said inner shell, a plurality of injection nozzles randomly distributed around the outer shell, said nozzles injecting fuel in the form of a fine spray into the inner shell, a plurality of unrestricted orifices provided in said inner shell, said orifices being of greater diameter than the tips of said nozzles, said orifices being in concentric relationship with respect to the respective nozzles, and an exhaust duct connected to said spherical duct through said intermediate shell for conveying the products of reaction from said inner shell through said orifices and through said spherical duct and into said exhaust duct.

2. A reaction chamber comprising outer, intermediate and inner metallic spherical shells; means for supporting said intermediate shell within and in spaced and concentric relationhip with respect to the outer shell; said means also supporting said inner shell within and in spaced and concentric relationship with respect to said intermediate shell; the outer surface of said inner shell and the inner surface of said intermediate shell defining a spherical exhaust duct; the space between the intermediate shell and the outer shell providing a gas-filled insulation jacket for said intermediate and inner shells; a plurality of injection nozzles randomly distributed around the outer shell; said nozzles having injection tips for injecting fuel as a fine spray into the inner shell; a plurality of unrestricted orifices, or ports, provided in said inner shell, each of said ports having a greater diameter than the diameter of the adjoining nozzle tip, said ports being aligned with the respective nozzles; and an exhaust tube connected to said outer and intermediate shells for conveying the products of reaction from said inner chamber to said exhaust tube through said ports, said spherical exhaust duct, and past said injection tips.

3. A reaction chamber, said chamber comprising an inner shell, the inner space bound by said inner shell constituting the reaction space of said chamber, a second shell surrounding and being in spaced and concentric relationship with respect to said inner shell, the space between the two shells constituting a spherically shaped exhaust duct, an exhaust tube connected to said second shell for conveying gases from said reaction space through said exhaust duct, a plurality of injection nozzles randomly distributed around said second shell, each of said nozzles being positioned to inject fuel as a spray directed toward the center

of said reaction space, and a corresponding plurality of unrestricted orifices in said inner shell, said orifices having a larger diameter than the tip portions of the respective nozzles, each nozzle and its orifice having a common longitudinal axis, said fuel, after being converted into hot gases, leaving said reaction space through said orifices, and past said nozzles, in the directions opposite to the directions of the respective sprays.

4. The reaction chamber as defined in claim 3 which also includes an electrically heated heater element centrally mounted in said inner shell.

5. The reaction chamber as defined in claim 3 which also includes a third outer shell surrounding said second shell, said third shell being concentric and in spaced relationship with respect to said second shell, the space between the second and the third shell constituting a gas-filled insulation medium for said inner and second shells.

6. A reaction chamber comprising an outer metallic spherical shell, an intermediate metallic spherical shell, an inner metallic spherical shell, means for supporting said intermediate and said inner shells within and in spaced and concentric relationship with respect to the outer shell, said inner shell being fixedly held by said means in spaced relationship with respect to the intermediate shell, the outer surface of said inner shell and

the inner surface of said intermediate shell forming a spherical exhaust duct, said intermediate shell being also held by said means in spaced relationship with respect to said outer shell, the space between the intermediate shell and the outer shell providing an insulating space surrounding said inner shell, an injection nozzle mounted on the outer shell for injecting fuel into the inner shell, and an unrestricted port of greater diameter than the tip of said nozzle and in concentric relation therewith for conveying the products of reaction from said inner chamber into said spherical duct.

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