Sept. 25, 1956 W. KRETSCHMER 2,763,987

PROPELLANT SUPPLY SYSTEMS FOR JET REACTION MOTORS

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FIG. 1.

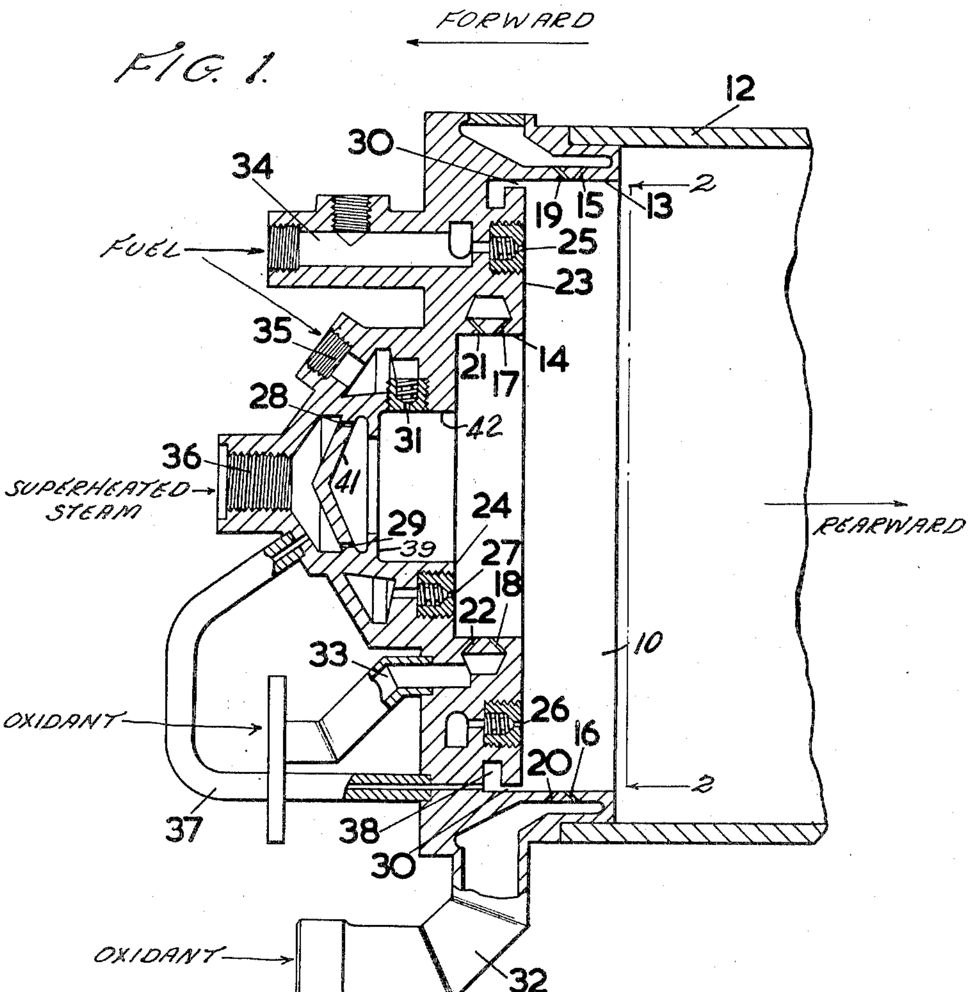
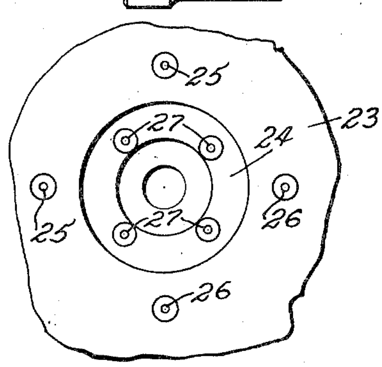


FIG. 2.



INVENTOR
Willi Kretschmer
BY
W. E. Thibodeau + A. W. Dew
ATTORNEYS

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PROPELLANT SUPPLY SYSTEMS FOR JET REACTION MOTORS

Willi Kretschmer, Southcourt, Aylesbury, England, assignor to the Minister of Supply in Her Majesty's Government of the United Kingdom of Great Britain and Northern Ireland, London, England

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8 Claims. (Cl. 60—39.55)

This invention relates to jet reaction motors of the kind comprising a combustion chamber formed with a gas ejection orifice at one end and having at its other end a closure in the form of a burner for liquid propellants such as are used in rockets. In general, at least two propellants are supplied to the burner of such a motor in the form of fuel, such as kerosene, and an oxidant, such as hydrogen peroxide, which are mixed and ignited at the burner end of the combustion chamber.

The invention has for an object to provide improvements in burners for such motors with a view not only to obtaining thorough mixing of the fuel and oxidant but also to ensuring that burning shall take place as close as possible at the burner end of the combustion chamber.

According to the invention, in a motor of the kind referred to, an oxidant is introduced in the form of a fine spray directed inwardly of the combustion chamber substantially transversely of the direction of gas ejection from the chamber and fuel is introduced at a region more remote from the gas ejection orifice and in the form of a fine spray directed towards said orifice to mix with the first propellant spray.

Preferably, the oxidant is introduced in the form of jets or inclined sheets or layers, so directed as to impinge one upon another and produce the inwardly transverse spray. Thus a combustion chamber or a burner arrangement therefor, according to the invention, may have for the introduction of the oxidant a first annular passage, or annular series of passages, corresponding to the curved surface of a conical frustum and directed inwardly and away from the gas ejection orifice and, at that side of the first passage or series of passages, remote from said outlet, a second annular passage, or annular series of passages, corresponding to the curved surface of a conical frustum and directed inwardly but towards the gas ejection orifice.

The fuel is preferably introduced through swirl type nozzles whose axes extend in the general direction of gas ejection from the combustion chamber.

If desired, superheated steam may be introduced turbulently at that side of the mixed or mixing oxidant and fuel sprays remote from the gas ejection orifice.

Fig. 1 is a sectional side elevation of a preferred form of the burner according to the invention and

Fig. 2 is a transverse section of the device taken on line 2—2 of Fig. 1.

As shown, the burner comprises essentially a substantially circular internally stepped plate or head indicated generally at 10 which fits into the end remote from the gas ejection outlet (not shown) of a combustion chamber of circular cross section, part of which is indicated at 12. Two annular sets of passages for the supply of oxidant to the combustion chamber 12 are formed in the cylindrical walls 13 and 14 of the outer and intermediate steps, and each of these sets comprises two annular series of passages or jet-forming apertures, all inwardly directed. In one set, one series, of which latter

two passages or apertures are indicated at 15, and 16, are directed at substantially 45° to the direction of ejection of gas from the combustion chamber and up stream while the other series as indicated by the passages or apertures, 19, 20, are directed at 45° to the direction of ejection of gas but downstream. Also each passage in one series, is paired with a passage in the other series, for example, the passages 15 and 19. The other sets of passages in the intermediate cylindrical wall 14 are similar to the set in the outer cylindrical wall 13, the passages 17 and 18, and 21 and 22 corresponding with the passages 15 and 16, and 19 and 20, respectively. Two annular sets of swirl type nozzles for the supply of fuel to the combustion chamber are located in the outer and inner flat faces 23 and 24, respectively, two nozzles 25 and 26 of the one set and one nozzle 27 of the other being shown. These fuel nozzles are all arranged with their axes substantially parallel to the direction of ejection of gasses from the combustion chamber. For supplying superheated steam to the combustion chamber, a set of axially directed passageways of which two are shown at 28 and 29 in a closure wall 41, and an annular slit 30 in the outer flat wall 23 adjacent the outermost series of oxidant passages are connected with a common steam intake 36 by a pipe 37 and an annular chamber 38. Also, four radially inwardly directed swirl type fuel nozzles of which one is shown at 31, are also provided in the inner cylindrical wall 42. An inlet pipe 32, is provided for the supply of oxidant to the outer series of passages 15, 16, 19 and 20 in the outer cylindrical wall 13 and a further inlet pipe 33 is provided for the supply of oxidant to the inner series of passages 17, 18, 21 and 22 in the intermediate cylindrical wall 14. An intake 34 is provided for the supply of fuel to the outer annular set of nozzles 25, 26 in the outer flat wall 23 and a further intake 35 is provided for the supply of fuel to the inner annular set of nozzles 27 in the inner flat wall 24 and the four radially inwardly directed nozzles 31 in the inner cylindrical wall 42.

The burner is intended for use with means for supplying oxidant, fuel and superheated steam under pressure thereto to build up its maximum thrust in two stages, for example, as follows:

For the first stage, relatively easily ignitable ignitor fuel is supplied under pressure to the fuel inlets 34 and 35 whence it passes to the inner cylindrical wall nozzles 31, to the inner flat wall nozzles 27 and to the outer flat wall nozzles 25, 26. Superheated steam is supplied under pressure to the inlet 36 whence it passes to the closure wall passages 28, 29 and, by way of the pipe 37, to the annular slit 30. The steam from the closure wall passages 28, 29 impinges on an annular baffle 39 whereby its velocity is reduced and it passes on turbulently and meets and ignites the spray of igniter fuel from the inner cylindrical wall fuel nozzles 31. Oxidant is supplied under pressure to the inlet 33 (but not yet to the inlet 32) and issues from the intermediate cylindrical wall passages 17, 18, 21, 22, the oxidant from the passages 17, 18 impinging on that from the passages 21, 22, respectively, and said oxidant travelling inwardly and transversing in the form of a spray and being met by the igniter fuel spray from the inner flat wall fuel nozzles, and the resulting oxidant-igniter fuel mixture being ignited by the burning steam-igniter fuel mixture from within the inner cylindrical wall 42. The steam from the annular slit 30 effectively prevents unburnt igniter fuel from the outer flat wall fuel nozzles 25, 26 from entering the outer cylindrical wall oxidant passages 15, 16, 19, 20 and igniter fuel from said outer flat wall fuel nozzles 25, 26 ensures a fuel rich mixture. First stage operation now obtains.

For second stage operation, oxidant is supplied to the inlet **32** whence it passes to the outer cylindrical wall passages **15**, **16**, **19**, **20** and that issuing from the passages **15**, **16** impinges on that from passages **19**, **20**, respectively, all said oxidant travelling in the form of a fine spray which is met by igniter fuel spray from the outer fuel nozzles **25**, **26**, and the resulting oxidant-igniter fuel mixture being ignited by the already burning mixture from within the intermediate cylindrical wall **14**.

Finally, the supply of igniter fuel to the burner is terminated and less easily ignitable normal fuel is supplied instead and the pressure at which oxidant is supplied to the intake **32** and so to the outer cylindrical wall passages **15**, **16**, **19**, **20** is increased.

Satisfactory operation as above set forth has been obtained with hydrogen peroxide as the oxidant, with "C-fuel," which is a mixture of methanol 57%, hydrazine hydrate 30% and water 30% by weight with a copper catalyst, as the igniter fuel and kerosine as the less easily ignitable normal fuel.

The means for effecting such operation may take any convenient form, for example, as set forth in the specification of co-pending aplication for Letters Patent No. 398,244, filed December 15, 1953.

Because the oxidant is always introduced transversely and down-stream of the fuel ignition and burning takes place close to the burner plate **10** and this ensures efficient utilization of the combustion chamber volume. Similarly, the high degree of turbulence occasioned by the impinging oxidant and fuel sprays ensures thorough mixing and, consequently, efficient combustion.

It will be apparent to those skilled in the art that in cases where it is desired to effect initial ignition by other means than superheated steam, the superheated steam inlet and outlet passages **36**, **28**, **29**, **30** may be omitted.

I claim:

1. In a jet reaction motor, means forming a combustion chamber having a central longitudinal axis and including a reaction end plate having first, second and third bores coaxial of said axis and of decreasing diameter in the forward direction along said axis to define first and second rearwardly-facing surfaces, a plurality of rearwardly directed nozzles in said first and second surfaces equiangularly spaced adjacent the peripheries thereof, a plurality of apertures opening radially inwardly through the wall surfaces of said first and second bores, each said aperture being contiguous to a respective nozzle, there being discrete passageways in said plate to supply fuel and oxidant to said nozzles and said apertures, respectively.

2. In a jet reaction motor, a cylindrical casing, a combustion head closing the forward end of said casing, said head having first, second and third bores coaxial of the central longitudinal axis of said casing and of decreasing diameter in the forward direction to define first, second and third rearwardly-facing annular surfaces, a first set of circumferentially-spaced nozzles in and opening through said first surface, a second set of circumferentially-spaced nozzles in and opening through said second surface, there being passageways in said head supplying fuel under pressure to all said nozzles, there being apertures through the wall surfaces of said first and second bores, each aperture being adjacent a corresponding nozzle, there being discrete passageways in said head supplying oxidant under pressure to the apertures of said first and second bores, respectively.

3. In a jet reaction motor, means forming a combustion chamber having a longitudinal axis and including a combustion head having first and second coaxial bores of diameters decreasing in the forward direction along said axis to define first and second rearwardly facing surfaces, first and second sets of circumferentially spaced nozzles in said surfaces, respectively, first and second sets of circumferentially spaced jet-forming apertures radially inwardly through the cylindrical walls of said first and second bores, respectively each said aperture being disposed adjacent a corresponding nozzle and forming a jet impinging a jet from a respective nozzle, there being discrete passageways in said head to each said set of nozzles and apertures to supply fluids under pressure thereto.

4. A jet reaction motor as recited in claim 3, there being a pair of axially-spaced apertures adjacent each nozzle, said apertures forming jets directed radially inwardly and toward one another.

5. In a jet reaction motor, means forming a combustion chamber having a longitudinal axis and including a combustion head having first and second bores coaxial of said axis and of decreasing diameter in the forward direction along said axis to define first and second rearwardly facing surfaces, a first plurality of circumferentially spaced nozzles in said first surface, a second plurality of circumferentially spaced nozzles in said second surface, first and second sets of circumferentially spaced jet-forming apertures in the cylindrical walls of said first and second bores, respectively, each said aperture being adjacent a respective nozzle and forming a jet impinging upon and angularly related with the jet from the corresponding nozzle, there being a first pair of discrete passageways in said head conducting fuel under pressure to said first and second plurality of nozzles, respectively, there also being a second pair of discrete passageways in said head conducting oxidant to the apertures in said first and second bores, respectively.

6. A combustion end head for a jet reaction motor having a central longitudinal axis, there being first and second bores in said head coaxial with said axis and of decreasing diameter in the forward direction, to define first and second rearwardly-facing annular surfaces, there being first and second pluralities of circumferentially-spaced nozzles in said first and second surfaces, respectively, there also being first and second pluralities of circumferentially-spaced jet-forming apertures in the cylindrical wall surfaces of said first and second bores, respectively, each said nozzle being contiguous to a respective aperture, passageways in said head conducting fuel under pressure to said nozzles, and discrete passageways in said head conducting oxidant under pressure to said first and second plurality of apertures, respectively.

7. A combustion end head as recited in claim 6, there being a circular slit in said head between the nozzles and apertures of said first bore, and means adapted to supply steam under pressure to said slit.

8. A combustion head for a jet reaction motor having a central longitudinal axis, there being first, second and third bores in said plate coaxial with said axis and of decreasing diameter in the forward direction to define first, second and third rearwardly-facing plane surfaces normal to said axis, first and second sets of circumferentially-spaced nozzles in said first and second surfaces, respectively, first and second sets of circumferentially-spaced jet-forming apertures in and through the cylindrical wall surfaces of said first and second bores, respectively, a circular slit in said head between said first set of nozzles and said first set of apertures, a third set of nozzles in the wall of said third bore, passageways in said head supplying fuel under pressure to all said nozzles, a pair of discrete passageways in said head supplying oxidant under pressure to said first and second sets of apertures, respectively, and a passageway in said head supplying steam through openings in the end of said third bore.

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