March 3, 1964 B. J. FARMER 3,122,887

FUEL IGNITOR

Filed Nov. 17, 1960

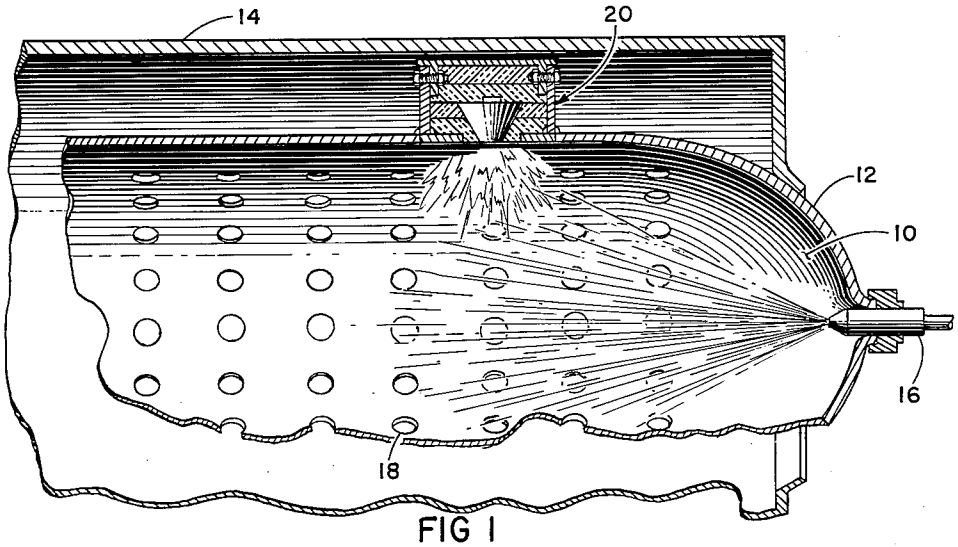


FIG 1

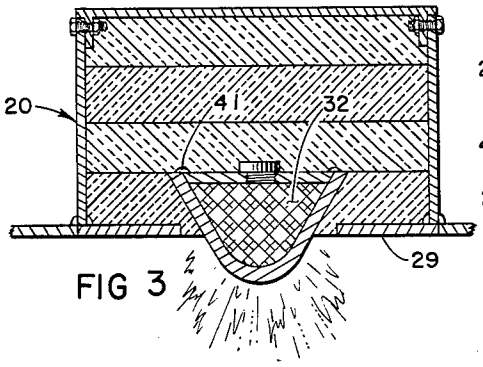


FIG 3

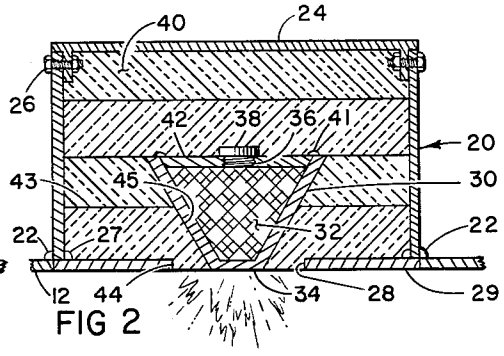


FIG 2

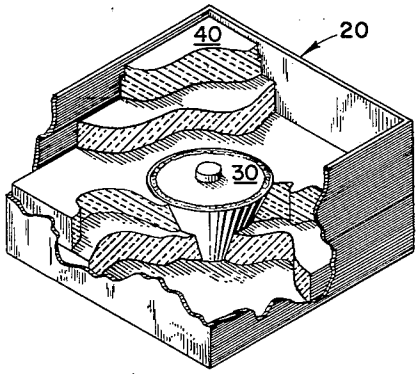


FIG 4

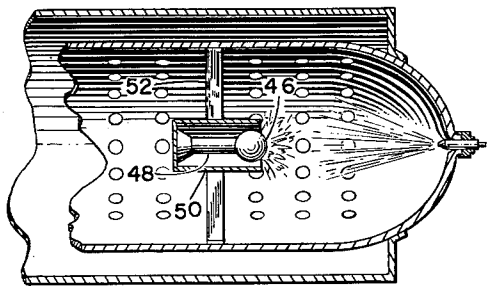


FIG 5

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FUEL IGNITOR

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This invention relates to ignition systems and particularly to ignition devices especially adaptable to ignite non-hypergolic fuels utilized as propellants in air-borne or space craft power plants.

Fuel ignition for such power plants can be provided by an electrical spark discharge between the electrodes of a suitable spark plug or by a glow plug comprising either a resistance wire or a coil resistance wire mounted within a protecting refractory sheath. Where glow plugs are used, the glow plug is generally brought to a temperature suitable for the ignition of combustible gases by the passage through the resistance wire of a substantially large quantity of electrical current. Other forms of internally heated incandescent devices for the ignition of combustible fuels are shown in Patents Nos. 2,823,519 and 2,648,951. Such previous forms of ignition devices are not particularly satisfactory, however, as they require such components as a generator, battery, transformer, coil and suitable conductors from such components to the ignitor unit, or require internal heating devices with their attendant accessories. Provision of these component accessories involves adding weight to the power plant as well as a multiplicity of units, the failure of any of which may result in operational failure of the system. In addition, in many instances such as with expendable missiles or rockets, the weight and space required by such systems is substantial and becomes and objectionable consideration. In addition, in such installations as rockets or space craft where it becomes necessary to intermittently operate the power plant by radio command signal from ground stations, the mechanism for making the ignition system of the power plant operable in response to such signal is both space consuming and a hazard to the reliability of the entire craft.

It is an object of the present invention to provide a simple, reliable and compact ignition device for igniting combustible fuels in combustion chambers.

It is a further object to provide an incandescent device of determinable life for the ignition of combustible fuel mixtures in combustion chambers.

An additional object is to provide an incandescent device for the ignition of the combustible fuels in a combustion chamber where the state of incandescence is maintained constant over a predetermined life without the aid of outside mechanism to make the ignitor operable.

These and other objects and advantages of this invention will become apparent to those skilled in the art from the following description of a preferred embodiment thereof as illustrated in the drawing.

The objects are attained in accordance with the present invention by providing an ignition device including radioactive material encapsulated in a suitable casing and insulated over a major portion of its surface, the exposed surface maintaining a state of incandescence from the heat energy obtained from the radioactive material, the incandescent exposed surface serving to ignite the fuel.

In the drawing:

FIGURE 1 is a diagrammatic view with parts broken away and parts in section illustrating a combustion chamber with an ignition device embodying the present invention positioned for ignition of the combustible fuel in the chamber;

FIGURE 2 is an enlarged view in section of the ignition device of the present invention;

FIGURE 3 is a modification of the ignition device shown in FIGURE 2;

FIGURE 4 is an isometric view of the device with portions broken away; and

FIGURE 5 is a view of a modification of the device shown in FIGURE 1.

Referring now to the drawing, there is illustrated in FIG. 1 an assembly comprising a combustion chamber 10 having walls 12 mounted within a surrounding chamber or tube 14. One or more fuel nozzles 16 are positioned in the end of the combustion chamber, or in other suitable positions, and are adapted when connected with a source of fuel, not shown, to deliver a conical spray of fuel into the combustion chamber. The combustion chamber 10 is provided with a plurality of apertures 18 which serve to admit an oxidant to the combustion chamber 10 from the tube 14 for supporting combustion therein and to provide for a continual flow of cooling gas around the outer surface of the combustion chamber.

Positioned in the side wall 12 of the combustion chamber 10 are one or more units of the ignitor housing 20 of the present invention which is fastened to the walls 12 as by welds 22. Housing 20 may be cylindrical or any convenient shape for particular applications, but for purposes of this example I have shown a parallelepipedon. For purposes of assembly, a back 24 of housing 20 (FIG. 2) is fastened to its side walls as by fasteners 26. The front plate 29 is fastened to the sidewalls as by welds 27 and is provided with a large circular opening 28. Mounted (as hereinafter explained) in housing 20 is the ignitor casing 30, preferably of hollow frusto-conical shape, which forms the incandescent ignitor element of the subject ignition device. The casing 30 encapsulates a body of radioactive material 32 and may be made of one of a number of high-temperature, non-corrosive metals such as rhenium, columbium, beryllium, coated molybdenum and others which will withstand the high temperatures (approximately 2500° C.) within the combustion chamber. Rhenium is particularly adaptable for this casing since it has properties including high density, high melting point, has high conductivity for conducting heat to its outer surface, and provides a surface with a low emissivity. The thickness of the casing 30 should be greater than 0.1 inch to shield against beta radiation and to act as an absorber of the radioactive emissions. Casing 30 may be positioned within housing 20 in such manner that its smaller face 34 is co-planar with but not touching the face plate 29 of housing 20 such as shown in FIGS. 1 and 2. Alternatively, the casing 30 may be positioned so that a minor portion of its body projects through and beyond the face plate 29 into the combustion chamber 10, as shown in FIG. 3 in which case it would be preferable to round off the projecting face of casing 30. The casing 30 may contain an opening 36 having a removable plug 38, through which opening the radioactive material in the form of a molten liquid or powder may be inserted within the hollow casing.

The radioactive material 32 should be selected from those having little or no gamma radiation in order to minimize radiation hazards to personnel installing the ignitor. Three radioisotopes in this category are cerium 144, promethium 147, and strontium 89 having half-lives, respectively, of 290 days, 2.54 years and 54 days. These three isotopes are presently available as by-products in the fission fragments of the waste materials from processed nuclear reactor fuel elements. It will be understood that the selection of the radioisotope will depend partly upon the intended mission of the power plant and its vehicle. For example, if used in an orbiting space vehicle, the selection would depend upon how long the vehicle is expected to remain in orbit.

As an exemplary radioactive body 32 with which casing

30 may be filled, I may use cerium 144 which emits mainly beta-rays, which are considered the least dangerous. This radioactive material may be diluted at a ratio within the range of between 1 and 10 diluent to one part by weight of cerium 144 with stable nonradioactive cerium 140. This avoids any chemical reaction effects due to heat or radiation caused by the use of a different chemical species. This radioactive material emits high energy particles which, when slowed down in passing through the cerium 144, the cerium 140 diluent and casing 30, produce heat which will result in a temperature at the exposed portion of casing 30 in the approximate range of 1000° C.–1200° C. which is sufficient to bring the exposed casing portion to a state of incandescence. It can be seen that casing 30 thus acts as a heat exchange device transferring the heat generated in the ignitor casing to the ambient atmosphere in the combustion chamber. It will be understood that the decaying radioactive material will gradually lose its beta emission activity and thus the heat energy source will be lost in time. However, it is expected that a temperature of at least 1000° C. could be maintained on the exposed surface of my ignitor casing over more than one half-life of promethium 147 and over many half-lives of cerium 144 or strontium 89. If desired, the radioactive material may be in the form of a compressed pellet of a form to fit tightly within the casing 30 in which case the rear plate 42 of casing 30 could be made to be welded as at 41 to the side walls to provide a thoroughly tight leakproof enclosure for the radioactive body.

The space within housing 20 surrounding the ignitor casing 30 is filled with an insulating material 40 having excellent high temperature properties. While several of the recently developed ceramic materials may be used, I prefer to use thoria, ThO_2, which has an extremely low thermal conductivity and a high melting point. Thoria is obtainable as a solid having an extremely high weight to volume ratio. It is contemplated that the thoria insulation 40 can be installed in flat sheets about ¼" thick in housing 20. As shown more clearly in FIG. 2, the sheet 43 at the face of the ignitor housing 20 is notched as at 44 so that a portion of the sheet extends into opening 28 where its face is co-planar with the face of front plate 29, the sheet 43 being supported by plate 29. The sheets of thoria adjacent to ignitor 30 have beveled openings 45 of graduated size to form a frustro-conical opening into which the frustro-conical ignitor 30 is positioned and where it is supported in position by the thoria sheets. The thoria sheets between ignitor back plate 42 and housing back plate 24 may be solid. My purpose in providing the thoria in sheet form instead of as a solid block is to reduce distortion of the thoria due to thermal shock as a result of the sudden high temperatures encountered immediately following ignition of combustible mixtures in the combustion chamber.

The thoria insulation not only tends to confine the maximum temperature to casing 30, but in addition, the heat loss through insulation 40 and housing 20, although not high, could act to some degree as a pre-heater for the oxidant passing over it in tube 14 before such oxidant enters combustion chamber 10. It will be understood, of course, that in some installations it may be preferable to mount the casing 30 at a position within the combustion chamber itself, such as shown in FIG. 5, in which case the major portion of insulation 40 could be dispensed with, and the ignitor casing could be made in a spherical shape 46 supported on a thoria pedestal 48 mounted in cylinder 50 having an open end facing the fuel nozle, the cylinder 50 being maintained in position by suitable support structure 52 extending from the combustion chamber walls.

In practice, the incandescent ignitors 30 are preferably positioned in the combustion chamber in a fuel zone supporting combustion preferably located in the conical spray area of nozzle 16, this being the area in which the oxidant entering the combustion chamber 10 through apertures 18 joins the stream of fuel from nozzle 16 to form a combustible mixture.

The area of the portion of the incandescent ignitor exposed to the combustible fuel can be very small with my device and this is of distinct advantage, especially when using radioactive material. For instance, to function as an ignitor, it is considered sufficient for the ignitor casing to have a diameter on its frustrate face of only ¼" and to have a volume of only 2.5 cubic centimeters.

It will be seen that the device heretofore described will provide a compact, efficient, simple and attention free ignitor for power plants using non-hypergolic fuels, while requiring no attendant components to make it operational. Its constant state of operative readiness makes is ideal for installation in those space vehicles which demand intermittent power plant operation.

While I have shown particular embodiments of my invention, it will be understood, of course, that I do not wish to be limited thereto since other modifications may be made, and I therefore contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of the invention.

I claim:

1. In combination with a non-hypergolic fuel combustion chamber, an ignitor comprising: a body of radioactive material, a casing of high temperature resistant metal encapsulating said radioactive material, an insulating material surrounding a major portion of the encapsulating casing, and a housing having an opening therein substantially enclosing said insulating material mounted in the combustion chamber; the portion of the casing not covered by said insulating material being exposed to said combustion chamber through the opening in said housing.

2. An ignitor in combination with a liquid fuel combustion chamber comprising: a body of radioactive material; a heat exchanger casing encapsulating said radioactive material and adapted to absorb the radioactive emanations therefrom whereby to heat said heat exchanger casing to a state of incandescence, a covering of insulating material over a major portion of the casing leaving a portion uncovered; and a high temperature resistant metallic housing substantially enclosing said insulating material mounted in the wall of the fuel combustion chamber and having an opening through which the uncovered portion of the casing is exposed to the combustion chamber; said casing being supported by said insulation material in non-contacting relationship to said housing.

3. A liquid fuel ignitor for mounting in the wall of a combustion chamber comprising: a housing having an opening therein; a body of radioactive material selected from the radioisotopes cerium 144, promethium 147 or strontium 89; a frusto-conical casing completely encapsulating said material and adapted to absorb the radioactive energy therefrom whereby the casing is heated to incandescence; and an insulating material between said housing and a portion of the casing, leaving a portion of said casing exposed through said opening in said housing to combustible mixtures within the combustion chamber, said insulating material supporting said casing in a position of non-contacting relationship with said housing.

4. The device of claim 3 wherein the portion of the heat exchanger casing exposed to the combustion chamber is an arcuate surface.

5. In combination, a combustion chamber; a source of combustible fuel; means for causing high velocity flow of fuel into said chamber; and an ignitor comprising: a housing having an opening mounted in said combustion chamber, a body of radioactive material, a high temperature resistant casing encapsulating said body and adapted to absorb the radioactive energy emanating therefrom whereby said casing is heated to a state of incan-

descence to ignite the fuel, and insulating means in said housing supporting said casing in non-contacting relationship with said housing, a portion of said casing being exposed to the combustion chamber through said opening in said housing.

6. In combination a combustion chamber; a source of combustible fuel; means for causing high velocity flow of fuel into said chamber; and an ignitor adapted to be contacted by said fuel comprising a cylinder having an open end facing said fuel flow means, high temperature resistant mounting structure supporting said cylinder, a pedestal of insulating material mounted on the inner surface of the closed end of said cylinder, a spherical casing mounted on said pedestal, and a radioactive body within said casing, whereby the radioactive energy emanating from said body heats said casing to a state of incandescence to ignite the fuel contacting the casing.

7. The device of claim 6 wherein the pedestal of insulating material is comprised of solid thoria.

8. In combination, a combustion chamber; a source of combustible fuel; means for admitting said fuel into said combustion chamber; and a fuel ignitor in said chamber comprising, a body of radioactive material, a high temperature resistant casing encapsulating said body and adapted to absorb the radioactive energy emanating therefrom whereby said casing is heated to a state of incandescence, means for mounting said casing in said combustion chamber, and insulating material between said mounting means and said casing; said fuel ignitor being installed in said combustion chamber in a position whereby at least a portion of said casing is adapted to be contacted by said combustible fuel.

9. In combination, a combustion chamber having defining walls; a source of combustible fuel; means for admitting said fuel into said combustion chamber; and a fuel ignitor comprising a body of radioactive material,

and a high temperature resistant casing encapsulating said body and adapted to absorb the radioactive energy emanating therefrom whereby said casing is heated to a state of incandescence; means for mounting said ignitor in said combustion chamber; and insulating material between a portion of said casing and said mounting means.

10. A fuel ignitor comprising:

a body of radioactive material,

a casing of high temperature resistant metal encapsulating said body,

a housing having an opening therein, and

insulating means supporting said casing in said housing,

at least a portion of said casing being exposed to said housing opening.

11. A device for the ignition of non-hypergolic fuel comprising:

a body of radioactive material,

a casing of high temperature resistant metal encapsulating said body,

a housing having an opening therein,

said casing being mounted in said housing whereby at least a portion of said casing is exposed to said opening, and

insulation means between said casing and said housing.

12. The device of claim 11 wherein the insulation means supports said casing in non-contacting relationship to said housing.

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