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RADIOACTIVE IONIZER FOR A COMBINATION CHANGER

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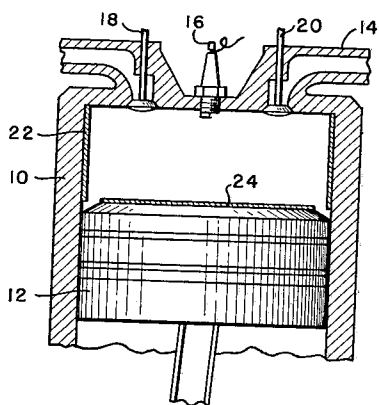


FIG. 1.

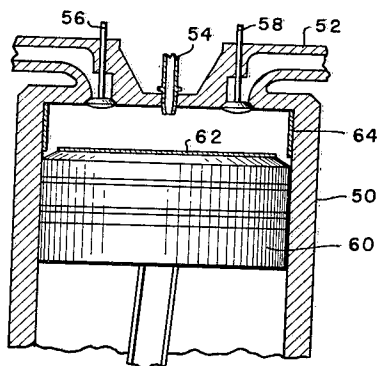


FIG. 2.

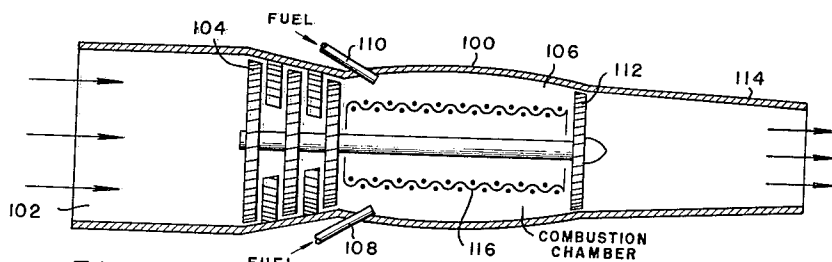


FIG. 3.

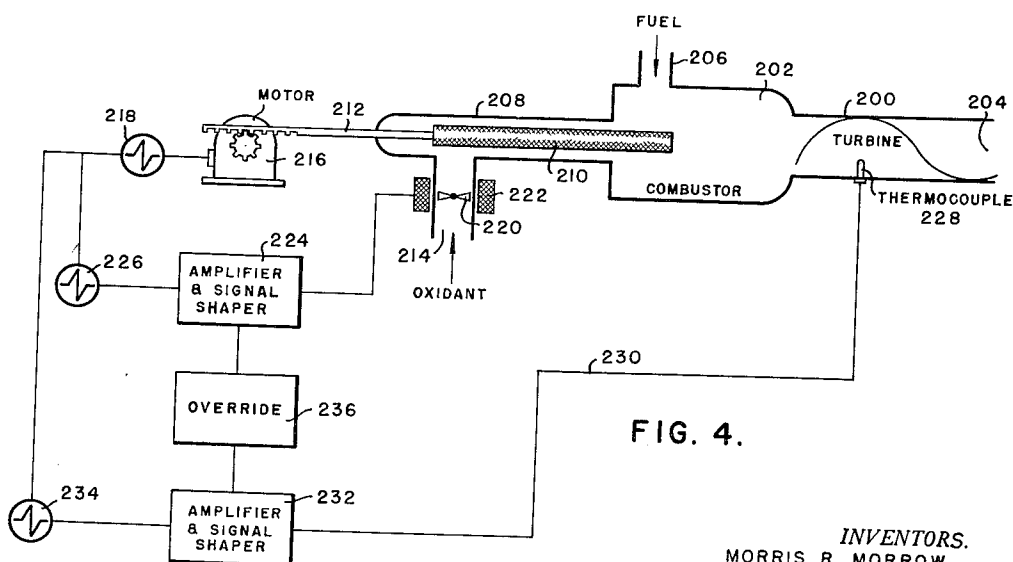


FIG. 4.

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1

3,049,874

RADIOACTIVE IONIZER FOR A COMBINATION CHANGER

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3 Claims. (Cl. 60—35.6)

This invention relates to new and improved combustion engines. More particularly, this invention relates to a combustion engine having a combustion chamber constructed so as to provide for a more complete utilization of a volatilized fuel, a more efficient utilization of a volatilized fuel, or both.

In the generation of power by the combustion of a volatilized fuel, such as a hydrocarbon, in the presence of a combustion agent such as hydrogen, air, etc., a severe limitation is imposed on the efficiency of combustion by the rate of production of the molecular fragments (e.g., free-radicals) which are necessary for efficient and rapid burning of the fuel.

In accordance with the present invention, there is provided a combustion engine constructed for the gas phase combustion of a fuel in a combustion chamber, such combustion chamber having a combustor containing a supported solid high specific activity film of a metallic radioactive material having a short-lived alpha active isotope or isotopic chain. For the purposes of this application, a short-lived alpha decay chain may be defined as a single alpha emission (single stage) or a series of two or more (2 to 10) alpha particles emitted with or without, but usually with, interspersed beta emission (plural stage). Thus, the alpha decay chain may have 1 to 10 stages. The intensity of alpha emission should preferably be from about 10^6 to 10^{10} alpha particles per square cm. of film surface per second. The half-life should be less than 100 years and is preferably about 2 to 10 times the expected life of the engine, for reasons to be set forth hereafter.

Representative examples of suitable radioactive metallic alpha emitters which may be utilized in accordance with the present invention include polonium²¹⁰, lead²¹⁰, radium²²⁷, uranium²³², etc.

It is a feature of the present invention that the alpha particle emitter is utilized in a combustor, the dimensions of which are not greater than about 4 times the range associated with the average energy of alpha decay. As an indication of the range associated with various alpha energies, we cite the following table.

TABLE I

Travel Distances, R, in Various Media

Particle energy E (mev.):	air (cm. air)
0.5	0.385
1.0	0.616
2.0	1.23
3.0	1.62
4.0	2.92
5.0	4.08
7.0	6.85
10.0	7.70

Typical energies of useful alpha particles lie between 4 and 12 mev. and generally between 5 and 10 mev. As will hereafter become more readily apparent, combustors to be utilized in accordance with the present invention may have diameters within the range of about 10 to 60 cm. Thus, the invention may be practiced efficiently and economically by simple modification of conventional type

2

combustion engines such as reciprocating combustion engines, diesel engines, jet turbine engines, combustors for gas turbines, etc.

In accordance with the present invention, the alpha source is positioned in the combustor (i.e., oxidation chamber). The ionization density of alpha particles is much greater than that of beta or gamma radiations and therefore its energy is dissipated over much smaller paths. The range of all alpha particles is less than 1 cm. of aluminum and, therefore, the need for shielding is greatly minimized. In the normal engine, alpha energy is completely attenuated in the engine. Thus, shielding is normally required only when decay chains are employed which also emit beta or gamma radiation, or both. The low energy electromagnetic radiation associated with alpha decay will also be efficiently absorbed in materials commonly used in engine construction.

Accordingly, in accordance with one form of the present invention, an alpha emitter which substantially exclusively emits alpha particles only is positioned in a manner to be described in an unshielded combustor. In accordance with another form of the present invention wherein beta or gamma radiation, or both, is present also, the emitter is utilized in an engine shielded in a manner to minimize bioradiological effects. Representative examples of emitters of both classes are given in the following table.

TABLE II

30 Po^{210} produced from Bi^{209} by the reaction $Bi^{209}(n, \gamma) Bi^{210} \xrightarrow{\beta-} Po^{210}$ Pb^{210} recovered from the decay of U^{238} and/or Ra^{226}			
35 Ra^{227} produced from Ra^{226} by the reaction $Ra^{226}(n, \gamma) Ra^{227} \xrightarrow{\beta-} Ac^{227}$			
40 U^{232} produced from Pa^{231} by the reaction $Pa^{231}(n, \gamma) Pa^{232} \xrightarrow{\beta-} U^{232}$			
Isotope	Max. Half-Life	E_{α} , mev.	E Avail., mev.
40 Po^{210} ----- Pb^{210} -----	138 days----- 26 years-----	5.3 5.3	5.3 5.7
$Ra^{227} \xrightarrow{\beta-} Ac^{227}$ -----	27.7 years-----	33.2	137.7
45 $Pa^{232} \xrightarrow{\beta-} U^{232}$ -----	70 years-----	38.0	139.9

¹ Includes a portion of the β - and γ - decay energy.

In general, in situations wherein the internal combustion engine is utilized as a source of energy for propulsion (e.g., automobiles, etc.) it will generally be preferable to utilize pure alpha emitters such as Po^{210} and Pb^{210} in order to minimize and reduce problems associated with shielding. However, in large stationary installations wherein maintenance can be effected by remote control or where massive shielding is feasible, it is desired to utilize decay chains such as Ra^{227} or U^{232} because of the potentially larger amount of recoverable energy contained in such chains.

In situations wherein the alpha emitter is emitted as a part of a decay chain, it is desirable that the alpha emitter be present in a stable, dense film in order that the emitting isotopes may be retained in the film. This is desirable in order to prevent contamination of the exhaust system and in order to utilize the energy recoverable from the decay products.

The invention will be further illustrated by the accompanying drawings wherein:

FIG. 1 is a schematic elevational side view, partially

3

in section, of a cylinder of an internal combustion engine;

FIG. 2 is a schematic elevational side view, partially in section, of a diesel engine;

FIG. 3 is a schematic elevational view, partially in section, of a jet engine; and

FIG. 4 is a schematic elevational view, in section, of a combustor for a turbine, such combustor having associated therewith suitable means for positively regulating alpha emission.

Turning now to FIG. 1, there is provided a cylinder 10 closed with a head 14 of conventional construction and having housed therein a reciprocating piston 12. The head 14 is provided with suitable ignition means such as a spark plug 16, an inlet valve 18 and an exhaust valve 20. In accordance with the present invention, a film of a material which preferably emits alpha radiation only is deposited on the inner surface 22 of the cylinder or the face 24 of the piston, or both. Normally, only the face 24 of the piston or the wall 22 of the cylinder will be surfaced. When the interior wall 22 of the cylinder is to be surfaced with an alpha emitter, the surfacing is applied only to that portion of the cylinder lying above the maximum stroke of the piston.

By way of specific example, a thin layer of a supporting metallic substrate such as copper, silver, gold, platinum, or rhodium is deposited on the face 24 of the piston 12. Onto this substrate there is deposited a very thin layer of free Po^{210} having a thickness not in excess of 10 micrograms per square cm. Both the substrate and the alpha emitter may be applied to the piston face in any suitable manner such as by way of electric deposition, sputtering, evaporation, or the ignition of readily reduced compounds or mixtures of such compounds.

In situations wherein the substrate is a catalyst for the combustion process as is the case with platinum, still greater efficiency of combustion is obtainable.

In the operation of a reciprocating piston-type internal combustion engine chamber of the type illustrated in FIG. 1, the combustion sequence is that which is normally associated with the operation of engines of this type. Thus, the fuel inlet valve 18 is opened on the downstroke of the piston to permit the introduction of a mixture of air and vaporized gasoline. The valve 18 closes and the mixture is compressed on the next upstroke of the piston 12. At the height of the stroke, a spark is generated by the plug 16 whereby ignition of the gasoline vapors is initiated. In contrast, with a conventional combustion process, however, the following sequence of events will occur. The ionizing radiation will have, previous to the spark, created a steady state concentration of radicals which will be present in a catalytically effective amount. That is to say, the free radicals in the unburned portion of the compressed mixture will have an excitation sufficient to permit an appreciably faster rate of travel of the flame front (i.e., an increase within the range of about 2 to 100 times). As a consequence, the accelerated flame front will develop a higher absolute temperature and move at a greater speed whereby the force exerted on the face 24 of the piston 12 will be increased. The expansion of the combustion products will force the piston 12 downwardly for the power generating stroke. Thereafter, on the next succeeding upstroke of the piston 12 the exhaust valve 20 is opened to remove combustion products from the interior of the cylinder 10.

The operation of the diesel-type piston shown in FIG. 2 is substantially similar. In this case, however, a heavier fuel such as Diesel oil is utilized and ignition is accomplished by more severe compression of the mixture of fuel and oxygen.

Thus, in the case of a combustor for a diesel-type engine, there is provided a cylinder 50 closed with a head 52 of any suitable conventional construction. The head 52 is provided with a fuel combustor 54, an inlet valve 56, and an outlet valve 58. A piston 60 is mounted within the cylinder 10.

4

In addition, a material which preferably emits only alpha radiation is deposited as a film 62 on the face of the piston 60. Optionally, the film may also be present on the inner surface of the cylinder as a film 64 positioned above the maximum stroke of the piston 60.

In operation, on the downstroke of the piston 60 the inlet valve 56 is opened to admit air and, at the same time, fuel is injected into the cylinder through the line 54. The valve 56 is then closed and on the upstroke of the piston 60 the mixture of gas and fuel is compressed to an extent sufficient to cause combustion. In this instance, however, the presence of the alpha emitter will promote the combustion process to provide for a more efficient utilization of the fuel.

After the power-generating downstroke, the piston 60 again returns upwardly and the outlet valve 58 is opened to remove combustion products from the chamber of the cylinder 50. The cycle then repeats.

Advantages are obtainable with diesel-type pistons to a greater degree than with internal combustion engines due to the nature of the flame ignition process. Thus, with a diesel engine, the presence of ionized fuel particles which will exist homogeneously throughout the compressed mixture of vaporized diesel fuel and oxygen makes possible ignition of the system at either a lesser pressure or the generation of greater power for the same pressure.

Another form of the present invention is shown in FIG. 3 wherein there is schematically shown a jet engine comprising a housing 100 defining an air intake 102 leading to a centrifugal compressor 104 communicating with a combustion chamber 106. A suitable jet fuel is fed to the combustion chamber 106 through fuel injection nozzles 108-110 to provide for combustion of the fuel in the presence of compressed air. Hot exhaust gases pass through a rotor 112 for operation of the compressor 104 and from thence through an exhaust duct 114 in order to generate the desired thrust.

In accordance with the present invention, a screen 116 comprising a radioactive material which substantially exclusively emits alpha particles is mounted in the combustion chamber 100. The screen 116 may be composed of a substrate formed of suitable metal such as platinum or rhodium, the wire of the screen having a diameter of 0.5 mm. or less, and a mesh of 5 to 10 mm. There is deposited on the wire substrate an alpha emitting isotope such as Pb^{210} . It is desirable that about 0.03 to about 1.0 kilocurie of the isotope be deposited uniformly on the screen in the form of a thin coating. Techniques mentioned above with respect to FIG. 1 may be utilized for this purpose. The screen is preferably cylindrical in shape, of a diameter approximating about one-half the diameter of the combustion chamber and a length substantially equal to the length of the combustion chamber.

In FIG. 4 there is shown, schematically, improved means for driving a turbine for the generation of power. Thus, there is schematically shown a turbine 200 to which hot gas is charged from a combustion chamber 202 and from which spent gas is discharged by way of an exhaust 204. An inlet line 206 is provided for introducing either air or a fuel into the combustion zone 202 and a separate inlet line 208 is provided for introducing the other element necessary for combustion into the combustion chamber. Mounted within at least one of the inlet lines, such as the inlet line 208, is a screen 210 composed of platinum or rhodium or other refractory metal having a thin film of U^{232} having a thickness of the order of about 1 to 100 micrograms per square centimeter. The screen 210 is movably mounted on a shaft 212 whereby a desired selected portion of the screen 210 may be physically introduced into the combustion chamber 202.

In operation, a suitable fuel such as natural gas may

be introduced by way of the line 206. Air is introduced into the inlet line 208 by way of a branch line 214, passes over the enclosed portion of screen 210 and from thence into the combustion chamber 202. Any ionized entities formed within the inlet line 208 will have substantially decayed prior to entry into the combustion chamber 202 whereby the effective ionization will occur substantially exclusively in the chamber 202. The combustion process is assisted in the above-described manner whereby the natural gas is heated to a higher temperature in the chamber 202 than would normally be obtainable. Stated differently, a greater volume of gas is burned per unit volume of combustion chamber per unit of time. It will be understood that in this situation it will be necessary to shield at least the inlet line 208 and the chamber 202 with a suitable material such as concrete, high density tungsten alloys, etc. if β and γ emitters are used.

A problem is encountered with an installation of this nature with respect to proper control of the process. In accordance with the embodiment of the invention shown in FIG. 4, suitable means are provided for controlling the intensity of radiation within the combustion chamber 202 in response to the combustion process and for causing any failure of the system to be a "fail safe" failure.

Thus, by way of specific example of a control system of this nature, the shaft 212 for the screen 210 is actuated by a prime mover such as a motor 216 which, in turn, is regulated by a suitable control mechanism such as a slave Selsyn 218.

The slave Selsyn 218 may, in turn, be actuated in response to a process variable. The position of the screen 210 is thus made dependent upon selected variables of the engine or turbine such as the rate of flow of fuel and/or the temperature at various positions in the system. Thus, in operation of the turbine or engine, the flow of either component may be used to rotate a small aerometer or rotameter 220 which, in turn, actuates an alternator 22 whose frequency or potential is a proportional function of the gas flow. The signal generated in this alternator is amplified (and shaped, if desired) by a control unit 224. An output signal from the unit 224 may be fed to a master Selsyn 226 in order to control the motor 216 which guides the screen 210 into or out of the combustion zone 202. In this way, it is possible to control the reaction rate and maintain optimum conditions. Should it also be desirable not to exceed a preselected temperature, a temperature sensing device such as a thermocouple 228 may be positioned at a critical location in the device and used as a source for an override control.

Thus, a signal may be transmitted from the thermocouple 228 through a line 230 to a control unit 232 which may be, for example, a signal amplifier and shaper. One output signal from the control unit 232 may pass to a second master Selsyn 234 electrically coupled with the slave Selsyn 218 and the initial master Selsyn 226 in the manner shown in FIG. 4. The second signal from the control unit 232 may pass to an override control unit 236 designed to nullify the signal from master Selsyn 226 when the temperature is excessive. Thus, the override signal will control the motor for the screen 208 in response to a signal from the control unit 232.

Accordingly, if the temperature at any point exceeds a selected value, the source 208 will be withdrawn and the combustion rate decreased until the temperature has fallen to the desired value, at which time the override 236 is cut out. The source 208 is advanced into the chamber 202 under control of the unit 224. In this way, a "fail safe" control is maintained regardless of the selected operating conditions.

Special attention should be directed to selecting radionuclides which have high specific power. For example, 1 gram of carrier-free Po^{210} releases about 24 cal. sec.⁻¹ or 100 joules per second (i.e., 100 watts) and the other activities mentioned produce similar powers. This is to

be contrasted with the specific power of U^{238} , thorium²³², or even Ra^{226} which release less than one-thousandth the amount of energy cited here. This is desirable, if not absolutely essential, because the range of the alpha particle being short precludes the use of thick deposits. Motors which are subject to frequent maintenance will naturally employ the pure alpha decay isotopes of short half-life (e.g., Po^{210}) while those which will operate for extended periods of time without attention will be sustained by the longer-lived decay chains.

In the applications under consideration, alpha activities are preferred to other emissions. The range of alpha particles is short and they are stopped entirely in the gases being burned while the beta particles or gamma rays will only partially be attenuated under these conditions. Furthermore, the energies of alpha decay generally exceed 5 mev. while an energetic beta of useful or suitable half-life seldom has more than 3 mev. maximum energy and in unforbidden beta decay two-thirds of the energy is carried off by neutrons which have extremely small absorption cross-sections.

Having thus described our invention, what is claimed is:

1. In a device for generation of power by the burning of a volatilized fuel with a volatilized combustion agent in a combustion zone to provide hot combustion gases for the actuation of a turbine fed with hot gases from said combustion zone, said combustion zone being provided with separate conduits for the introduction of said fuel and said combustion agent, the improvement which comprises, in the combustion zone, a metallic screen, a high surface area deposit of a metallic radioactive material emitting principally alpha particles, having an intensity of alpha emission within the range of about 10^8 to about 10^{10} alpha particles per square centimeter of film surface per second and having an alpha decay chain with about 1 to 10 stages, said screen being reciprocally mounted within one of said inlets, and control means for reciprocating the mounting for said screen whereby a selected desired portion of said screen may be withdrawn from said combustion zone.

2. In a device for the generation of power by the burning of a volatilized fuel with a volatilized combustion agent in a combustion zone to provide hot combustion gases for the actuation of a turbine fed with hot gases from said combustion zone, said combustion zone being provided with separate conduits for the introduction of said fuel and said combustion agent, the improvement which comprises, in the combustion zone, a metallic screen composed of a metal of the group consisting of platinum and rhodium, the wire of said screen having a diameter of not more than about 5 mm. and the mesh of said screen being not more than about 10 mm. and, deposited on said wire, a metallic alpha emitter selected from the class consisting of lead²¹⁰ and polonium²¹⁰ in an amount sufficient to provide a deposit having an intensity within the range of about 0.03 to about 1.0 kilocurie of alpha emitter, said screen being reciprocally mounted within one of said inlets, and control means for reciprocating the mounting for said screen whereby a selected desired portion of said screen may be withdrawn from said combustion zone.

3. A device as in claim 2 including operating means for regulating said control means, said operating means comprising first electrical detecting means for measuring a combustion variable, first electrical output means coupling said first detecting means with said control means for regulation of said control means in response to said measurement of said combustion variable, second electrical detecting means for measuring the temperature of the combustion products at a preselected critical point, second electrical output control means electrically coupling said second detecting means with said control means and an override electrically coupling said first output means with said second output means for overriding said first output means in response to measurement of a pre-

selected temperature by said second electrical detecting means.

2,791,883
2,850,641

References Cited in the file of this patent

UNITED STATES PATENTS

1,777,554 Ducloux ----- Oct. 7, 1930
1,820,878 Wyckoff ----- Aug. 25, 1931
2,721,788 Schad ----- Oct. 25, 1955
2,723,349 Rylsky ----- Nov. 8, 1955
2,766,582 Smith ----- Oct. 16, 1956

5

782,908
792,776

Moore et al. ----- May 14, 1957
Martin ----- Sept. 2, 1958

FOREIGN PATENTS

France ----- Mar. 25, 1935
France ----- Oct. 28, 1935

OTHER REFERENCES

Production of Unipolar Air With Radium Isotopes,
reprint from "Electrical Engineering," January 1954,
published by the A.I.E.E.

10