

United States Patent [19]

Cassidy et al.

[11] 3,753,345

[45] Aug. 21, 1973

[54] **POWER FLUID**

[75] Inventors: **Frank H. Cassidy**, Orangevale;
Ramon Garcia, Sacramento, both
of Calif.

[73] Assignee: **Aerojet-General Corporation**,
El Monte, Calif.

[22] Filed: **Nov. 1, 1971**

[21] Appl. No.: **194,271**

[52] U.S. Cl. **60/36, 252/67**

[51] Int. Cl. **F01k 25/00**

[58] Field of Search **60/36; 252/67, 78,**
252/162

[56]

References Cited

UNITED STATES PATENTS

3,584,457 6/1971 Davoud..... 60/36

3,173,872 3/1965 Broadley..... 252/78 X
3,234,734 2/1966 Buss et al..... 60/36

FOREIGN PATENTS OR APPLICATIONS

294,243 6/1929 Great Britain..... 60/36

Primary Examiner—Martin P. Schwadron

Assistant Examiner—Allen M. Ostrager

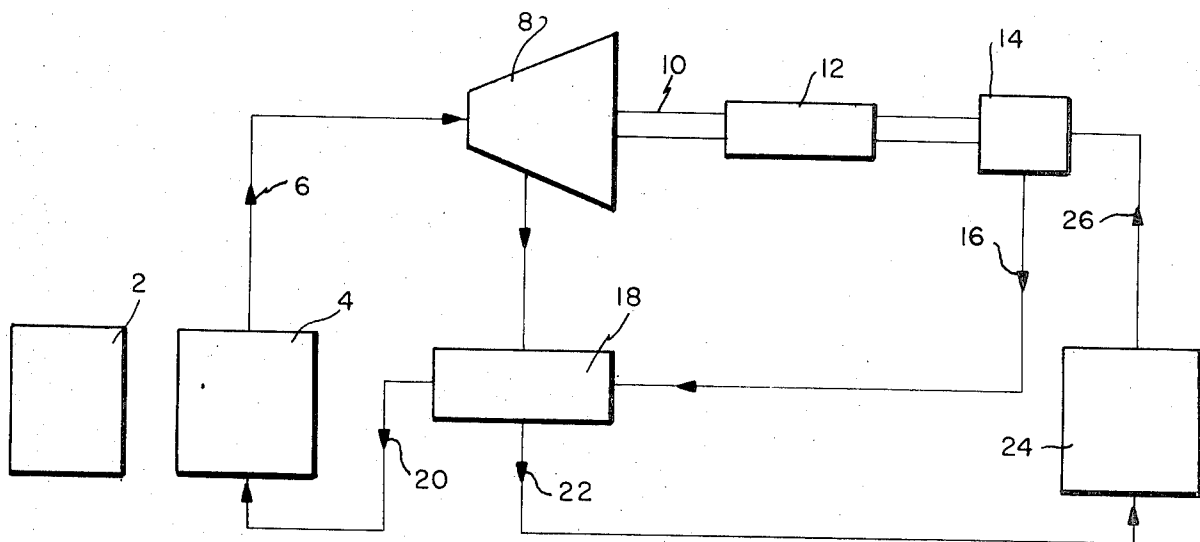
Attorney—Edward O. Ansell et al.

[57]

ABSTRACT

A working fluid for use in a Rankine cycle engine consists of a mixture of hexafluorobenzene and perfluorotoluene.

7 Claims, 2 Drawing Figures



PRIOR ART

1 POWER FLUID

BACKGROUND OF THE INVENTION

1. Field of the Invention

There are many needs for a power supply which include automotive propulsion and supplies for electrical and chemical power. These needs in the past have been supplied by such power sources as coal, oil, natural gases, and in more recent times, nuclear power systems.

One way of obtaining this power supply has been in the use of the Rankine cycle engine, which employs an external heat source to vaporize a working fluid.

2. Description of the Prior Art

There have been many applications of various working fluids utilizing the Rankine cycle for producing power generation. These include the patents to Davoud, U.S. Pat. Nos. 3,584,457; Tabor et al., No. 3,040,528; Murphy et al., No. 3,282,048; Angelino, No. 3,376,706; McEwen, No. 3,516,248; and Paxton, No. 3,512,357.

In addition, there is described in Chemical Abstracts, Volume 65, 1966, on page 11791, the use of fluorochemicals as working fluids for small Rankine cycle power units.

SUMMARY OF THE INVENTION

The invention can be described as a working fluid primarily used in a Rankine cycle engine, which consists of hexafluorobenzene and perfluorotoluene.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a description of the prior art showing the operating characteristics of a Rankine cycle engine.

FIG. 2 is a eutectic graph of the temperature vs. physical characteristics of the two fluids.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Shown in FIG. 1 is a typical Rankine cycle engine. A heat source is shown at 2 which vaporizes the working fluid for a vaporizer 4. This vapor travels in a direction of arrow 6 to an expander and in the preferred embodiment is a turbine expander 8. This generates power which is transferred by shaft 10 to an alternator 12 to generate electrical power, or is transferred by shaft 10 to mechanical power, such as a transmission, or in the case of a steady-state power need, to a pump or another suitable mechanical mechanism.

Shown at 14 is a pump which, as indicated by arrow 16, delivers fluid to a regenerator 18. The regenerator 18, as shown by arrow 20, exits into the previously described vapor generator 4.

The regenerator 18, as shown by arrow 22, cycles the fluid to condenser 24 and as shown by arrow 26 into pump 14.

This is a typical Rankine cycle power conversion system and it is considered as prior art.

The Rankine cycle power conversion system, as previously described, typically utilizes what is known as "working fluid." In the past, this working fluid usually consists of water which is vaporized into steam at either a critical or a sub-critical phase. In other words, the water or other working fluid is vaporized by a source of heat and expanded into a turbine to produce work and the condensed fluid redelivered to the heat source and vaporized again.

2

Examples of problems encountered with the use of water or other working fluids are freezing temperature, boiling temperature, pressure conditions, toxicity, breakdown of their constituents, corrosiveness, and related problems.

As mentioned above in the description of the prior art, there have been many attempts to solve these problems among which are the various fluorocarbons and other organic fluids.

The instant invention provides a combination of two fluids, namely, hexafluorobenzene and perfluorotoluene, which are identified by the empirical formulas C_6F_6 and C_7F_8 , respectively. The physical properties of these compounds are substantially identified as follows:

PHYSICAL PROPERTIES

	Hexafluorobenzene	Perfluorotoluene
Boiling Point	176°F	221°F
Freezing Point	41°F	-83°F
Empirical Formula	C_6F_6	C_7F_8
Molecular Weight	186	236
Critical Temperature	471°F	500°F
Critical Pressure	480 psia	395 psia
Flammability	Non-flammable	Non-flammable
Toxicity	Non-toxic	Non-toxic

In FIG. 2 a eutectic liquid-solid-phase diagram for the aforementioned compounds is shown.

Thus it can be seen by the dotted line which is -25°C the working fluid is in liquid phase and thus for most purposes is ideal for automotive propulsion use. Referring back to the physical properties, it can be seen that the freezing point is a compromise between the two compounds and that percentage of the components of that mixture can be selected depending upon the critical temperature conditions, the critical pressure conditions, and other factors, to optimize the mixture ratio for any application.

The two constituents according to this invention can range in percentages of 1 to 99 percent of hexafluorobenzene and perfluorotoluene which is dependent upon the application in the Rankine cycle (preferably) application, and which may range from such aspects as automotive propulsion to electrical power conversion. In other words, the output of the Rankine cycle engine can be varied so as to meet the conditions of such applications as automotive propulsion and electrical power.

The advantage advanced by the mixture is their high efficiency, high temperature operation, inertness, non-corrosiveness, non-toxicity, and its safety.

What is claimed is:

1. A method for converting heat energy to another form of energy, which comprises:

vaporizing a fluid comprising

a mixture of hexafluorobenzene and perfluorotoluene by passing said fluid in a heat exchange relationship with a heat source; and

utilizing the kinetic energy of the resulting vapors to perform work, wherein the amount of perfluorotoluene is sufficient to substantially reduce the freezing point of the mixture, below the freezing point of hexafluorobenzene.

2. The method according to claim 1 in which said fluid is utilized in a Rankine cycle engine.

3. The method according to claim 2 in which a turbine expander is utilized to perform said work.

4. A method according to claim 3 in which mechanical energy is produced by said turbine expander.

5. Method according to claim 3 in which electrical energy is produced by said turbine expander.

3

4

6. A working fluid for power generation which comprises:

a mixture of hexafluorobenzene and perfluorotoluene, said mixture having a range of 1 to 99 percent of hexafluorobenzene and 99 to 1 percent of

perfluorotoluene.

7. A working fluid according to claim 5, having approximately equal amounts by weight of hexafluorobenzene and perfluorotoluene.

* * * * *

10

15

20

25

30

35

40

45

50

55

60

65