

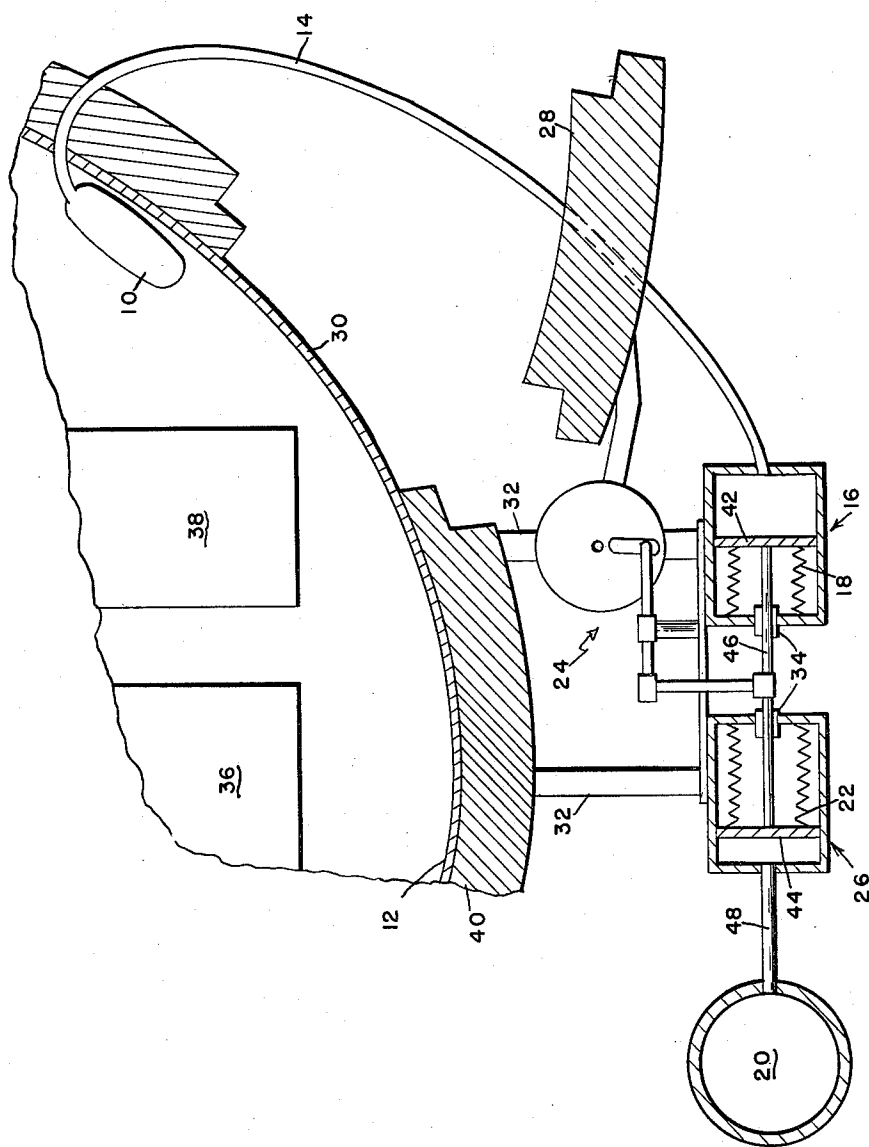
June 29, 1965

J. H. VOGT ETAL

3,192,069

RADIOACTIVE ISOTOPE POWERED THERMOELECTRIC GENERATOR SYSTEM

Filed July 9, 1963



INVENTORS
Joseph H. Vogt
Charles N. Young
Willard C. Reed

BY

Roland A. Anderson

Attorney.

1

3,192,069

RADIOACTIVE ISOTOPE POWERED THERMOELECTRIC GENERATOR SYSTEM

Joseph H. Vogt, Manchester, Conn., and Charles N. Young and Willard C. Reed, Baltimore, Md., assignors, by mesne assignments, to the United States of America as represented by the United States Atomic Energy Commission

Filed July 9, 1963, Ser. No. 293,916

2 Claims. (Cl. 136—4)

This invention relates to a radioactive isotope powered thermoelectric generator system, and more particularly to such a system wherein heat loss is continually adjusted so as to compensate for diminishing heat generation.

In a radioactive isotope powered thermoelectric generator a thermoelectric element is excited by heat emitted from a decaying radioactive source. Excitation of the thermoelectric element generates an electric current which may be utilized as desired. Such a system has particular application in the field of space technology where a space vehicle must provide its own auxiliary power for long periods of time.

Initially the radioactive source emits maximum heat; heat emitted then diminishes as the source decays. The initial maximum heat is greater than the system is designed to utilize. Heat loss through the outer skin of an insulated space vehicle is inadequate for maximum heat loss requirements, particularly in the vacuum conditions in which a space vehicle must function. Accordingly, space thermoelectric generators are provided with thermal shutters which, by varying the degree of insulation of the vehicle, fill the initial need for high heat loss capability and compensate for successively diminishing heat loss requirements.

Previous isotopic generator systems utilized electrically operated thermal shutters. The signal from a thermocouple, or resistance bulb thermometer, was fed through amplifiers and a comparator which varied the electrical power supplied to the shutter drive electric motor, and hence positioned the thermal shutters so as to either increase or decrease heat containment according to the need. The utilization of this type shutter system necessitated the use of electrical power and was subject to the failures of electrical components, especially when exposed to radiation damage. Further, the weight of such systems and space requirements were excessive.

The object of this invention is to provide a radioactive isotope powered thermoelectric generator system in which the heat loss control mechanism is simple and reliable, does not consume electrical power, is relatively immune to radiation damage, and achieves a reduction in weight and in space requirements.

This object is accomplished by the following invention which is a radioactive isotope powered thermoelectric generator system utilizing a thermohydraulic thermal shutter control mechanism. This system converts changes of vehicle hot skin temperature into linear motion which is used to open and close thermal shutters and thereby vary the rate of heat containment.

FIGURE 1 is a diagrammatic elevational sectional view of the system with radioactive isotope power source and the thermoelectric element shown in block form.

The system comprises a radioactive isotope source 36 in proximity to a thermoelectric element 38, both such as are well known in the art, and disposed within a metal shell 12 which completely encompasses the radioactive isotope source 36 and the thermoelectric element 38. The major portion of the exterior of the metal shell 12 is covered by thermal insulation 40 which serves to conserve the heat emanating from the radioactive isotope source

2

36. Portions 30 of metal shell 12, referred to herein as hot skin heat radiation surface, can be exposed so as to diminish heat conservation, that is, expedite heat loss. A temperature sensing reservoir 10 containing a working fluid is disposed within the metal shell 12 and is connected by tube 14 to an active pressure cylinder 16 located outside of the metal shell 12, which active pressure cylinder contains an active pressure bellows 18 and a first piston 42. The first piston 42 is attached by common shaft 46 to a second piston 44. The second piston 44 and gas actuated bellows 22 are disposed within a gas cylinder 26. The gas cylinder 26 is connected with a constant pressure gas reservoir 20 by a connecting tube 48. A linkage and gear system 24 transmits movement of common shaft 46 to the moveable thermal shutter 28. Brackets 32 serve as supporting struts.

During operation the radioactive isotope source 36 produces heat which excites thermoelectric element 38 and thereby produces useful electrical power. As the radioactive isotope source decays so that there is a reduction in heat generated, and the metal shell 12 decreases in temperature, vapor of the working fluid within the temperature sensing reservoir 10 condenses until the active pressure system reaches the vapor pressure corresponding to the lower temperature. The force acting upon second piston 44 due to the gas reservoir 20 pressure, and bellows 18 and 22 spring force, is greater than the force acting upon the first piston 42 due to the working fluid vapor pressure. The piston common shaft 46 moves in the direction of the active pressure cylinder 16 until these forces equalize. Motion of the piston common shaft 46 toward active pressure cylinder 16 is transmitted through the mechanical linkage and gear system 24, which transforms linear motion to rotational motion, to the thermal shutter 28, causing the thermal shutter 28 to pivot to a more closed position. With less hot skin heat radiation surface 30 exposed, the system heat losses will be reduced, tending to raise the metal shell skin temperature back to its original value. On the other hand, if the metal shell skin temperature increases, the thermal shutter 28 will be moved to a more open position which will tend to decrease the temperature to its original value.

The controlled temperature range span (from full open to closed) is solely a function of bellows 18 and 22 spring rate, working fluid vapor pressure characteristics, and the travel of the piston common shaft 46. The control temperature set point is the function of the same parameters and the magnitude of the gas pressure in the gas reservoir 20. The control temperature can therefore be set by the gas reservoir gas pressure. Under ideal conditions, the thermal shutters will gradually close from the full open position during the life of the unit, thus compensating for decay of the radioactive isotope.

Low friction bearings are used in the mechanical linkage and gear system 24, and for the axial motion of the common shaft at 34, to allow for good sensitivity to temperature changes.

A mechanical spring may be used in place of the active pressure bellows 18 and the gas actuated bellows 22 as a means of restraining movement of the pistons.

Any suitable linkage or gear mechanism may be used to transmit movement of the shaft 46 to the thermal shutter 28.

The criteria for the selection of the working fluid are as follows: (a) low vapor pressure at the temperature involved. This is to make heavy walled containers unnecessary and save on weight; (b) chemical stability within the operating temperature range; (c) must have suitable corrosion properties at temperature of operation; (d) must be unaffected by gamma irradiation; and (e) the change in vapor pressure with temperature must be

great enough to provide the necessary sensitivity and temperature control range. Though the thermal properties of mercury have been found to be preferred for thermal shutter control application, other working fluids may be utilized in temperature sensing reservoir 10.

Examples of a suitable radioactive isotope for the source include strontium-90 and polonium-210.

Additional advantages of the thermal hydraulic system over the electric systems previously employed include the following: (1) it is simple and reliable; (2) utilizes only excess generator thermal energy; (3) utilizes materials unaffected by gamma radiation; (4) has few moving parts, all non-lubricated; (5) has slow response but good sensitivity, needed for the required overdamp control system for thermoelectric generators; and (6) is of lighter weight and requires less space.

It should be noted that the system described above is merely exemplary and not limiting insofar as the invention is concerned, since it will be apparent that other similar arrangements will be suggested to those skilled in the art. Hence, the invention is limited only insofar as is set forth in the following claims.

What is claimed is:

1. A radioactive isotope powered thermoelectric generator system having a metal shell, a radioactive isotope source, and a thermoelectric element, said source and said element disposed within said metal shell, a temperature sensing reservoir within said shell connected to an active pressure cylinder outside said shell, a piston disposed within said cylinder, mechanical means of restraining movement of said piston, a second cylinder opposed to the active pressure cylinder, a piston disposed in said sec-

ond cylinder, mechanical means of restraining movement of said piston in said second cylinder, said pistons interconnected by a common shaft, a constant pressure gas reservoir connected to said second cylinder, mechanical linkage means attached to said shaft between said cylinders and attached to and activating thermal shutters, whereby a change in temperature affecting said temperature sensing reservoir actuates said thermal shutters.

2. A radioactive isotope powered thermoelectric generator system having a metal shell, a radioactive isotope source, and a thermoelectric element, said source and said element disposed within said metal shell, a temperature sensing mercury reservoir within said shell connected to an active pressure cylinder outside said shell, a piston disposed within said cylinder, an active bellows restraining movement of said piston, a second cylinder opposed to the active pressure cylinder, a piston disposed in said second cylinder, a gas bellows restraining movement of said piston in said second cylinder, said pistons interconnected by a common shaft, a constant pressure gas reservoir connected to said second cylinder, mechanical linkage means attached to said shaft between said cylinders, and attached to and actuating thermal shutters, whereby a change in temperature affecting said mercury reservoir actuates said thermal shutters.

References Cited by the Examiner

UNITED STATES PATENTS

2,765,414 10/56 Gendler et al. ----- 290—2

CARL D. QUARFORTH, *Primary Examiner.*