GEOTHERMAL ENERGY CONVERSION SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to the conversion of energy from an enclosed geothermal source into electrical energy using shape memory alloys, and is related to the heat engine disclosed in my prior copending application, Ser. No. 07/444,350 filed Dec. 1, 1989, now U.S. Pat. No. 4,938,026 issued July 3, 1990, with respect to which the present application is a continuation-in-part.

The use of shape memory alloys, especially Nitinol, in a heat engine has been proposed for conversion of solar radiation energy into a more usuable form, according to my aforesaid prior copending application, the disclosure of which is incorporated herein by reference. Such heat engine included a thin sheet of Nitinol material formed into a tube having corrugations acting as gear teeth in mesh with teeth of similar profile on a gear roller. One region of the tubular Nitinol sheet is adapted to receive radiation from the sun, whereby the portion of the Nitinol sheet so exposed to the sun expands circumferentially to induce rotation because of unbalanced forces transmitted to the gear roller in mesh with the tubular Nitinol sheet at a non-equilibrium force location spaced away from the heat receiving region. Such gear meshing location is substantially cooler than the radiation heated region by virtue of a space vehicle installation according to my prior copending application aforementioned.

SUMMARY OF THE INVENTION

In accordance with the present invention, geothermally heated fluent material is circulated through a closed chamber in heat conductive relation to a bath of non-corrosive heat conducting liquid within which a tubular gear made of shape memory alloy sheet material is immersed for partial exposure to geothermal heat within a heating region through which deformable corrugations are displaced into a cooler region. The corrugations of the tubular gear meshes with a gear roller having fixed profile teeth at a force transmitting location within the cooler region in nonsymmetrical operational relationship to the heating region to induce rotation of the tubular gear in response to and as a function of a predetermined temperature differential between the liquid bath and the gear meshing location. The temperature differential may be controlled by flow of coolant through the gear roller which effects deformation of the corrugations on the tubular gear as a result of meshing engagement.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

FIG. **1** is a side section view of the generator in accordance with one embodiment of the invention.

FIG. **2** is an enlarged partial section view taken substantially along section line **2—2** in FIG. **1**.

FIG. **3** is an enlarged partial section view taken substantially along section line **3—3** in FIG. **2**.

FIG. **4** is an enlarged section view taken substantially along section line **4—4** in FIG. **2**.

FIG. **5** is a partial section view taken substantially along section line **5—5** in FIG. **2**.

FIG. **6** is a simplified partial top section view taken substantially along section line **6—6** in FIG. **5**.

FIG. **7** is a simplified electrical wiring diagram of the interconnection of the coil loops shown in FIGS. **5** and **6**.

FIG. **8** is a graph showing the voltage induced in the coil loop assembly depicted in FIG. **7**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

A generator constructed in accordance with one embodiment of the invention generally referred to by reference numeral **10**, comprises a tubular energy input gear **12** as shown in FIGS. **1** and **2**. The tubular gear **12** is made of thin Nitinol sheet material formed with corrugations **14** which extend axially and have in cross-section a substantially sinusoidal profile as seen in FIG. **3** and **4**. The dimensions of the corrugations are defined by their circumferential spacing or pitch p (the distance between two adjacent peaks), their depth d, measured from the peak to the deepest point of the valley, and the sheet material thickness t, as labeled in FIG. **3**. The generator **10** further comprises a driven tubular roller gear **16** having teeth similar in profile to the longitudinal corrugations **14**, in the martensitic state, and in mesh therewith at a predetermined force transmitting location on the tubular gear **12**. Roller gear **16** is made of a relatively rigid and lightweight material, such as graphite, aluminum, or plastics.

The corrugations **14** on the tubular Nitinol sheet are in an austenitic state prior to assembly of the generator. The dimensions of the corrugations will be "remembered" by each corrugation **14** as it is transformed from the martensitic to the austenitic state during operation of the generator. Such tubular Nitinol gear **12** is carried at each axial end by floating support means such as flexible metal spokes **20** attached to hubs **22** as seen in FIGS. **2** and **3**. According to one embodiment the spokes are attached to the hubs by brazing or threading. The hubs have shaft extensions **24** rotatably supported in bearings **26** affixed to axial end discs **28** of a frame assembly generally referred to by reference numeral **30**. The tubular gear **12** is thus able to rotate freely about an axis **32** fixedly established between the stationary axial end discs **28**. The roller gear **16** is also rotatably supported by the frame assembly and is provided with a tubular shaft **34** journaled by bearings **36** for rotation about an axis **35** fixedly spaced from axis **32**.

Each of the floating support means for the tubular gear **12**, including the hub **22** and the plurality of flexible spokes **20**, is shown in detail in FIG. **4**. Axially spaced threads are formed on an end portion **38** of each spoke **20** which projects with clearance through openings **40** at peak portions of those corrugations **14** aligned with the spokes **20** in close adjacency to an axial end of the tubular gear. Internally threaded nuts **42** and **44** are located in adjustably fixed positions on the threaded portion **38** of each spoke **20** closely spaced on radially outer and inner sides of the corrugation peak to limit any displacement of the tubular gear relative to its rotational axis **32** extending through the shaft **24**.

As shown in FIG. **1**, the Nitinol tubular gear **12** receives heat from an enclosed geothermal source to which the tubular gear is partially exposed within a thermal heating region **50** spaced from a non-symmetrical, force transmitting location of mesh **48** between the gear roller **16** and tubular gear **12**. The heat exposed portion of the Nitinol tubular gear **12** assumes its austenitic expanded (AE) state within region **50** spaced from a cooler region within which it loses heat before meshing