

[54] THERMAL-MECHANICAL ENERGY TRANSDUCER DEVICE

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[58] Field of Search**60/23, 24, 25, 27; 165/105, 165/80, 32; 236/101; 73/349, 368.3, 362.8; 116/114 V; 337/2**

[56] References Cited

UNITED STATES PATENTS

3,604,503	9/1971	Feldman, Jr. et al.	165/105 X
2,208,267	7/1940	Ridge	73/368.7 X
3,229,759	1/1966	Grover	165/105
3,472,314	10/1969	Balch.....	165/105 X
3,543,841	12/1970	Eastman	165/105 X
3,516,487	6/1970	Keiser	165/105
2,504,588	4/1950	Rinia	73/349

OTHER PUBLICATIONS

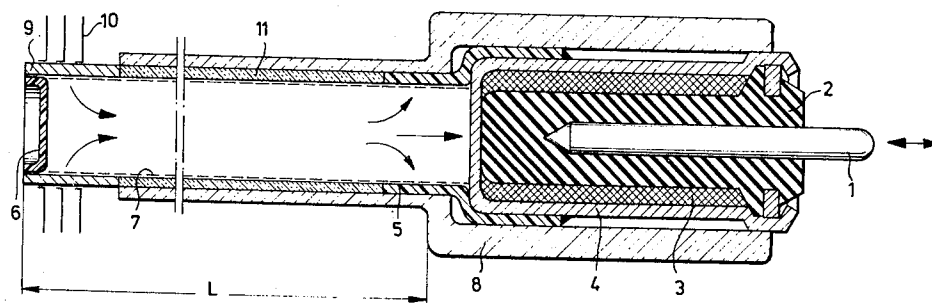
Seely, J. H. Combination Cooling System, IBM Technical Disclosure Bulletin, Vol. 11, No. 7, 12/1968

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[57] ABSTRACT

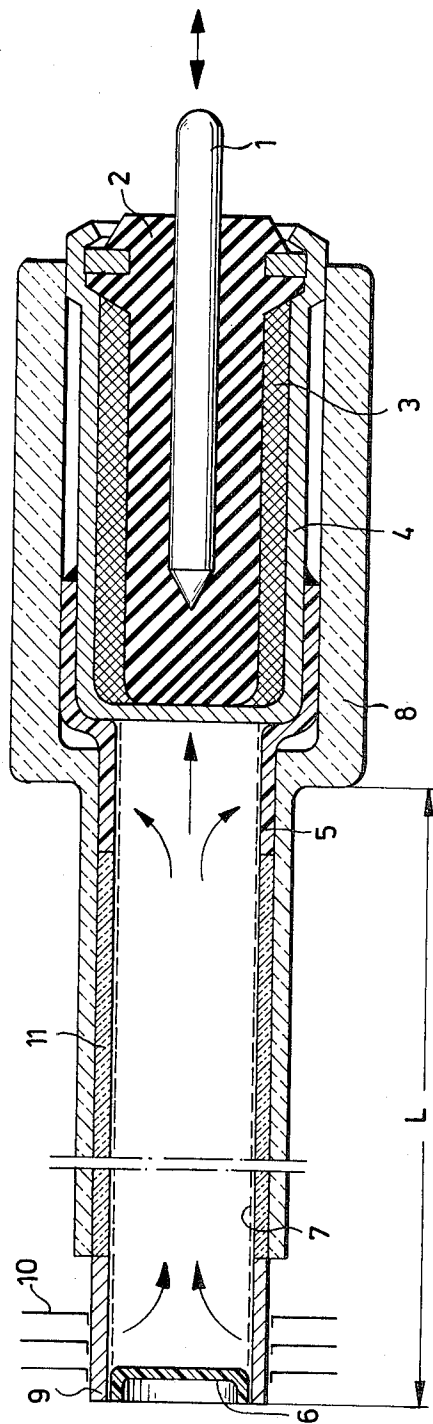
To permit remote location of a thermal-mechanical energy transducer unit having a heat sensitive operating element, a heat pipe, such as a capillary tube containing therein a fabric, such as fiberglass fabric, and a vaporizable substance is connected in heat transfer relationship to the operating element to form a unitary device. The heat pipe having another terminal end adapted to be placed in a location where it can be heated, so that the heat pipe will upon heating of the other end above the vaporization temperature of the contents of the heat pipe, rapidly and effectively transmit heat from the source to the heat sensitive operating unit. To modify the transfer characteristics, the heat pipe may be insulated, wholly, or in part at the outside, to prevent heat loss during transmission, or to provide sharp on-off characteristics at predetermined temperatures, the temperatures being determined by the vaporization temperature of the filling of the heat pipe.

6 Claims, 1 Drawing Figure



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THERMAL-MECHANICAL ENERGY TRANSDUCER DEVICE

The present invention relates to a thermal-mechanical energy transducer system having a sensing arrangement to sense temperature rises at a given point, and more particularly to systems of this kind in which an operating unit is caused to provide mechanical displacement output upon increase in temperature, and in which the mechanical displacement output is available at a location remote from the point at which the heat is generated.

Mechanical-thermal energy transducer systems operate on the principle that a substance which has a high temperature expansion coefficient, upon being heated, operates a piston or a linkage upon expansion of the high temperature coefficient material. Displacement of the piston or the linkage can be used to control various control systems, effect automatic or feedback controls, or the like. The material of high temperature coefficient, hereinafter termed "expansion material" (although, of course, upon drop in temperature it will contract) is usually included together with an operating piston, linkage or the like in a housing which includes materials which are highly heat conducting, in order to obtain a fast operating time of the operating piston or linkage. As soon as an increase in heat develops, heat applied to the housing should operate the piston as rapidly as possible. Heat should thus preferably directly affect the housing of the expansion element. This is a constraint on the design, since the operating element must be associated with the heat transfer housing, and thus must be placed at the source of the heat, so that control displacement, due to the displacement of the operating element, must be transmitted over linkages or the like, connected with the expansion element itself. Such linkages or other transmissions cause difficulties, particularly if longer distances are to be bridged and remote operation controlled by an expansion element is thus difficult to obtain, frequently expensive and often unsuitable.

It is an object of the present invention to provide a thermal-mechanical energy transducer system in which the mechanical displacement, that is the mechanical energy can be obtained at a point remote from the point of heat generation.

SUBJECT MATTER OF THE PRESENT INVENTION

Briefly, the heat sensing element includes a heat pipe which is sealed and secured to the casing of an expansion element. The heat pipe conducts heat from a source to the heat sensing element and consists of an evacuated, tightly closed tube, the inner walls of which are supplied with a material of capillary construction, such as woven fiberglass. The pores between the fiberglass weave—preferably rather wide and loose—are filled with a liquid which can easily vaporize, and heat is transmitted by the vapor. Such heat pipes have a heat conductivity which is roughly 10,000 times the heat conductivity of copper, so that heat is transmitted rapidly and with high efficiency from a source to a heat sink.

By forming the sensing element of the transducer system as a heat pipe, it is possible to locate the operating element close to a control system, or close to the

point where control is desired, and to utilize the heat pipe as a practically lossless transmitter of heat from a source to the operating element itself. This provides for a simple, flexible and inexpensive arrangement of parts and which can usually be readily located in an operating system, as desired.

The invention will be described by way of example with reference to the accompanying drawings, wherein: the single FIGURE illustrates, schematically and partially in section, a heat transducer system utilizing a heat pipe.

An operating piston 1 is located in a rubber membrane or sleeve 2 which, in turn, is surrounded by an expansion element 3 which has a high temperature expansion coefficient. The parts of the thermostatic expansion operating unit are enclosed in a brass tube 4 forming a casing, sealed and, connected to a heat pipe 5 in heat exchange relation. Heat pipe 5 may have an overall length L and is closed off at both ends; the end remote from the brass tube 4 is closed by a plug 6.

The interior of the heat pipe is supplied with a capillary wick, or net 7, shown schematically only, and consisting of fiberglass material, preferably loosely woven, which serves as a return guide for condensed liquid. The operating unit as well as the heat pipe are insulated by an outer insulating jacket 8 against heat radiation, the insulating jacket 8 preferably extending over the entire operating and at least in part over the heat pipe. The front part 9 of the heat pipe, to be located at the source of heat, is furnished with heat exchange elements 10, shown as fins in the FIGURE. In order to prevent heat flow in the walls of the heat pipe 5 below the operating unit, the walls of the heat pipe themselves are formed in the region 11 of a material which is poorly heat conductive.

The wick 7 extends substantially to the end of the heat pipe formed by the bottom wall of casing 4. If end 6, that is the heat exchange elements 10 has heat applied thereto, the liquid within the heat pipe will vaporize. The resulting vapor transports heat from the pickup end of the heat pipe to the transducer end, which heat is applied to the expansion element. The temperature gradient over the length of the heat pipe will be approximately zero.

In a preferred form, the heat pipe is so arranged that it has an on-off characteristics of transfer at a predetermined temperature, which is the temperature of vaporization of the liquid within the heat pipe. By suitable choice of the filling of the heat pipe, therefore, the on-off temperature can be selected. The heat pipe itself can be made of flexible material, for example a plastic tube, or the like, which additionally is poorly heat conducting.

The operating unit itself has been shown schematically, and in one form only since any desired type of operating unit can be used, as determined by the system which is to be controlled, or the type of displacement output required. The heat transfer characteristics from the heat exchange end 10 to the operating unit can further be varied by suitable choice of materials, extent and effectiveness of insulation jacket 8, and characteristics of the materials of heat pipe 5 and the poorly heat conductive material 11, as determined by design requirements.

I claim:

1. Unitary thermal sensing and remote mechanical energy transducer device comprising

a heat responsive operating element having a casing (4), a movable operating output element (1), a solid thermal expansion element (3) of a material having a high thermal coefficient of expansion in thermally conductive relation to the casing (4), a rubber membrane (2) located between the solid expansion element (3) and the output element (1) and transferring movement of the expansion element, upon change in temperature applied thereto by the casing (4) to the operating output element;

a heat pipe (5) including a capillary wick (7) and a vaporizable liquid in said heat pipe, the heat pipe being sealed and secured to and connected at one end thereof in heat exchange relation to said casing (4), to form an end wall portion of the heat pipe at said one end, a heat exchange sensing element secured to the other end of said heat pipe and adapted to be exposed to a source of heat, the capillary wick extending substantially up to the end wall portion,

to provide a unitary device effecting direct application of heat from the sensing element over the heat pipe to the operating element and providing for remote location of said operating element with

respect to the heat source;

and a unitary insulating jacket (8) covering said casing (4) and then extending over said heat pipe (5) for at least part of the length thereof.

2. Device according to claim 1 wherein said heat pipe (5) is of the on-off type conducting heat upon reaching a pre-determined temperature and being, below said pre-determined temperature, essentially a non-conductor of heat.

3. Device according to claim 1 wherein said heat pipe comprises a tube of poorly heat conducting material.

4. Device according to claim 1 wherein said heat pipe is formed of good heat conductive material at the end remote from the heat responsive operating element.

5. Device according to claim 1 wherein said heat pipe comprises a tube of flexible material.

6. Device according to claim 1, wherein the casing (4) is a cylindrical, cup-shaped body closed at one end, said end being exposed to the interior of the heat pipe (5);

and the expansion element (3) is cylindrical and located wholly within the inside of, and against the inner walls of the casing (4).

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