United States Patent

[11] **3,576,210**

[72] Inventor **Donald S. Trent**
Corvallis, Oreg.

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[73] Assignee **The United States of America as represented by the United States Atomic Energy Commission**

[54] **HEAT PIPE**
1 Claim, 2 Drawing Figs.

[52] **U.S. Cl.** **165/105**
[51] **Int. Cl.** **F28d 15/00**
[50] **Field of Search** 165/105

[56] **References Cited**

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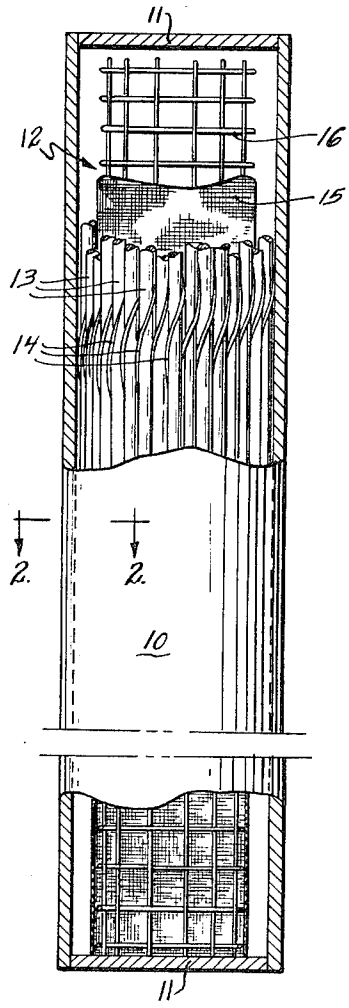
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Primary Examiner—Albert W. Davis, Jr.
Attorney—Roland A. Anderson

ABSTRACT: A heat pipe incorporates a novel wick including a single row of small-diameter rods disposed about the periphery of the heat pipe, each of the rods being wrapped in a spiral spacer wire, a cylindrical fine mesh screen located just inside the single row of rods, and a coarse support screen located just inside the fine mesh screen. A conventional working fluid such as sodium is employed in the heat pipe.



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Fig. 1

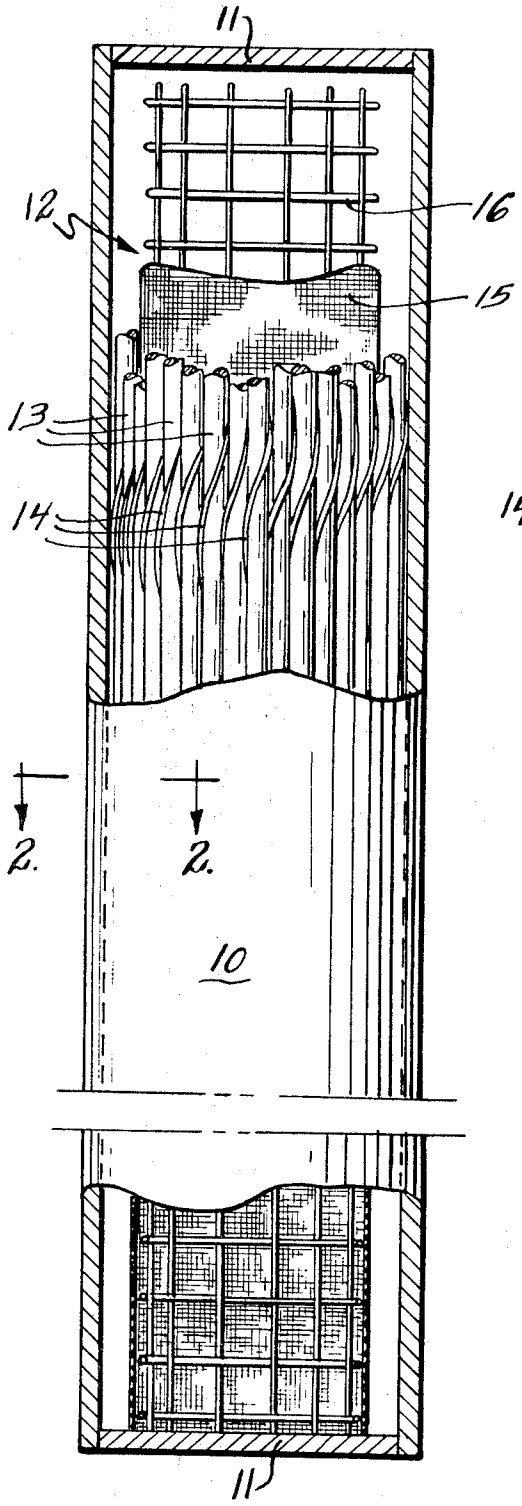
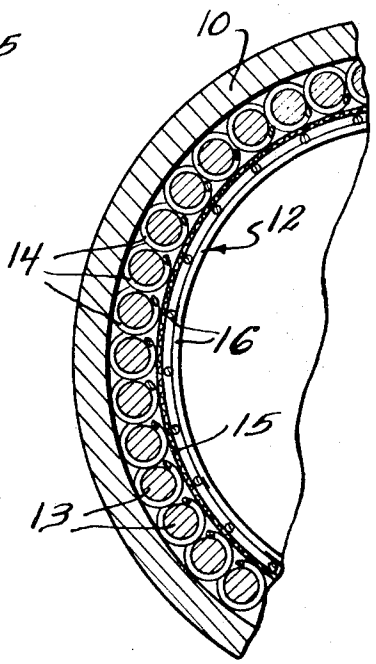


Fig. 2



Inventor
Donald S. Trent
By: Robert A. Anderson
Attorney

HEAT PIPE

CONTRACTUAL ORIGIN OF THE INVENTION

The invention described herein was made in the course of, or under, a contract with the United States Atomic Energy Commission.

BACKGROUND OF THE INVENTION

This invention relates to a heat-transfer device. In more detail, the invention relates to a heat-transfer device of the type commonly known as a heat pipe. In still more detail, the invention relates to a wick for a heat pipe.

The heat pipe is a high-flux, heat transport device which utilizes the evaporation, condensation, and surface tension of a working fluid to attain an exceptionally high thermal conductivity. A liquid is evaporated in a hot zone of the heat pipe, the gas thus formed flows to a cold zone where it is condensed, and the liquid flows back to the hot zone through a wick under the influence of capillary forces. The heat pipe can transfer over 500 times as much thermal energy per unit weight as can a solid thermal conductor of the same cross section. The heat pipe is simple, relatively inexpensive and operates silently and reliably over a long lifetime. Thermal energy may be transferred to or from a heat pipe by radiation, convection or conduction; it can be used with a variety of energy sources, such as open flames, electric heaters or nuclear sources.

The only structural elements required to form a heat pipe are a closed outer shell, a porous capillary wick and a working fluid. The outer tube of the heat pipe is normally circular in cross section and may be formed of glass or a variety of metals. The working fluid may be, for example, water, an organic liquid, ammonia, a molten salt or a molten metal.

Performance of a heat pipe is greatly dependent upon the wick design, since the wick is the capillary pump for fluid return to the hot zone.

The desirable features of a heat pipe wick include:

1. Low viscous drag in the capillary structure.
2. Small pore sizes at liquid-vapor interfaces to maximize capillary suction pressure.
3. A fairly rigid barrier to separate the liquid and vapor phases so that momentum interchange is minimized between the liquid and vapor phases.
4. Ease of wick saturation and wettability.

Several different types of wicks have been developed but, due largely to the sometimes conflicting desirable features listed above, no single design appears ideally suited for all applications.

As pointed out in UCRL–50453, "A Critical Review of Heat Pipe Theory and Applications," by Henry Cheung, wick design has undergone three major stages of development, namely mesh, channel and screened channel. A mesh wick consists of one or more layers of fine screen pressed closely against the wall of the heat pipe; a channel wick is a series of small axial grooves in the wall of the heat pipe and a screen channel includes a screen mesh fitting tightly over axial channels in the wall of the heat pipe. Recent variants on these wick designs include artery wicks and annular wicks. An artery wick includes a liquid return conduit whose wall is simply a fine screen and an annular wick is merely a fine screen tube standing at a desired distance from the pipe wall.

It is accordingly an object of the present invention to develop a heat pipe of novel design.

It is also an object of the present invention to develop a heat pipe which is easy to build.

It is another object of the present invention to develop a heat pipe including a wick which transmits substantial quantities of liquid with a low pressure drop and which is easy to rewet.

SUMMARY OF THE INVENTION

These and other objects of the present invention are attained in a heat pipe incorporating a wick consisting of a single row of small-diameter rods disposed around the periphery of the heat pipe, the rods being spaced one from the other and from the inner wall of the heat pipe by spacer wires wound spirally around the rods, a fine mesh cylindrical screen located just inside the row of rods and a coarse support screen located just inside the fine mesh screen. A conventional working fluid is also employed.

BRIEF DESCRIPTION OF THE DRAWING

The invention will next be described in connection with the accompanying drawing wherein:

FIG. 1 is a vertical cross section of a heat pipe constructed in accordance with the present invention, and

FIG. 2 is a horizontal section thereof taken on the line 2–2 in FIG. 1.

As shown in the drawing, the heat pipe includes an elongated, cylindrical tube **10**, closed at both ends by end caps **11**, and a cylindrical wick **12** disposed within the pipe about its periphery and extending the length of the pipe. Wick **12** comprises a single ring of small-diameter rods **13** spaced one from the other and from the inner wall of tube **10** by spacer wires **14** wound spirally around the rods. Just inside of the ring of rods **13** is a cylindrical wire mesh **15** having small-diameter openings therein. A cylindrical coarse wire screen **16** is disposed just inside of wire mesh **15** and serves to hold mesh **15** against rods **13** and the entire wick **12** against the inner wall of tube **10**. It will be appreciated that a working fluid, not shown in the drawing, is necessary for operation of the heat pipe. The working fluid may be, for example, sodium.

The operational characteristics of a sodium heat pipe of this type were investigated. The heat pipe used in these experiments was constructed of type **316** stainless steel. The tube employed was 1⅛ inches in inside diameter and 18 inches long. Inside the tube were a ring of 1/16-inch-diameter rods wire wrapped with 10-mil wire to space them apart. Inside the solid rods two layers of 100-mesh screen were followed by a support screen. One end of the tube was heated by an induction coil and the other end was cooled by two stainless steel water-cooled collars.

Once the wick was made and inserted in the outer tube, the end caps, an inner tube for instrumentation and auxiliary filling and evacuating assembly were welded on. The entire assembly was then vacuum degassed at 1,200° F. Thirty-five grams of sodium was then distilled into the heat pipe, and the end tube was pinched off and welded shut.

The heat pipe was then operated in what may be considered a normal way by applying power and turning on one of the cooling coils after all the sodium in the heat pipe was molten. After turning on the cooling coil the power was slowly increased until dryout occurred. Until dryout occurred, the heat pipe behaved satisfactorily and in normal fashion in transferring heat from the hot end of the pipe to the cold end. After these first tests, attempts were made to get to dryout prematurely and to see just how easily the wick does rewet after dryout. At a rate of heat removal of 1,060 watts, the power was increased and a decrease in performance of the wick was noticed. No settings were changed and after an hour the wick had recovered and was operating at 1,140 watts. This is the first experimental observation of spontaneous rewetting without taking any power decrease.

The dimensions within the wick and of the heat pipe are not critical. The rods must, of course, be small enough relative to the size of the heat pipe to provide sufficient vapor space. The width of the wire wrap must be less than the diameter of the rod. The only limits on the overall dimensions of the heat pipe are those applying to all heat pipes due to the fundamental character of the device.

It will be understood that the invention is not to be limited by the details given herein but that it may be modified within the scope of the appended claim.

I claim:

1. A heat pipe comprising an elongated cylindrical housing containing a wick consisting of a single row of small-diameter

rods disposed about the periphery of the housing, said rods being spaced from each other and from the wall of the housing by wires wrapped spirally around the rods, a cylindrical fine mesh screen located just inside the row of rods, a coarse support screen located just inside the fine mesh screen, said housing containing a low-melting metal as working fluid.