United States Patent

[11] 3,561,525

[72] Inventor Stephen C. Baer
Albuquerque, N. Mex.
[21] Appl. No. 838,598
[22] Filed July 2, 1969
[45] Patented Feb. 9, 1971
[73] Assignee Energy Conversion Systems, Inc.
Albuquerque, N. Mex.
a corporation of New Mexico

[54] HEAT PIPE CONDENSATE RETURN

7 Claims, 3 Drawing Figs.

[52] U.S. Cl. 165/105, 62/514
[51] Int. Cl. F28d 15/00
[50] Field of Search 165/105; 62/514

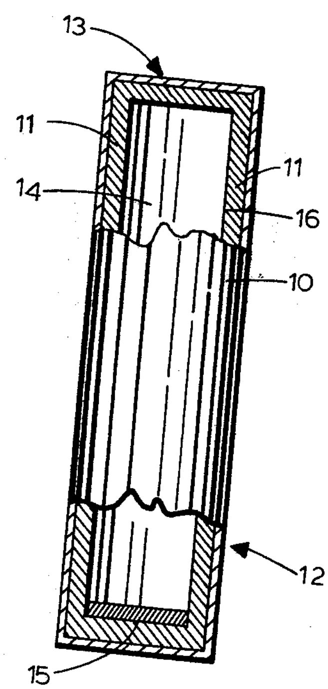
[56] **References Cited**

UNITED STATES PATENTS

3,229,759 1/1966 Grover 165/105

Primary Examiner—Albert W. Davis, Jr.
Attorneys—James E. Snead and William R. Hinds

ABSTRACT: This invention is an improved device for returning the condensate in an evaporation-condensation heat exchanger to the evaporation end utilizing the principle of osmotic action to improve the rate, efficiency and distance of return of the condensed heat exchange fluid.



PATENTED FEB 9 1971 3,561,525

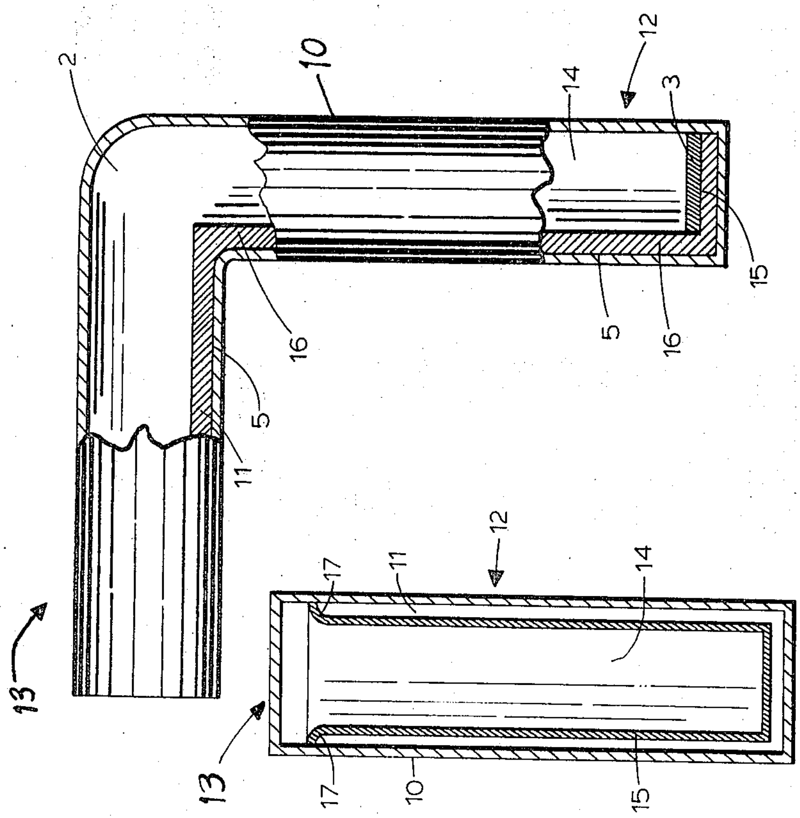


FIG. 2

FIG. 3

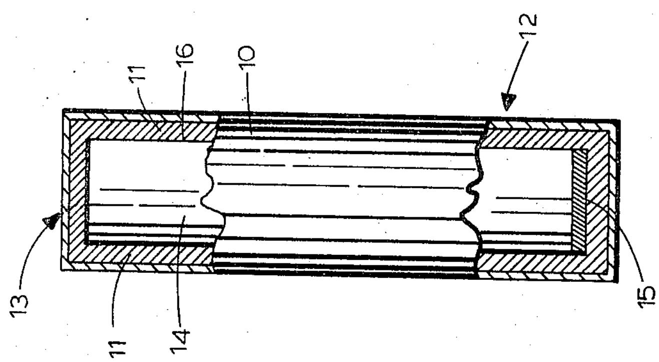


FIG. 1

STEPHEN C. BAER
INVENTOR

BY James E. Snead
ATTORNEY

HEAT PIPE CONDENSATE RETURN

HEAT EXCHANGER CONDENSATE RETURN

This invention relates to a device for improving the return of condensate from the condensation end of an evaporation-condensation heat exchanger to its evaporation end. In particular, the present device incorporates the principle of osmotic action to supply the pumping force to return the condensed heat exchange fluid in an evaporation-condensation heat exchanger to the evaporation end, whereupon the heat exchange cycle is repeated.

Evaporation-condensation principles are well known in the heat exchange art. Many different devices exist for transferring the heat exchange fluid both in its vaporized form from the evaporation end or the heat source end of the heat exchanger to the condensation or heat rejection end, and for return of the condensate to the heat source for repetition of the heat exchange cycle. Heat pipes are an example of one of the many different types of devices for accomplishing this type of heat exchange. A heat pipe generally consists of a sealed container having a certain amount of working fluid contained therein with one end of the container being exposed to the heat source. The application of heat to the fluid causes it to evaporate. The vapor travels through a passage within the heat pipe to its cooler end where the heat is rejected and the fluid condensed. In heat pipes the condensate is returned to the heat source or vaporization end through the capillary action of a wick. The surface tension of the condensate within the wick provides the pumping action for the return of the condensate.

Evaporation-condensation heat exchangers have in the past been somewhat limited in their use, and one of the major limitations is that the capillary condensate return system is a very weak "pump." The capillary action is only able to lift the condensate a distance of between 1 and 4 feet depending upon the fineness of the wick and the type of working fluid contained in the system. The pumping action is further limited by various acceleration forces to which a particular heat exchange system is subjected in use, to its particular position with relation to the force of gravity and to the size of the return passage for the condensate.

It is therefore an object of this invention to provide an improved condensate return system for evaporation-condensation heat exchangers.

A further object of this invention is to provide an improved condensate return system for evaporation-condensation heat exchangers wherein the return of the condensate to the heat source is not materially affected by the force of gravity or by other external forces exerted on the heat exchange system.

A further object of this invention is to provide an improved condensate return system for evaporation-condensation heat exchangers which increases the power and efficiency of return of the condensate from the condensation end of the heat exchanger to its evaporation end by utilizing the principle of osmotic transfer of liquids.

A further object of this invention is to provide an improved condensate return system in an evaporation-condensation heat exchange system wherein a semipermeable membrane is interposed between the liquid-vapor interface to supply an osmotic pumping action to the condensate return system.

A further object of this invention is to provide an improved condensate return system which may be used singly or in conjunction with a wick condensate return.

Other objects and advantages of this invention will become apparent as the same is better understood by reference to the following specification and the accompanying drawings.

Referring to the drawings:

FIG. 1 is a cross-sectional view of one embodiment of this invention showing a semipermeable membrane interposed at the vapor-liquid interface in a heat pipe.

FIG. 2 is a cross-sectional view of a second embodiment of the invention showing a second heat pipe with a semipermeable membrane interposed at the vapor-liquid interface.

FIG. 3 is a cross-sectional view of a third embodiment of this invention wherein a semipermeable membrane forms one side of the vapor passage.

Reference will now be made to the drawings wherein like numbers represent like parts. It should be specifically understood herein that the present invention is not limited to the specific embodiments thereof shown in FIGS. 1, 2, and 3. There are many various types of evaporation-condensation heat exchangers, some utilizing the heat pipe principle and others utilizing different heat exchange principles. Basically, the improvement disclosed herein could be used in any heat pipe type heat exchanger requiring pumping action to return the condensate from the heat rejection end of the heat pipe to the working liquid reservoir.

This invention comprises a sealed container **10** having a solution return channel **11** formed in the interior thereof which contains a predetermined amount of working solution such as sugar and water or some other suitable heat transfer solution. The hollow interior **14** of the sealed container **10** forms a vapor passage. One end **12** of return channel **11** is designed to be the condensation end of the container **10**, and the other end **13** is the evaporation end, being exposed to a heat source.

To facilitate passage of the vapor into solution in return channel **11** and to supply the pumping action for return channel **11** a semipermeable membrane, such as cellulose, **15** is interposed at the liquid-vapor interface. As shown in FIGS. **1** and **2** a wick **16** may be inserted into return channel **11** to complement the osmotic pumping action, or it may be omitted as shown in FIG. 3. Moreover, as shown in FIG. **3** the entire return channel may be formed of semipermeable membrane **15**, or it can be positioned only at the bottom of vapor passage **14**. Return channel **11** in FIG. **3** could be supplied with a wick as shown in FIGS. **1** and **2** if desired.

In the embodiment shown in FIG. **3** the osmotic pumping action occurs along the entire surface of return channel **11**, and this modification could be added to the embodiments shown in FIGS. **1** and **2**. Conversely, the membrane in FIG. **3** could be limited to the bottom of vapor passage **11** if desired. Where the entire return channel **11** is formed of membrane **15** it may be desirable to provide periodic openings in the membrane to expedite passage of solvent to solution and solution to solvent.

A seal **17** is provided on return channel **11** in the embodiment shown in FIG. **3** to prevent contamination of the solvent in vapor passage **14** by the solution. Seal **17** is particularly important in applications where wick **16** has been omitted, but can be used in conjunction with the wick.

The operation of this invention is the same in all three embodiments. End **13** having a working solution contained in channel **11** is exposed to a heat source. Application of heat to the working solution causes its evaporation to a pure solvent which enters vapor passage **14** either from wick **16** in FIGS. **1** and **2** or through seal **17** or the sides **15** of return channel **11** in FIG. **3**. In the embodiment shown in FIG. **3**, seal **17** could be eliminated and periodic openings could be provided in membrane **15** to expedite passage of solvent into vapor passage **14**. The vaporized solvent is conducted by vapor passage **14** to condensation end **12** of container **10** where the relatively cooler temperature condenses the vapor onto semipermeable membrane **15** causing it to give up its latent heat of vaporization through the walls of container **10**. The pure liquid solvent then passes through semipermeable membrane **15** into solution in return channel **11**.

As is well known, the passage of the solvent through semipermeable membrane **15** into solution creates an osmotic or pumping pressure considerably stronger than the usual capillary action caused by the surface tension of the fluid. The pressure is also considerably above the hydrostatic head of the solution in return channel **11** and does not depend on the position of sealed container **10** nor is it materially affected by gravitational or acceleration forces acting on the fluid.

The osmotic pressure in return channel **11** combined with the capillary action of wick **16** in FIGS. **1** and **2**, and independently in FIG. **3** forces the solution through return channel **11** to end **13** of container **10** where the evaporation-condensation cycle is repeated.

The osmotic force creates a terrific pumping pressure in the condensate return system. This pressure makes the heat pipe independent of gravitational or acceleration forces and considerably broadens the scope of application of the evaporation-condensation heat exchange principle.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the attached claims, the invention may be practiced otherwise than as specifically described.

I claim:

1. In an improved heat exchanger condensate return the combination comprising:

- a hermetically sealed container made of heat conducting material and having a heat receiving and a heat rejecting end;
- a solution return channel formed within the interior of said hollow sealed member which channel has one wall formed of the interior of the walls of said sealed member;
- working solution contained within said solution return channel;
- a vapor passage within said hollow sealed member and connecting said solution return channel to the heat rejecting end of said sealed member;
- a semipermeable membrane in said heat rejecting end of said sealed member in oppose between said vapor passage and said solution return channel so that vapor condensed in said vapor passage at said heat rejecting end of said sealed member passes into said solution return channel by osmosis; and

whereby a pumping force is applied to said solution return channel to force the solution within said solution return channel to the heat receiving end of said sealed member.

2. The invention as defined in claim **1** wherein the interior wall of said solution return channel is formed of the semipermeable membrane and the exterior wall is formed of said sealed container.

3. The invention as defined in claim **2** wherein the top of said solution return channel adjacent to the heat receiving end of said sealed member is open.

4. The invention as defined in claim **2** wherein the top of said solution return channel is sealed by said semipermeable membrane.

5. The invention as defined in claim **2** wherein said semipermeable membrane has openings spaced about its periphery to facilitate passage of solvent therethrough.

6. The invention as defined in claim **1** including wick means within said solution return channel to complement the osmotic action of said semipermeable membrane in returning the solution from the heat rejecting end of said sealed container to the heat receiving end.

7. The invention as defined in claim **6** wherein said semipermeable membrane forms the interior wall of said solution return passage and the walls of said sealed member provide the exterior surface of said solution return channel.