

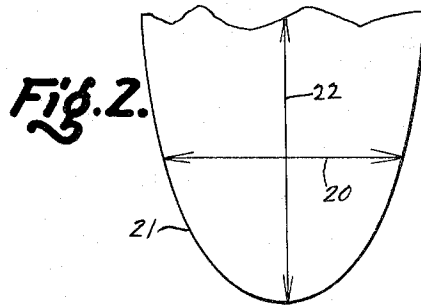
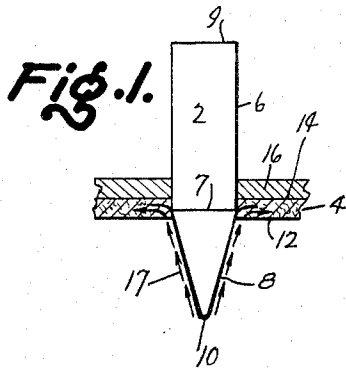
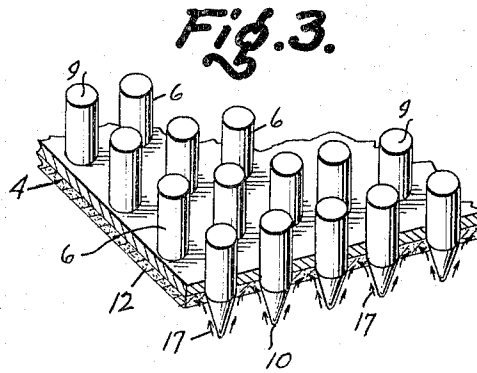
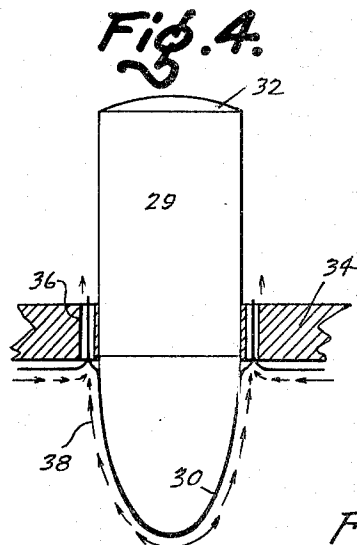
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CONDENSING HEAT TRANSFER DEVICE

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CONDENSING HEAT TRANSFER DEVICE

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My invention relates to condensers, and more particularly, to a condensing heat transfer device that operates in any position within or without the presence of gravity.

With the rapid advances in modern technology, the need arises for a device that condenses liquid by relying on phenomena other than a gravitational field. Applications in outer space and where gravity forces are limited, require condensing devices that operate continuously regardless of the position they are in, with respect to a gravitational field, or any other reference point. Condensers are therefore required that operate under any loading conditions from that of a normal gravitational field to that of the complete absence of gravity; also including a gravity loading that fluctuates between extremes during operation. With applications in outer space, it is most desirable to have a condenser that has no moving parts and occupies a minimum of area.

Presently, free convection condensers rely heavily on the effects of gravity for condensing the liquid and recovering its condensate. Such condensing devices must then operate in a stationary position so that gravity properly exerts its effect on the process. These condensing devices would be incapable of proper operation where gravity is either absent or varying during operation. If these condensing devices are employed in a weak or zero gravitational field they either have a very low performance or fail to operate since the condensate is removed either very slowly or not at all. The need then arises for a condensing device that operates in any orientation with or without a gravity field and continues to operate in the same efficient manner even if its position or gravity field changes during operation.

My invention envisions a condensing device with no movable parts which operates continuously in any position regardless of whether a gravitational field is present or not.

The chief object of my invention is the provision of a condensing device which condenses a liquid and transports the same to a recoverable area regardless of the position the condensing device is in at the time, or regardless of whether a gravitational field is present as the condensing is taking place.

Another object of my invention is the provision of a condensing device having only stationary members with no movable parts.

Another object of my invention is the provision of a condensing device that acts in combination with the condensate recovering device to operate regardless of the relative position in which they are positioned.

Another object of my invention is the provision of a condenser having no moving parts therein which operates under conditions of a zero gravitational field.

A further object of my invention is the provision of a condensing device whose shape results in flow in a specific direction regardless of the direction of the gravitational field, if any, that is present.

These and other objects of my invention will be more readily perceived from the description which follows:

One of the features of my invention is a condensing device having stationary parts that operates at high efficiency in any position it is placed regardless of whether a gravitational field is present or not.

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The drawings illustrate preferred embodiments of my invention in which:

FIGURE 1 is a view of the condensing device of my invention;

FIGURE 2 is an enlarged diagrammatical view of the tip of the condensing device of FIGURE 1;

FIGURE 3 is a view of a plurality of the condensing devices of FIGURE 1 operating in unison;

FIGURE 4 is a modification of the condensing device of FIGURE 1.

FIGURE 1 illustrates an embodiment of the condensing device of my invention. The construction includes condensing pin 2 having upper portion 6 which is uniform in diameter throughout its length, and lower portion 8 which gradually tapers to rounded end 10, to provide the condensing surface. Surrounding pin 2 is condensate recovery means 4 which in the example of FIGURE 1, embodies wicking material. Means 4 encircles pin 2 at point 7, the intersection between straight section 6 and tapered section 8 of pin 2, permitting only tapered section 8 to project therebelow. By this configuration surface 8 tapers into wicking 4 to properly transport the condensate thereto, thereby preventing interference of non-tapered surface 6, as will subsequently be described. Adjacent surface 14 of wicking 4, proximate straight section 6 of pin 2, is surface 16 which acts as support for pin 2 in maintaining its position with respect to the liquid being condensed. The composition of surface 16 does not need to take a significant part in the condensation process so that its choice can be left to considerations other than those pertaining to heat transfer. Alternatively, for example, surface 16 can be made of insulating material, if desired.

In FIGURE 2, there is shown a view of tip 10 of the condensing device of my invention. This view illustrates the relationship between diameter 20 of tip 10 and the curvature 21 along its length 22. Curvature 21 is determined by the balance between the liquid surface tension forces that accelerate the condensate along the length of the pin toward wicking 4 and the surface friction forces which decelerate the condensate during this travel. Pin 2 is constructed so that condensate flows from tip 10 towards wicking 4 regardless of what position pin 2 is in. This permits the pin to be placed in any position and rotated therefrom during operation without effecting the recovery of condensate.

In FIGURE 3, there is illustrated a plurality of condensing pins 2 of FIGURE 1 arranged in a geometrical pattern. This illustrates the usual arrangement of the condensing pin of FIGURE 1, where it is placed in close proximity to others to provide the maximum condensing effect in a limited area. In this arrangement of FIGURE 3, the wicking or absorption means transports the liquid from the condensing surface to the desired location.

In operation, the vapor to be condensed impinges against tapered section 8 of pin 2 and is condensed thereon. Pin 2 is maintained at a low temperature by means of a low temperature substance in contact with section 6 or by radiation of heat from section 6 to a lower temperature environment to provide the requisite low temperature in section 8 for condensing the vapor impinging thereon. This low temperature region of pin 2 conducts the heat of condensation away from surfaces 8 and 10 of pin to condense the vapor impinging thereon.

As the vapor surrounds and impinges against pin surface 8 and 10 and because of the low temperature maintained throughout pin 2, the vapor condenses and forms a liquid film on surfaces 8 and 10. The liquid in this film on surface 8 and 10 thus begins to rise along the length of tapered section 8 of pin 2. This vertical move-

ment of the condensate is caused by a pressure drop that exists due to surface tension at the liquid-vapor interface as it is being condensed. As the liquid moves forward the circumference of pin 2 that the liquid comes into contact with is greater, the liquid surface tension effect, and hence the local pressure, is thereby reduced. The pressure then at any point along surface 10 and 8 of pin 2 is always decreasing as the local diameter increases. This travelling condensate phenomena is indicated by the arrows 17 shown in FIGURE 1 whereby the condensed liquid flows in a direction towards the bottom surface 12 of wicking 4 from tapered section 8. This phenomena takes place regardless of any gravity present and even takes place in a direction opposite to the force of gravity. As aforementioned, this phenomena relies mainly on the shape of the tapered section 8 of pin 2. Taper 21 is constructed so that the liquid surface tension forces that cause the condensate to flow upward along the length of the pin are always greater than the friction forces and gravity forces which tend to impede the progress of the liquid flowing in this upward direction.

As the liquid flows towards the top of tapered section 8, it finally comes into contact with wicking or absorption medium 4 and is absorbed therein. Wicking 4 is placed at a point just below the interface 7 between tapered section 8 and straight section 6 of pin 2 to recover the liquid before it comes into contact with straight section 6 of pin 2. Because straight section 6 has a uniform circumference, no pressure drop would occur along its length and thus there would be no upward flow of liquid. It is, therefore, essential that the wicking be placed slightly before interface 7 or at the interface so that the liquid does not come in contact with straight section 6 which as aforementioned would defeat the purpose of my condensing device. As previously indicated, the plurality of condensing devices 2 of FIGURE 3 operate in exactly the same manner as the single condensing device of FIGURE 1. The plurality of condensing devices provide an intensified condensing unit in a restricted space and as the single unit 2, also operate regardless of gravity forces present or the position in which they are placed.

FIGURE 4 illustrates a modification of the condensing device of FIGURE 1 in which tapered portion 30 of pin 29 is convex in curvature having a constantly increasing rate of slope throughout its length. The operation of this modification is in principle exactly the same as section 8 of pin 2 of FIGURE 1 which tapers uniformly to curved tip 10. It also will be appreciated that opposite end 32 of pin 29 is curved as opposed to flat end 9 of pin 2.

In place of the wicking and support surfaces of FIGURE 1, a solid surface 34 is provided with pin 29 of FIGURE 4, which surface provides support means for pin 29. The condensed liquid is drawn from surface 30 by means of capillary tubes 36 which pass through surface 34 adjacent pin 29 as shown by arrows 38, to be used as desired. Surface 34 can act as an insulator if desired.

Pin 29 may be employed with wicking 4 in place of solid surface 34 as also pin 2 may be employed with surface 34 with equal efficiency. It is noted that pin 29 may be employed in a plurality arrangement in the same manner as pin 2 is employed in FIGURE 3.

It is now apparent that my invention attains the objectives set forth. Apparatus embodying my invention is sturdy in construction and well adapted for use in conjunction with atmospheric and outer space environments. Ease of operation because of the lack of moving parts makes my device extremely adaptable to a multitude of applications.

Specific embodiments of my invention have been illustrated but the invention is not limited thereto since many modifications may be made by one skilled in the art and the appended claims are intended to cover all such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A device for condensing a vapor and recovering the condensate comprising
 - a pin for condensing a vapor including a surface means tapered so that the condensate flows in a specific direction regardless of gravity forces, and
 - means adjacent the largest diameter of said tapered surface means for recovering condensate from said surface means.
2. A device for condensing a vapor and recovering the condensate comprising
 - a pin having means for condensing a vapor and including a surface means tapered so that the diameter of the pin increases in the direction of condensate flow causing the condensate to flow towards the increasing pin diameter regardless of any gravitational forces present; and
 - means adjacent the largest diameter of said tapered surface means for recovering the condensate from said surface means of said pin.
3. A device for condensating a vapor and recovering the condensate comprising
 - a pin including a first section of constant diameter which projects into an area wherein a low temperature is maintained and a second section being tapered so that the diameter of the pin increases until the diameter of this second section becomes the same as the diameter of said first section, said taper increasing in the same direction as the flow of condensate to cause the condensate that forms along said second section to travel along said second section in the direction of increasing diameter regardless of any gravitational forces present; and
 - means positioned adjacent the largest diameter of said second tapered section towards which the condensate flows for recovering the condensate from the surface of said pin.
4. A device for condensing a vapor and recovering the condensate in a zero gravitational field comprising
 - a pin including a first section of constant diameter which projects into an area wherein a low temperature is maintained and a second section being tapered so that the diameter of the pin increases until the diameter of the second section becomes the same as the diameter of said first section, said taper increasing in the same direction as the flow of condensate to cause the condensate that is formed on said second section to travel along said second section in the direction of increasing diameter by surface tension forces; and
 - condensate absorption means positioned adjacent the point of intersection of said first and second sections of said pin, said absorption means recovering the condensate from the surface of said pin.
5. A device for condensing a vapor and recovering the condensate comprising
 - a pin including a first section of constant diameter which projects into an area wherein a low temperature is maintained and a second section from which the heat of condensation is removed being tapered to a tip so that the diameter of the pin increases until the diameter of the second section becomes the same as the diameter of said first section, said taper increasing in the same direction as the flow of condensate to cause the condensate that is formed on said second section to travel along said second section in the direction of increasing diameter by surface tension forces regardless of any gravitational forces present; and
 - wicking positioned adjacent the largest diameter of said second tapered section for recovering the condensate from the tapered surface of said pin.
6. A device for condensing a vapor and recovering the condensate comprising

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- a pin including a first section of constant diameter which projects into an area wherein a low temperature is maintained and a second section from which the heat of condensation is removed being tapered to a tip so that the diameter of the pin increases until the diameter of the second section becomes the same as the diameter of said first section, said taper increasing in the same direction as the flow of condensate to cause the condensate that is formed on said second section to travel along said second section in the direction of increasing diameter by surface tension forces, regardless of any gravitational forces present, wicking positioned adjacent the largest diameter of said second tapered section for recovering the condensate from said tapered surface of said pin, and means positioned adjacent said wicking through which said pin passes for supporting said pin.
7. A device for condensing a vapor and recovering the condensate comprising
- a pin including a first section of constant diameter which projects into an area wherein a low temperature is present and a second section from which the heat of condensation is removed being tapered to a tip so that the diameter of the pin increases until the diameter of the second section becomes the same as the diameter of said first section, said taper increasing in the same direction as the flow of condensate to cause the condensate that is formed on the tip to travel along said second section in the direction of increasing diameter by surface tension forces, regardless of any gravitational forces present, and a solid support member through which said pin passes and having capillary apertures adjacent said pin through which the condensate is withdrawn from the surface of said pin, said member also providing support for said pin to maintain said pin with its point out into the vapor and with the junction of said first and second sections adjacent the condensate withdrawing apertures.
8. A device for condensing a vapor and recovering the condensate in a zero gravitational field comprising
- a pin including a first section of constant diameter which projects into an area wherein a low temperature is present and a second section from which the heat of condensation is removed having a taper with a constant slope so that the diameter of the pin increases until the diameter of the second section becomes the same as the diameter of said first section, said taper increasing in the same direction as the flow of condensate to cause the condensate that is formed on the second section to travel along said second section in a direction of increasing diameter, because of the liquid surface tension forces that accelerate the condensate, and condensate absorption means through which said pin passes positioned adjacent the largest diameter of said second tapered section towards which the condensate

flows for recovering the condensate from said tapered surface of said pin.

9. A device for condensing a vapor and recovering the condensate in a zero gravitational field comprising

a pin including a first section of constant diameter which projects into an area wherein a low temperature medium is present and a second section from which the heat of condensation is removed having a taper with an increasing slope in the direction of condensate flow so that the diameter of the pin increases until the diameter of the second section becomes the same as the diameter of said first section, said taper increasing in the same direction as the flow of condensate to cause the condensate that is formed on said second section to travel along said second section in a direction of increasing diameter, because of the liquid surface tension forces that accelerate the condensate, and

condensate absorption means through which said pin passes positioned adjacent the largest diameter of said second tapered section towards which the condensate flows for recovering the condensate from said tapered surface of said pin.

10. A device for condensing a vapor and recovering the condensate comprising

a plurality of pins including first sections of constant diameter which project into an area wherein a low temperature medium is present and second sections from which the heat of condensation is removed having tapers so that the diameter of the pins increases until the diameter of the second sections becomes the same as the diameter of said first sections, said taper increasing in the same direction as the flow of condensate to cause the condensate that is formed on the second sections to travel along said second sections in a direction of increasing diameter regardless of any gravitational forces present, and

condensate absorption means through which said pins pass and whereby said pins are spaced from one another, said absorption means being positioned adjacent the largest diameter of said second tapered sections towards which the condensate flows for recovering the condensate from said tapered surfaces of said pins.

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