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CONDENSER

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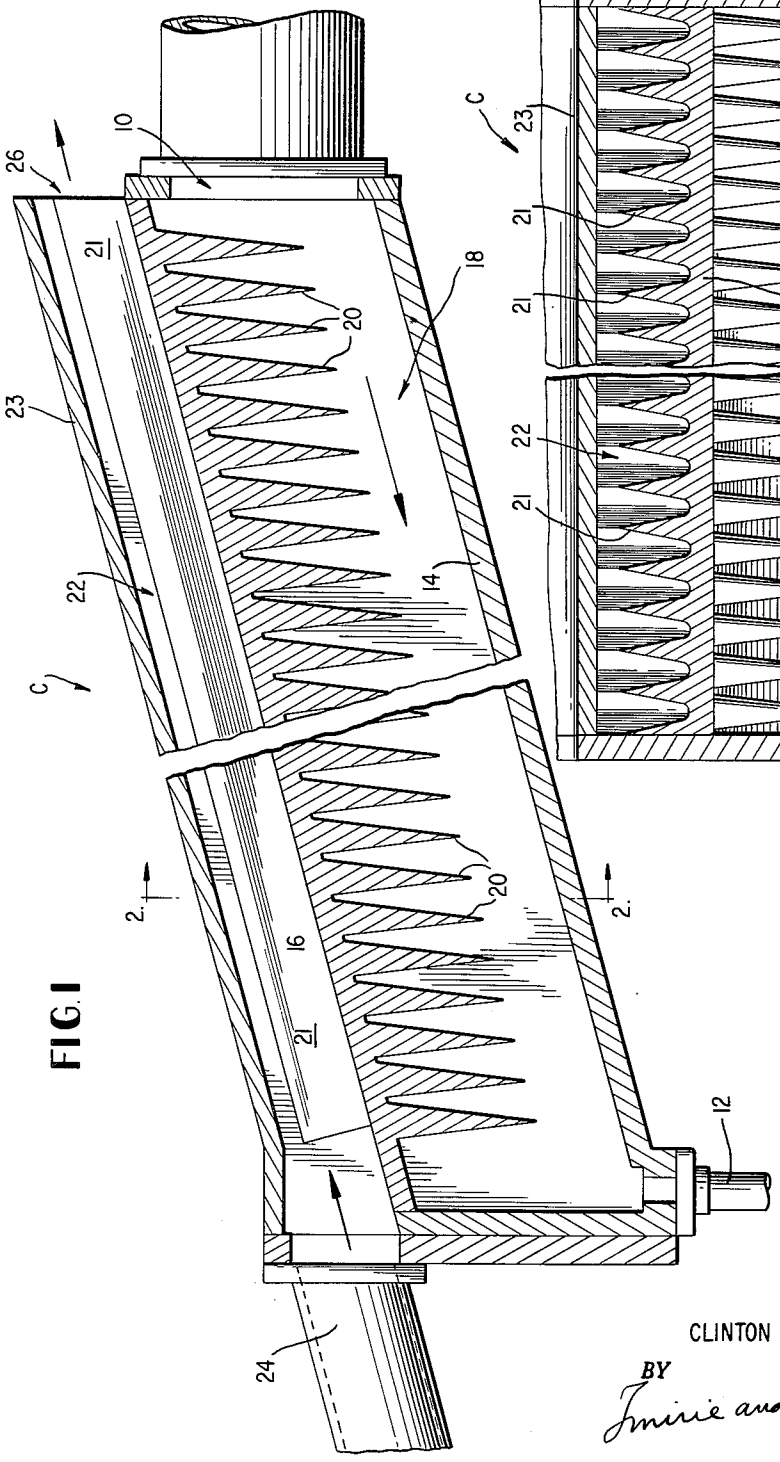


FIG. 1

FIG. 2

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CONDENSER

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This invention relates generally to condensers, and more particularly to a condenser which takes advantage of the cohesive and adhesive characteristics of water to provide for efficient operation.

The object of this invention is to increase the rate of heat flow out of aqueous vapor and into metal by controlling the formation of the condensate into liquid drops before the condensed liquid can spread over the metal surface, thereby forming a film of definite thickness and low thermal conductivity which creates a high resistance to the higher rate of heat flow from the metal surface which is directly proportional to its thickness.

The foregoing object and others ancillary thereto are accomplished according to a preferred embodiment of the invention, wherein the metal surface condensing shape is that of inverted circular cones extruded from or attached to a flat metal horizontal plate. As the condensing vapor wets this cone, the liquid will form around and over this conical area. This area being greater than its surface base area will energize the surface tension and cohesive force faster than ever before continuously accomplished.

The novel features that are considered characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment when read in connection with the accompanying drawings, wherein like reference characters indicate like parts throughout the several figures and in which:

FIG. 1 is a vertical longitudinal section through the condenser comprising the present invention, and

FIG. 2 is a vertical transverse section through the condenser.

Referring now more specifically to the drawings, C designates the inclined condenser comprising the present invention, having a vapor inlet **10** at one end and a condensate outlet **12** at the other end thereof. Note that outlet **12** is disposed at the lowest point in the condenser to provide for proper drainage of liquid.

The floor **14** of the condenser is inclined with respect to the horizontal and between floor **14**, plate **16**, and the side walls, a condensing chamber **18** is formed which communicates with inlet **10** and outlet **12**.

A plurality of inverted cones or stalactite like metal members **20** depend from plate **16**, project into condensing chamber **18**, and provide surfaces upon which the vapor may impinge.

On the upper surface of plate **16** longitudinally extending fins **21** are provided. A top plate **23** encloses a chamber **22** through which the cooling medium may flow. An air inlet **24** in communication with chamber **22** directs air through the chamber between fins **21** and out through air outlet **26**.

In operation, aqueous vapor enters the condenser through inlet **10** the entire metal surface of which is disposed at an angle with the horizontal. The cones are 90° and the flat plate **16** at 10 to 30°. Because of this all the condensate formed, wetting the metal surface, is under gravitational force downward. As the liquid forms, and under its adhesive force spreads and wets the metal surface, it is apparent the wetting must cover and surround each individual cone consequently circularly and downwardly since that is the lateral area of the cone's surface.

Thus, the adhesive force being downward in the direct line of the acting gravitational force increases the rate of liquid flow whereby decreasing the film thickness covering the cone's lateral area. This thinning of the liquid film increases the cooling of the condensate film so rapidly that the surface tension quickly becomes strong enough to form spheres on the colder decreasing lateral surface and disengages as rain drops of water, many before flowing down to the cone's tip where all must disengage as the area for adhesion becomes nearly zero.

By creating spherical formation, the condensing vapor is prevented from blanketing over and wetting the metal to increase surface resistance, thus preventing film formation of a thickness approximating one-fourth the drop's diameter. Water vapor consists of atoms of hydrogen plus atoms of oxygen. In the vapor state, there is no cohesion between these two gases. Even in the form of saturated fog, these atoms are only "pushed" together.

However, aqueous vapor, no matter how small its contact surface is, on contact with a cold surface, changes to a liquid at the point of contact and at that moment an affinity is created for each other that causes cohesion between the molecules which is 73 dynes at 32° F. The rate of increase of this cohesive force causing the surface tension depends only on the rate of temperature decrease in the liquid or condensate.

When the liquid "speck" is formed, this particle posesses adhesion, if it wets the surface, and will spread, and its area in liquid film form as at the contact speck, the adhesion is greatest, there being then no cohesion. By making the temperature drop sufficiently, very quickly, the cohesive force becomes greater than the adhesive force and exerts itself within the liquid to form a sphere. This slow increase in surface tension at the initial period of contact tends to determine the area of the condensate film or drop.

When the rate of cooling is fast enough and the temperature drops sufficiently to generally ease the surface tension enough, the liquid will be contracted into spherical form or liquid drop. In the adhesive stage, the form of the wetting metal can be controlled by its shape and design to assist the surface tension in forming as well as quicken its aggregation.

The aqueous vapor, as fast as liquefied, will, because of its adhesive property, "film-form" in all directions following the metal plate of tube surface. At the moment of condensation, temperature cohesion and adhesion exist, but surface tension does not and cannot exist until the liquid temperature lowers sufficiently. But the surface tension does increase in force with the rapidity of cooling, and when time is decreased to instantaneous, adhesion ceases to be a factor. Therefore, by means that lowers quickly the temperature of the condensate, the force of tension can be increased and drops form continuously and very quickly. Also, by proper design, the metal cooling or wetting surface can be so shaped that the adhesive force causes the liquid film to spread over the metal as shaped.

Surface tension, in effect, is a contracting circular force causing spherical drop formation when its intensity becomes greater than its external adhesive force. Therefore, in the old method of film-surface-spread condensation, because of no cohesion in the condensed liquid and its obstinate adherence, the film thickness becomes so great that the heat-flow from the high conductivity of the metal wetted metal surface is slowed to the low conductivity of water at its condensation temperature and pressure.

Thus, when condensing of aqueous vapor (steam) is slowed to the conductivity of water the temperature of the condensate and the rate to that of the water coefficient,

then surface tension develops so slowly that the film flow remains unbroken except when its density increases and is disrupted by gravitational force. In this device, making use of the controlled or forced film shape the liquid must take, it will be seen that the following things are accomplished:

First, the high conductivity metal surface which the aqueous vapor must contact is greatly increased.

Second, because of the greater metal surface area attained on the vapor side, the effective mean thickness of the plate of the metal can be reduced, guaranteeing a faster heat transfer rate from the metal surface into the aqueous vapor during its re-change of state to liquid and thereafter.

Third, by the adhesive force movement of the liquid on the metal, it can only be circular in flow and in perpendicular direction on the cones, and the depth or thickness of the condensed film is limited by the gravitational pull as its density increases and because of its weight and adhesion, causes the liquid to flow down the wetted face of the cone's smooth surface.

Fourth, because the cone's wetted face area is greater than its base, the rate of cooling becomes greater than that possible from a flat or curved tube surface. Because of this high cooling rate, the surface tension in the liquid is formed first, and quickly increases in force, thus creating a hollow liquid sphere which flows down to the cone's tip where its adhesive force is less than the pull of gravity.

It is possible to use atmospheric air as the cooling medium in contact with the condensers outside or cooling surface. This is true for several reasons:

(1) Dry air is without adhesion to metal, therefore, dry air does not wet the metal wall, therefore,

(2) High velocity air flow with turbulence becomes very effective in dissipating the heat from the heated wall,

(3) And by this structure, the effective air cooling surface is increased from the flat plate area.

(4) The cooling side, when raw water is to be used as coolant, must be smooth for streamline flow. When air is the cooling fluid, then the metal face may be slightly rough to attain turbulent air flow.

The design of this condenser and its control of the condensate form takes into consideration the fluid to be used as the cooling medium. The metals used in its structure, conductivity, design, thickness, shape and other dimensions such as diameter and length of cones are influenced by the type of coolant used.

That is to say, the condenser may be cooled by salt water, river water, spring water or gases such as air under force or thermal flow, but each has different requirements which may dictate the use of different metals.

The condenser particularly illustrated and described is for the use of ambient air for two very important reasons:

(*a*) The elimination of chemical reaction between it and the air-face.

(*b*) Elimination of soluble gases and soluble chemicals and deposition of suspended "dirt."

Using air as the heat extracting medium, pure metals can be used with their high conductivity instead of alloys with their low conductivity. For example, for chromium alloys, $K=19.3$ to 13.8, whereas with wrought iron, $K=36$, and copper (pure), $K=216$. Because of this, it is possible to make the stalagtite cones very small with copper as the conduction material, as surface tension increases quicker and thus the condensate drops are formed more rapidly.

We can now show that although K_w for water is higher than K_a for air, because of its great adhesive force and film thickness, the rapid heat flow outward into the coolant from the metal is reduced by the: liquid coolant film thickness, rough surface, and the turbulent flow and scale of mud-added resistances.

However, it is to be noted that the laminar air flow over the cooling metal face does not adhere to or air-wet the metal and therefore, without adhesive force, its heat removal rate from the metal is increased by a flow velocity causing violent turblence in the air stream.

Because of this and the absence of pitting scale and oxides, where the ambient air is free of acid, the heat transfer from the metal exterior cooling face into the air will be relatively rapid. When using air as the coolant and when drops from three to five millimeters in diameter are desired, the cone dimensions will be 3/8" altitude and 7/32" diameter. The cone dimensions affect the surface tension and heat content, and the greater the surface tension, the less the cone length.

Although a certain specific embodiment of the invention has been described, it is obvious that many modifications thereof are possible. The invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the spirit of the appended claims.

What is claimed and desired to be secured by Letters Patent is:

1. A condenser comprising an elongated hollow body formed by substantially parallel upper and lower walls and parallel end walls completely enclosing the space within the body, a heat conducting partition wall intermediate said upper and lower walls and substantially parallel thereto dividing the space within the body into an upper coolant chamber and a lower vapor chamber, said upper, lower and partition walls being inclined to the horizontal, a vapor inlet at the upper end of said vapor chamber and a condensate outlet at the lower end of the vapor chamber, a coolant inlet to said coolant chamber at the same end of the condenser as the condensate outlet and a coolant outlet to said coolant chamber at the other end of the condenser, the walls of said body being imperforate except for said inlets and outlets, the lower surface of said partition wall having a plurality of inverted cones integrally protruding downwardly therefrom, said cones having axes disposed substantially vertically and being adapted to quickly cool vapor and form spherical condensate droplets which will flow by gravity to and off the cone apices, and a plurality of longitudinally extending fins along the upper surface of said partition wall extending upwardly into said coolant chamber for substantially the full length thereof for conducting heat to a coolant fluid in said coolant chamber.

2. A condenser according to claim 1 wherein said vapor and coolant chambers are parallel and have longitudinal axes disposed at an angle from 10 to 30 degrees with the horizontal.

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