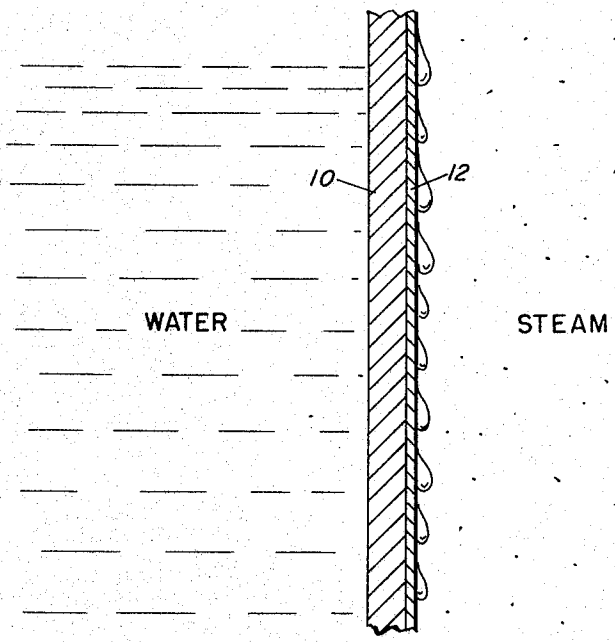
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METHOD AND APPARATUS FOR DROPWISE CONDENSATION

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METHOD AND APPARATUS FOR DROPWISE CONDENSATION

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This invention is concerned with promotion of dropwise formation of water on the surfaces of heat transfer devices, particularly condensers.

Advantages of dropwise condensation over film-type condensation, particularly in decreased thermal resistance between vapors to be condensed and the cooling fluid, is well known in the prior art, e.g., U.S. Patent No. 2,248,909. This patent discloses the use of zirconium and tantalum to promote dropwise condensation. Other materials have also been employed for this purpose, e.g. chromium (U.S. Patent 2,259,024), oleic acid (U.S. Patent 2,919,115), resins such as polyfluoroethylene (U.S. Patent 2,923,640) and copper sulfide (Trans. A.I.Ch.E, vol. 31, No. 4, Dec. 1935, pages 593–621).

It has now been found that very effective dropwise condensation on condenser surfaces may be achieved by the use of a platinum metal as the surface on which the water condenses. This surface may be achieved by the use of a solid platinum metal or by coating another metal with a platinum metal.

The platinum metal coatings are usually achieved by means of electroplating. A base coat of nickel is usually advisable to enable the use of smaller amounts of platinum metal. Any application technique from which a final smooth surface can be obtained may be employed. This could include, in addition to electrodeposition, vacuum deposition (including sputtering), chemical deposition, mechanical cladding or flame spraying.

Although rhodium has been found to give particularly good results, other platinum metals (platinum, palladium, osmium, iridium and ruthenium) are also effective promoters of dropwise condensation.

Although distilled water was used in the examples below, the method of the invention is also beneficial in promoting dropwise condensation of vapor distilled from water containing impurities, e.g., sea water.

The accompanying drawing, which is not to scale, schematically illustrates a device according to the present invention. In that drawing, **10** represents a metal substrate which may be, for example, nickel as explained above. **12** represents a coating of a platinum group metal, which, as explained above, may be of a platinum group metal,, such as platinum, palladium, osmium, irridium, ruthenium or rhodium.

It is seen that steam dropwise condenses on the coated side of the lamination when a cooling fluid, such as, for example water, is brought into contact with the opposite face of the plate.

The invention will be more specifically illustrated by means of the following examples.

Example 1

The heat transfer apparatus used in this example consisted of a copper block having cooling water flowing through a hollowed out central portion. The block was suspended over boiling water in a heated vessel under

slightly-above atmospheric pressure. Attached to the block were 42 test 1 x 3 inch metal flats consisting of various test materials on different substrates, having a total thickness of about 0.05 inch. The block and flats were arranged so that the flats were disposed vertically over the boiling water. Steam arising from the boiling water condensed on the metal flats, which were in thermal transfer relationship with the cooled copper block. The water which condensed on the test flats dripped back into the boiling water.

Rhodium, platinum and palladium samples tested and results are given in Table 1. The platinum and palladium flats were commercially rolled and polished sheet stock cleaned with detergent and rinsed with pure ethanol. The electroplated rhodium coatings were approximately 0.001 inch thick and were polished with Nos. 400 and 600 aluminum oxide and jeweler's rouge. The dropwise quality, Q, defined by the following equation, has been found to give a reliable measure of the ability of a surface to promote dropwise condensation.

Q=1.0 times the precent sample area which is dropwise condensing +0.5 times the percent mixed area.

"Drop appearance" in the table is based on the following scale:

E (Execellent)—Drops have circular base line and high contact angle. Sliding drops are of small diameter.

G (Good)—Drops nearly circular ellipses. Base line convex.

F (Fair)—Drops often have base lines with straight line segments. Drops grow to large size before sliding.

P (Poor)—Drop base lines often have concave segments. Usually tracks and/or droplet residues result in sweeping. This class when seen is often a precursor to mixed condensation.

As is apparent from the data of the table, the rhodium surfaces in particular, exhibit dropwise condensation even after long periods of exposure to condensation.

Example 2

The heat transfer apparatus used in this example consisted of closed-end bayonet-type condenser tubes, 0.5 inch in diameter and 5 inches long. These tubes were suspended vertically over boiling water in a closed vessel with steam pressure maintained at 9 p.s.i. gauge. Water which condensed on the tubes dripped into self-flushing collectors (permitting measurement of condensation rate) which emptied into the boiling bath. Table 2 shows a comparison of condensation rates for three tubes: (1) 10 microinch electroplated rhodium over 100 microinch electroplated gold over 90–10 Cu-Ni alloy; (2) 500 microinch electroplated chromium over 1000 microinch nickel over 90–10 Cu-Ni alloy; (3) 90–10 Cu-Ni alloy control. These tubes had the following exposure history: 2000 hours in steam from distilled water followed by 550 hours in steam from sea water.

As is apparent from the data of the table, the condensation rate with the rhodium surface is significantly higher than that with the bare 90–10 Cu-Ni control sample or with the chromium-plated sample, both of which show filmwise condensation.

The invention may be used in any heat transfer device in which heat is removed from a vapor through a heat transferring wall by means of a suitable cooling fluid, either liquid or gaseous, the vapor being condensed on

the heat transferring wall. Examples of such devices are heat exchangers, evaporators, condensers, tubular heaters, tempering coils, etc.

TABLE 1.—CONDENSATION BEHAVIOR AS A FUNCTION OF TIME

Sample Description	115 Days		150 Days	
	Q	Drop Appearance	Q	Drop Appearance
Rhodium coated on silver	100	G	100	G+
Rhodium coated on 90-10 Cu-Ni alloy	100	G+	100	E−
Rhodium coated on mild steel	100	G+	85	G−
Platinum metal	62.5	F−	92.5	F
Palladium metal	97.5	G	97.5	G−

TABLE 2.—CONDENSATION RATE AT A COOLING WATER VELOCITY OF 8 FT./SEC.

Sample description:	Condensation rate (cc./sec.)
Rhodium on 90–10 (dropwise)	0.72
Chromium on 90–10 (filmwise)	0.54
90–10 Cu-Ni control (filmwise)	0.53

What is claimed is:

1. A method of improving the condensing efficiency of a heat-transfer device in which water vapor is condensed on a cooling surface, comprising utilizing a platinum metal as the cooling surface to promote dropwise condensation.

2. The method of claim 1 in which the platinum metal is rhodium.

3. The method of claim 1 in which the cooling surface is formed by coating a platinum metal on a substrate consisting of another metal.

4. The method of claim 3 in which the platinum metal is coated on a Cu-Ni alloy base.

5. In a heat transfer device comprising a cooling fluid zone, a water vapor zone having a temperature greater than that of said cooling fluid zone, and a heat conducting impermeable partition disposed between said zones, whereby mass transfer between said zones is prevented, said partition having a first surface in contact with said cooling fluid zone and a second surface in contact with said water vapor zone, the improvement comprising employing a platinum group metal as said second surface.

6. The device of claim 5 wherein the platinum group metal is rhodium.

7. The device of claim 5 wherein said partition is metallic and said second surface comprises a coating of a platinum group metal.

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