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INTEGRAL VAPOR COOLING SYSTEM

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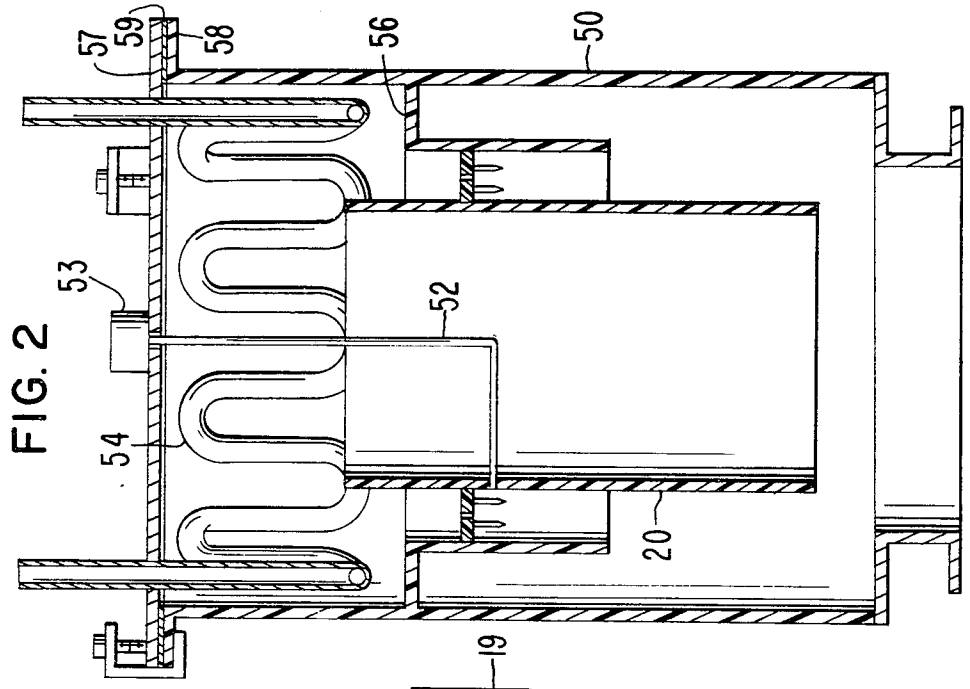


FIG. 2

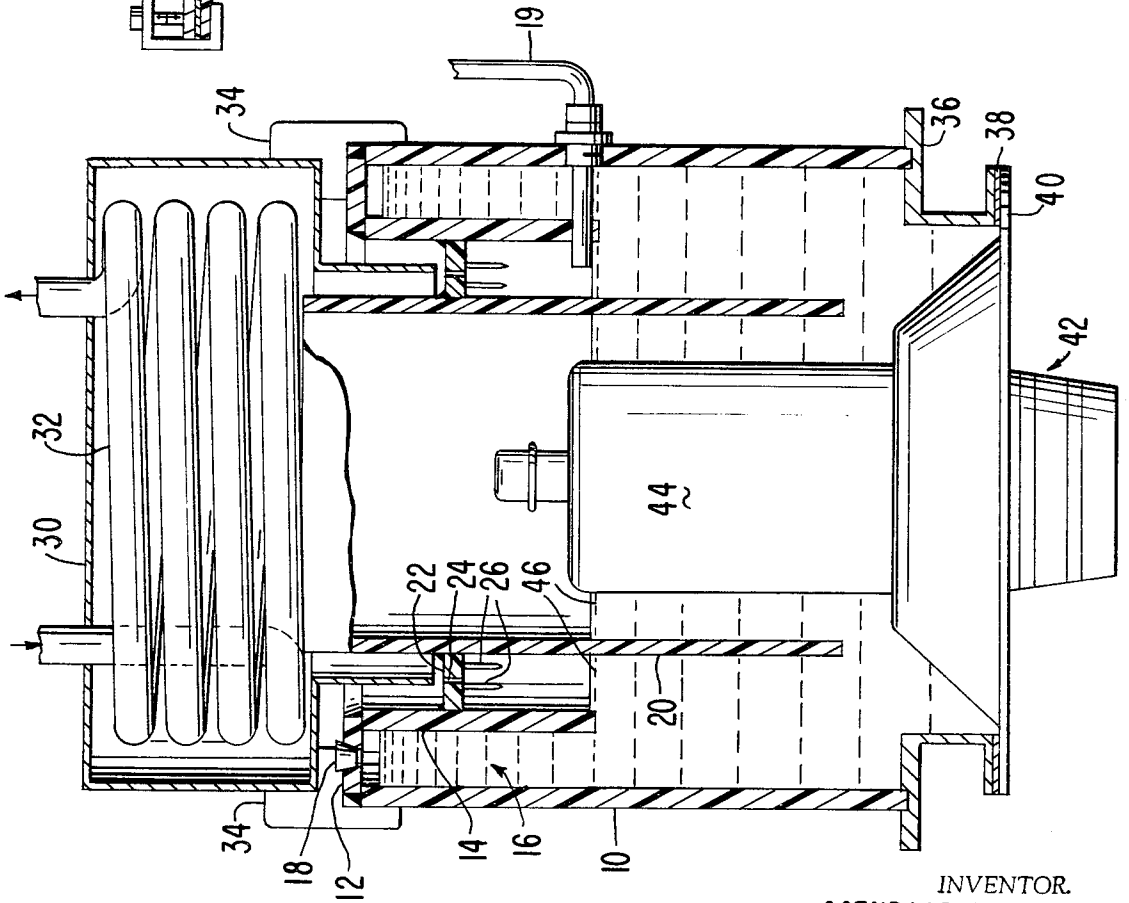


FIG. 1

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INTEGRAL VAPOR COOLING SYSTEM

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ABSTRACT OF THE DISCLOSURE

An integral vapor cooling system comprising a tubular shell, a tubular boiler housed within the shell in spaced relationship therewith, and means for sealing the lower end of the shell with an object to be vapor-cooled housed within the boiler. Portions of the shell and boiler are adapted to be filled with a liquid cooling agent to a predetermined level with liquid communication between the portions under the predetermined level. Condensing means are disposed circumferentially about the boiler above the liquid level. Means are provided for deflecting vapor rising above the liquid level within the boiler to the condensing means. Means within the integral system are also disclosed for controlling the level of liquid coolant and for electrically insulating the condensing means from the object to be cooled.

BACKGROUND OF THE INVENTION

Vapor cooling systems typically comprise a boiler, a condenser or heat exchanger, a water level control box, an auxiliary water supply, and a water-water vapor separator. Heretofore these components have usually been structurally distinct and independent. They have been linked together by various interconnecting pipes, joints, voltage isolators and pressure equilization lines to form an operative vapor cooling system. Inherently these systems have been heavy, occupied substantial space, and have been mechanically vibrant.

Accordingly, vapor cooling systems having all their component parts integrally housed within one confine are desirable insomuch as they occupy less space and are not as heavy or vibrant as classical systems. One such system is disclosed in U.S. Pat. No. 2,886,746 as comprising an open-ended tube spacially enclosed by a closed-end tube which is largely filled with a liquid cooling agent. The closed-end tube is placed in a relatively cool environment whereby that portion of the tube above the liquid serves as a condenser itself when a heated object housed within the open-ended tube evaporates some of the cooling agent. This condenser structure inherently limits the thermal dissipative capacity of the system. Its utility is thus confined to the evaporative cooling of low powered devices such as transistors.

U.S. Pat. 2,882,449 discloses another example of an integral vapor cooling system in which the boiler-condenser assembly forms a self-contained unit. Here condenser piping is submerged in water within the boiler to maintain the water itself at a temperature well below its boiling point. The water serves to condense vapor which is generated on the surface of a body being cooled within the water. Much as in the case of the first mentioned patented example, the condenser here too has been found to be incapable of dissipating the quantities of heat generated by the high powered electron tubes of today. Such condensers inherently have less efficiency than those in which the condenser pipes are housed in a gaseous medium.

FIG. 19 of British Patent 706,209 provides yet another example of an integral vapor cooling system, and in this case a conventional condenser is used comprising coiled condenser piping housed in a gaseous medium above the system boiler. A tubular conduit links the top of the boiler with the bottom of the condenser housing. However, both the vapor rising from the boiler and the condensate descending from the condenser must pass through the linking conduit. As a result descending condensate impeads the ascent of vapor. This system is thus effectively limited to the vapor cooling of medium powered devices. Furthermore, this integral system, as well as the two others previously described, contains no means for maintaining the liquid coolant level constant within the boiler, for replacing liquid coolant lost to the system, or for breaking up the columnar flow of condensate returning from the condenser to the boiler for voltage isolation purposes.

Accordingly, it is an object of the present invention to provide an integral vapor cooling system occupying less space than existing vapor cooling systems having equivalent heat dissipating capacity.

Another object of the invention is to provide a vapor cooling system which is lighter in weight than existing systems of equivalent cooling capacity.

Yet another object of the present invention is to provide a rugged vapor cooling system which produces less mechanical vibration during operation and which is capable of withstanding such self-generated vibration.

Another object of the invention is to provide a vapor cooling system having an external configuration generally conforming to that of the object to be vapor-cooled therein in order to conserve space.

Another object of the invention is to provide an integral vapor cooling system adapted to fit coaxially about the tubular anode of an electron tube.

Yet another object of the invention is to provide a vapor cooling system having improved uniformity of flow by a liquid cooling agent such as water over the surface of a tubular object to be cooled therein such as an external anode of an electron tube.

SUMMARY OF THE INVENTION

Briefly described, the present invention is an improved integral vapor-cooling system comprising a shell, a tubular boiler housed within said shell in spaced relationship therewith, the boiler weir defining a boiling zone. Means are provided for sealing one end of the shell with an object to be vapor-cooled housed within the boiler in the boiling zone. The shell is adapted to be filled to a predetermined level with a liquid cooling agent. Condensing means are disposed circumferentially about the boiling weir zone above the liquid level. Means are provided for deflecting vapor rising above the liquid level in the boiling zone to the condensing means. Liquid communication means are also provided below the liquid level through the bounds of the boiling zone.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a cross-sectional view of a vapor-cooling system incorporating features of the present invention. An electron tube is shown in elevation with its anode housed within the system and submerged in a liquid coolant.

FIG. 2 is a cross-sectional view of another embodiment of the present invention without an object to be cooled or cooling agent housed therein.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now in more detail to the drawing, there is illustrated in FIG. 1 a vapor-cooling system having a tubular shell **10** preferably made of a dielectric material such as plastic defining the radial bounds of a tubular

boiler. The upper end of shell **10** is sealed to the outer surface of a dielectric ring **12**. A dielectric, tubular member **14** is disposed coaxially within shell **10** with its upper end sealed to the inner surface of ring **12**. Shell **10**, ring **12** and tubular member **14** serve to define a void **16**. Ring **12** has a small hole into which a plug **18** fits, the purpose of which will be explained later.

A dielectric tubular boiler **20**, also preferably made of plastic, is coaxially mounted within tubular member **14** by dielectric ring **22** which is sealed to both the boiler and the tubular member. Tubular boiler **20** partially defines a boiling zone which, for the purposes of this specification, is designated as being that cylindrical column of space within the integral vapor cooling system which passes through and is partially bound by the boiler. Ring **22** has a series of holes **24** therethrough. A series of parallel spikes **26** project downwardly from ring **22** in spacial relationship with holes **24**. Ring **22**, holes **24** and spikes **26** serve to interrupt the flow of liquid to render such flow electrically nonconductive as will be hereinafter operatively explained.

A removable condenser having a tubular casing **30** housing a coiled condenser pipe **32** is coaxially situated above boiler tube **20**. The condenser rests on three or more separators **34** which preferably are made of plastic. Inlet and outlet piping in communication with the coiled pipe project through the top of casing **30** as shown. The space between adjacent separators provides the integral system with large air vents.

To the lower end of tubular shell **10** is sealed in water-tight relation a U-shaped member **36** preferably made of copper. Flange **40** of an electron tube **42** is secured to the U-shaped member by several clamps (not shown). Washer **38** is placed between the U-shaped member and flange **40** to form a water-tight seal therebetween. Anode **44** of the electron tube is coaxially positioned within boiler tube **20**.

Once the anode of electron tube **42** has been placed within the vapor cooling system and flange **40** thereof secured to U-shaped member **36**, plug **18** is removed and the boiler filled with a liquid having a high latent heat of vaporization, such as distilled water. Plug **18** is then replaced in ring **12** and drain **19** swiveled downwardly. This causes the water level within boiler **20** to drop to surface level **46** while the water level within void **16** remains stationary. The condenser is then placed atop separators **34**. The system is now ready for operation.

When electric power is applied to electron tube **42** anode **44** heats to a temperature in excess of the boiling point of the surrounding water. As a result water adjacent the anode vaporizes thereby liberating 540 calories of heat per gram of vaporized water from the anode. Vapor bubbles form on the anode surface, rise to the water surface and ascend towards the condenser. This action by the vapor bubbles produces water surface turbulence which causes sheets of water and water droplets themselves to become airbourne, intermixed with the vapor. In ascending through boiler **20** above level **46** in route to the condenser much of this airbourne water is deaccelerated and caused by gravity to fall back to the water surface. Thus the upper portion of weir **20** serves as a water-water vapor separator. As the boiler is quite wide, the path through which vapor and airbourne water flows is unimpeaded virtually preventing any practical problem of back-pressure from arising.

As the ascending vapor centers the condenser it is laterally deflected by casing **30** into contact with coiled pipe **32** through which a coolant flows. The vapor condenses on the surface of the pipe. The condensate then falls onto and spreads laterally over much of the upper surface of dielectric ring **22**. Water on the upper surface flows through holes **24** and onto the lower surface of water will then flow down spikes **26** and form pendant the ring to which it is held by adhesive force. The droplets on the ends thereof which individually fall to water surface. **46**. The function of ring **22**, with its holes and spikes, is to break up the columnar flow of condensed water from the condenser to the body of water surrounding anode **44** in the boiler to prevent such flow from providing a high resistive electrically conductive path between the anode and the condenser which is at ground potential. The dielectric nature of the material forming the structure communicating between the body of water and the condenser prevents electric flow through the structural members themselves. With the fall of condensate to the water surface, he vaporizaion-condensation cycle is complete: Though the returned condensate is initially merged into that portion of the body of water between boiler **20** and shell **10**, it is free to descend and flow under the lower end boiler **20** and to the surface of anode **44** from every radial direction. This, of course, provides optimum mechanical flow.

The vapor cooling system of FIG. 1 also has integral means for replacing water lost to the system by the slow venting of water vapor. This is the function of void **16** which serves as an auxiliary reservoir once it is filled with water. Should water surface level **46** fall below tubular member **14** an air bubble will immediately pass thereunder and ascend to the top of void **16**. This will permit the column of water within the void to descend since air is now thereabove rather than a would-be vacuum. This water descent will in turn cause level **46** to rise back to the lower end of tubular member **14** at which level the system is designed to operate.

FIG. 2 illustrates another embodiment of the present invention without holed and plug **18** and without an object to be cooled nor a cooling liquid shown housed therein. As in FIG. 1 the system is designed to cool an electron tube having an external anode mounted in an anode up position. But of course the system could easily be converted for anode down mounting, if desired.

In the embodiment of FIG. 2 shell **50** houses that section of the vapor-cooling system which shell **10** does in FIG. 1, namely, the boiler. The shell also provides tubular side walls for the condenser. A pressure relief line **52** and valve **53** are provided in lieu of open vents between the boiler and condenser as in the case of FIG. 1. Accordingly, less water is lost in this embodiment during operation through the slow venting of water vapor.

A circularly arranged, serpentine pipe **54** is coaxially disposed above ring **56** within shell **50**. Inlet and outlet piping communicate with pipe **54** through a removable roof **57** which is clamped tightly to shell flange **58**. Washer **59** is placed between the roof and shell flange to insure water-tight security therebetween. As in the system of FIG. 1 the condenser pipe has greater diameter than boiler **20** in order that the condensate fall outside weir **20** and thus not impead the flow of ascending vapor therebetween.

It should be understood that the above-described embodiments are merely illustrative of two applications of the principles of the invention. Obviously, many modifications may be made in these specific examples without departing from the spirit and scope of the invention as set forth in the following claims.

What is claimed is:

1. In an integral vapor-cooling system, means defining a centrally disposed boiler having a boiling zone therein to receive an object to be vapor cooled and adapted to be filled with a liquid cooling agent to a level, means defining a vapor condenser disposed in vapor communication with said boiler and having a portion disposed above the liquid level in said boiler for condensing vapor rising from said boiler into said condenser, means defining a condensate return passageway disposed externally of said boiler in liquid communication between said condenser means and said boiler for returning condensate to said boiler at a position below the liquid level in said boiler, the improvement comprising, means forming a

liquid coolant reservoir in liquid communication with said boiler and disposed surrounding said boiler, said reservoir having an elevated portion to be filled with a column of liquid coolant above the liquid level in said boiler, means for sealing said elevated reservoir portion containing said column of liquid coolant relative to atmospheric pressure to support a subatmospheric pressure head on the liquid column in said reservoir portion, and liquid level control means for introducing air into said sealed portion of said reservoir to release liquid therefrom into said boiler when the liquid level in said boiler falls below a predetermined level.

2. The apparatus of claim 1 wherein said condensate return passageway is an annular passageway concentrically disposed of said boiler intermediate said boiler and said reservoir.

3. The apparatus of claim 2 including vent means for venting said condensate return passageway to atmospheric pressure.

4. The apparatus of claim 1 wherein said liquid level control means comprises a passageway interconnecting said reservoir and said condensate return passageway at the predetermined liquid coolant level in said boiler such that when the liquid level in said boiler and condensate return passageway falls below the predetermined liquid level air will flow into said reservoir to release liquid coolant therefrom into said boiler and condensate return passageway.

5. The apparatus of claim 2 wherein said annular condensate return passageway includes a perforated ring having a plurality of dependent spikes carried therefrom for catching the condensate and for breaking the condensate into droplets to electrically insulate said condenser from the object being cooled.

6. The apparatus of claim 1 wherein said boiler, condensate return passageway and reservoir are made of electrically insulated material for electrically insulating the object to be cooled from said condenser.

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165—74; 313—12, 22, 34, 36