Kit to cool bus without puncturing any part of bus

Brief of Invention:

In tropical climates, air-conditioning is not a luxury but a necessity. In summers of tropical climatic areas, effect is more pronounced. Add to it the greenhouse effect and interior of a standing or parked bus in sunshine can reach up to 55 degrees Celsius even while ambient temperature is below 40. The more sophisticated a bus, more glass windows it has and more hot it gets. Of course the air conditioning gets to the task the moment passengers step in. But look at the unusual load on air conditioner and hence engine to get from 55 to 25 for comfort.

The current invention is neither a substitute for air-conditioning system nor a use in cold climates. But looking at fact that more than 70 per cent of Earth's population* lives in hot climates (Asia being densest is mostly under scorching Sun), this invention can:

1. Save air-conditioning load on engines of buses and cars used as transport in hot climates. *Some cities like New York noted for cold winters and snow, touch 40 degrees easily in summers and hence finding air conditioners in city isn't common.
2. Enable poor people to move in non air conditioned buses of ordinary kind.
3. Lengthen life of metallic paint on exterior that fades at high temperatures. Enable using dark colors as bus external colors because dark colors are notoriously heated.
4. Can be retrofitted in sense that bus need not be punctured in any way and kit can be installed from outside only. The warranty given by bus manufacturer isn't violated.
5. Additionally solar panels on roof of bus can power this cooling kit and hence there is no load on engine.

Description:

The air under the bus (shaded region) is cooler than on its rooftop (Sun lit region). This difference is highest in parked vehicles when engines are not running and hot moving road not below it. Animals like dogs and cats often rest underneath parked

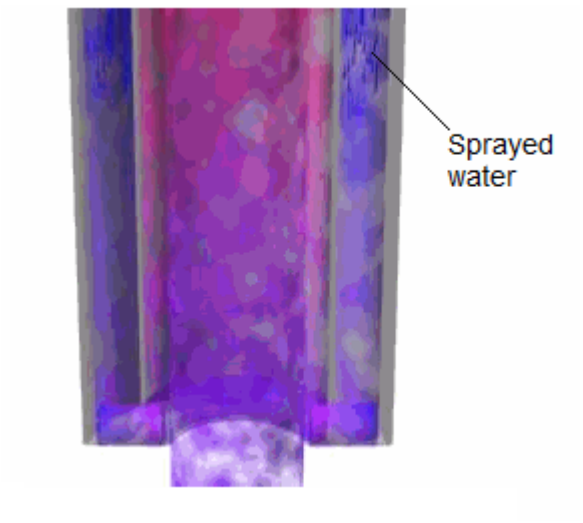
buses. Relatively cooler air is pumped from underneath the bus and then with water added, is sprayed on to the roof. Certain fixtures are installed over roof to enable efficiency of heat transfer between moisturized cooler air and hot dry roof. Roof is cooled by two mechanisms: a) Heat transfer primarily by conduction, convection and bit by radiation modes; 2) Well known physical effect ‘evaporation causes cooling’ as water evaporates away extracting heat.

To maximize efficiency of above two mechanisms, several existing patented inventions and well-known physical effects are used. The invention is unique because it combines several inventions harmoniously and efficiently in manner not done before. The invention is also unique because of its application to a technology not attempted before. The invention is also unique because it captures temperature difference in two regions close to bus – top and below.

Few Effects ,Patented inventions that inspired present invention

1. Cooling by spraying water

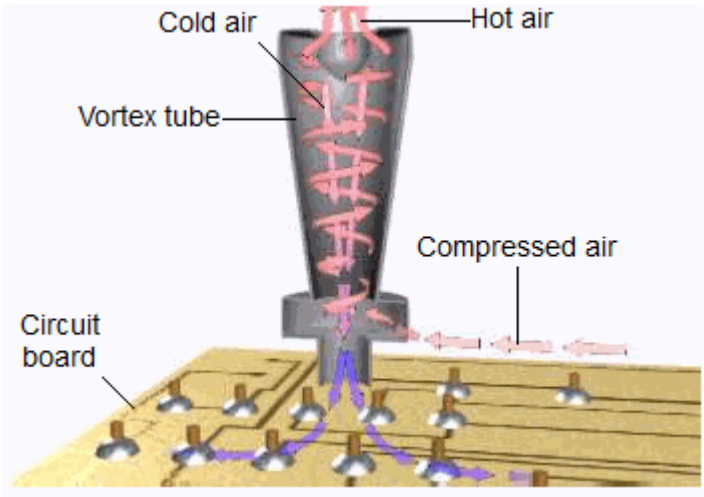
   This effect used in refrigeration plants and centrally air condition systems. U.S. Patent. 4,854,129; Hickley P., Classen C.J., Transvaal Province, South Africa.; Aug. 8, 1989; "Cooling process and apparatus."



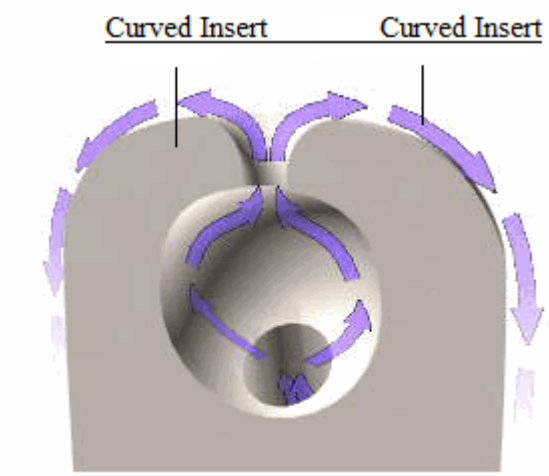
2. A vortex tube is used to supply air on to roof to separate out cold axial flow of air.

   This has been inspired from a patented invention used in air cooling of circuit boards. A vortex tube is used to supply air on to roof. This separates compressed air into a hot peripheral flow and a cold axial flow. The flows are opposite in direction. The cold air is directed at a circuit board. Cooling is accompanied by the removal of volatile components that remain after soldering. *The hot air is discarded in present invention whereas in above patent it is collected by a separate pipeline.*

   In the patent, an air flow produced by a fan cools soldering points of circuit boards. The temperature of the air flow is not high enough to accelerate solder crystallization. A cool air flow from a vortex tube cools a circuit board. U.S. Patent. 5,623,829; BTU International.; Apr. 29, 1997; "Vortex tube cooling system for solder reflow convection furnaces”



3. The roof of bus has curved surface inserts so that air adheres to them. Inspired from cooling of gas turbine vanes

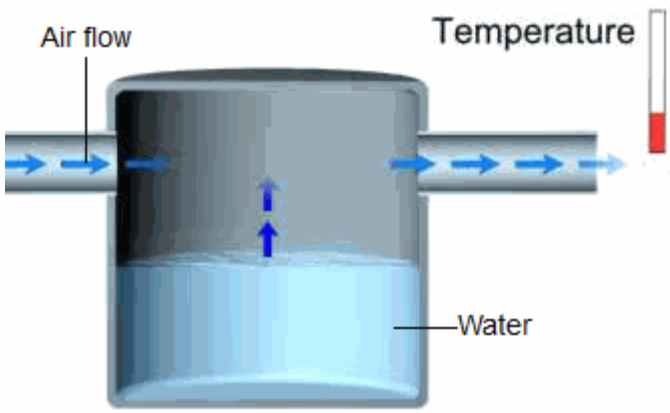


The cool air flow gets onto the gas turbine vanes. The changing shape of the external surface of a vane changes the character of the air flow motion. If a laminar flow is generated at the interface, the air flow adheres to the surface of the vanes in accordance with the Coanda effect. The increased contact area of the cool air and the vane improves the heat exchange and the cooling. Such cooling of vanes produces the air flow damping. This reduces the noise made by the operating turbine. US Patent 5 097 660, 03. 24. 92,

Coanda Effect Turbine Nozzle Vane Cooling. Jack R. Shekleton, Sundstrand Corporation, Rockford, USA.

4. Moisturizing subsystem. Inspired from portable cooling unit,

Shade and air circulation are provided to ease heat stress on athletes, spectators, and firefighters. More complicated solutions, such as circulating refrigerated air, are generally not favored because of their high cost. Moreover, such methods would require a team of workers to move, install, operate and maintain the setups, and would require some means to vent the warm side of the cooling devices. The portable evaporative cooling unit includes a conduit structure with an inlet and outlet, an air blower, and several nozzles to emit water or other coolant into an air flow. The nozzles are connected with the coolant source and are positioned in the conduit structure so that the sprayed coolant forms a mixture with the air. The temperature of the mixture decreases due to the evaporation. One or more porous membranes can be placed along the flow path, particularly at the outlet. The membranes restrict the flow to maintain the inflation. The cooling unit is advantageous for a range of applications. U.S. Patent. 5,497,633; Jones Michael; Mar. 12, 1996; “Evaporative cooling unit”; Cool Zone Products & Promotions, Inc.



5. Drop wise evaporative cooling – Well known physical effect.

   Liquid droplets start evaporating in a gas flow due to a difference in liquid vapor partial pressure on the droplet surface and in the gas. The latent heat of evaporation of liquid absorbs energy from the gas. If there is no energy source in the gas, its temperature will drop. The rate of cooling depends on the mutual velocity of droplets and gas, droplet size, and latent heat of evaporation of the liquid used. 1. The liquid vapor may not change the heat transfer characteristics of gas 2. The liquid and gas may not chemically interact 3. The liquid need not fully evaporate

Effect Index

$$DT = \frac{G_l\, r}{G_g\, c_p}$$

DT – gas cooling degree, K
G_l – evaporating liquid flow rate, kg/s
r – latent heat of evaporation of liquid, J/kg
G_g – mass flow rate of gas, kg/s
c_p – specific heat capacity of gas, J/kgK

Limitations
The cooling degree depends on the gas and liquid flow rate, type of liquid used.

Materials
At the air flow rate of 5.5 kg/s, supply of a sprayed water with the flow rate of 0.05 kg/s provides air cooling by 22°C.

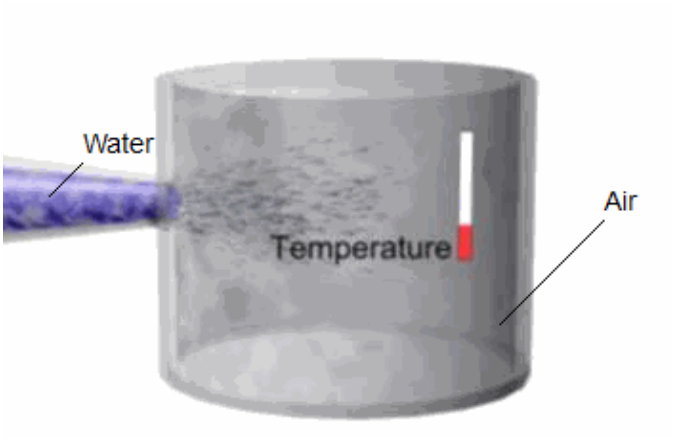
Formula

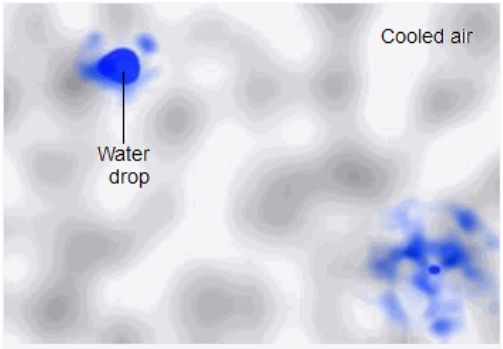
$$DT = F(X_0, G, X_1, d)$$

DT – gas cooling degree, ^{o}C
X_0 – injection of liquid droplets into a gas
G – mass flow rate of gas, kg/s
X_1 – thermal properties of liquid
d – liquid droplet size, mm

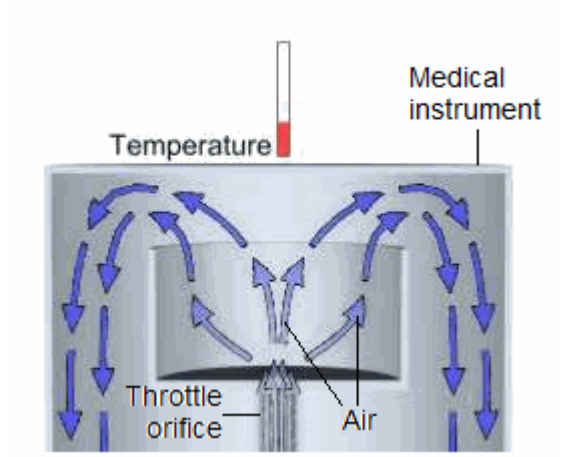
Conditions
1. Liquid droplets must be small enough
2. Liquid droplets must be uniformly distributed in a gas flow

References
Heat Exchanger Design Handbook, Hemisphere Publishing Corp.





6. Nozzle is used to discharge air on to roof. The high pressure enables fast cooling. Inspired from patent in medical devices area.



To be destroyed, a malignant tissue is brought into contact with a cooled medical instrument. Usually, it is a probe-heat exchanger through which liquid nitrogen is passed.

However, the production, transportation and storage costs of liquid nitrogen make this method of cooling malignant tissue very expensive.
The medical instrument is an assembly of two metal jackets. Inside the jackets, there is a gas expansion chamber. Air under high pressure is charged into the chamber through a narrow (0.12 mm) orifice.

Inside the chamber, the air is intensively expanded and cooled. Such an effect is called the positive (positive Joule-Thomson effect). A cool air flow quickly (in less than 15 seconds) cools the medical instrument down to 203 K (-70 ^{0} C).

Advantages
Cheapness ; Compressed air is much cheaper than liquid nitrogen.

U.S. Patent. 5,522, 870; Ben-Zion; Jun. 4, 1996; “Fast changing heating - cooling device and method"; State of Israel, Ministry of Defense, Rafael Armaments Development Authority, Israel, Maytal Ben – Zion.

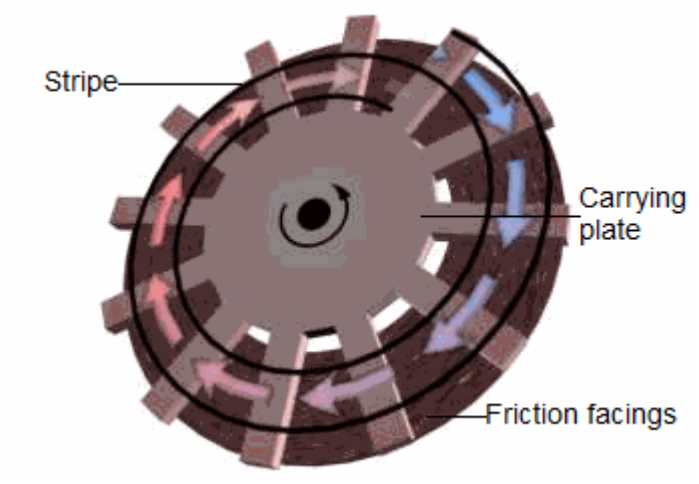
7. The discharge of air is done at front end of bus so that if bus moves forward, the boundary air layers developing by virtue of air friction enable forced cooling. Inspired from :

   Forced cooling of clutch plate facings

   The friction facings are bonded to the clutch plate on both sides using circular stripes. Transmitting the torque heats the friction facings as they are rubbed against the flywheel and the clutch components. The continuous circular stripes prevent free access of cooling air to the facings. This overheats the facings, causing them to fail. In order to cool the clutch plate friction facings in the course of operation, it is proposed to make the stripe in a spiral form.

   The clutch plate consists of a carrying plate, two stripes made of resilient material and two friction facings. The stripes are bonded in the spiral form on both sides of the friction plate. The adjacent stripe turns are disposed at a

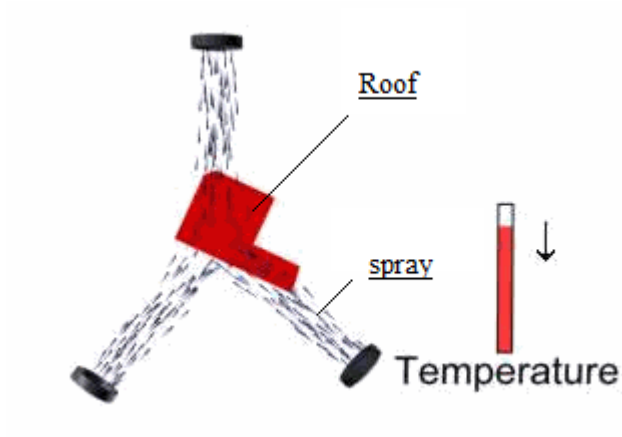
distance from each other. The friction facings are placed on the stripes. This forms a spiral channel between the plate surface and each of the facings. As the plate rotates, the air circulates continuously in the spiral channels. This results in the forced cooling of the friction facings. The forced cooling reduces the heating of the facings.



In effect, the air circulating between the spiral stripe turns cools the plate facings as the plate rotates.

U.S. Patent. 5,076,410; Maycock, et al.; Dec. 31, 1991; “Friction facing material and carrier assembly”; Automotive Products plc.

8. Multi-spraying. Instead of single nozzle discharge, the air-water mixture is divided into multiple parts and sprayed together from different angles. Inspired from hundreds of applications in engineering. Not inspired-Original.



The surface of hot bodies is cooled with fluid, e.g., water. The fluid prevents the removal of vapor from the zone of phase transformation. The vapor forms a vapor interlayer over the body surface, which forces back the fluid from the surface, causes its overheating and worsens the heat transfer conditions.
A harmful interaction between the continuous cooling medium and vapor in the zone of phase transformation (worsening heat transfer near the hot surface) is removed by dispersing a jet of cooling fluid. Droplets of dispersed fluid with a sufficient initial speed penetrate the layer of vapor, reach the surface and cool it, the formed vapor being free to leave the evaporation zone. Regulating the spray density by means of water spray guns, it is possible to change the cooling rate over the surface depending on its thickness and temperature. Advantages are:

1. Temperature stresses are eliminated in bodies of complex configuration.
2. The cooling time is reduced.

9. Jet cooling: Well known physical effect.

The device with turbulent surface-hitting jets provides short working fluid paths along the surface. The laminar boundary layer has no time to stabilize. The cold fluid from the jet core is in direct contact with the surface. Due to the short path along the surface, the fluid has no time to be heated. This also enhances heat transfer.

Advantages
Non-uniformity of the heat transfer factor along the surface is possible. At H/D > 8, the curve of the heat transfer factor dependence of the coordinate along the surface is bell-shaped. At H/D < 8 the curve has two maximums.

Effect Index

$$a = CV^{2/3}$$

a – mean heat transfer factor
C – coefficient depending on the cooling device geometry and thermal properties of working fluid
V – working fluid velocity

Limitations
The value of heat transfer factor strongly depends on the nozzle position and working fluid properties.

Formula

$$a = (l/D)\, Pr^{0.42} (D/r)\, [(1 - 1.1D/r)/(1 + 0.1(H/D - 6)\, D/r)]\, 2\, [Re\, (1 + Re^{0.55}/200)]^{1/2}$$

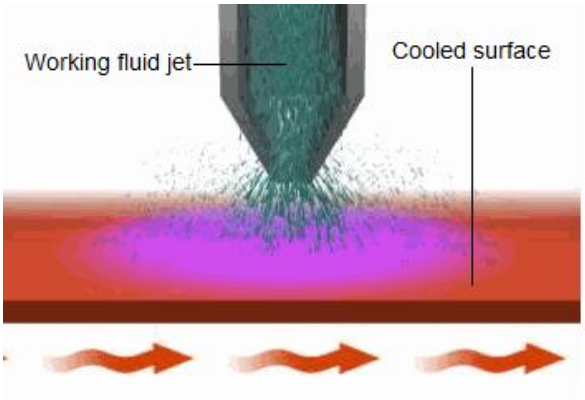
$$Pr = a\, D/\, l$$

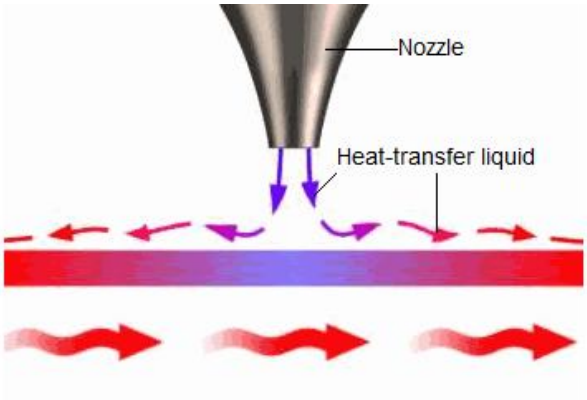
$$Re = V\, D/\, v$$

Pr – Prandtl number
Re – Reynolds number
a – heat exchange coefficient, $W/m^2 \times K$
l – heat carrier thermal conductivity, $W/m^2 \times K$
v – heat carrier kinematic viscosity, m^2/s
V – jet velocity, m/s
D – nozzle diameter, m
r – distance from the critical point, m
H – distance between the surface and the nozzle, m

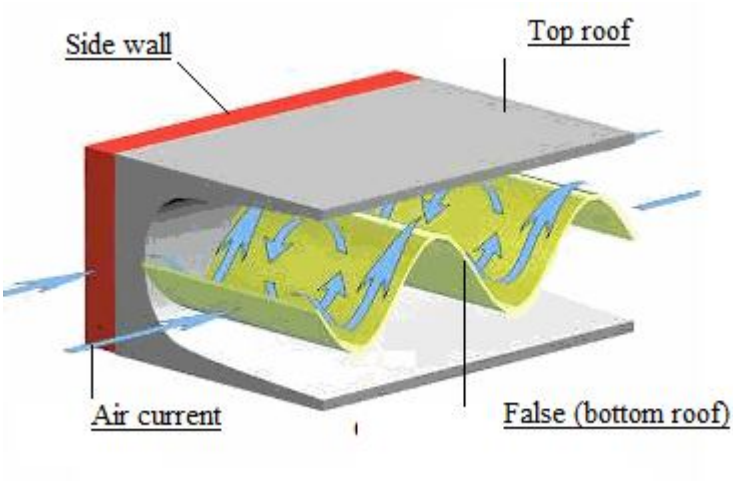
Conditions
1. The working fluid must freely escape from the surface being cooled.
2. The distance from the nozzle to the cooled surface may not be great lest the jet structure be broken down.

References
Heat Exchanger Design Handbook. Hemisphere Publishing Corp. 2 (1983.)





10. Corrugated inserts to enhance efficiency between dual-layered roof. If dual roof not there, an extra roof layer like false ceiling can be inserted. Not inspired – Original.



Corrugated inserts are fitted in the channels created between roofs. The air is blown through the channels. The corrugated inserts cause swirling agitation of the air current. As a result, the air current becomes turbulent. The turbulent flow rearranges level distribution of air in the fin channels. This results in greater cooling rate of the device. The turbulent flow reduces thermal resistance of the device by 30 to 35 percent. Cooling by a turbulent flow increases the cooling rate and turbulent flow reduces the weight of the heat sink.

11. Spray cooling effect - Physics

When a hot surface is sprayed with a dispersed fluid, the evaporation of the fluid droplets cools the body. The droplets absorb heat from the body in the amount of their latent heat of vaporization. The size of the drops, their velocity, and the jet moisture content are selected so that drops of fluid cross the boundary layer to the surface and form a liquid blanket. The vaporization (boiling) of fluid in the liquid blanket provides a maximum heat transfer rate. The vapor formed is then free to leave the body surface. The dispersion of a jet of cooling fluid eliminates heat transfer between the counterflows of vapor and fluid.

Advantages

Isothermal cooling occurs without substantial temperature stresses in the body being cooled.

Effect Index

$$\frac{Q}{A} = r^{*} c \frac{\rho}{4}$$

Q/A - specific heat flux, W/m^2

r* - latent heat of vaporization, J/kg

c - mean thermal velocity of vapor molecules, m/s

r - fluid density, kg/m^3

Materials

Dispersed water produces a cooling rate on the order of 10^7 W/m^2.

Formula

$$\frac{Q}{A} = Dnwr^{*}$$

$$G = Dnw$$

Q/A – specific cooling heat flux, W/m^2, ($Watts/m^2$)

D – droplet mass, kg

n – concentration of droplets, $1/m^3$

w – thermal velocity of vapor molecules, m/s

r* – latent heat of fluid vaporizaiton, J/kg (Joule/kg)

G – mass density of spray flux, $kg/m^2 \times s$

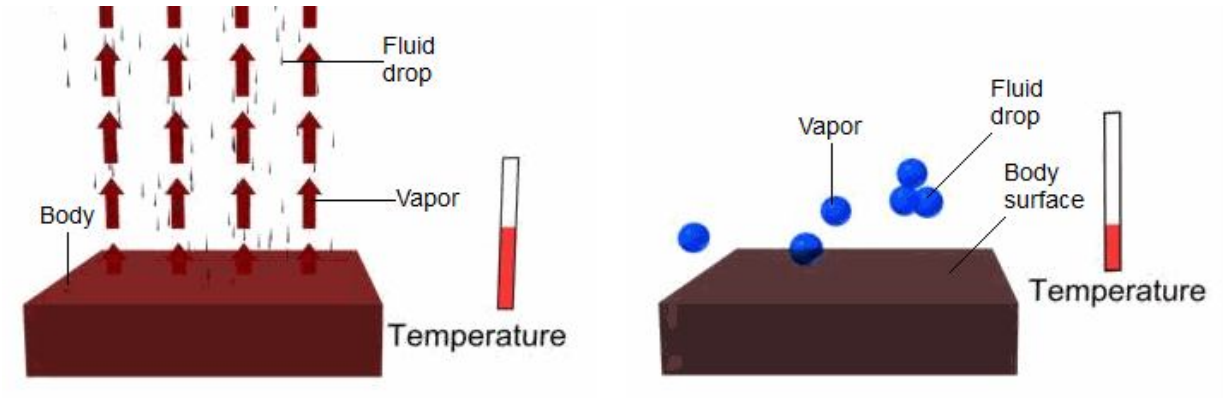
A – area, m^2

Conditions

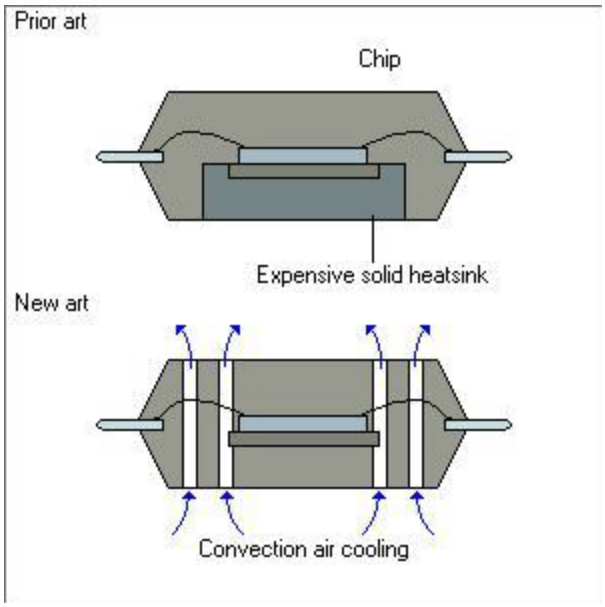
The boiling point of the fluid under cooling conditions must be lower than the surface temperature of the body being cooled.

References

"Quenching of Steel." *Metals Handbook* 2: 1076



12. Placing heat sinks by making holes in roof area. Inspired from:



Plastic packages have poor heat conduction. Therefore, special heatsinks are placed in them. However, heatsink cost can exceed the cost of the device itself.

It is proposed to cool a chip by air that flows through holes in a plastic package.

Holes are formed in a plastic package. This inexpensive operation provides chip cooling due to air convection streams. However, package durability is reduced.

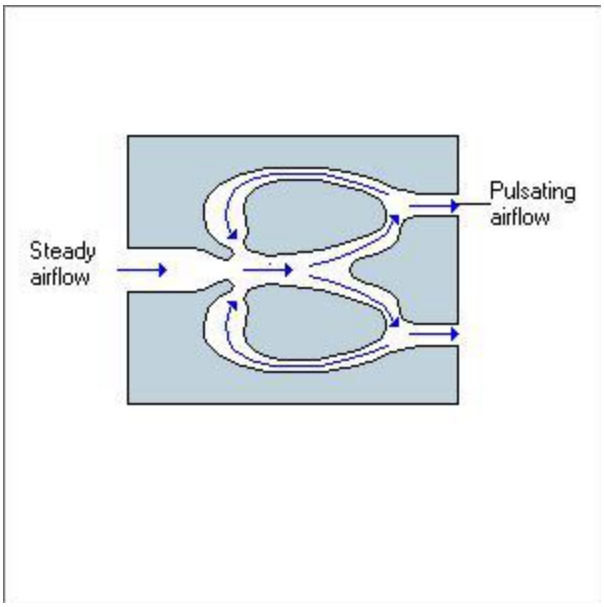
United States Patent 5 369 550 Date of Patent: Nov. 29, 1994 VLSI Technology, Inc., San Jose, Calif.

13. Pulsating air discharge is done instead of steady one.

    Inspired from:

    A steady airflow is usually used to cool electrical components during operation. Pulsating forced air would be more efficient. However, a complex system with numerous moving parts is required in this case. It is proposed to use an asymmetric fluidic oscillator with negative feedback.A fluidic oscillator consists of a supply port, vent ports, output ports, feedback lines, and input ports. Since it is impossible to fabricate a perfectly symmetric fluidic oscillator, unbalanced flow will always be created within it. This results in a pulsating airflow.

    United States Patent 5 190 099 Date of Patent: Mar. 2, 1993 The United States of the America as represented by the Secretary of the Army, Washington, D.C.


Pulsating
airflow
Steady
airflow