Part 4. Terrestrial application of passive heat pipe systems

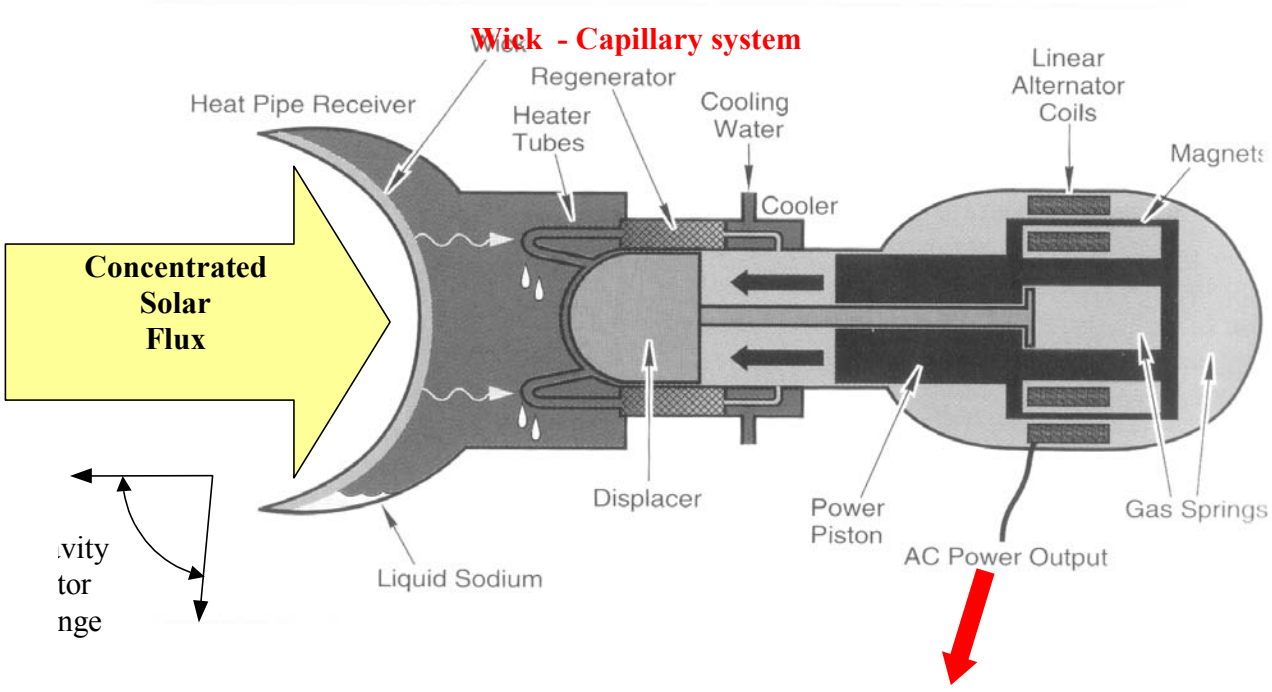
Sources:

- V. Baturkin et al. Study Of Structural And Mechanical Properties Of Metal Felt Wicks Intended For High Temperature Heat Pipes - Solar Receivers. Proc. Of the 12th IHPC, Russia, 2002, pp.547 -552
- Technical note. Integrated Plate Heat Pipe. Sowa Aluminium Corporation. 1999, 995.10PR-0. HTTP://WWW.SHOWA-ALUMI.CO.JP
- Technical note. Advanced Cooling Technology for Electronic Products. Micro Heat Pipe. Heat Sink. The Furukawa Electric Co., Ltd. DSE-004 I 2BI
- V.Baturkin et al. Heat Pipe Application for Welding of Polymeric Pipelines. . Proc. of the 10th IHPC, Germany, 1997

Heat pipe for solar concentration program

High temperature heat pipe receivers have some advantages to be used in solar energy converters. They receive a concentrated light energy from helio-dish - concentrator and transfer this energy to Stirling engine. Main advantages in comparison with conventional designs of directly illuminated receivers (DIR) are: increasing conversion efficiency of sunlight to electricity up to 28%, possibility to operate with higher heat fluxes and to have independent design of concentrator and engine.

SCHEME OF CONVERTER
"SOLAR ENERGY - ELECTRICAL ENERGY"



Source: A Compendium of Solar Dish/Stirling Technology" SAN93-7026

Typical heat pipe configuration for solar receivers:

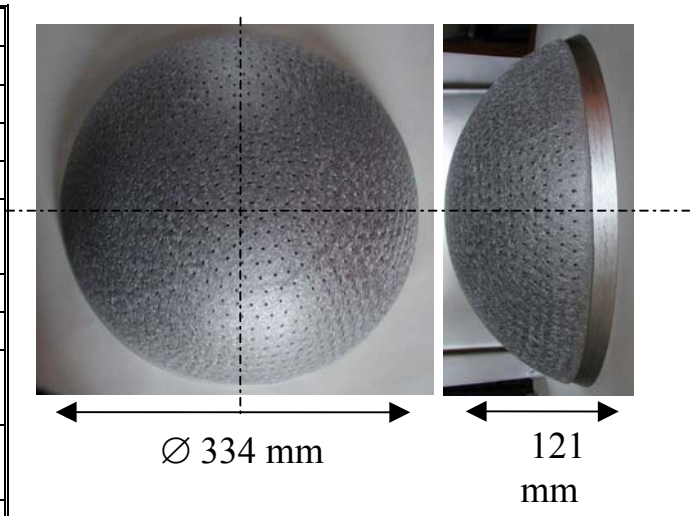
German/Saudy
50 –kW$_{-e}$ dish/Stirling system

DLR/IKE/ University of Stuttgart (Germany). Heat pipe solar receiver 32 kW –thermal power

NTUU "KPI"'s fabrication for Sandia National Laboratories , USA:

- middle temperature gas fired heat pipe, ∅76 x 450 mm for sodium at 750 C with seam and without seam, design heat power of 14 kW (against gravity)
- flat wicked evaporators 50 x 450 x 4 mm for sodium at 750 C, designed heat flux rate of 1.5 kW (against gravity

Sphere radius, mm	178
Angle, grad	140
Bottom diameter, mm	334.4
Dome height, mm	121.4
Wall thickness, mm	0.9
Approximate wick thickness, mm	4
Surface area, cm^2	1295
Shell mass, g.	920
Wick mass at approximate porosity of 85 %, g.	635
Mass of receiver with wick, g.	1555
Average heat flux density, W/cm^2	30

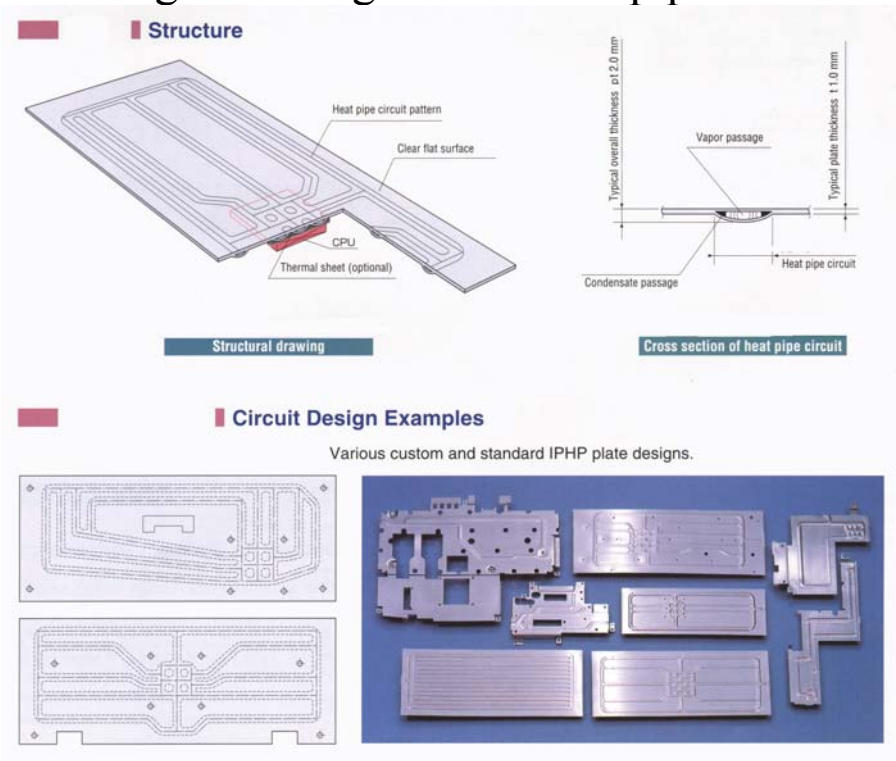


Designed heat flux rate of 36 kW , operation against gravity

Projected heat flux rate for heat pipe receiver R244 mm is 68 kW at operation against gravity. Receiver is under fabrication.

Heat pipe for PC cooling.

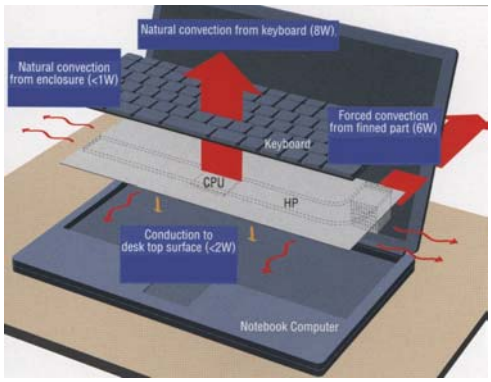
Notebooks cooling with usage of flat heat pipes



Material: Aluminium plate AA1100
Operating temperature up to 100 ^{0}C
Maximal thickness: 1.9 –2.2 mm for one side inflation

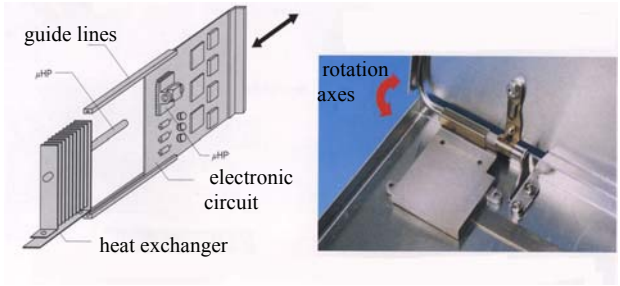
Working fluid HFC4310
Inclination within 5 degrees
Maximal thickness: 3 –3.8 mm for two side inflation

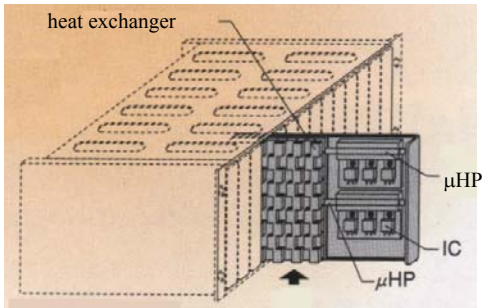
Variants of plate heat pipe fabrication

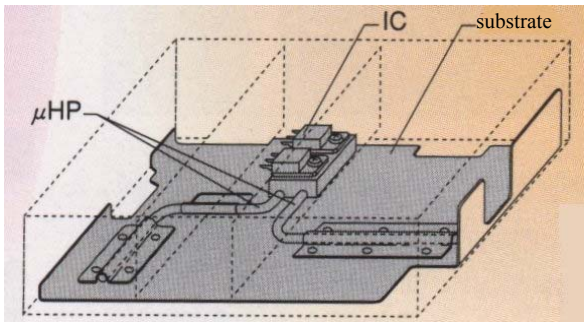


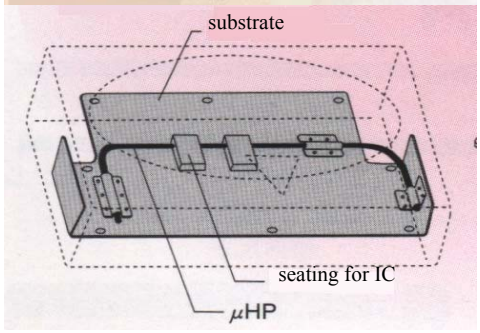
Flat heat pipe in notebook

Mini heat pipe in notebooks and PC



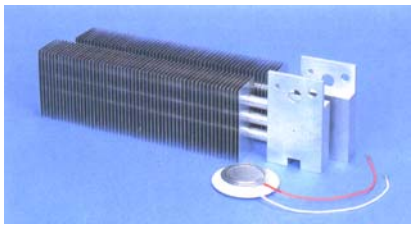




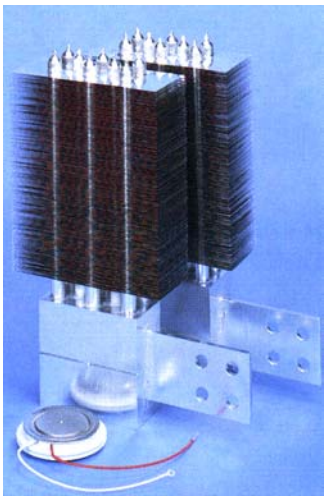


Mini (micro or μ) heat pipes have diameter x length in the range from 3 x 100 to 6 x 400 mm with possible bending radius R= 11...27 mm. Heat transfer rate for tube of 3 mm is (0.5 – 1) W·m for grooved HP and (2-2.5) W·m for meshed HP at horizontal position. Thermal resistance is 0.2 K/W (grooved HP) and 0.7 K/W (meshed HP), exploitation temperature + 35 …+ 65 ^{0}C

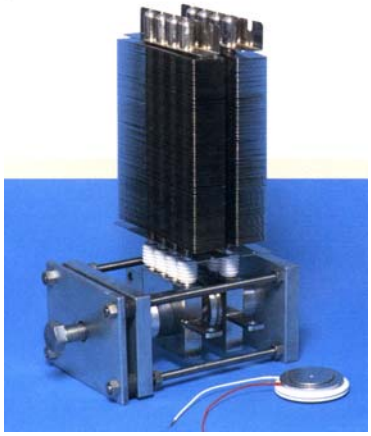
Heat pipes for high-power electronic cooling



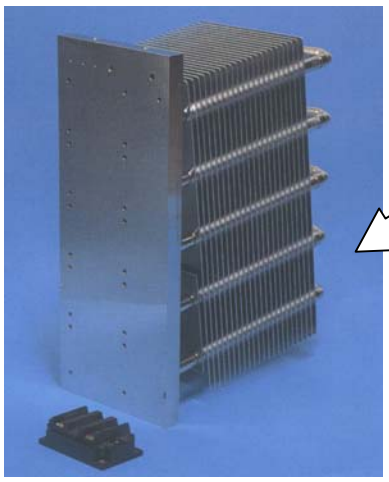
Seating place diameter
30..80 mm
Power 200 … 1500 W
Thermal resistance
0.14..0.019 K/W



Seating place diameter
30..80 mm
Power 150 … 800 W
Thermal resistance
0.2..0.043 K/

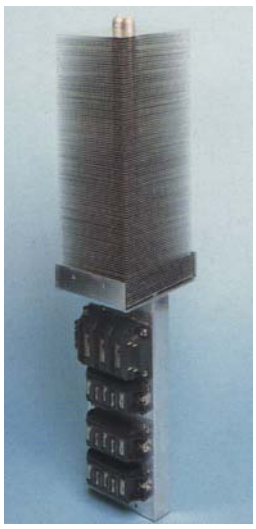


Dielectric cooling system



Power 500 … 5000 W
Thermal resistance
0.1..0.01 K/W

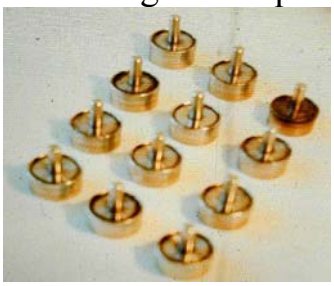
Power 90 … 700 W
Thermal resistance
0.05..0.01 K/W



Passive heat pipe system for welding, brazing, soldering

Heat pipe system for welding, soldering and other temperature sensitive processes should provide the uniform temperature surface or volume. In most cases temperature level should be controlled. The uniform temperature can be obtained by vapour condensation, a control of the temperature– by gas controlled principle.

Small size heat pipes - ∅ 30 x 15 mm. They are intended for growing of thin layer of semiconductors. Temperature level 20 … 80 ^{0} C. Provide uniform temperature ± 0.1 ^{0} C of surface contacting with liquid

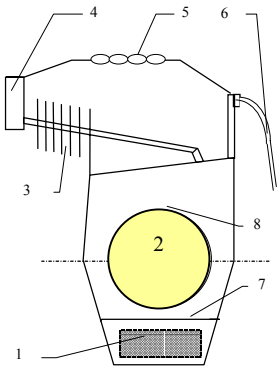


Cylindrical heat pipe for providing homogeneous surface roller temperature of 29 ^{0}C for offset printing, extrusion laminators

Soldering tool on the base of VCHP
Temperature level 258 ^{0}C ± 2

Soldering bathes for tin-lid alloys on the base of VCHP. Temperature level is 258 ^{0}C ± 2

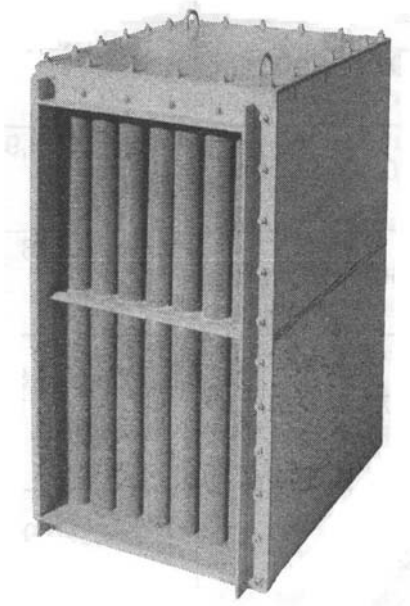
Thermostable plate for tin-lid alloys on the base of VCHP
Temperature level 220 ^{0}C ± 2

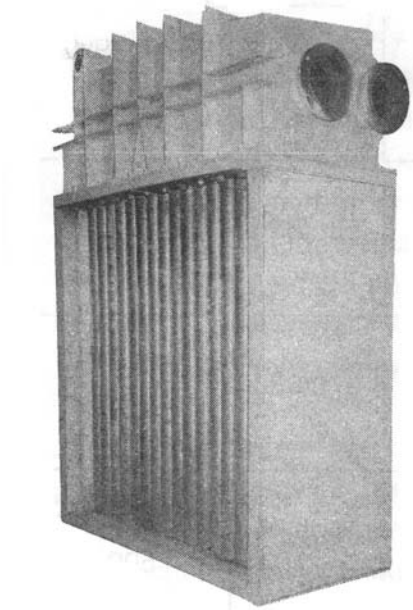


Soldering tool for polymeric pipeline connection on the base of VCHP
1 – heater, 2 – isothermal surface; 3 – finned condenser; 4 - gas reservoir; 5 - handle; 6 – electric cable; 7 – liquid level; 8 – vapour space. Test summary: T= 214...231^{0}C at power input 400 W ±15%, T_o = -10.. +20 ^{0}C, air velocity 0...10 m/s

Heat exchangers for utilisation of waste gases energy

Task of utilizers is to capture the heat from waste gas, to transport it to zone of heated gas flow and to heat up this gas. Some heat energy is saved and the temperature of exhaust gas is decreased. Hottest side of heat exchange is located in the bottom part. Examples of gas - gas and gas - liquid utilizers by ukrainian Interprice РИКС are presented below:





Typical characteristics of heat utilizers, fabricated by enterprise РИКС / Ukraine

N	Purpose heat exchanger utilizer	Flow rate of waste gas, nm/s	Flow rate of gas nm/s or water (kg/s)	Temperature of waste gas, °C		Temperature air or water, °C		Utilised Heat Flux, kW	Hydraulic resistance to gas/ to air (water), Pa	Overall Dimen-sions (width x length x height), m Mass, kg
				entry	exit	entry	exit			
1	**Air-heater steam-boiler 1 t/h**	0.3	0.25	250	120	30	170	49	200/100	0.5x0.6x 0.9
2	**Air-heater steam-boiler 2.5 t/h**	0.75	0.625	250	120	30	155	120	310/340	0.79x0.7 9x0.9
3	**Air-heater Steam-boiler 50 t/h**	19.3	15.5	310	180	50	220	3330	1060/700	4.0x1.3x 2.6
4	**Section air-heater boiler heat power plant**	4.86	3.93	265	135	30	205	900	665/745	1.33x1.3 x2.6
5	**Air-heater hot-water boiler 2.5 MW**	1.1	6.9	160	120	40	42	62	200/1240	0.6x0.3x 0.9 150
6	**Air-heater hot-water boiler 4.65 MW**	2.06	1.64	160	107	30	98	140	1500/1500	0.79x0.7 9x0.9 450
7	**Air-heater hot-water boiler 7.56 MW**	3.34	2.65	160	102	30	104	250	560/630	1.0x0.7x 1.8 1000
8	**Air-heater hot-water boiler 9.65 MW**	4.26	3.39	190	120	30	118	380	970/950	1.0x0.7x 1.8
9	**Air-heater hot-water boiler 9.65 MW**	4.26	27.4	190	130	50	53	366	490/9430	1.0x0.4x 1.4 500
10	**Air-heater drying unit**	0.5	0.48	105	68	30	69	24	300/310	0.5x0.6x 0.9