NASA TECH BRIEF
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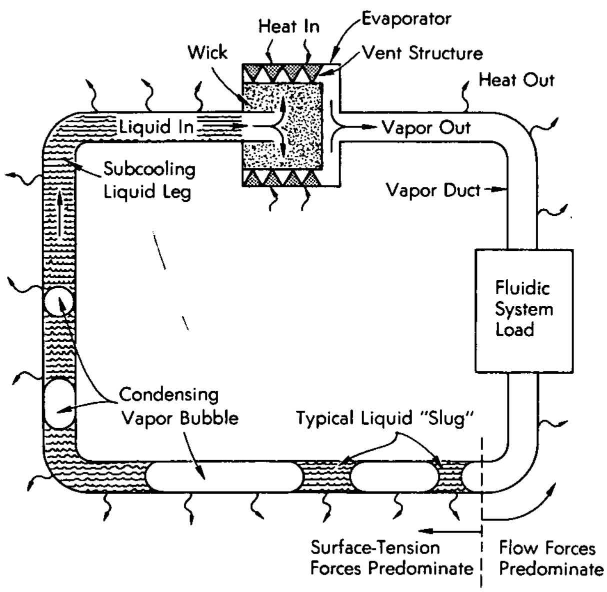
Closed-Cycle Power Supply for Fluidic Control Systems

A closed-cycle power supply has been designed to operate fluidic control systems in spacecraft. As indicated in the diagram, in principle it utilizes small quantities of a two-phase fluid of suitable thermo-



dynamic properties for circulation in a capillary-pumped heat transfer loop. The fluid is vaporized in an evaporator, passed through a fluidic system load, condensed, pumped by a multistage capillary pump, and returned to the evaporator. Condensate pumping is provided by the capillary pumps of the form that are used extensively for heat-transfer applications.

Selection of the working fluid depends on the available heat sources and heat sinks. The working fluid must be a gas at a nearly constant temperature during its transit through the fluidic circuits and it must then be converted to a fluid at the lowest working pressure and temperature available (e.g., the condenser heat sink on a spacecraft). Use of a working fluid with a low heat of vaporization will minimize the thermal energy required for the desired gas flow rate, but the heat energy requirements (a function of the source and sink temperature, gas volume, and the necessary gas pressure) can be estimated from the type of thermodynamic cycle involved, the working fluid in use, and an allowance for estimated system losses. Since the performance of capillary liquid pumps in thermodynamic gas/liquid cycles is not accurately predictable by use of available idealized theory, experimental and empirical design information must also be used. Mathematical analysis of the system pressure drop indicates that an optimum design for maximum flow to the useful load can be obtained by substitution of analytic expressions for viscous gas and liquid pressure drops in the capillary ducts, neglecting all other parasitic drops.

The operating pressure can be multiplied approximately n times by using n stages of capillary pumps with associated boilers and condensers in series; in these instances, the boilers are operated from a common heat source and the condensers from a common heat sink. Superheated vapor may also be supplied to the load if a superheater is included after the boiler, but the degree of superheat must be sufficient to avoid condensation in the fluidic system, because the presence of condensate could impair the operation of the fluidic elements. The working fluid is condensed and then recycled without the use of a positive mechanical pump.

(continued overleaf)

To make the arrangement practical, the heat source and sink must be located to obtain the increased boiler and condenser temperature required by the higher pressure boiler and condenser sections. This requirement must be satisfied by connecting the heat source to the high-pressure end of the system and inserting a thermal resistance between each successive boiler-to-supply connection so as to obtain the desired operating temperature for each boiler at full rated output. The corresponding requirement for the common condenser can be satisfied by connecting the heat sink at the low-pressure boiler end with a thermal resistance from the heat sink to each condenser to obtain the desired condenser temperature at full output.

Note:

Requests for additional information may be directed to:

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Reference: TSP 72-10163

Patent status:

No patent action is contemplated by NASA.

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