PREFACE

During the era since the launching of the first Sputnik, Americans have risen to the challenge of space exploration with vast scientific and technical research programs. Recognizing the fact that much of this space research and development might prove valuable to the general public and commercial enterprises, NASA's Technology Utilization Program developed a system of six centers for disseminating the results of this research. The Technology Application Center at The University of New Mexico is the center serving the Rocky Mountain Southwest. Its mission is to promote the beneficial use of new technology.

One of the activities of the Technology Application Center has been to identify new, high-interest areas of technology and to assemble and update abstract volumes on these subjects. Dr. K. T. Feldman, Jr., of the College of Engineering, Josef E. Spitzer, an Applications Engineer at the Technology Application Center, and Eugene Burch, Assistant Director of the Center, conceived the idea of a comprehensive reference to the area of Heat Pipe Technology, which would be kept up-to-date by the Center's wide contacts in heat pipe research. This volume is the product of that concept.

Today, the engineer or scientist who is not constantly keeping himself aware of new developments in his field of expertise soon finds his knowledge obsolete. In addition, estimates indicate that at least 10 percent of our Nation's $12.5-billion-plus research-and-development expenditures is spent on duplication of previous efforts. To meet these challenges in an area of declining research budgets and tremendous environmental problems, we at the Technology Application Center are sincerely committed to a continuous interaction with those forward-looking individuals, companies, and industries seeking to develop a better nation and world.

William A. Shinnick
Director
Technology Application Center
University of New Mexico
INTRODUCTION

Since the invention of the modern heat pipe at Los Alamos in 1963, the growth of information on pipes has been rapid and diffused. At the present time, publications on heat pipe are increasing at a rate of about 200 per year. Consequently, a considerable number of important references may not be widely known and may be difficult to obtain. Examples of such references include government laboratory reports, industrial contractor reports, university research reports, and some journal articles.

Recognizing the need for complete and up-to-date information on heat pipes, the Heat Pipe Information Office was established at The University of New Mexico. The most modern literature-search techniques as well as the assistance of many workers in the field have been used to compile an extensive bibliography with abstracts on all types of heat pipe references including patents. Also, a library containing essentially all of these articles has been established. In addition to publishing this bibliography with abstracts, the Heat Pipe Information Office will publish a quarterly update of the bibliography and will provide copies of references. Some foreign references have been translated into English.

Although a considerable effort has been made to insure that the bibliography is complete, readers are encouraged to notify the Office of omissions.

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ACKNOWLEDGEMENTS

This volume is, in large part, based on the efforts of Josef Spitzer, who devoted a vast amount of time and energy in preparing, editing, and promoting Heat Pipe Technology, and to Dr. K. T. Feldman, Jr., the technical editor, whose bibliographies, documents, and encouragement and guidance assisted in the success of this effort. Appreciation is extended to Mr. Monte F. Mott, Chief of the Patents and Technology Utilization Division of the NASA Pasadena Office, whose collection of Heat Pipe Patents was made available for this work. The cooperation of Dr. C. A. Busse of EURATOM and his efforts in collecting and announcing papers and references in the European sector were extremely helpful.

Thanks are further extended to staff members of the Technology Application Center, Walter W. Long, Associate Director; Mark Money, Administrative Officer; and especially to Eugene Burch, Assistant Director, all of whom participated in the successful publication of this volume.

This publication was further made possible by the Technology Utilization Program of NASA, from which the Technology Application Center derives the major portion of its support, and by the close cooperation of the College of Engineering of The University of New Mexico.

W.A.S.
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A. GENERAL INFORMATION, REVIEWS, SURVEYS
65001 THEORY OF HEAT PIPES
A heat pipe is a self-contained structure which achieves very high thermal conductance by means of two-phase fluid flow with capillary circulation. A quantitative engineering theory for the design and performance analysis of heat pipes is given.

65002 ON THE OPERATION OF HEAT PIPES
B. D. Marcus, Applied Thermodynamics Dept. Physical Electronics Laboratory - Physical Research Div., TRW Space Technology Laboratories, Redondo Beach, Cal. (9895-6001-TU-000) 19 p 4 refs Avail:TAC
Description of a heat pipe and analysis of the transfer processes involved. A heat pipe is a closed system capable of transferring large quantities of thermal energy between a source and sink which exhibit only a small temperature difference. Hypothesized external and internal heat pipe configurations are diagrammed and the optimum wick thickness is considered. Included are a description of nomenclature and appendices on contact angles and thermal conductivities.

66001 SURVEY OF LOS ALAMOS AND EURATOM HEAT PIPE INVESTIGATIONS
A review is presented of investigations of heat pipes for thermionic diode uses. The theory of heat pipes is presented. Experimentally obtained properties of heat pipes and several possible pipe designs are discussed.

67001 PROCEEDINGS OF JOINT ATOMIC ENERGY COMMISSION/SANDIA LABORATORIES HEAT PIPE CONFERENCE, VOLUME I
CONTENTS:
1. STATUS OF THE ENGINEERING THEORY OF HEAT PIPES, T. R. Cotter (Los Alamos Scientific Lab), p 5-9 (See N67-26792 14-33)
2. HEAT PIPE CAPABILITY EXPERIMENTS, J. E. Kemme (Los Alamos Scientific Lab), p 11-25 refs (See N67-26793 14-33)
4. FEASIBILITY STUDIES OF SPACE RADIATORS USING VAPOR CHAMBER FINS, H. C. Haller and S. Lieblein (NASA Lewis Res. Center) p 47-67 refs (See N67-26795 14-33)
5. NOTES ON HEAT PIPES AND VAPOR CHAMBERS AND THEIR APPLICATION TO THERMAL CONTROL OF SPACECRAFT, S. Katzoff (NASA Langley Res. Center) p 69-89 refs (See N67-26796 14-33)

67002 HEAT PIPE ANALYSIS
The paper assesses the performance capabilities and limitations of heat pipes through a parametric analysis and, to a limited extent, comparison with experimental heat pipe results. A number of parametric curves are presented to provide quantitative insight regarding the physical phenomena that govern heat pipe operation and to provide heat pipe design guidelines. The principles of heat pipe operation are briefly discussed along with a concise history of their development.

67003 HEAT PIPE
The heat pipe is a unique and simple heat transfer device which has an effective thermal conductivity several hundred times that of copper. The operating principles
and characteristics of the heat pipe are described. Performance characteristics, possible applications, and current research and development activities are discussed.

67004 THE HEAT PIPE, A UNIQUE AND VERSATILE DEVICE FOR HEAT TRANSFER APPLICATIONS
RCA - Electronic Components and Devices; Direct Energy Conversion Dept., Lancaster, Pa., (RCA REF 994-619) Avail:TAC (17p)
Description of a heat pipe with a discussion of how it works and possible areas of application. A heat pipe is an efficient and economic heat transfer device for use at any temperature range. Using the principles of vapor heat transfer and capillary attraction, the heat pipe is so highly efficient and versatile that it finds numerous space age applications.

67005 DAS WAERMEROHR (HEAT PIPE)
As high-efficiency heat conductor, the versatile, enclosed heat pipe, which requires no supervision during operation, promises a simple solution to many heat transfer problems, particularly in space travel; the inner wall of the tube is lined with wick which is saturated with a liquid heat conveyor; it evaporates at the heated end of the tube, condenses at the cool end, and is brought back to initial point through capillary action of the wick; theory of heat pipe is developed, and data on pipes so far constructed are given. 21 refs. Before VDI, Bad Mergentheim West Germany, Oct. 1966. In German with English abstract.

67006 HEAT PIPE
Simple and inexpensive device which can transport thermal energy at efficiencies greater than 90% and, by relying on evaporation, condensation, and surface tension characteristics of working fluid, is able to transfer up to 500 times as much heat per unit weight as can solid thermal conductor of same cross section; heat may be transferred to or from heat pipe by conduction, radiation, or convection, and it may be used with variety of heat sources such as electric heaters, open flames, or nuclear heat sources. 11 refs.

67007 THE HEAT PIPE
Description of the heat pipe, essentially a closed, evacuated chamber the inside walls of which are lined with a capillary structure, or wick, that is saturated with a volatile fluid. The operation combines vapor heat transfer and capillary action. Vapor heat transfer is responsible for transporting the heat energy from the evaporator section at one end of the pipe to the condenser section at the other end. The capillary action is responsible for returning the condensed working fluid back to the evaporator section to complete the cycle. The device can be several thousand times as effective in transporting heat as the best metals. Its special properties are high thermal conductance, temperature flattening, heat-flux transformation, and separation of heat source from heat sink. It shows promise of being immediately useful in many areas of technology.

68001 THE HEAT PIPE
Daniel B. Dallas, ASTME Student Quarterly, Fall 1968. Avail:TAC (3p)
Description of a heat pipe with a discussion on how it works and different factors that affect its working like operating temperatures, latent heat, thermal conductivity, viscosity, surface tension, wetting ability and boiling point. Mentions the Atlas Agena Flight where a heat pipe was used and other potential areas of application.

68002 CRITICAL REVIEW OF HEAT PIPE THEORY AND APPLICATIONS
A critical review of the theories and experiments relating to heat pipes was made to provide an introductory reference which summarizes and interprets the information useful in practical applications. The areas to be studied to extend current knowledge are indicated. The open literature up to March 1968 is evaluated and interpreted.

68003 THE HEAT PIPE
Daniel B. Dallas, ASTME Student Quarterly, Fall 1968. Avail:TAC (3p)
Description of a heat pipe with a discussion on how it works and different factors that affect its working like operating temperatures, latent heat, thermal conductivity, viscosity, surface tension, wetting ability and boiling point. Mentions the Atlas Agena Flight where a heat pipe was used and other potential areas of application.

68004 APPLICATIONS OF THE HEAT PIPE
Discussion of applications of the heat pipe, a device consisting of a tube, a
wick, and a fluid that can transfer heat at a very rapid rate. The heat pipe has a
fraction of the weight, and several hundred times the heat transfer capability of
solid copper, silver, or aluminum. Because it operates almost isothermally and can
act as a thermal transformer, it can readily couple thermal power sources to energy-
conversion devices. The heat pipe can go around corners, can absorb vibration, and
can be flexible. Applications are described which are particularly suited to thermal
control of aerospace and terrestrial energy-conversion systems.

69002 INTERNATIONAL CONFERENCE ON THERMIonic ELECTRICAL POWER GENERATION, 2ND, STRESA,
ITALY, MAY 27-31, 1968. PROCEEDINGS.
Conference sponsored by the European Nuclear Energy Agency. Luxembourg, EURATOM
Center for Information and Documentation (EUR No. 4210 f, e), 1969. 1438 p. In English
and French. Avail:TAC
CONTENTS:
FOREWORD. H. Neu (EURATOM and Comitato Nazionale per l'Energia Nucleare, Ispra,
Italy). p. 5.
21, 22.
WELCOMING ADDRESS. H. Kramers (EURATOM and Comitato Nazionale per l'Energia Nu-
INTRODUCTION. H. Neu (EURATOM and Comitato Nazionale per l'Energia Nucleare,
Ispra, Italy). p. 24-27.

69003 HEAT PIPES FUNCTION ISOThERMALLY AND ADAPTABLEY
F. G. Arcella and G. S. Dzakowic (Westinghouse Electric Corp., Astronuclear Laboratory,
Study of the heat pipe, a closed mass transport device which effectively trans-
ports heat at a temperature that remains nearly constant over its entire surface. Be-
cause it is also light in weight, requires no pumping power, and may be made in many
different shapes, it is highly suitable for space applications. Latent heat associ-
ated with phase change and capillary action are the two phenomena which afford the
heat pipe its exceptionally good thermal conductance. Temperature control through
choice of fluid is discussed. It is emphasized that wick structure is crucial for
pumping. A wide range of fabrication methods is described.

69004 THE HEAT PIPE--A PROGRESS REPORT
G. Y. Eastman (Radio Corporation of America, Lancaster, Pa.). IN: AMERICAN INSTITUTE
OF CHEMICAL ENGINEERS. INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, 4TH,
co-sponsored by the American Institute of Aeronautics and Astronautics, the American
Nuclear Society, the American Society of Mechanical Engineers, the American Chemical
Society, the Institute of Electrical and Electronics Engineers, and the Society of
873-878. Avail:TAC
Review of heat pipe development work at RCA since December 1963. More than 1100
heat pipes have been fabricated in a variety of sizes and shapes for operation over a
range of temperatures and power levels. Much of this work has been performed under
energy conversion programs, many of them government sponsored, some classified. A few
comments are made on future applications of the heat pipe within the energy conversion
context as well as some of the desirable spinoffs of this space-age technology in the
commercial and industrial marketplace.

69005 THE HEAT PIPE AND ITS OPERATION
Schwartz, J., Heat Transfer/Thermodynamics Research Group 353, Jet Propulsion Lab.,
This report, a general survey of the present state-of-the-art of heat pipe theory
and applications, is derived from many sources as well as investigations carried out
at JPL by the author. The primary purpose of the report is to introduce the reader to
the heat pipe and discuss its operation and capabilities. For the reader who may be
interested in specific heat pipe applications, there is enough preliminary information
available in the body of the report as well as references which list a large number of
related papers.

69006 HEAT PIPE TRANSFERS HEAT WITH NEARLY UNIFORM TEMPERATURE
Westinghouse R & D Letter, March 1969, Avail:TAC (4p)
A description of the principles of operation of a heat pipe is given emphasizing
its high efficiency. The importance of selection of working fluid and wick geometry
and their influence on the operating characteristics of the heat pipe are outlined.
Heat pipe applications for thermoelectric generators and other devices are listed.

70001 APPLICABILITY OF HEAT PIPES TO ENERGY CONVERSION SYSTEMS
The heat pipe is a unique, high flux, heat transport device which utilizes the evaporation, condensation, and surface tension of a working fluid to give it an effective thermal conductivity several thousand times that of copper. The major operating characteristics of a heat pipe are nearly perfect isothermal operation over lengths of several feet, thermal transformer operation where heat is added over a small area at high flux and removed over a large area at a low flux and vice versa, thermal power flattening where large variation in output heat flux cause very little variation in output heat flux. The heat pipe is ideally suited for energy supply, removal, and thermal control of energy conversion systems. Performance characteristics and possible applications to conventional and direct energy conversion systems for terrestrial and space use are discussed.

70002 THE HEAT PIPE EXPERIMENT
A system capable of achieving a constant and uniform temperature over a sizable volume was described. It is relatively immune to problems of localized heat additions and subtractions and possesses remarkable simplicity, low cost, and reliability properties, and is susceptible to simple and direct operational checks under space conditions.

70003 HEAT TRANSFER DEVICE Patent Application
Westinghouse Electric Corp., Pittsburgh, Pa. Ralph W. Kalkbrenner, inventor (to NASA)
A heat transfer device characterized by a hermetically sealed tubular housing including a tubular shell terminating in spaced end plates, and a tubular mesh wick concentrically arranged and supported within the housing is described. A feature of the device is an improved wicking restraint formed as an elongated and radially expanded tubular helix concentrically related to the wick. It is adapted to be axially fore-shortened and radially expanded into engagement with the wick in response to an axially applied compressive load, by which the wick is continuously supported in a contiguous relationship with the internal surfaces of the shell.

70004 THE HEAT PIPE (LE CALODUC)
Discussion of the heat pipe, which is a quasi-isothermal heat transfer device. It can be used for lengths above several tens of centimeters for various temperatures, and for heat flows of several kW/sq cm. The heat pipe consists of a metal or insulating tube the inside wall of which is lined with a grid which constitutes a capillary system. The tube contains a metallic or insulating substance which is sufficiently volatile at operating temperature so as to slightly oversaturate the capillary system. Advantage is taken of the latent heat of vaporization of the liquid, the vapor of which is transferred from the evaporator to the condenser, where the heat is recovered in the form of condensation heat, and the condensed vapor flows back to the evaporator under the effect of capillary force or gravity.

70005 HEAT PIPE: SPACE SPINOFF FOR HEAT TRANSFER
A discussion is given on the principles of design and operation of heat pipes.

70006 HEAT TUBES
Data on heat pipes is contained in this survey. The authors describe the operation principles, methods of preparation, choice of working fluid, operating conditions of heat pipe, limits of heating efficiency which can be experimentally realized, compatibility of materials, and problems involving the use of heat pipes. 45 refs.

71001 THE STUDY AND CLASSIFICATION OF TWO AND MULTI-COMPONENT HIGH THERMAL CONDUCTANCE DEVICES Interim Report
A comprehensive literature review covering the period from 1964 through midyear 1970 on heat pipe technology is presented. A brief citation of early heat pipe work is followed by a presentation of heat pipe phenomenology in which the mechanism of operation, external boundary conditions, operational limits, the influence of noncondensible gases, and startup behavior are discussed. Experimental investigations directed at determining the suitability of various substances for use as working fluids and wicks are described. In addition, numerous experimental studies dealing with operational characteristics of heat pipes are evaluated. Several possible areas of heat pipe application including heat transfer, temperature control, heat flux conversion and control of thermal conductance are examined. A discussion of basic heat pipe theory together with numerous modifications and simplifications concludes the review.

71002 HEAT PIPE - A NEW HEAT TRANSFER SYSTEM (DAS WÄRDEROHR - EIN NEUES WÄRMEÜBERTRAGUNGSSYSTEM)


Description of the principle, design, and applications of heat pipes. Different heat transfer systems are described, and their output is compared with that of a heat pipe. Liquids used for heat transfer in heat pipes over different temperature ranges are reviewed. The applications of heat pipes are discussed, including temperature homogenization, transformation of the heat flux density, and temperature control.
B. HEAT PIPE APPLICATIONS
B.1 GENERAL APPLICATIONS
65003 ANALYSIS OF A DOUBLE FIN-TUBE FLAT CONDENSER-RADIATOR AND COMPARISON WITH A CENTRAL FIN-TUBE RADIATOR

An analytical study of a flat condenser-radiator with a double fin-tube geometry (closed sandwich) with variable tube side-wall thickness was performed for a Rankine space-power electric-generating system. The analysis of the double-fin radiator included consideration of tube and header pressure drops, meteoroid protection for the tubes and headers, along with a detailed presentation of the heat-rejection analysis and total weight characteristics. The double fin-tube radiator is compared to a conventional central fin-tube configuration on a heat rejection to weight basis for a four-panel radiator configuration. Both fin and tube geometries are compared on the basis of the same power level, working fluid temperature, tube and header pressure drop, radiator material, and meteoroid protection criteria. A beryllium radiator for a 1-MW system and a columbium alloy radiator for a 500-kW system, both at a radiating temperature of 1700° R, were chosen for the weight and geometry comparisons.

65004 ANALYSIS AND EVALUATION OF A VAPOR-CHAMBER FIN-TUBE RADIATOR FOR HIGH-POWER RANKINE CYCLES

An analytical investigation of a flat, direct-condensing fin-tube radiator employing segmented vapor-chamber fins as a means of improving heat rejection was performed for illustrative high-power, high-temperature Rankine space power electric generating systems. The analysis of the vapor-chamber fin-tube radiator considered pressure drop in the radiator tubes and headers, meteoroid protection for the tubes, headers, and vapor-chamber fins, and temperature drop in the tube armor in the development of the descriptive equations. The heat transfer, weight, and geometric characteristics of the vapor-chamber fin-tube radiator were determined over a wide range of variables for two illustrative radiator design applications. The vapor-chamber fin-tube radiator was also compared to the more conventional solid-conducting double fin-tube and central fin-tube radiators on a weight and geometry basis for a nonredundant configuration with a high level of nonpenetration probability. The radiator can function as a solid-conducting configuration after the vapor chambers have been punctured by meteoroids, hence, its thermal effectiveness does not decrease in direct proportion to the number of fin segments punctured.

65005 NEW METHOD FOR VAPOR-PRESSURE MEASUREMENTS AT HIGH TEMPERATURE AND HIGH PRESSURE

The known methods for metal vapor-pressure measurements at high temperatures and high vapor pressures are troublesome and require rather complicated equipment. Not too much experimental data, therefore, has been published in the pressure range above 500 Torr and above 600°C. In this article, a method is described for measuring the vapor pressure in this region with rather simple equipment. This method is based on an observation published by Grover et al., that an inert gas is clearly separated from the metal vapor in a working "heat pipe."

67007 HIGH TEMPERATURE INORGANIC CHEMISTRY Annual Progress Report, 1 Jul 1965-31 Jul 1966

Results are reported for studies on electric conductivity of liquid tin to 2200°K, liquid bismuth to 1600°K, and liquid lead to 1800°K; use of heat pipe to measure thermal conductivity of solids and liquids by using it with centrifugally rotating liquid pipes; liquid aluminum oxide window; interaction of tungsten with liquid tin, bismuth, and lead; behavior of liquid tungsten carbide with the liquid solution of carbon in zirconium carbide; and centrifugal plasma jet apparatus.

67008 THE HEAT PIPE AND THE THERMOSIPHON FOR COOLING GAS TURBINE BLADES (LE CALODUC ET LE THERMOSIPHON POUR LE REFROIDISSEMENT DES AUBES DE TURBINES A GAZ)

Study of methods of keeping turbine blades at a temperature level compatible with the behavior of the material of the blades. The purpose is to make possible improved turbojet performance by increasing the temperature of the combustion gases. In order
to keep the blades at a safe temperature, it is suggested that cooled extensions might be fitted to the roots of the blades, thus forming a body like a tight capsule containing a molten metal of high conductivity. The isothermal nature of the system can be obtained by using the thermosiphon effect for the moving blades and the heat pipe effect for the stationary blades.


The surface tension and the density of the liquid earth alkaline metals Mg, Ca, Sr and Ba were determined in a region of high temperature. The method used is described. Fair discrepancies in temperature dependences or absolute values or in both with regard to existing data were found. The measurements correspond to the following formulas: Mg: \( \sigma = 721 - 0.149T \) \( \rho = \text{Ref. (5)} \) confirm. Ca: \( \sigma = 472 - 0.100T \) \( \rho = 1.613 - 2.21 \times 10^{-4}T \) Sr: \( \sigma = 392 - 0.085T \) \( \rho = 2.648 - 2.62 \times 10^{-4}T \) Ba: \( \sigma = 351 - 0.075T \) \( \rho = 3.59 - 2.74 \times 10^{-4}T \) The intersection of all surface tension lines in one point near \( \sigma = 0 \) is interpreted as a consequence of equal surface energy per surface atom for all earth alkalines.


The vapor pressure of Cs, Rb, Na, Li, Sr, Ca, Ti, Bi, Ba, Pb, and Ag was measured in the pressure range of 50 to 4000 torr. The method used for these experiments is relatively independent of impurity concentration. All measured values for the different metals follow regression lines. The constants of these lines are listed as well as the boiling points and the latent heats of vaporization. The experimental data are compared with those in the literature.


The vapor pressure of Yb was measured in an open "heat pipe." The method which has been described by the authors recently is briefly as follows. A tube closed at one end contains the test metal and argon at a certain pressure. The tube is heated in a vertical position by a RF furnace at the lower (closed) end. The heated part, enclosing the test metal, is brought to a temperature where the vapor pressure of the metal in the tube equals the argon pressure. At this point the vapor pushes the argon in the upper part of the tube and a zone of constant temperature is established in the lower part by the metal vapor; in fact there is a sharp change over in temperature between the metal vapor part and the argon. The pressure of the argon--measured at cold conditions--and the temperature in the hot zone give the corresponding data for vapor pressure and temperature of the test metal. This method works at vapor pressures above 40 torr.


The surface tension of the alkali metals has been measured at high temperature, using the maximum bubble pressure method in an open heat-pipe. The investigated temperature range was between 1200°K and 1600°K for lithium and between 700°K and 1200°K for the other metals. The experimental results are compared with existing experimental and theoretical data.


A preliminary study of heat pipe gas turbine regenerators for future Army aircraft power plants was carried out, and a feasibility evaluation was made. Heat pipe regenerators appear to be technically feasible, and they can readily be integrated with gas turbines with a minimum of duct pressure losses and engine modification. Regenerator weight is comparable to or greater than that of other regenerator types. Considerable development can be anticipated for both individual heat pipes and regenerator core modules prior to completion of a successful prototype. Regenerator costs are expected to be high.


The heat pipe appears to have great potential for determining the total
hemispherical emissivities of surfaces. If a heat source is located inside a heat pipe, the heat input to the system is accurately known. All of the heat input must be radiated from the external surface of the heat pipe and if the surface is isothermal, the total emissivity can be determined. The heat pipe, with its two-phase fluid flow, has this ability to maintain isothermal conditions over large areas and provides a simple, accurate method for emissivity measurements. By using various heat pipe containers and plating or spraying the containers with different materials, the emissivities of numerous materials can be established. The total emissivities of several different surfaces have been determined over a wide temperature range using a variety of heat pipe sizes and operating fluids. The results indicate that accurate, absolute measurements can be made by this method.

68006 TWO PIECE HEAT PIPE CONVERTER

Development of a light weight hydrocarbon-fueled thermionic generators intended for military field use; improved performance results from physical separation of heat source and converter by means of heat pipe; use of aluminum oxide flame barrier to prevent diffusion of combustion gases into converter and to protect emitter from oxidation.

68007 THE SURFACE TENSION OF Ag, Tl, Pb AND Bi AT HIGH TEMPERATURE

A new method has recently been described to measure the surface tension of liquid metals at temperatures where their vapor pressure ranges from 20 to 400 torr. In this method use is made of an open heat-pipe. The application of the open heat-pipe is of especially great advantage at high temperatures where the creation of an isothermal liquid pool by other methods is rather difficult. In this open heat-pipe surface tension measurements on Ag, Tl, Pb and Bi in the temperature range of 1300°K (Bi)-2200°K (Ag) are reported.

68008 IMPROVED RELIABILITY OF TWT'S THROUGH USE OF NEW LIGHT-WEIGHT HEAT REMOVAL DE-VICE

It has been demonstrated that "heat pipe" cooling technique can be applied to TWT's (traveling-wave tubes); since heat pipe will reduce temperature drop and operating temperatures along vacuum barrel, improved reliability can be attained; in addition, design flexibility is increased, and overall TWT weight can be reduced.

69007 EXPERIMENTS USING A 25 KW HOLLOW CATHODE LITHIUM VAPOR MPD ARC JET

Description of the performance of a 25-kW, lithium fueled, applied field magnetoplasmadynamic (MPD) arc jet which incorporates a unique feed system with an open-ended heat-pipe vaporizer and a hollow cathode. The arc typically operates at currents of 250 to 500 A, voltages of 40 to 60 V, and magnetic field strengths between 500 and 3000 G, and produces a highly ionized lithium beam which transports 70% of the input electrical power to the beam stop. The ambient tank pressures range as low as 2 x 10^-7 torr. A comparison of hollow-cathode and conventional MPD arc performance is made, and it is concluded that the hollow-cathode arc is superior to the conventional design. The efficiency of a process which converts input electrical power into kinetic energy is discussed in terms of a model which sets the plasma into rotation with subsequent expansion in a magnetic field.

69008 HEAT PIPE GAS TURBINE REGENERATORS

A preliminary evaluation of small aircraft gas turbine regenerators employing heat pipes as the active heat transfer elements has been carried out. The heat pipes permit the use of single ducts for the transport of the compressor discharge and turbine exhaust streams through the regenerator. This feature simplifies regenerator design and facilitates integration of the regenerator with the gas turbine. However, on the basis of weight and cost, the heat pipe regenerator does not appear to be competitive with other regenerator types at the present time.
69009 THE HEAT PIPE AND SOME POTENTIAL NAVAL APPLICATIONS

The heat pipe is a high heat conductance device that works on the principle of vapor heat transfer resulting from boiling a liquid in one end (evaporator) of a closed container—pipe or duct—and condensing in the cool end (condenser). This seemingly simple device can transfer extremely large amounts of thermal energy with a very small temperature drop. The theories of operation of the heat pipe are complex, but development has proceeded very rapidly in the past few years to the point where heat pipes can now be considered competitive for many naval applications, from the cryogenic to the 2000°C temperature region.

69010 HEAT PIPES FOR TEMPERATURE CONTROL

Several techniques for using a heat pipe to control temps. are reviewed. A detailed anal. of a self-controlled thermal control heat pipe using a non-condensing gas is presented. The model describes the variation of the heat source temp. Ts as a function of heat flow Q and sink temp. Tq. Exptl. results are given for a pipe using MeOH and operating at 40°.

69011 CRYOPUMPING OMNITRON ULTRA-VACUUM SYSTEM USING "HEAT PIPES" AND METALLIC CONDUCTORS

An omnitron is a synchrotron accelerator with concentric storage ring that will deliver beams of light and/or heavy ions in high-charge state for 25 msec requires that vacuum be specified more carefully than is common in everyday speech; cryopumping is done by cold fingers inserted in each gap between magnets on both synchrotron and storage rings; each finger, consisting of 80 K jacket around 4 K core, is cooled at one end of metallic attachment to nitrogen and helium distribution rings; pump-down tests of one full size pumping station comprising alumina beam tube brazed to stainless steel are reported using "heat pipes" (thermal siphons) and metallic heat conductors in cold finger design; superior pumping performance is achieved, i.e., pump down requires 7 hr to omnitron figure of merit; garden variety oil sealed mechanical pump and oil (convol 20) diffusion pump provided with fail safe LN trap-valves are used.

69099 HEAT-PIPE OVEN: A NEW, WELL-DEFINED METAL VAPOR DEVICE FOR SPECTROSCOPIC MEASUREMENTS

A new, well-defined metal vapor device called the heat pipe has been developed on the basis of the heat pipe, a heat conductive element designed by Grover and his co-workers in Los Alamos. It continuously generates homogeneous vapors of well-defined temperature, pressure, and optical path length. The vapor is confined by inert gas boundaries which remove the window problem and allow a direct pressure measurement without relying on vapor pressure curves. Due to the continuous evaporation and condensation the vapor purifies itself during operation.

70007 ADVANCED RANKINE CYCLE PROVIDES BASIC TECHNOLOGY FOR OTHER POWER PLANTS AS WELL

Review of the technology of the advanced Rankine cycle power plant as it evolved over eight years, and of how the high-temperature refractory alloy, and liquid-metal experience gained in the technology development is applicable to that required for the nuclear Brayton cycle and thermionic power systems. A comparison of technology requirements of the advanced Rankine cycle three-loop system, the three-loop Brayton cycle system, and the two-loop reactor thermionic power plant is given. The advanced Rankine cycle technology is then reviewed to point out the present status and show the relevancy to the needs of the Brayton cycle and thermionic power plants. It is shown that for all three systems the most attractive heat source is a compact fast spectrum nuclear reactor using an alkali-metal coolant which presents one of the most prominent features of the advanced Rankine cycle technology. The most significant advantage of such nuclear reactors is the minimum reactor vessel size required, so that it may be effectively used in space. Heat-rejection systems of all three power plants may also be most effectively designed by the employment of liquid coolants. The employment of heat pipes as radiation fins attached to the liquid-
coolant ducts may be an additional attractive possibility in any of the three systems. Finally, heat exchangers with liquid metals on one or both sides, pumps, valves, structural materials fabrication techniques, and liquid metal purification and handling techniques are all common to the three power plants.

70008 DEVELOPMENT AND FEASIBILITY TESTS OF ISOThERMAL IRRADIATORS
(CONF-690110-, pp 184-96) Weaver, C. V.; Patrick, A. J.; Ranken, W. A. (Los Alamos Scientific Lab., N. Mex.)

Laboratory and reactor tests are described which are used to show that specimen temperatures in irradiation experiments can be established and regulated through the use of inert-gas-filled heat pipes. When properly constructed, such pipes will last almost indefinitely and require no servicing. With the wide choice of available working fluids, there is no real restriction on the operating temperature of such devices other than the temperature of the reactor coolant.

70009 FINAL REPORT FOR ICICLE FEASIBILITY STUDY

A feasibility study and conceptual definition of an integrated Cryogenic Isotope Cooling Engine System (ICICLE) have been completed. This investigation included a study of the possible applications of such a system and the performance requirements thus identified. The basic system configuration studied was based on a heat driven cryogenic refrigerator operated from a radioisotope heat source and thermally coupled with heat pipes.

70010 ICICLE. INTEGRATED CRYOGENIC ISOTOPE COOLING ENGINE SYSTEM

The cryogenic refrigeration requirements of future spacecraft are reviewed and a central refrigeration system providing 5 w of cooling at 75 K is described. ICICLE (Integrated Cryogenic Isotope Cooling Engine System) utilizes a low electric power Vuillemin cycle refrigerator powered by a radioisotope heat source. Thermal linkage from the VM engine to the radioisotope, to the sensors requiring cooling, and to a radiator is accomplished by means of heat pipes. Discussion of the physical principles involved with all of the system components, as well as a performance description of each, is included. The integration of the system into a typical spacecraft is discussed with projected life, performance and weight.

71003 TECHNIQUE FOR THE DIRECT MEASUREMENT OF THERMAL CONDUCTIVITY AT HIGH TEMPERATURES BY THE USE OF A HEAT PIPE

An experimental technique for accurately measuring thermal conductivity in the temperature range of 800 to 1500 C is presented. The procedure is capable of making a direct measurement of the heat flux and temperature drop across a sample by the use of a heat pipe to transport the heat flux. The technique eliminates many of the uncertainties associated with methods presently employed to measure thermal conductivity at these high temperatures. Other applications of the method are also discussed.

71004 HEAT PIPE PRINCIPLE PUT TO USE

A short review of the heat pipe development is followed by the description of a Thermal Recovery Unit (TRU) that is utilizing heat pipes. The use of the TRU in heating and air conditioning systems is suggested. The TRU consists of a number of parallel heat pipes installed in an airtight diaphragm such that one end of the heat pipes is exposed to the make-up air and the other end to the exhaust air with no cross-contamination of outgoing with incoming air. In a heating system the make-up air would be pre-heated by the warm exhaust air while in a cooling system the make-up air would be pre-cooled. The two operations take place with no physical reversal of the unit and the system requires essentially no maintenance due to the fact that it is self-contained and has no moving parts. Other possible applications are listed such as ovens, sleeping bags and the use in a climate control system in spacecrafts and in the preservation of permafrost under buildings in arctic regions.

71043 EXPERIMENTAL EVALUATION OF AN AUTOMATIC TEMPERATURE CONTROLLED HEAT PIPE
B.2 THERMIonic AND THERMOELECTRIC CONVERTERS
65006 THE USE OF A NEW HEAT REMOVAL SYSTEM IN SPACE THERMIONIC POWER SUPPLIES

Structures of very high thermal conductance known as heat pipes are described. For a specific method of fabrication and operation in gravity-free conditions, a relation is derived for computing the optimum heat transfer as a function of the pipe radius, length and the physical properties of the fluid. For a pipe of one centimeter radius and fifty centimeters long, the theory predicts heat fluxes of from 3 to 95 kilowatts. Possible uses of heat pipes in space power supplies are discussed. These uses depend strongly on the lifetime and operating temperature limits.

65007 THE DEVELOPMENT OF AN INSULATED THERMIONIC CONVERTER-HEAT PIPE ASSEMBLY
Radio Corp. of America, Lancaster, Pa., Direct Energy Conversion Dept. W. E. Harbaugh, 30 Jun 1965 49 p, Avail:TAC (Contract AF33(615)-2617) (QTR-1; AD-468477)

This report covers the effort applied during the first three months on the subject contract. The development of a long life insulated thermionic converter integrated with an efficient, constant temperature heat transfer device. Specifically, the cylindrical converter, RCA Type A-1198B will be adapted for heating by means of a heat pipe to operating temperatures of 1500°C. The module available from prior work was life tested for more than 1000 hours. Irreparable damage was caused by equipment failure and the test halted.

65008 THE DEVELOPMENT OF AN INSULATED THERMIONIC CONVERTER-HEAT PIPE ASSEMBLY
Radio Corp. of America, Lancaster, Pa., Direct Energy Conversion Dept., quarterly technical rept. no. 2, Mar-Sep 65., by W. E. Harbaugh, Sep 65. 30p. Contract AF33 6152617

This report covers the development of a long life insulated thermionic converter integrated with an efficient, constant temperature heat transfer device. Specifically, the cylindrical converter is being adapted for heating by means of a heat pipe to operating temperatures of 1500°C. Progress was made in the development of high temperature ceramic-to-metal seals for use in the improved three converter module. High quality cesium was produced, using a purifying device based on heat pipe principles. The effect of xenon on thermionic converter performance was determined at an emitter temperature of 1350°C. Aluminum oxide insulated emitters were tested to 1600°C to determine the electrical and thermal resistance of the tri-layer. The heat pipe test vehicle gave satisfactory performance and produced design data used to fabricate prototype heat pipes. An A-1198C converter was fabricated for integration with the heat pipe. Electrical test indicated the need for minor modifications.

65009 THE DEVELOPMENT OF AN INSULATED THERMIONIC CONVERTER-HEAT PIPE ASSEMBLY
Radio Corp. of America, Lancaster Pa., Direct Energy Conversion Dept., quarterly technical rept. no. 3, 15 Sep-15 Dec 65, by W. E. Harbaugh, Dec 65, 35p. AFSC 2617-12

A contract objective was met during this report period when an A-1198C converter produced uniform electrical power output for a period of 506 hours when heated solely by a heat pipe. Progress was made in the improvement of the three converter module although problem areas still exist in high temperature ceramic to metal seal technology. Cesium was produced by the use of ultra high vacuum processing equipment. The effect of xenon on argon on converter performance was determined at emitter temperatures up to 1550°C. Tests continued on the insulating capabilities of aluminum oxide layers at 1600°C. Heat pipe processing was improved and simplified and prototype heat pipes were tested to 1600°C. Fabrication of additional A-1198C converters was continued. These converters will be used to obtain calibration test data with an electrical heater and for additional life tests.

65010 THE DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE WITH THERMIONIC ENERGY CONVERTERS

Work concerned the most efficient method of coupling a simulated thermionic converter to a heat pipe. The heat pipe incorporates a gas barrier and is used to conduct the heat from a fossil fuel burner to the simulated converter. A theoretical analysis of the operation of the heat pipe will be made and confirmed experimentally. Progress was made on the following tasks: the construction of a sodium heat pipe which operated to 1000 Centigrade; the evaluation of sodium as a working fluid; the evaluation of the wetting characteristics of lead on different capillary structures; the fabrication of vacuum tight ram seals and the development of a high strength alumina body for the barrier. Preliminary evaluations of the permeation characteristics of barrier materials was initiated.
Heat pipes have been suggested as heat removal systems in space thermionic power supplies. In one concept, heat is removed from the reactor at emitter temperature, each fuel rod consisting of a heat pipe ("emitter heat pipe") with the uranium containing fuel attached externally to the pipe. The pipe extends through the reflector, and a thermionic converter is located on the extended portion of the pipe. A second heat pipe is used to carry away the waste heat from the collector and act as radiator to dissipate this heat to space (collector heat pipe). Following this concept heat pipe thermionic converters have been built and operated with power outputs of up to 100 W, simulating the nuclear heating by RF. The experiments prove the feasibility of heat pipe thermionic converters. Their electrical power output corresponds to what is measured with normal thermionic converters, if care is taken with regard to diffusion of the heat pipe working fluids into the converter. Either the wall materials must be impervious to the working fluids, or working fluids must be chosen which are compatible with the converter operation (as Cs) or which may even have a favorable influence (e.g., Ba).

A relation for the electrical power output of a cylindrical heat pipe thermionic converter is derived, taking into account ohmic losses in emitter, collector and lead wire. The maximum electrical power output is determined for a given specific mass of the converter, emitter radius and lead wire length by optimizing the load voltage, the length of the emitter and the cross sections of emitter, collector and lead wire. The electrical power which can be generated with a single converter unit is limited by the tolerable specific mass and diameter of the emitter; large power outputs necessitate large specific masses and/or large diameters. The bulk properties of emitter, collector and lead wire material enter into the relation for the maximum electrical power output only as the product of electrical resistivity and mass density. The power output is higher the smaller each of these products is. The electrical power output of the converter differs from the power output of an ideal converter with zero electrical resistivities by Joule losses and shift losses. The efficiency of the converter reaches values of up to about 75% of the efficiency which would be obtained in case of no thermal losses through the lead wire and of zero electrical resistivities of emitter, collector and lead wire.
be satisfactory, a fossil fuel-heated converter was assembled which delivered 100 watts of power during testing.

66006 THE DEVELOPMENT OF AN INSULATED THERMIONIC CONVERTER-HEAT PIPE ASSEMBLY

Considerable progress was made on the five-fold research projects of Phase I. In evaluating current design, an improved metallizing technique was developed for stronger ceramic-to-metal seals. In the area of performance improvement, cesium purification methods were investigated and positive contributions obtained. Testing and evaluation of the heat pipe continued with particular emphasis on problems inherent to the lithium working fluid. Evaluation of aluminum oxide as an emitter insulation probed into the merits of increased layer thickness. Converter-Heat Pipe Assemblies 4 and 5 received performance testing; thereby yielding valuable data; while fabrication of Converter A-1198C, No. 6, was completed and the unit readied for life testing.

66007 THE DEVELOPMENT OF AN INSULATED THERMIONIC CONVERTER-HEAT PIPE ASSEMBLY

The effort reported covers the first phase of a program of developments leading to the integration of long life, insulated, thermionic converters with efficient, constant temperature, heat transfer devices. The report details the investigations which demonstrated reliability of thermionic modules by life test and of high temperature ceramic-to-metal seals. An improved module was designed for operation up to 1500°C.

66008 THE DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE WITH THERMIONIC ENERGY CONVERTERS


66009 THE DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE WITH THERMIONIC ENERGY CONVERTERS


66010 EMPLOYMENT OF HEAT PIPES FOR THERMIONIC REACTORS

It is shown how heat pipes can be used in thermionic reactors. For this purpose the mass per power ratio of three different systems was calculated: hollow sphere reactors with out-of-core thermionic converters cooled by heat pipes; cylindrical reactors with out-of-core thermionic converters heated and cooled by heat pipes; and reactors with heat pipes instead of cooling fins. For these systems, lower mass per power ratios are obtained with heat pipes.
Heat-pipes are closed tube structures, wherein heat is transported by evaporation and condensation of liquids. The condensate flows back to the heating zone along small grooves inside the tube walls, propelled by the capillary forces. This new heat removal system also works well in gravity free space and shows very little temperature drop between the heating and cooling zone (some degrees). A review is given of the theoretical and experimental work carried out at Ispra. Possible combinations of tube material and working fluid and the physical and technological properties of heat-pipes are treated. Heat-pipes can be used for the heat supply to, and the heat removal from thermionic energy converters. A first experimental unit of this kind showed the expected properties. The advantages and disadvantages of a thermionic reactor concept for space using three different kinds of heat-pipes are discussed. The use of heat-pipes may also lead to special advantages for energy supplies with radioisotopes and thermionic converters.

The report describes the basic components of a 3 KW (150 lb) thermionic energy converter. The basic components are: Fossil fuel burner, heat pipe-thermionic converter unit, and power conditioner. Special features of the power generator are the low noise level and the low weight, which makes the unit suitable especially for military application.

The paper describes development work on space auxiliary power system utilizing heat pipes to transfer the energy generated by radioisotopes to thermionic converter. Test results of heat pipe performance and converter performance are given.

A study was made of a nuclear electric space propulsion system. This study assumed that the system was composed of a thermionic reactor, "heat pipe" radiator and a lithium arc jet propulsion unit. The specific weight of the entire system (unshielded) was 3.9 kg/kW jet power. Because of limited experimental evidence on fuel burn-up, the reactor operating time may be limited to 5000 hrs. This operating time is sufficient to accomplish the manned Mars mission.

The paper describes the advanced made in fossil-fuel-fired thermionic energy converters resulting from the use of a heat pipe to couple the converter with the heat source. Since the advent of the heat pipe, the power output of the converters has been increased from 10 to 100 watts. Improved performance results from a separation of the heat source and the converter. This separation allows for individual...
optimization of the regenerative swirl burner and permits the construction of a larger-sized cylindrical converter. Improved performance is also a result of the inherent characteristics of the heat pipe. The heat-flux transformation property of the heat pipe allows the converter, which requires a high heat flux for operation, to be operated from a low-heat-flux burner. The nearly isothermal property of the heat pipe contributes to a uniform emitter temperature and a reduction in the thermally induced stresses in the ceramic flame barrier. A heat pipe of two-piece construction, consisting of an alumina flame barrier and a molybdenum emitter, is also described, and the problems associated with its use are discussed, such as the need for a compatible working fluid, establishment of an effective temperature at the alumina-molybdenum braze to reduce external oxidation, and the search for high-purity, high-strength alumina flame barriers. The advantage to be gained from the use of two-piece heat pipes is that the temperature gradient necessary to transfer the power from the burner to the heat pipe is reduced. This temperature difference allows the thermionic converter to operate at a correspondingly lower source temperature.

67016 A LOOK AT NUCLEAR THERMIONIC SYSTEMS

Discussion of the in-pile thermionic reactor, the core of which consists of an array of thermionic diodes, each containing uranium to maintain a fission reaction and achieve the emitter temperature needed for production of electricity. The in-pile thermionic reactor is said to be suitable for auxiliary power and nuclear-electric propulsion, especially if combined with the "heat pipe". Basic components such as the arc jet, heat pipe, and the thermionic cell are described, and a conceptual design of a moderated reactor is investigated.

67017 THERMIONIC CONVERTERS WITH HEAT-PIPE RADIATORS

An analysis of heat-pipe dynamics is conducted to develop criteria for the design of thermionic converter heat-pipe radiators and the selection of their working fluid. The evolution of the design of a particular thermionic converter prototype is presented in order to demonstrate the progress of heat-pipe technology, and the reduction in thermionic converter weight made possible by the application of heat pipes. The first version of this prototype used conduction heat transfer in its collector-radiator structure, and, after thorough design optimization through the construction of several models, it weighed 320 g. An initial model of the heat-pipe version of the same prototype appeared to be well optimized and weighed only 78 g.

67018 OUT-OF-PILE HEAT PIPE THERMIONIC SPACE-POWER CONCEPT

67019 NUCLEAR REACTOR WITH THERMIONIC CONVERTER

A nuclear reactor heat removal system is described comprising heat pipes having capillary linings extending into the reactor components from the exterior of the reactor and containing condensable vapors. The heat pipes can be employed as the heating means for thermionic energy converters.

67020 HEAT PIPES FOR THERMIONIC CONVERTER WITH ISOTOPIC FUEL

Some results of the calculation of the design of a heat pipe for the emitter of the thermionic converter with 500 W(t) isotopic source were given. A sodium prototype was constructed and tested from 600 to 900°C in order to verify the satisfactory operation of the heat pipe in weightless regime. In the case of lead or silver heat pipes (1500°C) the importance of acceleration forces, which can affect the operation of the heat pipes at the time of launching, was emphasized.
67021 EURATOM'S ACTIVITY ON RADIOISOTOPE POWERED THERMOELECTRIC AND THERMIONIC GENERATORS
Design studies of generators using a thermoelectric conversion system were carried out for a 5 W(e) generator based on Pb Te thermoelectric couples, powered with a thulium-170 source. A demonstration device of a "sandwich" type (two modules of couples in series on both sides of the flat isotopic source) has been constructed and tested by electrical heating. Some studies have been made on electrode-element bonding. The heat source (in preparation) will be made of 15 small tubes filled with Tm₂O₃ pellets and pressed between metal plates. A parameter study for a 50 W(e) generator with Ge Si elements and an actinium-227 source shows that units with reduced size and weight should be producible for space application. Replacing the thermoelectric system by a thermionic converter has the advantage of a higher thermal efficiency. Parameter and design studies on radioisotope powered thermionic generators show however a rather strong decrease in the efficiency with decreased power output below 50 W(e). The importance of using a new heat transfer system, called heat pipes, for heat removal and heat flux concentration is discussed.

67022 ADVANCED CONVERTER DEVELOPMENT
Two converter models of identical design but differing in collector material were fabricated and tested to determine the difference in converter performance obtained with rhenium and palladium collectors. The data cannot be compared directly because of important emitter temperature errors. The errors are ascribed to the difficulty of incorporating a suitable black-body hole in a hardware-type emitter structure. A thermal analysis is made with the assumption that the heat losses other than interelectrode radiation are identical for the two converters, and emitter temperature corrections are implicitly derived. Based on the corrected data, the use of palladium instead of rhenium as a collector is judged to reduce the output voltage of a thermionic converter of the present design by 0.037 volt. A third converter model with an identical emitter structure but incorporating a heat-pipe collector-radiator structure was also fabricated and tested. The heat-pipe structure was used to reduce the collector overheating at large output currents which has persisted throughout the development of the previous models. The performance obtained on this model demonstrated that the collector overheating problem has been overcome. The model operated in excess of 400 hours at full power, including twelve abrupt thermal cycles, without failure. It has a niobium collector, and using the thermal analysis described above to interpret its performance data, it is concluded that the output voltage is reduced by 0.074 volt with the use of niobium in place of rhenium as the collector material.

67023 INTEGRATE CESIUM-GRAPHITE RESERVOIR SYSTEM IN A HEAT PIPE THERMIONIC CONVERTER
A heat-pipe thermionic converter with a Cs-graphite absorption reservoir has been built and tested. The Cs-graphite lamellar compound enclosed by the collector heat-pipe is operated at collector temperature. The collector temperature can be changed by a movable radiation shield which surrounds partly the collector heat-pipe. A temperature sensitive bimetal system moves the radiation shield in such a way that in dependence of emitter temperature the optimum reservoir temperature is adjusted. Experimental results are reported and problems connected with the reservoir system are discussed.

67024 USE OF A NEW HEAT REMOVAL SYSTEM IN SPACE THERMIONIC POWER SUPPLIES
Structures of very high thermal cond. known as heat pipes are described. For a specific method of fabrication and for operation in gravity-free conditions, a relation is derived for computing the optimum heat transfer as a function of the pipe radius, length, and the phys. properties of the fluid. For a pipe of 1 cm. radius and 50 cm. long, the theory predicts heat fluxes of 3-95 kw. Possible uses of heat pipes in space power supplies are discussed. These uses depend strongly on the lifetime and operating temp. limits.

67025 TESTS ON FLAME HEATED THERMIONIC DIODE
Development of 45w gasoline-fueled thermionic diode converter with bonded shell-emitter structure; advantages of direct bonding of protective shell to emitter over configuration where emitter is separated from shell by vacuum, liquid, or gas are discussed; problems inherent in bonding SiC shell to W emitter attributed to WSi2 formation; C interposed between SiC and W prevents WSi2 from forming and insures adequate bond; heat pipe performance characteristics graphed; power output 100 w, W emitter, Ni collector, and operating temperature 1450 °C.

67026 HEAT-PIPE THERMIONIC REACTOR CONCEPT
Pedersen, E. S., Nuclear Eng v 12 n 129 Feb 1967 p 112-14 Avail:TAC
Main components are reactor core, heat pipe, thermionic converter, secondary cooling system, and waste heat radiator; thermal power generated in reactor core is transported by heat pipes to thermionic converters located outside reactor core behind radiation shield; thermionic emitters are in direct contact with outside envelope of heat pipes and collectors are in contact with liquid metal secondary cooling system that transfers waste heat to radiator.

68009 SMALL OUT-OF-PILE THERMIONIC CONVERTER
The preliminary design of a nominal 10-kW electrical space power supply is presented. The design uses heat pipes together with radiation coupling to transfer heat from a small compact reactor to a converter consisting of a large number of thermionic diodes of planar design. Heat pipes are used to concentrate and to disperse heat flux within individual diodes. Each component of the power supply is conservatively designed, and considerable improvement could be realized from additional study and a modest development program. The unshielded specific weight of the power supply is 95 lb/kW electrical.

68010 NUCLEAR THERMIONIC SPACE POWER SYSTEM CONCEPT EMPLOYING HEAT PIPES
A space power system employing out-of-pile thermionic diodes and using concentric heat pipes for both heating and cooling of these diodes has been examined. For an early application, the out-of-pile thermionic diode has some advantages over an in-pile system because it is removed from the reactor environment. Moreover, the heat pipe permits emitter temperatures that are not much less than the temperature of the fuel clad. Laboratory data on the performance of heat pipes has been examined and the results used to estimate reasonable performance levels for thermionic diodes which were consequently incorporated into a small, fast-spectrum nuclear reactor concept. Performance levels and system weights including shield weights, have been estimated from first order calculations. The overall system can have the advantage of the safety inherent in heat pipe redundancy and the improved performance available from components that are removed from the reactor environment.

68011 APPLICATION OF HEAT PIPES TO SNAP 29
A heat-pipe heat rejection system for the SNAP 29 radioisotope thermoelectric generator is currently under development. The system is comprised of a number of individual water heat pipes extending from the generator cold plate to the space radiator. The heat pipes are nominally 15 ft. long, have an outer diameter of 3/8 in., and a curved condenser which conforms to the vehicle circumference. Each heat pipe is capable of transporting 200 W at a nominal operating temperature of 300°F. The paper discusses the requirements prescribed for the heat pipe system and the design chosen to meet the specifications, as well as the fabrication and assembly methods being used.

68012 THERMIONIC HEAT PIPE SPACE POWER CONCEPT

68013 REACTOR CONCEPT FOR SPACE POWER EMPLOYING THERMIONIC DIODES AND PIPES
Heath, Colin A.; Lantz, Edward (National Aeronautics and Space Administration,
A thermionic generator power system using a reactor heat source connected to external diodes by heat pipes is investigated. A concept capable of supplying up to several hundred kilowatts of electrical power is described. Experimental results from laboratory tests of both heat pipes and thermionic diodes have been used to set reasonable performance levels for thermionic diodes which are both heated and cooled by heat pipes. A reactor fueled with slab geometry fuel elements of uranium-233 nitride could provide a minimum power of 36 kW(e) limited by criticality considerations. Reactor control is effected by a combination of moderator and neutron absorbing material in a central region of the reactor. Neutronic calculations indicate that a 6% swing in reactivity is obtainable with this control system. Total mass of the reactor, thermionic diodes, radiator and reactor shield for an instrumented payload is estimated to be 300 kg.

Heat-Pipe Thermionic Converter with Graphite Absorption Cesium Reservoir Working at Collector Temperature
Test results for converters having cesium-graphite lamellar compound reservoirs and working below 1 torr; it was found that at optimum Cs pressure collector temperature can be chosen between numbers of discrete values corresponding to different Cs-graphite compositions; experimental data, describing functionality of converters and their limits are given.

Development of Insulated Thermionic-Converter/Heat-Pipe Assembly
Feasibility of operating high-power thermionic converter from heat pipe; heat pipe is integrated with cylindrical converter; assembly was extensively tested to determine operating characteristics and life capabilities; program included evaluation of heat-pipe processing techniques and capillary structures and determination of methods for supplying thermal input; converter designs and results of analyses and tests; converter power output in 275 w, output current 610 amp; molybdenum was used as collector and emitter material; emitter temperature was 1500 C, area 40 sq cm, converter weight 3.75 lb.

Investigation of Performance of an Out-of-Core Thermionic Space Power System
California Univ., Livermore, Lawrence Radiation Lab., William E. Loewe, 18 Mar. 1968, 24 p refs Submitted for publication. Supported by AEC (UCRL-70984; Conf-680802-5) Avail:TAC
Conceptual designs of out-of-core thermionic space power generators using heat pipes have been produced for various powers, temperatures, and constraints or parameter values. Since major impediments to in-pile thermionic systems are alleviated or eliminated in the out-of-core concepts, a competitive degree of feasibility and competitive specific masses are adequate to establish the need for emphasis on these systems in future studies and development activities. Feasibility in the six cases shown in conceptual detail appears to be limited only by lithium heat pipe feasibility and a favorable outcome of current technology development of UN, W, and Li materials in the temperature range considered. For example, one man-rated system at 300 KW(e) and 1800 K shows a specific mass of 7.9 kg/KW(e) and will accommodate an 18 m payload at a 50 m distance.

Primary interest during this period was on the fabrication of system components, on qualification testing of the sodium heat pipe, on emissivity tests of tantalum specimens coated with zirconia and alumina, and on the assembly of the SiGe stage to the heat pipe and subsequent delivery. This report includes a status summary of the major system components along with test results obtained where applicable.

A Nuclear Thermionic Space Power Concept Using Rod Control and Heat Pipes
A space power system using a fast spectrum nuclear reactor, out-of-pile thermionic
diodes, heat pipes, and a dual central absorber rod type of reactivity control has been studied. Emphasis is placed on the neutronic aspects and general feasibility of the concept. Comparison is made between uranium-233 and uranium-235 nitride and plutonium-239 nitride fuels. In this concept heat is transferred from the reactor core to the thermionic diodes by layers of radial heat pipes stacked alternately with slabs of fuel. For this out-of-pile concept, which would supply about 130 kilowatts electric, the reactor can be considerably smaller than the equivalent reactor with in-pile diodes.

69015 ADVANCED HEAT PIPE THERMIONIC TECHNOLOGY TASK 1. DEVELOPMENT OF HIGH VOLTAGE MODULE
The design of a heat pipe-thermionic module concept capable of output potentials as high as 28 volts was investigated. Technologies required for this module design were developed beyond the state-of-the-art. An advanced Al2O3 casting technique was developed for the fabrication of the key insulated tri-layer assembly. Arc suppression coatings were developed for the prevention of voltage arcs in the module due to potentials above the ionization potential of cesium. Fabrication and assembly techniques necessary for the logical development of the high voltage module concept were also investigated. Heat pipe designs capable of transferring the required thermal throughput for high voltage module concepts were also investigated.

69016 DESIGN AND FABRICATION OF ADVANCED THERMIONIC CONVERTERS Final Report
Task I centered on the iterative construction of 10 engineering models of a solar energy thermionic converter, and Table 1 describes their main features. In the last three models, the collector-radiator structure of the previous models was replaced by a heat pipe. At the culmination of the effort, the converter with a heat pipe structure had achieved close to a 70% reduction in weight; however, its performance was the same as that of typical converters with rhenium electrodes, and it did not reach the goal of 20 watts/cm² at 0.8 volt, 1700°C. Task II involved a generator flux analysis to determine the best number of converters to match the converter heat requirements to the available solar energy, the optimum cavity aperture size, the required adjustments of surface emissivity and absorptivity values to insure even flux distribution, and the effects of changes in emitter temperature and heat input on flux distribution within the generator. Based on this analysis a 16-converter generator, using converters with heat pipe collector-radiators, was designed in detail.

69017 ANALYSIS OF AN OUT-OF-CORE THERMIONIC SPACE POWER SYSTEM
Conceptual designs of out-of-core thermionic space power generators using heat pipes have been produced for various powers, temperatures, and constraints or parameter values. Since major impediments to inpile thermionic systems are alleviated or eliminated in the out-of-core concepts, a competitive degree of feasibility and competitive specific masses are adequate to establish the need for emphasis on these systems in future studies and development activities. Feasibility in the six cases shown here in conceptual detail appears to be limited only by lithium heat-pipe feasibility and a favorable outcome of current technology development of UN, W, and Li materials in the temperature range considered. For example, one man-rated system at 300 kWe and 1800 K shows a specific mass of 8 kg/kWe and will accommodate an 18-m payload at a 50-m distance.

69018 HEAT PIPE STUDIES AT THERMO ELECTRON CORPORATION
The paper describes three studies concerned with the development of heat pipes for use with thermionic energy conversion devices. These investigations are concentrated in the areas of wick development, high temperature heat pipe life testing, and performance testing of relatively low temperature heat pipes. The results of tests with lithium heat pipes operating at 1550°C and 2500 W are given. Extended life test data for a TZM-lithium device are presented. In addition, a new high temperature distillation method used successfully with the lithium heat pipes is described. A program
to develop rigid porous tubes for use as capillary structures in heat pipes and the resulting capillary pore size data from several samples are presented.

69019  AN IMPROVED OUT-OF-CORE THERMIONIC REACTOR FOR LOW POWER

Description of an out-of-core reactor whose power output and specific power are increased by using a central heat pipe in a coaxial cavity of the core. By this means, the maximum temperature does not occur at the centerline of the core but somewhere between the cavity wall and the outer surface. Therefore, at a given maximum temperature, the heat flux at the outer surface is increased. The specific power of 20 to 30 W/kg is in the same order as for a thermal incore reactor in the low-power range. The out-of-core type with a central heat pipe might be an interesting power supply in the low 10 kWe power range and for long-time missions.

69020  A HEAT PIPE THERMIONIC REACTOR CONCEPT

Introduction of an out-of-core thermionic reactor concept for space power supply in the range of 30 to 40 kWe using lithium heat pipes in crossed layers, each heat pipe bearing one converter. The concept is based on the assumption of a successful development of high temperature heat pipes (1500 to 1600°C) and related converted systems for long period operation. The converters are located outside the beryllium reflector on four sides of a nearly cube-shaped fast reactor core. Heat is transported from the (Uzr) carbide fuel to the heat pipes by thermal heat radiation, thus eliminating high temperature compatibility and electrical insulation problems. The crossed layer arrangement combined with radiative heat transfer allows a simple core structure with a highly reliable cooling system using the redundancy principle. Four movable reflector segments on the top side serve for reactor start-up and power control.

69021  OUT-OF-CORE THERMIONIC SPACE POWER

Survey of conceptual out-of-core thermionic systems using heat pipes identifies critical technology areas, investigates feasibility for space application, locates parameter regimes of interest, and estimates specific mass values. Required, current, and the projected state-of-the-art in these critical areas of technology are compared. Temperatures and powers were surveyed in the ranges from 1400 to 2200 K and from 10 kWe to 10 MWe, respectively. A cylindrically symmetric geometry with a linear display of system components was studied. In general, out-of-core thermionic systems with heat pipes appear to be attractive candidates for use in space over a broad range of electric power levels, meeting the requirements of both advanced auxiliary power and nuclear (electric) propulsion.

69022  DESIGN AND CHARACTERISTICS OF AN ACTINIUM FUELED THERMIONIC GENERATOR

The thermionic generator to be built in cooperation between U.M. and B.B.C. is presented. Design and optimization of a thermionic generator as it stands now is
Experimental results of measurements with a plane parallel diode using a polycrystalline tungsten emitter and a molybdenum collector at emitter temperatures between 1800 and 1900 K will be discussed. The compatibility of systems containing the following elements or compounds have been considered: La2O3, PbO, Pb, ThO2, Th, W, O2, He. The experiments are carried out at temperatures up to 2500 K. Tests up to 2000 hr are conducted at 2100 K. The permeability of ThO2-coatings for helium has been tested on boron-containing spheres. Helium release is measured by heating the particles and collecting the gas. The metal ceramic seal has been developed, tested for about 5000 hr at 2000 K and 20 torr cesium pressure; it is still leak tight. A Nb 1% Zr collector heat pipe filled with sodium is running for about 12,000 hr. at 1100 K without degradation. The emitter lead has been proven to withstand temperature cycles between 750 and 2200 K.
thermionic conversion devices and related systems. High temperature lithium heat pipes for emitter applications and low temperature sodium and potassium heat pipes for collector applications have been investigated. Test results are presented for the following heat pipes: (1) unalloyed tungsten-lithium; (2) TZM-lithium at 1560 deg C; (3) nickel-sodium and nickel-potassium at 500 to 550 deg C. The results of a metallurgical examination of the TZM-lithium heat pipe are given. The heat transfer capability of the nickel-sodium, the nickel-potassium, and the tungsten-lithium heat pipes is discussed with respect to analytical predictions.

69027 POWER FROM THERMIONIC CONVERTERS
Papers presented at the International Conference on Production of Electrical Energy with Thermionic Converters, May 27 to 31, 1968, in Stresa are summarized. Converter fuel element development for ground-based reactors and heat pipe development for thermionic space reactors are emphasized.

69028 THERMIONIC CONVERTER DEVICE
The converter comprises an emitter, a collector, a first heat pipe for transferring heat from a source to the emitter surface, a second heat pipe for transferring heat from the collector surface to a heat sink, tubular means for introducing an easily ionizable gas into the space between the emitter and collector and means enclosing the aforementioned elements.

69029 DEVELOPMENT OF THREE CONVERTER HEAT PIPE--THERMIONIC MODULE

70011 A DESIGN STUDY OF A 350 kWe OUT-OF-CORE NUCLEAR THERMIONIC CONVERTER SYSTEM
Nuclear thermionic systems with the thermionic converters outside the reactor have been reexamined in the perspective of several recent technical advances; new high temperature, corrosion resistant, high strength alloys; high heat flux heat pipes; improved thermionic converters; and lightweight, vapor-cooled radiators. These have been combined to yield a new look to the out-of-core approach. A compact reactor results; insulators are eliminated by the use of heat pipes as electrically resistive elements; and weights are reduced by combining vapor-cooled radiators, structural supports, and current leads into vapor-cooled radiator modules. The overall design is also highly modular and thus provides high reliability and a reduction in development costs.

70012 A PARAMETRIC ANALYSIS OF A DEEP SEA RADIOISOTOPIC THERMOELECTRIC GENERATOR EMPLOYING A HEAT PIPE
A parametric design analysis was performed using a heat pipe in an existing deep sea Radioisotopic Thermoelectric Generator (SNAP-21). Heat is transferred from an annular fuel pellet to an annular thermoelectric generator through a connecting heat pipe. The fuel pellet is fully shielded so that the thermoelectric generator is easily removable. Overall efficiency and the weight of major components were determined for varying fuel radii of from 1.3 to 1.7 inches and for varying insulation thicknesses of from 1.0 inch to 2.0 inch. The analysis indicates that there is a particular fuel radius (at constant insulation thickness) at which minimum weight is reached, while the maximum overall efficiency is obtained at a larger fuel radius. The median design has an overall efficiency (at the beginning of life) of 5.4% and a total weight of 570 lbs. These design results, when compared to the existing SNAP-21 design gives an increase in overall efficiency of at least 7% and a reduction in total weight of 12%.

Radio Corp. of America, Lancaster, Pa., R. W. Longsderff, 30 Sep. 1969, 47 p, refs. (Contract AT(30-1)3979) (NYO-3979-3) Avail:TAC

B.2-12
The design of a heat pipe-thermionic module concept capable of output potentials as high as 28 volts has been investigated. Technologies required for this module design have been developed beyond the state-of-the-art. An advanced A1203 casting technique was developed for the fabrication of the key insulated tri-layer assembly. Arc suppression coatings have been developed for the prevention of voltage arcs in the module due to potentials above the ionization potential of cesium. Fabrication and assembly techniques necessary for the logical development of the high voltage module concept have also been investigated. Heat pipe designs capable of transferring the required thermal throughput for high voltage module concepts have also been investigated.

70014 THERMALLY CASCADED THERMOELECTRIC GENERATOR

A thermally cascaded thermoelectric generator is disclosed. The generator includes a first stage containing high-temperature thermoelectric elements and a second stage containing lower temperature thermoelectric elements. The stages are connected in thermal series by means of an elongated heat transfer pipe containing a liquid metal and a wick. A portion of the heat radiated to the first stage from a high-temperature radioisotope source is converted to electricity. The heat rejected by the first stage is conducted to the heat pipe and absorbed by the liquid metal as latent heat of vaporization. The vapor rises to the second stage and condenses to give up latent heat of condensation which is transferred to the second stage and is converted to electricity therein. The condensed liquid returns on the wick to the vicinity of the first stage.

70015 THERMIONIC CONVERTER ASSEMBLIES

A radioisotope-powered thermionic converter is designed with the collector-radiator structure functioning as a heat pipe for maximum efficiency in waste heat rejection. The heat pipe has a radiator configuration involving an enclosure of spaced heat-rejecting and -receiving surfaces. Several alternate designs are shown.

70016 SPACE ELECTRIC POWER R AND D PROGRAM

Development and testing of a thermoelectric module for direct conversion of heat to electricity is reported. Information is included on potassium-input heat pipe, heat-pipe radiator system development, mercury radiator heat pipe, phenyl ether radiator heat pipes, and mercury input heat pipes.

70017 ADVANCED HEAT PIPE THERMIONIC TECHNOLOGY. TOPICAL REPORT, TASK II. DEVELOPMENT OF ADSORPTION RESERVOIR

Work performed on the development of an integral adsorption reservoir thermionic converter is described. Three general areas were investigated during the study including cesium purification, material processing, and integral reservoir converter fabrication. The cesium purification employed a high temperature reaction to remove halide compounds. A study was also made to develop a large surface to volume ratio in a molybdenum matrix. Variations in time, temperature, and atmosphere for sintering the matrix were used as the basis of the study. The RCA A-1279 Thermionic Converter was modified to include an integral matrix reservoir and designated the RCA A-1345. The modified design included 80 cm³ of reservoir matrix integrally located within the converter. The device was fabricated, processed, and electrically life tested using its own internal cesium reservoir for a period of 380 hours before the heat pipe-heat source failed forcing termination of the test. Long term changes in electrical output were observed after installation of each new heat source which confirmed the slowly changing nature of internal cesium equilibrium. The ability of the converter to operate successfully and stabilize at a new satisfactory level of performance after each thermal cycle validates the fundamental design.

70018 GASEOUS-CORE REACTOR CONCEPT FOR ELECTRICAL POWER GENERATION
Gritton, E. C. (Rand Corp, Santa Monica, Calif) Pinkel, B; Nuclear Applications and Technology, v 8 n 4 Apr 1970 p 355-70 Avail:TAC

Feasibility of the application of the gaseous-core reactor to electric power generation systems. An analysis of the variation-heat-transfer process in the gaseous
core is presented. The results of this analysis are then combined with an estimate of the quantity of uranium required for criticality to determine the core temperature and pressure for various values of power generation and core diameters. This analysis indicated that attractive power levels in reactors of practical size can be obtained with gas pressures and wall temperatures within the potential capability of known structural materials. As an example, it is estimated that a spherical gaseous-core reactor with a radius of 152.4 cm would generate about 4000 Mw(th) with a gas pressure of about 11 atm. Several configurations of the gaseous-core reactor employing thermionic converters and heat pipes are described.

70019 THERMOELECTRIC-BIOMEDICAL HEAT PIPES

A thermoelectric-biomedical heat pipe for hypo- and hyperthermia applications which consists of a thermoelectric convertor and a slender flexible heat pipe is described.

71005 USE OF HEAT PIPES FOR ELECTRICAL ISOLATION

Some of the problems of electrical isolation of the emitter from the heat source in out-of-core thermionics can be circumvented by the use of long heat pipes as electrical resistive elements. The various relations governing electrical resistance, heat pipe geometry, heat pipe pumping limits, and temperature losses were used to estimate the performance of heat pipes used in this manner. The design variables are the form of the electrical network, heat pipe length, heat pipe diameter, wall thickness, the wick design in the adiabatic section of the pipe, and heat pipe materials. First order calculations project the attainment of 28 volts with small penalties in system performance.

71006 FABRICATION AND EVALUATION OF AN OUT-OF-CORE THERMIONIC CONVERTER MODULE

The mechanical design, fabrication procedure, and preliminary test results obtained for an out-of-core thermionic converter module, heated and cooled by heat pipes are presented. The mechanical and thermal evaluation of critical module components, including the cermet insulator, converter end structure, and collector heat pipe in the form of a vapor fin radiator, is also discussed.

71007 A DESIGN OPTIMIZATION OF AN OUT-OF-CORE THERMIONIC CONVERTER

The module is a cylindrical converter, heated and cooled by heat pipes with an integral finned radiator. Performance data illustrating the dependence of electrode efficiency and power density on emitter and collector temperature are used as input data. Design parameters such as electrode thickness and area, and current voltage operating points are varied, and the minimum specific weight is determined. For fixed converter designs, the sensitivity of performance to changes in heat pipe vapor temperature, electrical load, and radiator area is also explored.

71008 HEAT PIPE THERMIONIC DIODE POWER SYSTEM Patent

A power system utilizing a number of thermionic plasma diodes in parallel and heat pipes as cathodes is described. The diodes each contain a cathode which is integral to the heat pipe and which is heated by an isotopic heat source through the heat transfer function of the heat pipe. The system employs a circulatory cooling system, with a liquid metal as the coolant.
Precise heat balance measurements were performed at the collector of a heat pipe thermionic converter in order to test current converter theories. Good qualitative agreement has been found between the theoretical and experimental values for heat generation at the collector. A detailed discussion based on a theoretical relation for the electron temperature in the plasma made possible also the calculation of the ion production coefficient from measured data. Comparison with the theoretical values of this coefficient gave good agreement between measured and calculated effective ionization potential, but showed a discrepancy in the effective ionization cross section.

A high power (120 watts) radioisotope generator employing a heat pipe is described. The device can be operated in extreme environments and can resist acceleration forces up to 10000 g.
B.3 AEROSPACE ORIENTED APPLICATIONS
**65012 SATELLITE HEAT PIPE**


A heat pipe was developed which will be used in a satellite to transfer heat isothermally from an externally mounted radioisotope to the electronic component section. The purpose of this system is to reduce the amplitude of temperature cycling of the components when in orbit. Heat from the isotope capsule is transferred to the pipe through an aluminum block assembly. Stainless steel clamps hold the capsule in position and supply the necessary pressure for good thermal contact. This arrangement provides for simple removal of the isotope for shipping. Several test models were built and tested using electric heaters to simulate the isotope heating. A satisfactory design was developed which will transfer more than 90% of the isotope heat to the required zone.

**66014 TECHNOLOGY STUDY OF PASSIVE CONTROL OF HUMIDITY IN SPACE SUITS**


Two basic techniques for passive humidity control are discussed: (1) condensation of water vapor from a stagnant pressurization gas in the space suit on wicks cooled below the required dew point, and retention or transport of the liquid condensate by wicks; and (2) adsorption of the water vapor by desiccants. An analytical study is also presented of molecular diffusion, mass transfer within an adsorption bed, and condensation on a cooled wick. Tests on several wick materials indicated that wicks of glass fiber and Refrasil provide superior performance for space suit passive humidity control applications; this applies to water transport capability in a horizontal plane (simulated zero G) as well as to vertical water lift capability. Experimental findings confirmed the heat applicability of desiccants is limited by high weight penalty and by difficult regeneration procedures. However, desiccants may be useful in specific applications where the advantage of operation at temperatures higher than the required dew point is significant. The feasibility of using heat sinks of organic material with suitable melt point to provide sensible heat control for periods of 30 minutes to one hour was also demonstrated.

**66015 HEAT TRANSFER OF A HEAT PIPE OPERATING AT EMITTER TEMPERATURES**


Experimental investigation of the usefulness of heat pipes as heat removal systems in space thermionic power supplies. The assumptions made concerning the physical working conditions of the capillary structure and mass flow were checked, and the results of experiments conducted in the temperature range from 1500 to 1900°K are discussed. Relatively good agreement was found between the calculated and measured heat flow. The deviations are possibly caused by lack of exact data for the surface tension and viscosity of the working fluids. The transition from laminar to turbulent flow in the vapor phase was measured at a Re number of about 1500. It is noted that because laminar mass flow is always higher than turbulent mass flow (with equal pressure drop along the pipe), lower Re numbers should be preferred. It is shown that this is more easily achieved with liquids having a high latent heat of vaporization. Other physical parameters such as viscosity and surface tension are of equal importance in making the proper choice of a working fluid.

**66016 APPLICATION OF HEAT PIPES TO THE SNAP-19 HEAT REJECTION SYSTEM**


The objective of the proposed program is to develop for the SNAP-19 generator a heat rejection system which uses heat pipes to eliminate the temperature gradient across the fin width. It is shown that, with the establishment of a uniform temperature on the fins, it will be possible to either make the generator smaller in diameter by about 4 in. or to lower the hot junction temperature by about 40°F, while still producing the same power output. Included are a conceptual design of a heat pipe fin assembly and a program plan for developing the desired hardware.

**67027 ISOTOPES AND ISOTOPE THERMOELECTRIC GENERATORS**

Isotope properties, thermoelectric conversion, thermoelectric generators, and missions which illustrate the possibilities of using isotope power systems are discussed. Advantages and disadvantages of isotopic power are tabulated, and a brief history of isotopic-power generator development is presented. The figures of merit for lead telluride materials and silicon-germanium alloys as a function of temperature are compared. The combination of heat pipes with thermionic converters is described as a means of improving conversion efficiency in low-power generators. The heat pipe is an excellent thermal control device that can transfer heat from the isotope heat source to the cathode of a converter. Nimbus B mission employing two SNAP-19 generators and the SNAP-27 generator, which will provide power for scientific experiments in the Apollo lunar surface package, are mentioned to illustrate the use of isotopic power. The availability of isotopes, their production, and their cost are briefly considered.

67028 NOTES ON HEAT PIPES AND VAPOR CHAMBERS AND THEIR APPLICATION TO THERMAL CONTROL OF SPACECRAFT
Reviewed are studies concerning heat pipes and vapor chambers that were made relative to design studies of large orbiting telescopes. Discussed are studies focusing on: (1) The use of heat pipes to improve the temperature uniformity of the skin around a large cylindrical spacecraft. (2) The use of a small tube, or artery, to convey the liquid over long distances instead of depending on the wick proper. (3) Means of metallically bonding a screen wick to a wall in order to minimize the temperature difference between the wall and the liquid surface. (4) The relation of screen dimensions and construction to the suction available with it. (5) The general problem of verifying the operation of a heat tube or vapor chamber by means of tests in the laboratory 1-g environment. Also cited are areas where further developments would be useful.

67029 SPACECRAFT POWER
An overview is presented on the several photovoltaic evaluation systems being used to measure the electrical characteristics of solar cells. These include the tungsten light source for illuminating test specimens at a color temperature of 2800°K; a small simulator for evaluating individual silicon solar cells at intensity levels of one solar constant or less; and a very flexible solar simulator light source, using a 19-lens lenticular system to filter a 2.5 kW xenon source in such a way that the resultant spectral distribution is essentially that of sunlight. Also discussed is the program for developing the necessary technology to achieve a power density of 20 W/lb for a folding, modular solar array having a deployed area of 1250 ft². Converter and generator developments for thermionic energy conversion systems are discussed, and parametric test results and performance data are depicted. Attention is focused on a high thermal conductance heat pipe device for solving the problems of heat transfer and distribution.

67030 ORBITAL HEAT PIPE EXPERIMENT
The "Grover Heat Pipe" is a self-contained, thermal conductance device which has no moving parts, utilizes the heat being transferred for its operation, has a thermal conductance higher than any known material, and conducts heat with essentially no temperature difference. Heat is transferred by means of mass flow of a fluid utilizing the latent heat of a two-phase system. The proper functioning of a heat pipe in a zero gravity field is described. A water heat pipe, 12-in. long and 3/4-in. OD, was operated in an earth orbit and its performance monitored by telemetry at several tracking stations during 14 revolutions. Results indicate that there was no degradation of heat pipe performance in a zero gravity field as compared to the performance in laboratory tests.

67031 HEAT PIPE RADIATOR FOR A 50-MWt SPACE POWER PLANT
The concept and design of a heat pipe radiator suitable for high power levels of approximately 50 MW(t) are discussed. Design considerations include meteoroid protection, heat transfer, stress, fluid flow, pressure drop, etc. A representative heat

B.3-02
Pipe design is shown to reject 46 MW at 1100 K using a total mass of 13,220 kg for a specific weight of 1.322 kg/kW(e). The radiator is used as part of a Rankine-cycle nuclear reactor power plant suitable for a manned Mars mission of 10,000 hours.

67032 FABRICATION AND TEST OF AN ALUMINUM HEAT PIPE
N. P. Jeffries, Space Power and Propulsion Section, Missile and Space Division, General Electric Company, Cincinnati, Ohio 45215. Memorandum Rept. HC-7, Feb. 67. Avail: TAC (37p)

Description of the fabrication and testing of an aluminum heat pipe. Its heat-carrying capacity as a function of temperature drop along the pipe was determined. The working fluid was water at temperatures in the range of 200 to 375°F; the heat load was from 0 to 200 watts. Included are the testing results and appendices on specifications and maximum operating times.

68016 STUDY OF PASSIVE TEMPERATURE AND HUMIDITY CONTROL SYSTEMS FOR ADVANCED SPACE SUITS

Investigations were performed to develop techniques for control of temperature in an extravehicular space suit by passive means. These techniques are intended to be integrated with techniques for passive control of humidity in space suits. The techniques investigated are based on the use of the external suit surface as thermal radiator for rejection of exometabolic heat and on a space suit shell of controllable overall thermal conductance. The controllable thermal conductance is achieved by a system of thermal insulation which is bypassed by devices similar to "Heat Pipes", modified to provide controllable heat flow rates and geometries applicable to a space suit. Theoretical and experimental investigations demonstrated feasibility of the concept of a variable thermal conductance heat pipe. Concepts for the integration of a variable thermal conductance heat pipe into the fiberglass shell of a hard space suit were developed and fabrication techniques generated.

68017 HEAT PIPE APPLICATION FOR SPACECRAFT THERMAL CONTROL

A heat pipe is a device which exhibits an extremely high effective thermal conductivity by means of two-phase fluid flow with capillary circulation. The primary objective of the experimental program was to determine a suitable method of control for the heat pipe and to establish suitable wick/liquid configurations for the various temperature ranges of interest. The primary objective of the prototype program was to provide design, construction, testing for verification, and flight hardware specifications of a heat pipe applicable to thermal control of a spacecraft or a spacecraft subsystem. Thus, a thermal design improvement for spacecraft could be proposed; in addition, thermal resistances of heat pipes could be derived.

68018 THE GEOS-2 HEAT PIPE SYSTEM AND ITS PERFORMANCE IN TEST AND IN ORBIT

The GEOS-2 spacecraft is the first satellite to be equipped with a heat pipe as an integral part of the thermal design. The heat pipe, a device of extremely high effective thermal conductivity, is employed to minimize the temperature differences between transponders located in opposite quadrants of the spacecraft. Measured heat transfer rates through the pipe of as much as 64 watts, together with small temperature gradients on the outside of the heat pipe, are evidence of proper operation. Based on a period of observation of 60 days, transponder maximum and minimum temperatures show improvement over GEOS-1 performance.

68019 HEAT PIPES AND VAPOR CHAMBERS FOR THERMAL CONTROL OF SPACECRAFT

This monograph reviews the basic theory and application of devices that transfer heat by evaporation of liquid from heated areas and condensation on cold areas, with continuous return of the condensate to the heating area by capillary action. Computed examples are presented to indicate possible applications to the solution of thermal control problems and to illustrate the principles and methods of analysis. Items discussed include wicks and associated capillary structures for optimum transfer of heat and minimum resistance to fluid flow.
69030 ANALYTICAL STUDY PROGRAM TO DEVELOP THE THEORETICAL DESIGN OF SPACE BORNE ELECTROSTATICALLY FOCUSED KLYSTRON AMPLIFIERS

The objective was to extend the electrostatically focused klystron (ESFK) art to permit the design of considerably higher efficiency amplifiers for operation in a space environment. Primary emphasis was placed on the critical problems of obtaining higher efficiency and adequate heat transfer while maintaining long operating life, small size and light weight. Voltage jumps, extended interaction output resonators, low perveance electron beams and multistage depressed collectors were found to afford a solution to the problem of efficiency enhancement in ESFK's. A transverse-field de-pressed collector was conceived which promises to permit high efficiency amplification of AM signals as well as FM signals. The problem of heat transfer associated with spaceborne ESFK's was solved by using a liquid potassium heat pipe radiator operating at 500°C. Electrical and mechanical designs were made for ESFK's intended for TV satellite applications at 0.85, 2.0, 8.0, and 11.0 GHz.

69031 ANALYTICAL STUDY AND EXPERIMENTAL INVESTIGATION OF TECHNIQUES FOR IMPROVING ELECTRON TUBES FOR SPACE APPLICATION

A triode was designed and constructed with a heat pipe integrated into its cathode structure to allow the use of an external heater. A promethium-147 isotope heat source was used to heat the cathode. It was found that a higher power density source, such as curium-244, is much better suited to cathode heating. Using curium-244, the isotope is small enough to be inserted into the cathode support, thus eliminating the need for a heat pipe. An investigation of high power tubes indicated that most existing tubes are not suited to heat pipe cooling, since passages designed for liquid cooling are inadequate for use as evaporators. Integration of heat pipe evaporators into these tubes can be accomplished, however, with either modifications in existing designs or a completely integrated approach to the overall tube design. To demonstrate heat pipe cooling, a travelling wave tube was operated using heat pipe cooling. With 930 watts dissipated at the collector, the operating temperature of 200°C was not exceeded.

69032 HEAT PIPE DEVICES FOR SPACE SUIT TEMPERATURE CONTROL

Investigations performed to develop techniques for control of temperature in extravehicular space suits have provided technological knowledge of general applicability to temperature control systems. This report summarizes this knowledge. Other reports, referenced in this report, deal with the specific application to space suits and the related materials research performed. A heat pipe thermal switching device is described, and test results performed techniques for bonding of capillary structures to solid substrates are discussed. Recommendations for suitable bonding techniques are provided. Heat pipes of flexible materials are described, and data resulting from experimentation with flexible heat pipes presented. Concepts for preventing freezing or for restart of frozen heat pipes are discussed and experiments demonstrating feasibility of one of these concepts are described and data presented.

69033 A HEAT-PIPE-COOLED FAST-REACTOR SPACE POWER SUPPLY

A fast-spectrum, nuclear-reactor power supply was designed which compares favorably with radioactive isotope sources and SNAP thermal reactors in the 1 to 5 kW(e) range. The use of a 239Pu-based fuel in a relatively simple design, which employs in-core heat pipes and a heat-pipe radiator, yields a comparatively lightweight and low-cost system, which should have good intrinsic reliability. The specific weight for the proposed 1-kW(e) reactor system is about 525 lb/KW(e) (340 lb/KW(e) at 5 kW(e)), as compared to typical weights of about 1000 lb/KW(e) for isotope powered supplies and more than 800 lb/KW(e) for existing SNAP thermal-reactor designs in this power range. Unlike competitive isotopes, 239Pu will be available to meet the anticipated demand for unmanned experimental communication satellites in the 1970's. Moreover, the production cost of this fuel should be approximately 20-70% of the equivalent in isotope power in the 25 to 125 kW(t) power range.

69034 APPLICATION OF HEAT PIPES TO REDUCE CRYOGENIC BOILOFF IN SPACE
J. L. Thurman and E. H. Ingram (Brown Engineering Co., Inc., Huntsville, Ala.).

B.3-04
Description of a concept for reducing cryogenic boil-off during long-term storage in space by means of a heat pipe boil-off control system. The concept is attractive because it is simple, self-contained, maintenance-free, and requires no mechanical pumps or other hardware susceptible to failure. Preliminary calculations indicate that the radiator areas required for a system employing liquid O2 as the working fluid are not excessive.

69035 APPLICATION OF HEAT PIPE TECHNOLOGY TO ROCKET ENGINE COOLING

Analytical investigation of the use of heat pipes for the cooling of rocket engines. The rocket motor of the study is assumed to operate at a 100-psia chamber pressure with a 1-in.-diam throat and a thrust of 141 lb; the propellant system utilized is the high-energy space-storable system OF2/B2H6. Two motor designs are considered. In the first, the heat pipe is connected to a space radiator and maintained at about 3500°F. This minimizes the size of the radiator and allows for maximum heat rejection. In the second design, the heat pipe is connected to a heat-rejection device other than a space radiator where the heat flux that can be accommodated is limited—e.g., propellant heat exchanger. Heat fluxes through the heat pipes in the second design are approximately 10% of those for the first design and operating temperatures are much lower (100 to 200°F). For both of the designs, it is shown that the heat-pipe cooling technique is capable of transferring a large portion of heat away from the throat area to other cooling devices, where the heat is rejected. For prolonged operation in space, additional cooling must be utilized; use of these supplementary, more conventional cooling techniques, however, does not diminish the potential utility of heat pipes for rocket engines.

69036 THE "CONSTANT TEMPERATURE" HEAT PIPE — A UNIQUE DEVICE FOR THE THERMAL CONTROL OF SPACECRAFT COMPONENTS
R. C. Turner (Radio Corporation of America, Lancaster, Pa.).

Description of the application of a "constant temperature" heat pipe for the thermal control of spacecraft components. A conceptual design is presented which consists of a "constant temperature" heat pipe coupled to a radiator panel which is comprised of an array of conventional heat pipes. This concept permits the direct thermal coupling of an internal spacecraft component to an external radiator. The radiator location and sizing were optimized for a typical synchronous orbit. The spacecraft was assumed to be cylindrical in shape and spin-stabilized about the central axis at 1 to 3 rps. The component power dissipation was chosen to be 1 to 65 W. The individual heat pipes are joined to the central "constant temperature" heat pipe which carries the heat from the interior of the spacecraft to the external radiator panel. The radiator was sized for an initial power-handling capability of 72 W. A dual inert gas reservoir provides for two distinct operating temperatures of the central heat pipe. One reservoir volume is sized for a 25°C launch temperature, while the second is sized for a 10°C orbital temperature. A unique method for utilizing one or both of these reservoirs is presented. The heat pipe material is 6063T3 aluminum; either acetone or ammonia is used as the working fluid. Helium or argon is used as the inert gas.

69037 AN ATS-E SOLAR CELL SPACE RADIATOR UTILIZING HEAT PIPES

Use of heat pipe technology for thermal equalization around the circumference of 56-in.-diam solar-cell mounting panels on a gravity gradient-stabilized synchronous earth satellite. Thermal tests were conducted to demonstrate heat pipe performance in steady-state and transient (eclipse) conditions. Actual performance of the solar panel/heat pipe substrate showed excellent correlation with predicted performance. Temperature differences between the hot and cold sides of the panels were less than 1/8 of those for panels without heat pipes. The effective solar cell temperature was reduced from 120 to 45°F, resulting in approximately a 20% increase in power output.
69038 ADVANCEMENTS OF SPACE SUIT TEMPERATURE CONTROL TECHNOLOGY BY APPLICATION OF MODIFIED HEAT PIPES

Contract No. NAS 2-3817.

Evaluation of the use of heat pipes in radiative transfer from the external surface of a space suit for rejection of body heat. The difficulties in accomplishing this approach and its usefulness are discussed. The concept of a predominantly radiation-cooled space suit, applying modified heat-pipe devices for heat transmission and control of the heat rejection rate, is presented.

69039 SECONDARY POWER

Description of secondary power sources for space applications. The increasing requirements of post-Apollo programs for secondary power are outlined. Accordingly, the trend of development at the moment is toward building flightworthy components for high-power, long-duration devices, such as large solar arrays and static and dynamic thermal systems energized by isotopes and reactors, as well as for higher-powered batteries and fuel cells. In keeping with this trend, NASA is currently procuring machinery for a Brayton cycle converter, nonaqueous, sterilizable batteries; and heat pipes for thermal control of low-heat-producing power converters.

69040 PERFORMANCE OF THE GEOS-II HEAT PIPE SYSTEM

The GEOS-2 spacecraft is the first satellite to be equipped with a heat pipe as an integral part of the thermal design. The heat pipe, a device of extremely high effective thermal conductivity, is employed to minimize the temperature differences between transponders located in opposite quadrants of the spacecraft. Measured heat transfer rates through the pipe (as much as 64 W) and the small temperature gradients on the outside of the heat pipe are evidence of proper operation. Based on a 145-day observation period, transponder maximum and minimum temperatures show significant improvement over those of GEOS 1.

69041 DEVELOPMENT OF AN ADVANCED SPACE RADIATION SYSTEM

Description of an advanced space radiator system which employs the use of hybrid, water heat pipes to transport waste heat from a radioisotopic thermoelectric generator. The heat rejection system is capable of transporting and rejecting all module design and off-design heat loads. Practical, production-oriented, fabrication techniques have been developed for large length-to-diameter ratio heat pipe assemblies incorporating one or more radii of curvature in a single pipe. Structurally-adequate, curved, radiator panels employing multiple heat pipes have been successfully fabricated utilizing adhesive bonding techniques and have successfully passed thermal performance and thermal cycle testing. The results of the development program on this subsystem have proven that a lightweight, highly reliable space radiator system can be evolved utilizing heat pipes.

69042 AVIONIC APPLICATION OF A HEAT PIPE

Outline of the steps taken to design and develop a heat pipe for an avionic application. Wicking bench tests are used to characterize wick designs from which a
The final selection is made. The heat pipe is coupled to an air-cooled, compact heat exchanger to dissipate the thermal load into the ambient air. Results of design proof tests verify the adequacy of the cooling subsystem in maintaining the radio component below its maximum allowable temperature for the specified thermal environment.

AN AVIONIC HEAT PIPE


Description of the design, development, and fabrication of a heat pipe to cool a high-power airborne radio component. An air-cooled, compact heat exchanger is coupled with the heat pipe to dissipate the thermal load into the ambient air. Results of design proof tests verify the adequacy of the cooling subsystem in maintaining the radio component below its maximum allowable temperature for the thermal environment defined in MIL-E-5400.

HEAT PIPE RADIATOR FOR SPACE POWER PLANTS


A heat pipe radiator which forms the ternary loop of a Rankine power system and furnishes meteoroid protection and fluid isolation of the secondary loop is discussed. The radiator design is usable over a broad range of power and its fabrication is well within current technology. A representative value of specific weight which includes feed lines, return lines, manifolds and heater pipes is 1.1 kg/kW(e) considered for a 20,000 hour mission at 1100 K with a probability of no critical penetrating hits of 0.99.

ANALYSIS OF ADVANCED FAST-SPECTRUM HEAT SOURCES FOR SPACE APPLICATION


HEAT PIPE APPLICATIONS TO GRAVITY-GRADIENT SATELLITE (Explorer XXXVI)


Use of two heat pipes, using Freon-11, for thermal control of transponders in gravity-gradient satellite, GEOS-B; orbital results agree with theoretically expected temperature drops over heat pipe regime; a continuous operation over a period of 2 mo indicates no apparent degradation in the performance of the heat pipe; first use of heat pipes for satellite thermal control is complete success.

HEAT PIPES FOR SPACE SUIT TEMPERATURE CONTROL


Problem of temperature control in space suits; desirability of use of external suit surface as thermal radiator for rejection of metabolic heat is established; the difficulty consists in alternating needs for either high thermal conductance suit shell for preservation of body heat, caused by large temperature difference between solar irradiated and nonirradiated space suit surfaces is explained; approach taken to solution by integration of heat pipe type devices into space suit shell is described.

DESIGN OF 50,000-WATT HEAT-PIPE SPACE RADIATOR


Feasibility of using heat pipes as fundamental units in Rankine space-power-system radiator; analyses show wick-type heat pipes have advantages over "configuration-pumping" type; laboratory tests and computer programs were used to develop wick-type heat pipe that uses only one wrap of wire mesh and weighs only 48 g; weight-to-power ratio of radiator using this heat pipe is 0.24 lb/kw, or only one-third specific weight of earlier systems; meteoroid penetration studies indicate probability of 0.99 of radiator being at least 95% operational at the end of 10,000 hours in near-earth or lunar missions.

A STUDY OF HEAT PIPE APPLICATIONS IN NUCLEAR AIRCRAFT PROPULSION SYSTEMS

Preliminary studies of heat pipe systems for reactor-to-jet engine heat transport and for emergency distribution of reactor afterheat over the surface of the reactor containment vessel are described. The reactor-to-jet engine heat transport system includes 5480 small-diameter reactor heat pipes, four large-diameter adiabatic heat transport pipes, and 8300 small-diameter heat pipes in each of the four engine heat exchangers. The total system weight is about 47,000 lb. The emergency afterheat distribution system includes 4280 heat pipes 1 in. in diameter and 11.7 in. long, whose total weight is 3400 lb.

Heat pipes and vapor chambers, employing the principles of vapor heat transport, may be constructed with thermal conductances far higher than a solid metal structure with similar dimensions. The operation of these devices is described, and quantitative estimates are obtained of the performance to be expected from them. Ways in which they may be used to assist satellite thermal control are discussed.

A study was conducted to perform the neutronic calculation on the proposed heat pipe reactor design. The study revealed that utilizing heat pipes for a nuclear airplane reactor application appeared promising when heat pipe performance was applied to the limit of heat pipe technology. The design parameters calculated are number of heat pipes, radial heat flux, core diameter, cord L/D, heat pipe vapor temperature, fuel enrichment, fuel loading, clad temperature, clad stress, and power.

The estimation of maximum and minimum temperatures and temperature gradients in spacecraft components, subsystems etc. are discussed together with the use of thermal control coatings, multilayer insulation and thermomechanical devices such as louvers and heat pipes. The thermal analysis of experiments in terms of thermal modes and instantaneous power balances is considered in detail. Thermal simulation procedures are also outlined.

A preliminary study was conducted to determine the feasibility of using heat pipes in a nuclear aircraft propulsion system. Heat pipes were the sole transporter of heat. Three sodium coolant heat pipe systems were used. One transferred the heat from the reactor. Another transferred the heat to the air in the jet engine. The third heat pipe transferred the heat from the reactor pipe to the jet engine heat pipe. To get promising performance, the technology had to be pushed to the limit.

An initial design study of heat-pipe-cooled thrust chambers is summarized. The program was aimed at applying heat pipe technology to the cooling of high energy space storable propellants and a specific goal was the design and fabrication of a working model OP2/B2H6 thrust chamber cooled by the heat pipe principle. Program tasks reported include: (1) heat pipe technology review; (2) analysis and experimentation; and (3) working model design.

The applicability of heat pipes to the solution of thermal control problems
associated with future spacecraft, including the Saturn V workshop is investigated. The investigation includes a survey of reported experience in heat pipe technology, an analysis of the effect of variation in various design parameters on heat pipe performance, and establishment of concepts utilizing the heat pipe which offer unique solutions to specific thermal control problems. Concepts are described and analyzed which appear applicable to the solution of problems of cryogenic boiloff control, temperature nonuniformity of skin structure, removal of heat from concentrated sources, and radiator design.

70027 A MILLIMETER WAVE PARABOLIC ANTENNA FOR COMMUNICATIONS WITH A SYNCHRONOUS SATELLITE

Discussion of a systems engineering study of a millimeter wave parabolic dish antenna mounted on a satellite which continuously tracks a communication satellite in a synchronous orbit. Electrical and thermostructural considerations show that a major problem area in effecting an acceptable design is the elimination of thermal gradients which would result in distortions restricting antenna gain and frequency. A description and evaluation of a heat pipe network system which creates near isothermal conditions on the antenna surface are presented.

70028 THERMAL CONTROL (TERMOREGULIROVANIE)

Discussion of factors affecting the heat balance of a spacecraft in space and in planetary atmospheres, and evaluation of passive and active methods of thermal control. Conditions affecting planetary probes for earth, Mars, and Venus are analyzed, together with the heat inputs due to solar radiation and planetary albedos. Attention is given to the use of reflective coatings, insulations, and heat pipes. Open- and closed-cycle active cooling systems are discussed, along with control of the spacecraft's optical characteristics.

70029 CONCEPTUAL DESIGN OF A 10-MWe NUCLEAR RANKINE SYSTEM FOR SPACE POWER

The conceptual design of a 10-MWe Rankine system for nuclear-electric space power is described. A compact nuclear reactor operating at 1650 deg K uses uranium mononitride as the fuel, lithium as the coolant, and tungsten-25% rhenium as a structural material. The reactor is controlled by a dual control system consisting of lithium-6 liquid control tubes and a movable molybdenum side reflector. A lithium-hydride and tungsten nuclear shield, which reduces radiation to an acceptable dose for a manned payload over a 10,000-hr life, is provided. The shield accounts for about half the total system specific mass of 7 kg/kWe. A lightweight heat-pipe radiator rejects waste heat at 1100 deg K. Overall system efficiency is 17.5%.

70030 UNIDIRECTIONAL HEAT PIPES TO CONTROL TWT TEMPERATURE IN SYNCHRONOUS ORBIT

This paper discusses the principles of the unidirectional heat pipe (unipipe), its application to spacecraft thermal control, and the design of a multiple heat pipe system to control the temperature of high power traveling-wave tubes. Thermal analysis during one orbit of a synchronous communications satellite dissipating 5 kW of waste heat is presented along the experimental results for unidirectional heat pipe.

70031 HEAT-PIPE-COOLED THRUST CHAMBERS FOR SPACE STORABLE PROPELLANTS

Discussion of the design considerations, experimental results, and evaluation for
heat-pipe cooled thrust chambers for space storable propellants. A design concept consisting of an annular shaped sodium/nickel heat pipe with a regeneratively cooled condenser was chosen for a thrust chamber which will be designed to operate with OP2 and B2H6 propellants at 100 psia chamber pressure. The feasibility of fabricating a heat pipe in the shape of a rocket thrust chamber has been demonstrated and heat fluxes up to 5 Btu/sq in sec have been achieved in laboratory test devices. Lithium and silver are also shown to be potential working fluids for heat pipe thrust chambers; however, their near-term application for OP2/B2H6 thrust chambers is hindered by chemical compatibility problems.

71010 HEAT PIPES IN SATELLITE TECHNOLOGY (WÄRMEROHRE IN DER SATELLITENTECHNIK)
Heat pipes are construction elements with very high thermal conductance at small temperature gradients. A description of physical principles of heat pipes and of possible combinations of structure material and heat carrier for several temperature ranges is given. Some typical examples for space applications of heat pipes are discussed.

71011 BRAYTON CYCLE VAPOR CHAMBER (HEAT PIPE) RADIATOR STUDY
The vapor chamber (heat pipe) radiator is defined and evaluated as a potential candidate for rejecting waste heat from a Radiisotope Brayton Cycle space power system. A comparison is made with an operationally equivalent conduction fin radiator. Both radiators employed DC-200 heat transfer fluid within the primary ducts and aluminum as the basic structural material. Vapor chamber fluids are evaluated and selected for thermal performance and containment within the radiator. Vapor chamber compatibility and performance tests are made for a number of candidate fluids. Preliminary designs are developed for both conduction fin and vapor chamber radiator concepts. A comparison shows no significant advantages attributable to the Brayton cycle vapor chamber radiator where reliability and meteoroid criteria specify 0.99 to 0.999 probability of survival over a five-year lifetime.

71012 HEAT PIPE SYSTEM FOR SPACECRAFT THERMAL CONTROL
Circumferential heat pipes were fabricated to conform to the periphery of a large spacecraft to transfer component and solar heat to available rejection areas. A full-scale model of the vehicle was assembled including louvers, insulation, electrical heaters, realistic structural detail, and the heat pipe system. The model was tested in a simulated space environment. Operational heating modes were imposed and performance was observed with heat pipes both charged and empty. Results indicated that the heat pipes did reduce temperature gradients but the requirements of the selected vehicle could be met without the plexity of the heat pipe system.

71013 HEAT PIPE APPLICATIONS TO SPACE VEHICLES
Several attractive areas of heat pipe applications to space vehicle thermal control are presented and reviewed through a discussion of NASA requirements for future manned and unmanned spacecraft. Particularly noted are the areas of space radiators, experiment/equipment temperature control, structure isothermalization, and heat exchangers. In each case specific thermal control requirements and solutions are discussed relative to the potential application of heat pipe technology. Results are presented which indicate significant performance improvement possibilities and emphasize the necessity for including heat pipes in the thermal design of space vehicles.

B.3-10
operation of the heat pipe. These are: (1) the capillary pumping characteristics of a wick; and (2) the evaporative heat transfer characteristics of a liquid-saturated wick. To evaluate the effect of capillary pumping characteristics, a simplified analysis of a planar wick pipe is made. The result of this analysis gives the maximum operating length of a planar wick model in terms of the external boundary conditions, the heat pipe fluid properties, and the capillary pump characteristics of the wicking material. The capillary pump characteristics are found to be proportional to the equilibrium height to which the heat pipe liquid will rise in the wicking material divided by the wicking material friction factor. The latter is the reciprocal of the permeability for the wicking material. The results of wick equilibrium height experiments and wick permeability experiments run on the three classes of wicking materials are presented. Both water and Freon 113 are used in these experiments. These results are combined to yield the capillary pumping characteristics of each wicking material tested. To evaluate the effect of the evaporative heat transfer characteristics of wicks, experimental data on porous samples selected from the three classes of wicking materials is presented. These data result from evaporative heat transfer experiments run on planar wick samples saturated with water. All experimental results are compared with the heat transfer characteristics of a flat plate submerged in water. The data indicate that the entrapment of vapor bubbles in the wick matrix may cause the premature occurrence of film boiling in the porous material at relatively low heat fluxes, depending on the structure of the wicking material.

71042 CONCEPTUAL DESIGN OF A RADIOISOTOPE HEAT-PIPE- THERMIonic SPACE POWER SYSTEM
B.4 NUCLEAR SYSTEMS
67033 DESIGN OF A 1 KWE FAST REACTOR POWER SUPPLY
John J. Roberts and Edward J. Croke (Argonne National Laboratory, Argonne, Ill.). IN:
ADVANCES IN ENERGY CONVERSION ENGINEERING: AMERICAN SOCIETY OF MECHANICAL ENGINEERS,
INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, MIAMI BEACH, FLA., AUGUST 13-
17, PAPERS. [A67-42485 24-03]. New York, American Society of Mechanical Engineers, 1967,

Description of a fast-spectrum, nuclear-reactor power supply which compares favorably with radioactive isotope sources and SNAP thermal reactors in the 1 to 5-kwe range. The use of a Pu 239-based fuel in a comparatively simple design which employs in-core heat pipes and a heat pipe radiator yields a lightweight and low-cost system. A survey of potential fuels is presented, and areas such as control, heat-transfer analysis, and reactor optimization are also considered.

68020 COOLING SYSTEM FOR NUCLEAR REACTORS

In this reactor, especially designed for direct conversion of heat to electricity, a "heat pipe" is used instead of continuous fluid flow for heat transfer. The tubular fuel element surrounds a heat pipe which contains a quantity of liquid metal and is lined with a wick. Similar pipes are inserted into the moderator and reflector. The reactor core is horizontal and these pipes terminate in heat sinks to the right and left ends of the core. Heat transfer occurs by a cycle of vaporization and condensation of liquid returning by capillary action along the wick lining. The heat is converted to electricity by thermionic emitters and collector electrodes located in the heat sinks. Li and Cs are used as heat carrier fluids for the vaporization-condensation cycle depending on the temperature range required. Operating temperatures are 1800°C at the emitter electrode, 1000°C at the collector electrode and 500°C in the moderator and reflector.

68021 ISOTHERMAL IRRADIATION ASSEMBLY FOR STUDY OF FAST NEUTRON DAMAGE TO CERAMICS

Knowledge of the effect of fast neutron irradiation on the electrical, thermal and mechanical behavior of the ceramic and the bonded ceramic-metal components required for thermionic fuel rod construction is as yet very limited in extent. The EBR-II is a desirable facility for obtaining such data since its neutron spectrum is similar to that occurring in most thermionic reactor designs and the extrinsic testing cost is low. However, this facility has the disadvantage that temperature control and measurement must be accomplished without physical connections to the exterior of the reactor vessel. Therefore it has been necessary to develop irradiation assemblies in which the sample temperature can be preset and maintained to within 15°C despite inaccurate knowledge of gamma ray heat generation rates in the testing region. These isothermal irradiation unit designs feature gas-filled stainless steel heat pipes with sodium working fluid. Operating temperature is established by the amount of gas initially introduced into the heat pipes. Results of testing the assemblies both in the laboratory and in the Omega West Reactor are given.

68022 ADVANCED SPACE NUCLEAR POWER PROGRAM

Rhenium alloys and systems--Re-W, creep behavior of, effects of composition and heat treatments on; Hf-Mo-Re-W, surface hardness of, effects of hafnium content on nuclear auxiliary power systems--kinetics for SPR-4 reactor, use of zoom computer codes for calculation of; kinetics for SPR-6 reactor, use of zoom computer code for calculation of; physics measurements for SPR-5 reactor, description of optimum; physics measurements for SPR-8 reactor, description of optimum; shielding calculations for, description of geisha-2 computer code for; configuration of SPR-6 reactor, reference design

Thorium oxides ThO2-ThO2-W, density and weight loss of sintered, effects of heating rate on tungsten--creep behavior of, effects of composition and heat treatments on hafnium nitrides--HfN-W, co-vapor deposition of, effects of nitrogen on uranium nitrides UN--metallurgical properties of, effects of temperature and pressure on thermodynamics--saturation enthalpy and entropy for liquid or gas, calculation of, (E/T) heat transfer systems--configuration of SPR-6 reactor, reference design reactor fuel elements--assemblies of SPR-6 reactor, reference design

B.4-01
Experiments for simulating heat transfer by radiation from a reactor surface to a thermionic converter with a heat pipe-radiator are described. A cesium diode for a SRST-W system was built and a description in terms of design and data is given. The results of measurement on a front wall heated heat pipe are discussed. Technological problems of a cesium diode by electron beam welding are considered.

A nuclear fuel irradiation capsule capable of handling large (~300 W/cm²) and varying fuel specimen heat fluxes while inherently maintaining nearly constant specimen temperature was conceived and two bench models successfully tested using potassium and sodium as the working fluids. Test temperatures were in the 700°C range and heat source temperatures were preserved within ±15°C while undergoing factors of three changes in power.

Fluid dynamics in heatpipes are shown to transfer between 5 and 10% of the fluid mass from the evaporator end to the condenser end during normal operation as a function of radial heat flux. These effects were studied for K, Na, Li, BeF₂, Ag, and LiF in computer optimized heatpipes for mesh dimensions between 0.0075 and 0.0325 cm and for temperatures between 1300 and 2400 K. It is shown that this transfer of mass can be utilized in reactors cooled by heatpipes to yield strong negative reactivity effects when fluids with negative void coefficients are employed. (40 references)

An improved radioisotope powered thermodynamic system is described which incorporates a heat pipe for rejection of excess heat. The rejection of excess heat may be...
readily varied over the life of the radioisotopic fuel using a method which involves no mechanically moving parts. The amount of heat transferred between the ends of the heat pipe is determined by the rate of movement of the working fluid, which moves as a gas through the void and as a liquid, by capillary action through the pipe lining.

69053 CONCEPT FOR A GAS BUFFERED ANNULAR HEATPIPE FUEL IRRADIATION CAPSULE

A nuclear fuel irradiation capsule capable of handling large (=300 W/cm²) and varying fuel specimen heat fluxes while inherently maintaining nearly constant specimen temperature was conceived and two bench models successfully tested using potassium and sodium as the working fluids. Test temperatures were in the 700°C range and heat source temperatures were preserved within ±15°C while undergoing changes in power by factors of three.

70033 THE MODULE APPROACH TO BLANKET DESIGN: A VACUUM WALL FREE BLANKET USING HEAT PIPES

An analysis has been made of the blanket surrounding the thermonuclear plasma which is required to moderate neutrons, provide for kinetic to thermal energy conversion, remove the thermal energy produced, and regenerate the tritium burned in the D-T reaction. The study introduces two new features to blanket design: heat pipes and a modular structure. The study relocates the "standard" vacuum wall of a thermonuclear reactor outboard of the neutron-moderating, energy-converting blanket and thus places the entire moderator in a vacuum envelope and in an unobstructed view of the plasma. The new blanket is structurally designed in modular units which radially and tangentially interlock to form a neutron closed cylinder. The modules consist of sets of thin walled tube banks which have common mass flow and common pressure requirements so that structural design is simple and replacement straightforward. A reference design operating at approximately 1100 K and using natural lithium as a moderator and sodium heat pipes is discussed.

70034 ACHIEVING UNIFORM SPECIMEN TEMPERATURES IN AN IRRADIATION CAPSULE USING HEAT PIPES
Zielenbach, W. J.; Miller, N. E. (Battelle Memorial Inst., Columbus, Ohio) (CONF-690910-, pp. 157-64), Avail:TAC

Results of laboratory studies indicate that a lithium-filled annular heat pipe is feasible as a means of obtaining near isothermal conditions axially along the surface on the cladding of a short fuel sample in an in-pile fuel-irradiation capsule. At a 1500°C operating temperature the axial spread of temperatures was less than 20°C along a three inch length in an experiment simulating the irradiation capsule. The annular heat pipe would be incorporated into the current capsule configuration employed in the high-temperature-fuels program to achieve uniform specimen cladding temperatures of 1600 to 1900°C.

70035 ISOTOPE KILOWATT PROGRAM

A heat block-shield design has been evolved that is suitable for all three power conversion systems under study. This unit has the further advantage that it can be used with either SrTiO₃ or SrF₂ fuel. A preliminary design for a reduced scale test loop to evaluate the thermal radiation stability characteristics of Dowtherm A has been prepared and is being reviewed critically. A conceptual design of a heat pipe test has been prepared, and preliminary arrangements for fabrication of a test unit have been initiated. The design and construction of a full-scale thermoelectric module has been discussed with 3-M and it has been concluded that the principal problems associated with integrating the junctions into a complete heat pipe module assembly are much the same for lead telluride and the more efficient advanced material under development. As a consequence, it appears that the next step after a test of a heat pipe tailored to this special application should be a test of a full scale thermoelectric module with lead telluride junctions. A firm proposal from 3-M to fabricate such a unit is expected early in the next quarter.

70036 INDEPENDENT HEAT PIPES
Possibility is examined for designing new type of local heat pipe for intensive
heat transfer from heat source to heat receiver over long distances; the study is of interest to nuclear reactor engineering.

71014 A SPLIT-CORE HEAT-PIPE REACTOR FOR SPACE POWER APPLICATIONS
The design and operation of small U-235C- and U-233C-fueled cores with axial heat pipes for a 350 kWe out-of-core thermionic power system was investigated. A split in the core at midplane was used for reactivity control. Each half core was built up from modules, each of which consisted of a fuel element with a central heat pipe that extended beyond the axial reflector. With 1 cm-diameter heat pipes a typical U235 core has a 30 cm diameter and contains 123 kg of U235 and a typical U233 core has a 24 cm diameter and contains 55 kg of U233. The physics of the design concept are presented for both U-235C and U-233C systems. A study of the startup dynamics of the reactor and heat pipes shows that ramp reactivity inputs should be limited to less than 2 cents/sec for the U-233 reactor and less than 8 cents/sec for the U-235 reactor.

71015 CONCEPTUAL DESIGN OF A 2-Mwt (375 kwe) NUCLEAR-ELECTRIC SPACE POWER SYSTEM
Description of a power system which includes a unique nuclear reactor-boiler unit operating at 1500 K that utilizes heat pipes in lieu of a conventionally pumped primary loop. An efficient heat-pipe radiation rejects waste heat at 1035 K. Overall system efficiency is 18.8%, yielding a net electrical output of 375 kwe. The system specific mass is 10 kg/kwe, including a generous shadow shield for unmanned payloads.
B.5 ELECTRONIC APPLICATIONS
The latest development of high-power grid-controlled tubes is outlined. The advantage of using the heat pipe principle with the cooler are described briefly.

Description of the design of a heat transfer device and electrical insulator for service as an integral part of a traveling-wave tube collector. Heat-pipe cooled collectors have operated at a power density of 47.8 W/in.² for 1500 hr without degradation in performance. Collector depression was maintained at 12,000 V during operation and during shut down. Voltage breakdown problems common to insulators operated in air do not occur because of elimination of possible contamination along with the air itself.

Description of a thermal control system built to provide cooling for a traveling wave tube (TWT) mounted in a spacecraft. The system was designed to demonstrate the capability of heat pipes to provide high thermal conductance paths for 750 W (dissipated at the TWT collector) to flow to a flat plate radiator where the heat can be radiated to space. The evaporators of four heat pipes and the TWT collector are attached to a block located at the center of the radiator. The heat pipe condensers, placed along with the diagonals of the center radiator, maintain the diagonals very nearly isothermal, thus keeping the fin effectiveness high. Test results are included, showing the system thermal performance in several modes of operation for varying power dissipations. The results of failure of one, two, three, or all four pipes are presented. Also included is an analytical investigation of the weight and area requirements of both passive and heat-pipe space radiators. This analysis serves as a general guide in judging the effect of temperature limits and power dissipation on the thermal control system.

Description of a vacuum tube which has been constructed to obtain more efficient utilization of heat than is provided by thermoelectric or thermionic devices. The vacuum tube is such that its cathode is directly heated by a radioisotope source external to the tube. The tube design incorporates a heat pipe to provide almost iso-thermal transfer of heat from the external source to the cathode. Test results demonstrate operation with an external electrical heater and a radioisotope heat source.

Discussion of the relation of the properties of heat pipes to their performance in applications to thermal control in electronic equipment. The applications considered are those that have been specifically evaluated for potential use, or tested to establish feasibility, and applications which are simply presented conceptually. Constant temperature heat pipes used as a space radiator are considered, and a design concept using constant-temperature heat pipes is shown, together with a heat pipe used to remove heat from the hot side of a thermoelectric heat pump. A configuration which will make it possible to make a workable heat pipe for a nominal expense is shown.
69058 HEAT PIPE DESIGN FOR ELECTRON TUBE COOLING
Discussion of the design of heat pipes for cooling electron tubes operating at temperatures ranging from minus 40 to 300 deg C. Special attention is given to the heat pipe cooling of traveling-wave tubes. A review is presented of different heat pipe configurations, emphasis being given to a heat pipe, which is especially suitable for TWT collector cooling. The design and characteristics of a dielectric heat pipe are examined. The use of a dielectric heat pipe for cooling a traveling-wave tube is described.

69059 APPLICATIONS OF HEAT PIPES IN ELECTRONIC EQUIPMENT
This paper represents a heuristic presentation of heat pipe principles with particular emphasis on applications to electronic equipment. A fairly detailed account of the external characteristics of heat pipes is given, with particular attention to electronic equipment.

70037 LARGE TELESCOPE EXPERIMENT PROGRAM (LTEP). VOLUME 1, PART 2
Summaries are given for optical technology experiments, superresolution and apodizing with segmented active optics, telescope thermal considerations, heat pipe feasibility, non-space experiments, image tubes, the Echelle spectrograph, the use of vidicons in astronomy, and current problems in infrared astronomy.

70038 HEAT PIPES--A COOL WAY TO COOL CIRCUITRY
Discussion of the main design and operation features and applications of heat pipes. Waste heat removal in electronic devices, or also temperature leveling, is their main function. Sometimes the auxiliary function of providing structural support to the electronic components whose heat they remove is incorporated in their design. Vapor heat transfer and capillary action are their basic operational principles. Their operating temperature scope ranges from -200 to +2000 deg C, and the variety of fluids used runs from liquid nitrogen to liquid lithium or even silver. Their axial heat flux reaches above 25 kW per sq in. Superseding the bulkier fins and forced-air or liquid cooling systems, heat pipes substantially contribute to smaller packaging. The uses made of these thermal-conductance devices by various research organizations and manufacturers are reviewed. The interconnection methods used to form heat pipe systems are discussed.

70039 A SURVEY OF COOLING TECHNIQUES FOR AIRCRAFT ELECTRONIC EQUIPMENT
Discussion of avionics cooling techniques based on the heat transfer mechanisms of natural convection, forced convection, phase change (boiling and heat of fusion), and heat pipes. Present and near future aircraft electronics are processing more power than ever before. Equivalent or shrinking space allocations require greater packaging density resulting in increased heat flux for components such as microelectronics, large-scale integrated circuits, and other solid-state devices. Hot spot power densities of 100 to 1000 watts per cubic inch have become commonplace in advanced electronics. As a result, the heat removal process and temperature control techniques have become challenging design problems. Current avionics cooling systems and some state-of-the-art concepts that may have future application are discussed with the intent to examine the range of thermal design approaches available to the designer.

70040 AN ANALYSIS OF THE HEAT PIPE AS A HEAT SINK FOR SOLID-STATE R.F. SOURCES
Wilson, W. E., IEEE Trans. Electron Devices (USA), vol. ED-17, No. 11, p. 1013-14 (Nov. 70), Avail:TAC
Equations are developed for determining the temperature of a steady state power flux source incident on the heat pipe as a function of the pipe wall thickness. The analysis shows the heat pipe to be no better than a semi-infinite heat sink operating
at an elevated temperature for practical solid-state r.f. devices having power flux densities of $10^4$-$10^6$ watts/cm$^2$.

71016 MICROWAVE POWER RECEIVING ANTENNA
A microwave power receiving antenna is described having a solid state rectifier circuit comprising a plurality of diodes which converts high frequency energy to direct current. Each enclosure and its corresponding pair of dipoles is mounted on a heat conducting support post, which in turn is mounted on a large antenna reflector. The device effectively solves the problem of heat dissipation by constructing the dipole supporting posts, the antenna reflector, and the dipole elements as heat pipe devices. Each supporting post and the antenna reflector may either communicate for greater efficiency in dissipating heat or be physically separated to simplify fabrication. Brief descriptions accompany drawings of the antenna.

71017 CAPACITOR ENERGY STORAGE IMPROVEMENT BY MEANS OF HEAT PIPE
Analysis of the application of bidirectional heat exchange capability in order to thermally stabilize the capacitance of large capacitor banks over a wide temperature range. A quantitative analysis is given in terms of heat loss vs conducted heat, where the losses are expressed in terms of component geometry and the dielectric constant. The results show that the attachment of the capacitor to an infinite heat sink by means of a heat pipe will significantly reduce the bulk and weight of capacitors, and component reliability will be enhanced.
C. HEAT PIPE THEORY
c.1 GENERAL THEORY
65013 QUARTERLY STATUS REPORT ON ADVANCED REACTOR TECHNOLOGY (ART) FOR PERIOD ENDING APRIL 30, 1965

Results of a LAMPRE transfer function review is presented along with a discussion of fuel testing in Omega West Reactor Experiment. Component design and development for the Fast Reactor Core Test Facility is summarized. Supporting research and development are reported on activation determination of C, reactor blanket systems, Pu alloys and cermets, Los Alamos Turret Reactor, Plasma thermocouples, and heat pipes.

66017 ANALYSIS OF LOW-TEMPERATURE DIRECT-CONDENSING VAPOR-CHAMBER FIN AND CONDUCTING FIN RADIATORS

An analytical comparison of flat, direct-condensing finned-tube space radiators using vapor-chamber, double, and central fin-tube geometries was made for a low power output, low temperature Rankine space power electric generating system. Descriptive equations for the radiator investigation included consideration of vapor and liquid headers, pressure drop in headers and radiator tubes, meteoroid protection, and temperature drop in tube armor. Heat transfer, weight, and geometry characteristics of the three radiator fin-tube configurations were determined over a wide range of design variables for a 30-kilowatt powerplant that used steam as the thermodynamic cycle fluid. Thermal degradation of the vapor chamber fin-tube radiator due to fin-segment punc- tures, and the vapor chamber heat transfer and capillary fluid flow requirements were also investigated. Radiator geometry considerations indicated that, at the minimum weight, the vapor chamber fin-tube radiator had a smaller planform area, fewer radiator tubes, and larger tube inner diameters than the other two fin-tube geometries.

66018 QUARTERLY STATUS REPORT ON ADVANCED REACTOR TECHNOLOGY (ART) FOR PERIOD ENDING JULY 31, 1965

Progress on construction of the Fast Reactor Core Test Facility is reported. Descriptions are included concerning construction of the building and associated services, installation of a 20-Mw Na coolant system, installation of a control room, and construction of the reactor. Information is also included on design of a molten Pu burnup experiment and fuel testing in the Omega West Reactor. Data are included from accelerated fuel corrosion tests, mass transfer of Ta in molten fuel alloys, and preparation of UCl3-KCl-NaCl for blanket studies. Efforts devoted to research on Na purity, venting fission gases in Na coolant, and Na-fuel equilibria are discussed. Research is summarized on properties of Pu carbides, U2C3-Pu2C3 systems, Pu nitrides, and Pu-Sc alloys. Progress on construction and component testing the UHTREX program is summarized, along with research on plasma thermocouples and heat pipes.

66019 QUARTERLY STATUS REPORT ON ADVANCED REACTOR TECHNOLOGY (ART) FOR PERIOD ENDING OCTOBER 31, 1965

Further development in construction of the proposed Fast Reactor Core Test Facility is reported. Results from fuel capsule testing in the Omega West Reactor are presented. The containers were carbonized and noncarbonized Ta and Ta-W alloys. The fuel was Ce-Co-Pu alloys. Research on plutonium fuels is discussed. Various properties of the fuels are given. Further developments in the Turret Reactor are reported, and also research on a plasma thermocouple is discussed.

66020 QUARTERLY STATUS REPORT ON ADVANCED REACTOR TECHNOLOGY (ART) FOR PERIOD ENDING JANUARY 31, 1966

Further developments in construction of the Fast Reactor Core Test Facility (FRCTF) are reported. Preliminary calculations for the Molten Plutonium Burnup Experiment (MPRE) are given. The corrosive effects of molten Pu alloys on Ta and Ta-W fuel capsules are presented. The results are also presented for carbonized fuel capsules. Sodium technology and other supported research to be used in conjunction with the MPRE are included.

66021 QUARTERLY STATUS REPORT ON ADVANCED REACTOR TECHNOLOGY (ART) FOR PERIOD ENDING APRIL 30, 1966

C.1-01

Further developments in the various components of the Fast Reactor Core Test Facility are described. Some of the cores of the FRCTF are briefly described. Containers for the molten Pu-Co-Ce fuels were tested. Corrosion tests were made on carburized and uncarburized Ta, Ta-W, Ta-W-Y, Nb-Ta, and Nb-W alloys. The tensile properties of uncarburized and carburized Ta-W alloys are given. Burst tests were made on several of the containers. Other brief discussions of various supporting research are presented.

67034 STATUS OF THE ENGINEERING THEORY OF HEAT PIPES

The current theory for design and performance analysis of heat pipes is summarized briefly, and the principal areas limiting their development are discussed.

67035 OPERATING LIMITS OF THE HEAT PIPE

The rate at which heat can be transferred through a given heat pipe may be limited by one or more of the following considerations: evaporator heat transfer area; condenser heat transfer area; and capacity of the capillary pump. Reported are studies concerned with heat pipes limited by the last of these considerations. An analytical model of the heat pipe is presented. The model, based upon basic mass, energy, and momentum balances, is solved to yield an expression for the maximum heat transfer rate. Experiments resulting in data suitable for testing this model are described and the close agreement between analysis and experiment is demonstrated.

67036 A STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE

Work performed from January 1, 1967, through June 30, 1967, on the following is reported: operation of a stainless steel heat pipe at increased power levels and with several different wick bead sizes, heat pipe analysis, investigation of heat transfer through porous media, design of a controlled environment heat pipe experiment, and investigation of the fundamental aspects of capillarity.

67037 EVALUATION OF THEORETICAL HEAT PIPE PERFORMANCE

The heat pipe has been established as a thermal energy transfer device with many practical applications. However, the engineer who must design a heat pipe is confronted with numerous theoretical and experimental papers giving various results. The aim of this paper is to provide the engineer with a method for designing a heat pipe within the constraints of a system without the need for extensive parametric experiments.

67038 OPERATING CHARACTERISTICS OF CAPILLARITY-LIMITED HEAT PIPES

Heat pipe is cylindrical in shape, has annular porous wick, and consists of evaporator, adiabatic and condenser sections; in steady-state operation heat is added at evaporator section by conduction through wall, resulting in vaporization of convective fluid at wick surface and flow of vapor toward condenser end through hollow central region; heat is removed at condenser section by conduction through wall, resulting in condensation of vapor at wick surface; condensate returns to evaporator section by capillary flow through wick; many promising applications appear to be in space systems.

67063 PROCEEDINGS OF JOINT ATOMIC ENERGY COMMISSION/SANDIA LABORATORIES HEAT PIPE CONFERENCE HELD AT ALBUQUERQUE, NEW MEXICO, JUNE 1, 1966. VOLUME I.

The conference was divided into two sessions during which papers discussing theoretical analyses, development procedures, and a variety of applications for heat pipes were presented. Volume II contains the classified papers. Topics covered in Volume I include status of the engineering theory of heat pipes, heat pipe capability experiments, operating limits of heat pipes, liquid transport and heat transfer properties.
of heat pipe wicking materials, feasibility studies of space radiators using vapor
chamber fins, and heat pipes and vapor chambers and their application to thermal con-
control of spacecraft.

68025 SOME OPERATING LIMITS ON HEATPIPES
Werner, R. Lawrence Rad. Lab., U. of Calif., Livermore Space Power Note No. 293
Reasonable approximations for the values of AT to produce nucleate boiling in
heat pipe wicks for various liquid metals are provided. Some rather general comments
on sonic velocity of the heat pipe vapor and entrainment of the liquid in the vapor
are made.

68026 HEAT PIPE CAPABILITY EXPERIMENTS
Kemme, J. E., IEEE-Thermionic Conversion Specialist Conference--Conference Rec Nov 3-4
1966 p 159-68 Avail:TAC
Axial heat transfer limits were determined for several heat pipe systems to show
methods for increasing heat transfer capability and to check validity of existing heat
pipe equations; measurements at operating temperatures from 450 to 850 C; sodium and
potassium are used as working fluids; heat pipe preparation and construction tech-
niques; pertinent fluid properties are plotted as function of temperature; heat pipe
results are listed and experimental results are compared with calculated heat trans-
fer limits.

69060 HEAT PIPE RESEARCH IN EUROPE
C. A. Busse (EURATOM and Comitato Nazionale per l'Energia Nucleare, Centro per le
Ricerche Comuni, Ispra, Italy). IN: INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL
POWER GENERATION, 2ND, STRESA, ITALY, MAY 27-31, 1968, PROCEEDINGS. [A69-29172 14-03].
Conference sponsored by the European Nuclear Energy Agency, Luxembourg, EURATOM Center
for Information and Documentation (EUR No. 4210 f, e), 1969, p. 461-475. 17 refs.,
Avail:TAC
Review of recent work done on heat pipes in West-European laboratories, with em-
phasis on (1) the heat quantities that can be transported by means of a heat pipe,
(2) the maximum heating rate, and (3) the lifetime of a heat pipe. Research results
show that heat pipes make it possible to transport large quantities of heat with prac-
tically no temperature drop; heat transport rates up to 15 kW/cm² have been measured.
There seems to be a good chance of finding ductile heat pipe systems with a lifetime
of much more than 1000 hr, even at 1600°C.

69061 PRELIMINARY RESULTS OF A STUDY OF HEATPIPES AT HIGH TEMPERATURE [RESULTATS
PRELIMIAINES D'UNE ETUDE SUR LES CALODUCS A HAUTE TEMPERATURE
M. Armand and A. M. Shroff (Compagnie Générale de Télégraphie Sans Fil, Groupement
Scientifique et Technique, Orsay, Essonne, France). IN: INTERNATIONAL CONFERENCE ON
THERMIONIC ELECTRICAL POWER GENERATION, 2ND, STRESA, ITALY, MAY 27-31, 1968, PROCEED-
INGS. [A69-29172 14-03]. Conference sponsored by the European Nuclear Energy Agency,
Luxembourg, EURATOM Center for Information and Documentation (EUR No. 4210 f, e), 1969,
p. 557-563. In French, Avail:TAC
Consideration of the application of heat pipes for the transfer of the heat of
vaporization of fluids without loss of heat for the case of high temperatures, partic-
ularly for heating the emitters of thermionic converters. This mode of heating pro-
vides excellent homogeneity of emitter temperature, and the possibility of separating
the heat source from the diode, which is of interest in the case of nuclear heating.
Some theoretical results obtained for the optimization of the capillary system, as well
as the thermal resistance to be expected, are given. Experimental apparatus used to
evaluate the performance of heat pipes is described. In a technological study, the
materials utilized, the housings and heat carriers, methods of developing and forming
heat pipes, and lifetime tests are discussed.

69062 TWO-COMPONENT HEATPIPES
C. L. Tien (California, University, Berkeley, Calif.). American Institute of Aero-
nautics and Astronautics, Thermophysics Conference, 4th, San Francisco, Calif., June
Study of the operational characteristics of two-component heat pipes. A qualita-
tive description is given on the basis of the thermodynamic phase equilibrium for bi-
nary mixtures. The present physical model differs in several fundamental aspects from
the existing one in the literature. The experimental results obtained from a water-
ethanol heat pipe under various operating conditions lend direct support to the pres-
ent physical model.
69063 ANALYSIS OF TEMPERATURE DISTRIBUTIONS IN HEAT PIPE WICKS

Heat pipes are generally regarded as constant-temperature devices because the axial temperature drop in the vapor is small even at high heat transfer rates. Large axial temperature gradients do occur in the wicks of heat pipes using water, however. This work presents exact analytical solutions for the two-dimensional problem of liquid flow and heat conduction within the wick. The predicted axial temperature drops agree with values measured by other workers at low heat fluxes but are too large at high heat fluxes. The theory predicts large axial temperature gradients when liquids of low thermal conductivity are used in heat pipes. The theory also clarifies the nature of certain singularities which may prevent convergence of finite-difference techniques presently being applied to this problem.

69064 ANALYTICAL AND EXPERIMENTAL STUDY OF SODIUM HEAT PIPES

The results obtained in the course of theoretical and experimental studies carried out on sodium heat pipes, the capillary structure of which is made up of square-mesh sieves are discussed. The chief aim of this work was to determine the thermal power limit of the apparatus as a function of several parameters, with special reference to the specifications of the capillary network.

69065 A STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE. PART I. AN ANALYTICAL MODEL FOR THE PREDICTION OF OPERATING LIMITS OF HEAT PIPES. PART II. CAPILLARITY IN POROUS MEDIA

An analytical model is presented based on fundamental mass, heat, and momentum balances in the wick. It relates the maximum heat input to the fluid and wick characteristics and to the inclination of the pipe with respect to gravity. The model indicates that the critical parameters and operating characteristics are the capillary forces in the wick, pressure drop through the wick, and the operating temperature of the heat pipe. Maximum heat inputs in two experimental heat pipes were determined using packed beds of monel particles as wicking material and water as the working fluid. The agreement between the experimental results obtained and those predicted using the analytical model was excellent.

70041 INVESTIGATION OF CONSTRAINTS IN THERMAL SIMILITUDE, VOLUME 1

The studies described in the report clarify the effects of some of the limitations imposed by the laws of thermal similitude, and determine the thermal modeling laws for a heat pipe. In Volume 1 solutions were presented for the steady-state temperature distribution and heat transfer in a radiating fin having temperature dependent thermal conductivity. Using these solutions, modeling prediction errors were determined for fin type prototype/model systems with dimensional distortions, with material having temperature dependent thermal conductivity, and with low prototype temperatures. In volume 2 the thermal modeling laws for a heat pipe were derived and experimentally verified. A flexible heat pipe was also designed and experimentally tested.

70042 INVESTIGATION OF CONSTRAINTS IN THERMAL SIMILITUDE, VOLUME 2

The studies described clarify the effects of some of the limitations imposed by the laws of thermal similitude, and determine the thermal modeling laws for a heat pipe. In Volume 2 the thermal modeling laws for a heat pipe were derived and experimentally verified. It was observed that prototype thermal behavior could be predicted, from model data, to within 10 F over the temperature range tested (140 to 330 F). Heat pipe failure due to capillary failure was also predictable to within plus or minus 10%. A flexible heat pipe was also designed and experimentally tested. Performance was not degraded under conditions of bending.
AN ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF ROTATING, NON-CAPILLARY HEAT PIPES
An analytical review of the operation of rotating, non-capillary heat pipes is presented, including a discussion of film condensation on the inside of a rotating, truncated cone. Predicted results so far obtained indicate that the heat transfer capability of rotating, non-capillary heat pipes depends upon condenser performance and is substantially higher than the capability of conventional, wick-limited heat pipes. The design and manufacture of an experimental rotating heat pipe apparatus is also described.

ON THE EFFECTS OF CAPILLARY GEOMETRY ON OPTIMAL HEATING SURFACE LOADS IN HEAT PIPES
Possible limitations of energy transfer in heat pipes are studied with fluids of low thermal conductance and boiling retardation. Experiments with several capillary pipe structures indicate that open grooves attain the highest possible surface heat loads. A newly developed heat pipe with threaded arteries obtains high heat loads even at considerable bubble formation in the grooves; gravitational direction does not affect its heat flow. Equations for calculating maximum surface heat loads in open grooves are included and describe temperature as well as pressure effects on heat transfer.

EFFECT OF MAGNETIC FIELDS ON HEAT PIPES
Heat pipes have been proposed for use in environments where there are strong magnetic fields, as in controlled fusion reactors. The presence of a magnetic field can influence the performance of a heat pipe significantly, depending on the heat-pipe geometry, its orientation in the magnetic field, the heat-pipe materials and fluid properties as well as the magnetic field strength. A liquid-metal heat pipe, specifically designed to operate in a magnetic field, will employ a compound wick structure with the optimum liquid flow passage size larger and the vapor flow passage proportionately smaller than for the nonmagnetic field design. The basic conclusion is that the presence of a magnetic field always results in a lower maximum heat flux capability, but the detrimental effects of the magnetic field can be greatly reduced by using a heat-pipe geometry optimized for operation in the specific magnetic field environment.

THERMAL SCALE MODELING OF A HEAT PIPE
A parametric study of the defining equations for heat-pipe operation (i.e. energy, momentum, and continuity) was performed for the purpose of providing a method for predicting the performance characteristics of a heat pipe from the experimental behavior of a dimensionally and thermally similar (model) heat pipe. Two specific modeling techniques considered in this paper are (a) a technique preserving materials between model and prototype, and (b) a technique maintaining the same heat flux in both model and prototype. The similarity relations for the first modeling technique (material preservation) were verified by experiment and the similarity relations for the second modeling technique (heat flux presentation) are presented without experimental verification.

PARAMETERS FOR THE ASSESSMENT OF HEAT CARRIERS IN HEAT PIPES
A fundamental equation for heat pipes is derived from a pressure balance and is used for direct estimation of the characteristic dimensions for maximum possible axial transport of heat. A total of 5 limits for the operational efficiency of heat pipes could be determined by physical and chemical phenomena; these limits are closely investigated to achieve a qualitative comparison of various heat carriers. Metals whose vapor consists of monatomic...
The use of threaded arterial heat pipes offers advantages if large axial heat flows are to be transferred with simultaneous high radial heat transfer per unit surface; ease of manufacture offers further advantage over other types of heat pipes.

Equations for calculation of maximum possible transport by heat pipes and stipulations for their use are given; by way of example it is shown that arterial heat pipes (heat pipes of second generation) possess considerably greater transport possibilities than heat pipes of first generation, in which the core is made up of grooves or of several layers of gauze; experiments carried out for measuring critical heat flow density in hot zone are also discussed.

A thermal scale modeling program was instituted for the purpose of providing a method for predicting the performance characteristics of a heat pipe from the experimental behavior of a dimensionally and thermally similar (model) heat pipe. The equations for two specific modeling techniques, a technique preserving materials between model and prototype and a technique maintaining the same heat flux in both model and prototype, are derived. The similarity relations for the first modeling technique (material preservation) were verified by experiment and the similarity relations for the second modeling technique (heat flux preservation) are presented without experimental verification. Experiments were performed with two heat pipes (one model and one prototype) fabricated from identical materials. These heat pipes were tested in a high vacuum, cold wall environment without simulated solar, planet, or albedo radiation. Separate experiments were performed on the same two heat pipes to investigate the pumping capabilities of the wick.

A qualitative investigation of the performance of heat pipes using different working fluids was made, and the significance of liquid property variations on the performance of cryogenic heat pipes is described. A theory is developed for the cryogenic heat pipe which takes into account the liquid property variations. Predictions by the present theory compare favorably with Haskin's experiments. A computer program in Fortran IV language was written for the theory. Physical properties of cryogenic fluids, which are required as program input data are collected. For convenience of the user of the theory, a complete listing of the program with user's instructions and collected properties of cryogens are appended to the report. A chart is presented of the complete performance of cryogenic heat pipes. A procedure for computer aided design of cryogenic heat pipe is also described. The procedure consists of the following steps: (1) choice of fluid and wick structure, (2) determination of wick dimensions, and (3) generation of performance chart for the designed heat pipe.
C.2 HEAT TRANSFER
Experimental results are presented for boiling heat transfer to ethanol from a stainless steel heater surrounded by a capillary wicking material. The ability of the wicking to convey coolant to a heater when the liquid level is such as to expose part of the heater is demonstrated. The effect of small accelerations directed normally toward the heater surface is studied. It is concluded that the full capabilities of capillary wicking to supply coolant to a heater cannot be realized without proper venting of vapor produced by boiling. Some recently obtained data are presented for a surface supplied with water by capillary action. In obtaining these data proper venting was employed and extremely high heat fluxes were obtained, substantiating the conclusions of this paper.

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Description of the construction and operation of several simple devices for the transfer of a large amount of heat with only a small temperature drop. Within certain limitations on the manner of use, a heat pipe is regarded as a synergistic engineering structure with a thermal conductivity greatly exceeding that of any known metal. Included are test data from two liquid sodium heat pipes.

Data show how burnout heat flux varies with presence of capillary wicking, surface deposits, and heater size; surface deposits which improve wettability can produce two- to three-fold increases in burnout heat flux; Fiberglas wicking provides surface deposit improving wettability.

Description of a heat pipe which is a self-contained device exhibiting a very high effective thermal conductivity. The heat pipe consists of a vapor core and a fluid annulus (fluid flowing through the wick). As an extension to a previous study, the heat-transfer coefficients in the evaporator section are correlated, giving a rather good indication of the engineering performance. Experiments have been performed to show the temperature distribution, the boiling heat-transfer coefficients, and the vapor temperature and pressure drop. The wick boiling heat-transfer correlation is plotted, and it is confirmed that wick boiling is preferable at low heat fluxes. The temperature distribution on the heat pipe is plotted. The results indicate the potential usefulness of the heat pipe.

High heat transfer with small temp. drop may be obtained by evap. a liquid coolant, transporting the vapor and subsequent condensation of the vapor. If the condensate is returned to the evaporator by capillary forces, there is no need of auxiliary systems such as pumps. For heat pipes operating on this principle, the phys. basis is discussed and heat transfer is calc'd. based on an elementary model. A numerical example is given with regard to waste-heat transport from thermionic reactors.

Maximum heat flow measurements on sodium-columbium heat-pipe were carried out in temperature interval from 500 to 800 C; measured values could be explained by theoretical model regarding gravitational forces in liquid phase and acceleration forces in vapor phase; heat-pipe was operated at different inclinations to measure surface tension of liquid; maximum heat flow equations are given and verified by experiments in laminar flow regions.

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Heat-pipe experiments indicate that very high heat-flux densities can be removed from capillary lined evaporator surfaces. Data for the maximum attainable heat flux densities are derived from experiments, preferably with sodium-filled heat pipes. Hydrodynamic and gaskinetic calculations are presented which are in accordance with the measured data.

69067 VAPORIZATION HEAT TRANSFER IN CAPILLARY WICK STRUCTURES

The objective of the research here was to study the mechanism of vaporization heat transfer from wick covered, heated surfaces. Results for both normal operation (heat fluxes below the critical), and critical heat fluxes will be presented. The critical heat flux as used here is that value of the heat flux at which drying of the wick occurs and a large increase in the heated surface temperature is observed. In this sense, it is similar to the same term applied to ordinary pool boiling. The experimental configuration (flooded, wick covered surfaces) is not typical of heat pipe operation and is appropriate only for a study of the mechanism of the process.

70050 A SHORT STUDY OF CAPILLARY ACTION IN BOILING WATER HEAT TRANSFER THROUGH POROUS MEDIA

Experiments were carried out to test the proposal that a boiling process involving capillary action occurs when porous layers are built up between a heat transfer surface and its liquid coolant. A theoretical model was also set up and compared with the experimental results. Tests with real porous media were inconclusive owing to poor thermal contacts. Experiments with a single capillary indicated that boiling within pores was explosive owing to restricted bubble expansion, and was only well predicted by the theory when the resulting meniscus movement was small. This condition is expected to hold in porous media, and, by application of the theory to these, it was found that this process may provide an efficient heat transfer mode.

70051 A STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE, PART IV, HEAT TRANSFER IN THE EVAPORATOR ZONE OF A HEAT PIPE

The heat transfer mechanism in the evaporator section of a heat pipe was studied. Since several operating features of a typical heat pipe tend to complicate an experimental investigation of the heat transfer phenomena in the evaporator section, a controlled environment heat pipe was designed and operated. This controlled environment heat pipe was divided into an adiabatic section and an evaporator section. Both sections consisted of a rectangular duct which was completely filled with small particles to form a porous wick. One end of the adiabatic section was immersed in a pool of the working fluid which flowed by capillary action to the evaporator section where it was vaporized. The upper surface of the wick in this section was uncovered to permit disengagement of the vapor. The heat pipe was wholly enclosed within a flanged glass pipe which was filled, during operation, with vapor from an auxiliary pool of the working fluid to provide a constant temperature and pressure environment. Experimental data were obtained to determine the relationship between heat flux and temperature difference between the heated surface and the wick and to determine the limiting operation conditions. The heat flux-temperature difference data were obtained at atmospheric pressure using water as the working fluid and monel and glass particles for the wick. Data on the limiting operating conditions were obtained for monel particles using the same working fluid and at the same pressure. The particles ranged in size from 149 to 590 microns and the heat flux range was from 1,500 to 80,000 Btu/hr-ft². Based on initial data, a mechanism to describe the heat transfer phenomena was proposed which considered that heat transfer from the heated surface occurred by conduction with vaporization of the liquid occurring at vapor-liquid interfaces located in the layer of particles covering the surface, and that the critical heat flux was obtained when the capillary forces were no longer sufficient to keep a major part of the heated surface wet. Based on this proposed mechanism, theoretical expressions were developed for predicting an over-all heat transfer coefficient and the critical heat...
The agreement between the predicted and experimental values of the over-all heat transfer coefficient was excellent for normal conditions of the wick and the normal operating range. Even when the wick conditions were not normal, i.e., the bottom layers of particles fused to each other and to the heated surface, the proposed mechanism of heat transfer by conduction was still valid even though the predicted values were larger than the experimental ones. Also, it was shown that the upper limit of the normal operating range could be predicted and depended upon the limits of the particle size range used for the wick and the critical heat flux. The agreement between the predicted and experimental values for the critical heat flux was excellent when proper values were selected for the cross-sectional areas for vapor and liquid flow in the evaporator section. The selection of these values was necessary since no theoretical or experimental method was developed for predicting them.

70052 HEAT TRANSFER FROM THE WALL OF A POROUS SOLID INVOLVING GAS INJECTION AND VAPORIZATION


An experimental study was made of heat transfer with gas injection through a porous wall into a pool of liquid, including vaporization effects. Air bubbling from the surface of a graphite cylinder into water at atmospheric pressure was used. It was possible to determine limits on energy transfer due to convection and to latent heat transport. It was found that under some conditions it was possible to operate the system with the surface rejecting heat while at temperatures less than that of the bulk pool liquid.

70053 THEORY OF THE SONIC HEAT TRANSFER LIMIT OF HEAT PIPES

C. A. Busse, Euratom CCR, 21020 Ispra, Italy. Avail: TAC (17p)

The sonic heat transfer limit of cylindrical heat pipes is analyzed by a perturbation method assuming a two-phase equilibrium vapor and taking into account the radial variation of the axial velocity. The velocity profile is determined from an approximate solution of the Navier-Stokes equation for the limiting case of predominant inertia forces. This profile proves to be flatter than in the corresponding case of incompressible flow. Formulas are derived for the average heat flux density at the sonic limit, for the average velocity and the average vapor quality at the evaporator exit, and for the ratio of pressure, temperature, gas density and average vapor density at the beginning and at the end of the heating zone. The values of the sonic heat flux density are respectively about 15% and 7% lower than those obtained by Levy from an ideal gas model and a two-phase equilibrium vapor model with the assumption of a rectangular velocity profile. The agreement between theory and experimental data for Na, K, Cs and Hg is very good, except for low temperature data of Na and K.

70054 EFFECTIVE THERMAL CONDUCTIVITY OF DRY AND LIQUID-SATURATED SINTERED FIBER METAL WICKS


Experimental data are presented for the effective thermal conductivity of dry and water-saturated sintered fiber metal wicks. The data were obtained both along and across the fibers. Semiempirical correlations have been obtained for the effective thermal conductivities in terms of the thermal conductivities of the solid and fluid phases and the void fraction.

70055 MAXIMUM HEAT TRANSPORT OF OPTIMALLY DESIGNED HEAT PIPES


An account is given of the optimum design of 2nd generation heat pipes, particularly annular space heat pipes, with regard to max. heat transport capacity. The quantities of heat that can be transported are severely limited by such conditions as the heat transferred per unit surface and bubble formation. The diam. of annular-space heat pipes is also limited inter alia by the fact that the annular space must be filled completely against gravity. Whereas arterial heat pipes containing low-boiling heat carriers permit only low heat c.d.s., spiral arterial heat pipes can be used up to 140 W/cm² with the same heat carriers.

70056 DETERMINATION OF BOILING FILM COEFFICIENT FOR A HEATED HORIZONTAL TUBE IN WATER-SATURATED WICK MATERIAL


Using an absorbent wick material saturated with a coolant has become attractive from a design standpoint for some missile-cooling applications. However, published...
data for predicting film coefficients are very limited. In this study, boiling film coefficients for a 1.0-in. OD horizontal tube of copper embedded in water saturated ceramic fiber-wick material were correlated over a heat flux range from 1000 to 10,000 Btu per hr sq ft by the dimension equation

\[
\left( \frac{h}{G'Q} \right) (\frac{\rho \sigma}{\mu})^{0.6} (\frac{D}{\mu})^{-0.77} = 0.072 \left( \frac{D}{\mu} \right)^{-0.77}
\]

The presence of wick material next to a heat-transfer surface decreases turbulence in the region near the surface, increases the effective surface area, and provides active sites for bubble formation. This produces a higher film coefficient at low heat flux than occurs with pool boiling. At higher heat flux, the wick-boiling film coefficient was lower than for pool boiling.

71041 VAPORIZATION HEAT TRANSFER FROM FLOODED WICK
C.3 CONDENSATION AND EVAPORATION
60001 ON HYDRODYNAMIC BOUNDARY CONDITIONS FOR EVAPORATION AND CONDENSATION

The boundary conditions have been found for hydrodynamic equations in the presence of evaporation and condensation. For small evaporation rates the temperature jump and the deviation of the vapor pressure from the equilibrium value are shown to be of the order of the ratio between the speed of the vapor flow v and the mean speed of heat transfer c. It is shown that the expressions commonly used in the literature for the flow of materials and heat in the presence of evaporation and condensation contain an error.

67040 EFFECTS OF CONDENSER PARAMETERS ON HEAT PIPE OPTIMIZATION

Study of the maximum heat transport in heat pipes. It is indicated that the operation of heat pipes is constrained mostly by condenser parameters. The nonradiative type of condensers is discussed, and an application where the heat is radiated away from the exterior surface of the condenser is considered.

68028 THEORETICAL CONSIDERATIONS ON A VAPORIZATION COOLING SYSTEM WITH CAPILLARY DISTRIBUTOR [THEORETISCHE UEBERLEGUNGEN ZU EINER VERDAMPFUNGSKUEHLUNG MIT KAPILLARVERTEILER]

Theoretical calculations are indicated for a cooling system utilizing the vaporization heat. In the same way as in "Heat-Pipes" the boiling liquid is kept on the heated surfaces by open capillaries. Mach-Number and critical-heat-flux do limit the heat transport. A nuclear reactor equipped with thermionic power converters is shown as an example for the efficiency of the cooling system. At 650°C with potassium the following results were obtained theoretically: Mach-Number of vapor less 0.3, temperature difference between reactor-core and reactor-brink less 5°C, pump-power about one hundredth of liquid-metal cooling circuit.


Falling capillary equilibrium heights of water in porous media were determined under adiabatic and evaporative (boiling) conditions at atmospheric pressure. The packed beds consisted of stainless steel particles (40 to 100 mesh) and glass beads (80 to 100 mesh). For the glass beads, capillary heights were correlated as a function of the specific evaporation rate of the working fluid and found to be independent of evaporation rate over the range (0 to 50 lb/hr-ft²) studied. The data were explained by assuming that the sole effect of imposing a heat flux on the porous media was to change the surface tension and density of the liquid water. The effect of reduced surface tension and density alone were sufficient to explain the observed results; apparently no change in cost 8/1 was affected by the imposition of the heat flux.

69068 SPACE ELECTRIC POWER R AND D PROGRAM PART 1

Fluid pressure conditions which can occur with annular return heat pipes using cesium, mercury, potassium, or sodium as the working fluid are described, and calculated values are compared with experimental measurements.

69069 EFFECT OF NUCLEATE BOILING ON THE OPERATION OF LOW TEMPERATURE HEAT PIPES

Study of the effects of nucleate boiling using an everted stainless steel heat pipe designed to permit visualization of the wick structure and of bubble nucleation during operation. Four layers of 100 mesh stainless steel wire cloth were used as the wick structure. Results were obtained with water and ethyl alcohol over a range of operating pressures from 25-in. Hg vacuum to 5 psig. A type of nucleate boiling was observed which did not affect the overall operation of the heat pipe.

C.3-01
STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE. PART III. VAPORIZATION HEAT TRANSFER FROM FLOODED WICK COVERED SURFACES.


The mechanism of vaporization heat transfer on a system with a fluid-wick combination that had well-defined geometric parameters and physical properties has been examined. The experimental apparatus consisted of a horizontal, stainless steel surface with a bed of monel beads of various sizes and depths in contact with it. The beds were covered with 2- through 4-inch depths of distilled water. The experimental data indicated very strongly that, in contrast to ordinary pool boiling, the heat transfer coefficient was very nearly constant for all heat fluxes below the critical value and that the latter is reached when the capillary forces are no longer sufficient to maintain liquid in contact with the heated surface. Analytical models were derived for both the heat transfer coefficient and the critical heat flux and are shown to be in excellent agreement with the experimental results obtained.

INVESTIGATION OF HEAT EXCHANGE WITH BOILING WATER DELIVERED TO THE HEATING SURFACE BY A CAPILLARY POROUS BODY AT LOW PRESSURES


The results of an experimental study of boiling water supplied to a heating surface by a capillary porous body within the pressure range 0.006 to 0.800 bar are presented. The presence of the capillary porous body on the heating surface facilitates vapor bubble formation even at small temperature values. The heat transfer intensity mainly depends upon the conditions of vapor removed from the heat transfer surface. With a particular heat load, a non-stationary heat transfer regime was observed, characterized by a continuous increase of the wall temperature. The effect of pressure decrease upon the heat transfer intensity is in its quality, the same as that at water boiling in a free volume.

AN INVESTIGATION OF NUCLEATE BOILING FROM MESH COVERED SURFACES


A boiler apparatus, designed to simulate heat pipe operation, was built and used to investigate nucleate boiling at atmospheric pressure from mesh covered surfaces using distilled water as the working fluid. The wick materials used included 50 mesh, 80 mesh, and 150 mesh nickel screen; 100 count Lektromesh, a one-piece electrodeposited metallic-sheet material; and 30-40 mesh glass beads. Various wick compositions and water levels were investigated. Vapor bubble migrations within the wick material influenced the performance of the apparatus. Providing a means for vapor escape improved the performance considerably. As a result, performance could be improved by using wick materials having larger mesh openings. Sintering screen samples to the boiler surface to reduce contact resistance did not improve performance.

SURFACE WETTING THROUGH CAPILLARY GROOVES


The effects of capillary grooves on surface wetting and evaporation have been analysed. An attempt has been made to obtain expressions which approximately describe the increase in heat transfer in order to select for given properties and temperature differences a groove of optimum design. For this purpose, it is assumed that the heat transfer mechanism is determined by thermal resistance of the liquid layers inside the grooves. From a numerical evaluation of linearized equations, heat transfer rates have been computed for grooves with triangular, semicircular, and square cross sections.

IRREVERSIBLE THERMODYNAMIC ANALYSIS OF THE AXIALLY HEATED HEAT PIPE


The axially heated heat pipe is analyzed with the inclusion of the irreversible thermodynamic analysis of the phase change process. At low temperature operation an evaporation rate limit is found to limit heat transfer rates and the omission of non-equilibrium effects at the liquid vapor interfaces is shown to result in large errors in temperature distribution predictions.
The results of an experimental investigation of the mechanism of heat transfer during the evaporation of a fluid in a porous wick structure in contact with a heated surface are reported. The experimental configuration was such that the liquid was drawn to the heated surface by capillary action as in a typical heat pipe. Experimental results for both the heat transfer coefficient and the critical heat flux are compared with predicted values based on the mechanism proposed by Ferrell and Alleavitch. The results indicate the mechanism to be substantially correct. The wick materials studied were beds of monel and glass beads.
C.4 FLUID FLOW

C.4-1
50001 INVESTIGATION OF FLOW THROUGH SCREENS


Study of effects of perforated plates and relatively coarse lattices placed perpendicular to fluid flow; effects investigated were dictated by uses made of screens and were divided into three main categories: pressure drop across screen, modification of velocity distribution caused by screen, and turbulence resulting downstream from screen.

62001 RECIRCULATION OF A TWO-PHASE FLUID BY THERMAL AND CAPILLARY PUMPING


A closed-cycle gas-supply system for gas bearings and gas-floated devices is described which eliminates mechanical pumps or compressors and uses instead thermal and capillary pumping action. A small quantity of a two-phase fluid of suitable thermodynamic characteristics, such as Freon, is recirculated in a closed system. The fluid is thermally vaporized in an evaporator, and the superheated vapor, after passing through the gas bearing, is condensed and returned to the evaporator by capillary action. The system is of special interest to space applications, because it can operate in a zero-g environment from solar or nuclear power sources, without conversion to electrical energy.

66023 TWO-PHASE MOMENTUM FLUX AND DESIGN OF A HEAT PIPE


The momentum flux in upward two-phase flows through tubes is measured and analyzed, and models are studied. The calculations are presented in forms suitable for determinations of pressure drops in pipe flows. Fluctuations in momentum flux are studied. Excitation of physical oscillations by these fluctuations is discussed. The development of a heat pipe, and the factors governing the performance of such a pipe, are studied. The factor that limits heat transfer in water-filled wick-return heat pipes is found to be conduction through the wick at the cold end. For these heat pipes, it is found that very small amounts of noncondensable gases can cause dramatic reductions in the heat transfer performance of the heat pipe.

66024 EXPERIMENTAL FEASIBILITY STUDY OF WATER-FILLED CAPILLARY-PUMPED HEAT-TRANSFER LOOPS


Two capillary-pumped heat-transfer loops were fabricated and tested to study their general characteristics. With water as a working fluid, the loops were operated over a power input range from 248 to 1000 watts in a temperature range from 212° to 291°F. The first loop, with a vapor duct 0.193 inch in inside diameter, was 70 feet long and operated at a maximum power input of 823 watts. The second loop (0.180-in. i.d. vapor duct) was 52 feet long and operated at 700 watts in a variety of orientations with respect to gravity. Although capillary-pumped loops must be designed with care to prevent problems with noncondensable gas, the test results show that such loops can transfer kilowatts of heat over distances greater than 50 feet. The operation of the final test loop was not sensitive to its orientation with respect to gravity.

66025 VISCOUS FLOW IN A RECTANGULAR CHANNEL HEAT PIPE WICK


Analytical investigation of the flow in a channel wick. The pressure gradient required to carry a mass flow rate at some point down the channel is calculated by solving the much simplified Navier-Stokes equation for laminar flow. The friction factor at different channel depth to wall ratios and different flow velocities is determined and graphed.

66026 ANNULAR HEAT PIPE THEORY


Using the usual assumptions regarding fluid flow, the Navier-Stokes equation can be solved analytically for the annular type heat pipe. The author carries out the solution in detail and gives an additional first order approximation formula which is not only easy to use but sufficiently accurate for all practical cases.
A STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE

The operating characteristics of a stainless steel heat pipe are described along with an analytical model for predicting operating limits of capillarity-limited heat pipes. A continued analysis of a transient capillary rise model was performed along with comparisons with experimental data. Analysis of basic capillarity phenomena was continued, including determination of meniscus shapes under various conditions.

PRESSURE DROP IN THE VAPOR PHASE OF LONG HEAT PIPES
Busse, C. A. (Euratom CCR, Ispra (Vanese), Italy) Avail:TAC (11p), 6 refs.

Laminar vapor flow in cylindrical heat-pipes is analyzed assuming that the heat pipe consists of a heating zone, a heat-shielded zone and a cooling zone, that the length of each zone is large compared with the diameter, and that the heating and cooling rates are constant. The vapor flow is described by the Navier-Stokes equation which is simplified for the case of a long heat-pipe and solved by approximating the axial velocity component by a polynomial of the fourth power of the radius. The analysis shows that the profile of the axial velocity component (divided by the average axial velocity) is constant along the heating zone, that it approaches the Poiseuille profile in the heat-shielded zone, and that it varies strongly along the cooling zone deviating already considerably from the Poiseuille profile for radial Reynolds numbers of minus one. Analytical expressions for the axial pressure profile and relations for the integral axial pressure drop are derived for all positive values of the radial Reynolds number (heating zone), and for negative values (cooling zone) down to about minus one.

HEAT TRANSFER IN A TWO-PHASE THERMOSYPHON TUBE

Discussion of a particular form of thermosyphon (a sealed tube partly filled with a working fluid). The condensate is returned from the cooled end to the heated end by gravity. Such a tube has a conductivity that is at least two orders of magnitude higher than that of a solid bar of copper. As the condensate return is by gravity, this high conductivity is effective only when the heat flow is upward. A similar device known as a heat pipe is being developed for use in zero-gravity conditions. The heat pipe differs from the tube discussed in that the condensate is returned to the heated end by means of a wick that is built into the tube. Possible uses of the thermosyphon tube are enumerated and an experimental program is outlined.

THEORETICAL INVESTIGATION OF HEAT PIPES OPERATING AT LOW VAPOR PRESSURES

Consideration of the heat pipe, a device which can transfer a large quantity of heat with a relatively small temperature drop by the evaporation of a liquid, the transport of the vapor through a duct, and the subsequent condensation of the vapor at the heat-rejection surface. A one-dimensional analysis of a compressible vapor flowing within the evaporator section of a heat pipe is presented. Comparisons between the theoretical results and existing heat-pipe data show that the presence of a gasdynamic choking can limit the heat-transfer capacity of a heat pipe operating at sufficiently low vapor pressures.

LIQUID-VAPOUR INTERACTION AND EVAPORATION IN HEAT PIPES

Experimental study of liquid-vapor interaction in loop plates with different heat-pipe capillary geometries using water as the liquid in the open capillaries. The decrease of the transported water mass-flow by increasing air velocity was measured, and the results are compared with the analytical solution given by Di Cola (1968). In addition, the processes in the interior of a heat pipe were observed visually. An
inverse heat-pipe was constructed with water as the heat transporting medium. It consists of three concentric tubes, an inner stainless steel tube with a capillary system at the outer surface, and two involving glass tubes. The water is in the gap between the steel tube and the inner glass tube. One part of the steel tube is heated electrically, the other is cooled by a water flow. The investigations made with this heat pipe cover: liquid distribution along the capillaries, dry-out of the heated surface caused by bubble formation, asymmetrical liquid distribution, and rewettability of the surface after dry-out.

69073 ULTIMATE HEAT-PIPE PERFORMANCE
AEC-sponsored research

Ultimate heat-transfer limitations imposed by sonic vapor flow were determined in heat pipes for sodium, potassium, and cesium working fluids. Each fluid was investigated in a heat pipe consisting of an inner porous tube, an annulus for liquid return, and an outer container tube. Thin, rigid tubes with very small pores were obtained by compacting several layers of fine-mesh screen. These tubes allowed large capillary forces to develop so that sonic vapor flow could be achieved at several operating temperatures. The results of the investigation showed that sonic limitations were influenced strongly by the temperature and the working fluid. Reasonable agreement was found between the experimental results and existing theory. It was also found that the theory could be used to predict evaporator pressure and temperature gradients when the heat pipes were operated at various fractions of their ultimate heat-transfer capability.

69074 HEAT PIPE CHANNEL FLOW DISTRIBUTIONS
Lawrence S. Galowin (Singer-General Precision, Inc., Research Center, Fluidics Dept., Little Falls, N.J.) and Vincent A. Barker (Numerisk Institut, Copenhagen, Denmark). American Society of Mechanical Engineers and American Institute of Chemical Engineers, Heat Transfer Conference, Minneapolis, Minn., Aug. 3-6, 1969, ASME Paper 69-HT-22, 14 p., 10 refs., Avail:TAC

Solutions for the gas phase, self-induced pressure field and laminar velocity distribution of the working fluid within closed heat pipe channels were obtained by a momentum integral method. The von Karman-Pohlhausen boundary layer integral method was adopted with a two-parameter velocity profile. Wall boundary conditions at the wick simulate the vapor phase emission and return by a porous wall with distributed wall injection and suction along the length. The flow vanishes at the solid ends of the channel while the arbitrary injection and suction wall distributions are related to the surface area heat input and rejection distributions. Approximate closed form solutions of the resulting nonlinear differential equation were obtained for velocity distributions and pressure fields with constant and linearly varying distributions of suction and injection. A computer program for numerical solution was developed for arbitrary functions of wall injection and suction. Convergence and the uniqueness of a solution were investigated by numerical experiments.

69075 EXPERIMENTAL STUDY OF VAPOR VELOCITY LIMIT IN A SODIUM HEAT PIPE

For the understanding of heat transfer capability and startup behavior of heat pipes, an experimental study was conducted on the heat transfer limit due to maximum vapor velocity at the end of the evaporator section. Axial temperature profiles on a sodium heat pipe are reported with different rates of heat transport through the pipe. Good correlation is obtained between the measured and predicted heat transfer limits. A constant ratio of static pressures across the evaporator section is deduced from surface temperature measurements to substantiate the occurrence of sonic velocity.

69076 QUARTERLY STATUS REPORT ON THE SPACE ELECTRIC POWER R AND D PROGRAM FOR THE PERIOD ENDING JANUARY 31, 1969. PART I.

Equations used in heat pipe design are presented including an equation to show the effects of vapor density and velocity on heat transfer. Sonic limitations for Cs, K, Li, and Na heat pipe working fluids are given. Compatibility evaluation of the Re-Ag heat pipe at 2000°C was terminated because of a leak in the evaporator section of
the pipe. High purity Re when used in a two metal system will operate satisfactorily at 2000°C in excess of 300 hrs without detectable entrainment between the metals. If high purity W is employed in the W-Ag system, the system has the same capability. In the Re-W-Ag system, in which W was used as the wick mass transport of W was found. A new Hg pipe was built, loaded, and tested for 4,600 hr operation at 300°C. A modified variable-spacing diode system test indicated some degree of local thermodynamic equilibrium. Data were insufficient to determine the magnitude of departure from equilibrium. Electron temperatures did not exceed 2800 K despite the high current densities and close spacings.

69077 DETERMINATION OF LOSS OF PRESSURE IN CAPILLARY MEDIA CAPABLE OF BEING USED IN HEAT PIPES
The pressure loss in capillaries composed of several layers of a sieve with different meshes and placed horizontally in a square pipe was studied experimentally. The tests were made with water, but the results are valid for other liquids such as sodium. The coefficient of friction, f, was determined as a function of the Reynolds number (Re < 300) on the basis of the test results.

69078 LIQUID VAPOR INTERACTION IN HEAT PIPES
W. Hufschmidt et al., Wärme- und Stoffübertragung Bd. 2 (1969) S. 222-239 (In German) Avail:TAC (20p)
For heat pipes with a structure of open capillaries in the transport section the vapor flow in the tube influences the laminar liquid flow in the capillaries in contrary direction by the shearing of the vapor at the free liquid surface. The two dimensional Navier-Stokes equation for the liquid flow in the rectangular capillaries has been solved by a Fourier transformation. The evaluation yielded the friction factor of the liquid flow under the influence of the vapor shearing and has been found markedly greater than in case without vapor flow. By this effect the performance of the heat pipe is decreased (e.g. for a Na-heat pipe at 800°C, 1 m length, 20 mm diameter, the reduction will be about 30%). At the liquid surface are zones with considerable return flow in vapor flow direction which are important for corrosion problems. In an experimental facility have been investigated plates with different capillary geometries. In the capillaries flowed water and over the plates air in contrary direction. The decrease of the transported water flow rate with increasing air velocity has been investigated. The measured friction factors of the water flow followed rather well the predicted values. This means that the assumptions for the boundary condition at the liquid surface—locally constant shear stress and no ripple formation—hold for the solution of the Navier-Stokes equation. If the capillaries in the plates are covered by a layer of a fine mesh no influence of the shearing of the air flow in the waterflow in the grooves has been measured. Up to air velocities of 11.5 m/s (corresponding to an airflow Reynolds number of about 10^5) no entrainment of water droplets from the mesh could be observed.

70062 VAPOR COMPRESSIBILITY EFFECTS IN HEAT PIPES
The preliminary results from an analytical study of the effect of vapor dissociation and vapor supersaturation on the sonic velocity limit in sodium heat pipes are presented. For a sodium vapor flow which is in chemical equilibrium but which is frozen with respect to liquid-vapor phase change, computed values for the maximum rate of heat transfer based on the sonic limit and for the axial drop in heat pipe temperature are presented and are shown to be in good agreement with recent experimental results from the literature. A comparison between the chemical equilibrium, reacting, and frozen flow analyses shows small variations in maximum heat transfer rates but large differences in the amounts of vapor supersaturation.

70063 EFFECT OF GRAVITY ON THE HEAT TRANSFER IN HEAT PIPES (SCHWERKRAFTEINFLUSS AUF DEN WÄRMETRANSPORT IN WÄRMEROHREN)
Discussion of the maximum heat flow in a heat pipe in the presence of gravity effects of varying magnitude and of the effect of gravity on heat transfer during evaporation and condensation processes in a heat pipe. The maximum heat flow in a heat pipe which operates against the force of gravity is calculated, using a simple physical
model. The results are discussed, taking into account conditions in a sodium-filled heat pipe at a temperature of 900 deg K. The limits of transferable heat flow are investigated on the basis of the relations governing heat transfer during evaporation and condensation processes with allowance for the effects of gravity.

70064 FLOODING PHENOMENON IN A CRYOGENIC HEAT PIPE WITH VERTICAL COUNTERCURRENT TWO-PHASE FLOW

A vertical tube has been used to study experimentally the behavior of a vaporization-condensation cryogenic heat pipe, by analogy to the well-known heat pipe recently developed for higher temperatures. The flow in the vertical tube connecting the vaporizer to the condenser is countercurrent, the liquid flowing downwards as in annular film at the wall, while the vapor circulates upwards in the center. Experiments have been carried out in a glass apparatus using nitrogen, hydrogen, and deuterium boiling under medium pressures. The thermal power supplied to the boiler cell and the diameter of the vertical tube were varied until flooding occurred. A dimensional analysis permitting a good correlation of experimental results is presented. A comparison of the data with previous correlations established for other fluids at room temperature is also given.

71020 A STUDY OF NONCONDENSABLE EFFECTS IN A HEAT PIPE

Experimental data are presented showing the effects of introducing argon into the vapor space of a water heat pipe under conditions of low to moderate heat-transfer rates. At low heat transfer the presence of argon very greatly affected the thermal conductance of the heat pipe while at higher energy transfer rates the effects of the noncondensables were considerably diminished. Correlation equations are presented which take account of the effects of the presence of various quantities of noncondensable gas on heat-pipe performance.

71021 POSSIBLE APPLICATION OF ELECTRO-OSMOTIC FLOW PUMPING IN HEAT PIPES

This paper proposes a scheme of utilizing electro-osmosis for flow pumping to increase the maximum heat capability of the heat pipe, and pressure generation to overcome the presence of vapor lock in the evaporator section of the pipe. The theory of electrokinetics in connection with heat pipe dynamics is outlined. A model which predicts the relative contribution of electro-osmotic flow pumping on the heat capability of the pipe is presented. Numerical calculations for a supposed heat pipe, operating with different dilute water solutions and utilizing glass beads as a wick material, indicate an increase in the heat pipe capability of several orders of magnitude, depending on the applied electric potential.

71022 EFFECTS OF FRICTION ON THE SONIC VELOCITY LIMIT IN SODIUM HEAT PIPES

Analytical results are presented which demonstrate the effect which the wall shear stress acting in the vapor flow passage has on the behavior of a sodium heat pipe operating in the sonic limit regime. It is shown that because of the wall shear stress in the adiabatic region, gasdynamic choking will occur at the exit plane of the adiabatic region rather than at the evaporator exit. At a given value of operating temperature, the shear stress will reduce the maximum rate of heat transfer based on the sonic limit to a value lower than is expected from the frictionless analysis.
D. DESIGN AND FABRICATION
D.1 GENERAL
A general description of heat pipes operating as radiating fins is given. A review is made of heat pipe experiments which have been conducted and the literature pertinent to their functional aspects. Subsequently, the six functions of a heat pipe are examined to find the factor which influences heat pipe design and which determines their minimum size and weight.

Experimental investigation of the possibility of using heat pipes in space thermionic power supplies for carrying heat to emitters and for dissipating waste heat from collectors, provided that systems of sufficient lifetime can be implemented. This application necessitates heat pipes operating in the temperature regions of 1600 to 1800°C (for emitters) and 1000°C (for collectors). Work is being performed on both systems, with emphasis on emitter heat pipes which pose the more difficult problem, and for which an operational temperature of 1600°C has been envisaged. The following four heat pipe development steps are discussed: (1) selection of the working fluid, (2) selection of container material, (3) heat pipe fabrication, and (4) life testing. A table summarizes the status of development as of the middle of July 1965. Six systems have reached the testing or evaluation stages. Comments are made on each of the systems.

Progress is reported on the development of a converter which incorporates a heat pipe concept to transfer heat between the collector and the radiator. Four devices are being fabricated and tested to insure a thorough evaluation of each design before proceeding with the next. The first two designs include only the heat pipe, while the latter two are complete converter structures with the heat pipe collector radiator. The efforts during this period were concerned with the fabrication of the first of the two heat pipe models.

A heat pipe is a metal tube containing a two phase fluid to transport heat over several feet by evaporating liquid at the warm end and condensing the vapor at the cold end. An experimental heat pipe was constructed and instrumented to permit measurements of the heat transport in a nitrogen vapor tube wherein the vapor pressure and boundary temperatures could be monitored. No major effort was made to optimize the performance of the tube tested, but various designs and operating parameters were investigated experimentally to determine their effects on the thermal impedance of the tube. Heat loads of up to 130 watts were transferred axially in this 3/4-inch OD, 33-inch-long heat pipe with less than half the total temperature drop required by a copper rod of comparable size. The main temperature drops in the heat pipe are due to heat conduction through the tube wall and the fluid filled wick liner of the evaporator and condenser sections. When the tube surface temperatures were near the critical temperature of nitrogen, vapor film formation caused a large temperature drop.
HEAT PIPES AND VAPOR CHAMBERS FOR THERMAL CONTROL OF SPACECRAFT

Review of the basic theory and applicability of devices that transfer heat by evaporation of liquid from heated areas and condensation on cold areas, with continuous return of the condensate back to the heated area by capillary action. Computed examples are presented to indicate possible applications to the solution of difficult thermal-control problems and to illustrate the principles and methods of analysis. Items discussed include the following: (1) wicks and associated capillary structures for optimum transfer of heat and minimum resistance to fluid flow; (2) characteristics and possible applications of multicomponent systems, such as those using a mixture of two liquids having different vapor pressures; (3) thermal scale models; (4) the general problem of testing and validating the devices in the laboratory 1-g environment; (5) design for evaporative cooling (passing the vapors out of the spacecraft) and short-term applications; and (6) applications for cooling of space power plants.

OPTIMIZATION OF A GROOVED HEAT PIPE

The paper is concerned with the transport, or capillary pumping limitation, of heat pipes using microgrooves as the wick or capillary structure. A generalized heat pipe equation is presented and discussed. This equation is then particularized for the case of a tubular heat pipe with a wick consisting of rectangular grooves, operating either horizontally or in gravity-free space, and rearranged to solve for the ratio of the heat transport rate to the cube of the outer radius of the wick. This ratio is optimized with respect to the width and depth of the grooves, and the result is used to determine the wick configuration for a heat pipe of minimum diameter when the length and heat transport rate have been specified for a particular working fluid and temperature.

HEAT PIPE RADIATOR DESIGN

The design of a heat pipe radiator for SPR-6 is presented. A wide range of parameters may be quickly evaluated through the use of the computer code HPRAD4. A "near-optimum" design yields a 46 Mw radiator with a mass of 12,000 kg.

HEAT PIPE OPTIMIZATION

In existing analytical procedures for determining the optimum geometry and performance of heat pipes, certain simplifying assumptions have been made. This note assesses the error incurred in these assumptions by comparing the results of the analytical procedure with those of an exact numerical method. The difference in heat pipe performance predicted by the two methods is about 25%.

ADVANCES IN HEAT PIPE DESIGN

Performance and design of heat pipe static device capable of efficiently transferring large amounts of heat from fossil-fuel flame to heat sink--using lead as working fluid, alumina as flame barrier, and specially constructed seal joining emitter of thermionic converter and flame barrier; heat pipe designed around concept that fossil-fuel fired converter should use evaporator section of heat pipe as flame barrier and its heat sink section as emitter; iron plated D-43 Co alloy band force-fitted onto round hollow alumina refractory pipe used as seal; wick for return of cooling fluid to flame barrier was 150 mesh Mo screen; at 1450 C losses were only 85 w of heat.

AN ANALYTICAL AND EXPERIMENTAL STUDY OF HEAT PIPES

An analysis of the heat pipe is conducted which results in some design equations and gives a criterion by which working fluids and capillary materials may be chosen. Several heat pipe fluids are evaluated and the best fluids for various temperature ranges are chosen. The experimental effect investigated factors which determine good
capillary structures. Three types of capillary materials were used in heat pipe operation. Two heat pipe designs were built and operated to determine their capacities and the mechanism by which they fail. One pipe was frozen and subjected to a startup test at a low power level to investigate the possibility of bringing a heat pipe back to life. The heat pipes were operated using both water and ethyl alcohol as working fluids.

68033 HEAT PIPE THERMIONIC CONVERTER DEVELOPMENT

Engineering design data are presented for an experimental heat pipe collector radiator structure. Although similar to three previous models, the heat pipe diameter was enlarged by using a custom made niobium tube to match the ceramic seal size and a larger radiator area of 38.3 cm² was developed. Engineering drawings and specific fabrication techniques are included and equations are given for predicting the radiator temperature for any values of output current.

68034 SPACE ELECTRIC POWER R AND D PROGRAM. PART 1

Experiments which are being conducted to determine the effect of many variables on the performance of heat pipes are described. These variables include the heat pipe design, the materials used, vapor flow conditions, vibration, type of heat pipe fluid, and the wick design and material.

68035 ENGINEERING DESIGN OF THE HEAT PIPE

Mechanisms involved in the operation of a self-contained heat transfer device, the heat pipe. A typical configuration for this device is a long closed pipe having its inner wall lined with a liquid saturated wick. One end is heated and the other cooled. The liquid in the wick at the heated end vaporizes, flows to the cool end where it condenses, and then is returned to the heated end by capillary action. Two experimental heat pipes were constructed and instrumented so that their operating characteristics could be accurately and precisely defined at all levels. An analytical study was also made based on the assumption that capillary circulation was the controlling factor in heat pipe operation. The analytical model was based on fundamental mass, heat, and momentum balances in the wick. It related the maximum heat input to the fluid and wick characteristics and to the inclination of the pipe with respect to gravity. The model indicated that the critical parameters and operating characteristics were the capillary forces in the wick, pressure drop through the wick, and the operating temperature of the heat pipe. The developed model can be used to determine the operating limits of a capillary controlled heat pipe.

68036 A CONTINUOUS HEAT PIPE FOR SPACECRAFT THERMAL CONTROL

The paper presents data which confirm the feasibility of operating a continuous, circular heat pipe having many combinations of evaporator and condenser surfaces. The design and fabrication of such a heat pipe built in the form of a toroid having eight heat sources and eight heat sinks suitable for use in a spacecraft are discussed. Test data are presented showing temperature distributions with several different combinations of heat sources and heat sinks. A brief analysis is included to extend test data for prediction of performance under zero-g conditions.

68037 HEAT PIPE DESIGN MANUAL

Results of a program for compiling materials properties in a form useful to heat pipe designers are presented. For each potential heat pipe working fluid considered the properties presented in both engineering and scientific units as a function of temperature are vapor pressure, surface tension, density of liquid, density of vapor, viscosity of liquid, viscosity of vapor, thermal conductivity of liquid, and latent heat of vaporization. Useful groups of parameters presented are liquid transport factor, vapor transport factor, ratio of kinematic viscosities, and wicking height factor.
Where possible, the pertinent properties of water, sodium, cesium, and ammonia have been plotted over the entire range of temperatures from melting point to critical point. In those instances where authoritative data could not be found for certain properties over the useful range (presumably from about 0.1 to 10 atm. of vapor pressure) estimation by calculation and/or extrapolation was used and is so indicated. Melting, boiling and critical temperatures have been indicated on the individual graphs for convenient reference.

68038 WORKSHOP ON HEAT PIPE DESIGN AND ANALYSIS

The heat pipe is a unique high-flux heat-transport device which utilizes the evaporation, condensation, and surface tension of a working fluid to give it an effective thermal conductivity several thousand times that of copper. The major operating characteristics of a heat pipe are: (a) nearly perfect isothermal operation over lengths of several feet, (b) thermal transformer operation where heat is added over a small area at high flux and removed over a large area at a low flux and vice versa, and (c) thermal power flattening where large variations in input heat flux cause very little variation in output heat flux. The heat pipe is ideally suited for energy supply, removal and thermal control of energy conversion systems. Analysis of theoretical heat pipe performance gives the following equation for maximum heat transport rate:

\[ Q_{\text{max}} = \frac{(\rho f g) (KA)}{\mu L^2} \left( g_0 \right)^2 \left( \mu - L \cos \phi \right) \]

Heat pipes have been designed and applied to many thermal systems which are illustrated and discussed.

69079 THEORETICAL AND EXPERIMENTAL DETERMINATION OF THE LIMITING HEAT POWER TRANSFERRED BY SODIUM HEAT PIPES [DÉTERMINATION THÉORIQUE ET EXPERIMENTALE DE LA PUISSANCE THERMIQUE LIMITE TRANSFERÉE PAR DES CALODUCS A SODIUM]

Determination of the limiting heat power transported by sodium heat pipes, using both an analytical model and experimental results. The limiting heat power varies with the geometry of the capillary network, the dimensions of the heat pipe, the angle of inclination in relation to the horizontal, and the temperature of operation. Major attention is given to the capillary network, which consists of several coils of a metallic screen made of square mesh. In several heat pipes of the same geometry, the spacing of the mesh was varied between 0.055 x 0.055 mm and 0.36 x 0.36 mm. The optimum value for heat pipes working against gravity was found to be 0.21 x 0.21 mm. The optimum operation temperature ranged between 600 and 750°C, depending on the inclination of the heat pipe. For the finest screens, the pressure loss due to the flow of the liquid in the capillary network became too high; for coarser screens operating against gravity, the capillary rise was insufficient. Priming tests were conducted with a calcium heat pipe.

69080 HEAT PIPE DESIGN THEORY

Dimensionless approach to the calculation of maximum heat flow in heat pipes and optimization of the capillary structure. Parameters of twelve liquid metals at a temperature range of 600 to 2200 K are given and used in these calculations. Nomograms for direct evaluation of heat-pipe performance and optimum capillary dimension are presented.

69081 THE ROTATING HEAT PIPE--A WICKLESS, HOLLOW SHAFT FOR TRANSFERRING HIGH HEAT FLUXES
Description of a new type of heat pipe that rotates about its longitudinal centerline and utilizes centrifugal acceleration instead of capillaries for return-pumping of condensate. Several alternative design configurations are presented. Advantages cited include the ability to overcome effects of gravity and vehicular accelerations, and heat fluxes up to an order of magnitude higher than comparable capillary-type heat pipes. Research tests and analyses on various component parts of the rotating heat pipe are reviewed. Specifically, these tests include the effects of centrifugal accelerations in a rotating boiler, the condensation of vapors on rotating surfaces, the behavior of high velocity vapor in tubes, and the pumping of liquids by rotation of their containers. Finally, the overall performances of the rotating and conventional heat pipes are compared. Three of the many attractive applications of rotating heat pipes are illustrated and described. These examples involve cooling of motor rotors, cooling of jet engine turbine rotor blades, and air conditioning with a compact unit having one moving part.

A tubular heat pipe comprising an evaporation zone, with an internally mounted fissile heat source, and a condensation zone, with external secondary cooling means is described. The pipe is at least partially filled with a liquid coolant which evaporates in the evaporization zone and returns, after condensing, along the inner surface of the pipe walls to the evaporation zone. A circular gap is formed between the tube wall and the heat source with a capillary inlet.

The fabrication and test of converter T-209 were completed. This model was the second to incorporate a collector-radiator heat pipe structure. The heat pipe design was changed substantially in order to remedy a choked heat pipe vapor flow condition observed in the previous model T-208, and subsequent tests showed that this objective was reached. Converter T-209 equalled the highest output observed from any of the rhenium-emitter and rhenium-collector converters fabricated; however, during tests at high heat inputs, the output was found to deteriorate. This was the first instance of degradation experienced, and it appears that it was caused by a leak of sodium vapor from the heat pipe into the converter envelope, which resulted in an increase of the collector work function of 0.17 eV. The mechanism responsible for the sodium leak is not known. The layout of the 16-converter generator was completed, and the design is now ready for the preparation of detailed drawings.

Discussion of the principles of heat pipe operation and how these principles can be applied to improve their heat-transfer performance. Included is a description of the manner of operation and a discussion of the effects of various heat-transfer limitations on the capability of a heat pipe. Limitations discussed are sonic, entrainment, wicking and boiling limitations.

In the evaluation of heat-pipe performance, it is necessary to know the maximum axial heat flux obtainable with respect to the optimum capillary pore size. The LAM2 code was written to calculate this optimum pore size, \( r_{\text{opt}} \), and the corresponding maximum axial heat flux, \( \lambda_{\text{max}} \). A FORTRAN listing of the code and the results for a sample problem are presented.
provide a comparison in the performance of four-way joint heat pipes with equivalent straight pipes. The major conclusions are: (1) Four-way joint heat pipes incorporating a screen cross at the miter joint achieve comparable performance to equivalent straight heat pipes. (2) The heat transport rates and temperature gradients along four-way joints are of the order required on MADCAP heat pipe network system. (3) Freon-11 is a satisfactory working fluid. (4) Good correlation exists between analysis and test results. A heat pipe exhibits a very high heat transport capability while maintaining near isothermal conditions along its length. Its use on MADCAP antenna will radically reduce potential thermal gradients and associated distortions.

70066 THE SPACE ELECTRIC POWER R AND D PROGRAM, PART 1

Results of investigations directed toward a better understanding of heat pipe operational principles are presented. Progress toward the design of a mercury space radiator having a heat-rejection capability that is temperature-dependent is reported. Tests are in progress on heat pipes with wicks consisting of layered woven wire screen. Results of calculations on heat transfer limitations imposed by sonic vapor flow, liquid entrainment, wicking ability, and boiling in the wick are presented for each wick. In other work, treatment of stainless steel pipes to prevent internal hydrogen buildup is reported.

70067 OPTIMUM CRYOGENIC HEAT-PIPE DESIGN

Of the four common limitations in heat-pipe design (sonic, entrainment, wicking, boiling), the wicking and boiling limits are more frequently encountered in cryogenic heat pipes but the high vapor velocities leading to sonic and entrainment limitations in high-temperature heat pipes are not ordinarily present in cryo-pipes, which are generally not started up from a frozen condition and do not handle the large heat flux of their higher temperature counterparts. At cryogenic temperatures, the low working-fluid figure of merit results in low-capacity heat pipes extremely sensitive to gravity fields. Gravitational effects must be considered in cryogenic heat-pipe design because of possible applications on spin-stabilized spacecraft and the requirements for testing on the ground, where a 1-g field would exist across the diameter of a horizontal heat pipe. Since it is of utmost importance to determine capillary-pore radius and wick-thickness ratio that will yield the maximum heat pumping for a heat pipe operating in a particular gravity field, equations for optimum pore size, optimum wick-thickness ratio, and maximum heat pumping are derived. The equations are applied to oxygen and nitrogen heat pipes operating at temperatures from 77 to 90K in several gravitational fields. Relationships established for the maximum heat pumping and wick-thickness ratio as a function of heat pipe ID enable the designer to rapidly examine a number of configurations, all of which will transfer the maximum amount of heat the greatest distance for a given fluid and gravity field.

70068 ANALYSIS AND DESIGN OF HEAT PIPES
Feldman, K. T. Univ. of New Mexico (Engineering 868.4, Continuing Education in Engineering and Science. UCLA. Short Course June 22-26, 1970) Avail:TAC (83p), 36 refs.

The heat pipe is a unique high-flux heat-transport device which utilizes the evaporation, condensation, and surface tension of a working fluid to give it an effective thermal conductance many times that of copper. The major operating characteristics of a heat pipe are: (a) near isothermal operation over lengths of several feet, (b) thermal transformer operation where heat is added over a small area at high flux and removed over a large area at low flux or vice versa, (c) thermal power flattening where large variations in input heat flux causes very little variation in output heat flux, and (d) temperature control where a constant temperature may be maintained for large variations in heat transfer rate along the heat pipe. A simplified theoretical analysis of heat pipe performance is presented. Design data for water heat pipes is also presented. Using the theoretical performance equations and the design data, a heat pipe may be designed to satisfy given heat transfer specifications. The heat pipe is ideally suited for energy supply, removal, and thermal control of a wide variety of heat transfer and energy conversion systems. Numerous different heat pipe applications are illustrated and discussed. Finally, a list of suggested experiments, demonstrations and design projects is included.

70069 ORBITING ASTRONOMICAL OBSERVATORY HEAT PIPES - DESIGN, ANALYSIS, AND TESTING
This paper describes a program of developing and building a set of heat pipes for the Number 3 OAO Spacecraft to be launched in 1970. The heat pipes are incorporated into the spacecraft to minimize its structure temperature gradients and to validate a general approach to the thermal control of large structures. The design and its verification (analytical and experimental) data presented include the studies of interface heat transfer, heat pipe dryout, leak, vibration, chemical compatibility, and spacecraft response.

70071 THEORETICAL ANALYSES OF CRYOGENIC HEAT PIPES

A qualitative investigation of performance of heat pipes using different working fluids is first made; significance of liquid property variations on the performance of the cryogenic heat pipe is observed. Then, a theory for the cryogenic heat pipe, which takes into account the liquid property variations, is developed. Predictions by the present theory compare favorably with Haskin's experiments. A new procedure for design and performance calculations is also developed. The procedure, simple and quick to use, involves the use of the cryogenic heat pipe theory to generate design and performance charts. Examples using the design and performance charts are presented.

71023 CIRCUMFERENTIAL HEAT PIPE SYSTEMS FOR LARGE STRUCTURES

A program is described for the design and fabrication of two full scale 50-foot circumferential heat pipes (one water and one ammonia) for test with the subsystems test bed in the NASA/MSC chamber A thermal vacuum test facility. Conventional heat pipe technology was applied to the problems of large scale systems, and manufacturing techniques (e.g., modularization) were developed to permit their fabrication. Thermal vacuum testing was directed toward an investigation of steady-state and transient response characteristics, and to explore potential problems associated with diffusion freezeout and start-up.

71024 STUDY TO EVALUATE THE FEASIBILITY OF A FEEDBACK CONTROLLED VARIABLE CONDUCTANCE HEAT PIPE

Preliminary designs have been completed for both active and passive feedback controlled variable conductance heat pipe systems. In general, an active system appears to have greater design flexibility while at the same time giving sharper temperature control than an equivalent passive system.

71025 DEVELOPMENT OF CRYOGENIC HEAT PIPES

The operation of a LN2 cryogenic heat pipe has been demonstrated experimentally in the range from 78 to 90 deg K. This heat pipe involves a totally new wick concept, viz., the 'parallel capillary channel' wick, which affords a heat flux capability an order of magnitude higher than possible with the more conventional heat pipe wick structures. The experimental measurements were performed utilizing specially designed cryogenic heat pipe evaluation equipment which permitted heat flux measurements accurate to within 8 percent. The design and optimization of the cryogenic heat pipe is discussed including a description of the BCL generalized heat pipe computer program. A comparison of experimental data with analytical predictions is also provided.

71026 DESIGN AND PERFORMANCE OF NONCONDENSABLE GAS CONTROLLABLE HEAT PIPES

In this paper, a sequence of design steps and guidelines are described which will facilitate the design of noncondensable gas (NCG) controllable heat pipe systems. Working fluid selection, sizing of NCG reservoir, use of a wick in the reservoir, and interaction of the heat pipe with the surroundings are among the factors considered. The performance of several operational NCG heat pipes is described and the controllability is compared with theoretical predictions. Agreement is generally good. In particular, the presence of a wick in the reservoir is shown to increase the sensitivity of the temperature controllability to reservoir temperature variations.
A variable conductance inert gas type heat pipe has been built to provide fine temperature control for spacecraft equipment. The pipe consists of a self-filling artery with a grooved wall capillary system that provides low evaporator to condenser temperature drops. Storage of the inert gas in low temperature reservoir which communicates with the working fluid through the condenser eliminates the usual start-up problems with these devices. Fabrication of the pipe emphasizes the importance of adequate cleanliness procedures. Latest test results are presented.
This report describes an experimental and theoretical program formulated for obtaining an understanding of the operation of vapor-chamber fins. Results of this program should enable the application of this device to various proposed uses. A mechanistic model and a simplified analysis of fin operation are derived. This model indicates that experimental data is necessary on the permeability, capillary rise, and boiling in fin wicks before an understanding of fin operation can be obtained. Experiments are therefore defined to obtain these quantities. Permeability will be determined by measuring the pressure drop as a function of liquid flow rate through wick specimens. Capillary rise will be determined by measuring the maximum static height that a liquid will rise in a wick. Boiling tests will determine the maximum heat flux density that can be added to liquid-filled wicks before film-boiling occurs. Descriptions of the experimental apparatus to be used in each of these tests are presented. The manner in which the results from these tests will be used to define fin operating characteristics is indicated.

Progress is reported in studies to define the mechanism of heat transport in the vapor chamber fin concept for space radiators. Wicking and boiling studies of porous materials, applicable to fins, were conducted. Data from tests in the wicking rise apparatus showed that a relatively long time is required for a liquid front in a sample to reach equilibrium height. The construction of the wick permeability apparatus is described, and preliminary data indicates that the wick friction factor was independent of time. This result implied that dissolved gas was the cause of the time dependent wick friction factor previously reported. A description of the wick apparatus is also included. Preliminary tests were run using a flat plate sample, and a discussion of the results is provided.

Wicking ability, permeability, and boiling characteristics of various porous metallic materials were evaluated, and vapor-chamber fins using materials found to have the most promising capillary properties were tested. Porosity, pore size distribution, and free-flow area ratio of porous metal samples were determined. Wicking rise tests were conducted using water and Freon 113. The equilibrium height of the water front was found to vary from 2.10 in. in a sintered screen sample to 21.0 in. in a sintered powder sample. Equilibrium heights with Freon 113 were lower, due primarily to its lower surface tension. The wick friction factor was measured in permeability tests utilizing water. This factor was found to be independent of flow rate for low flow rates and independent of liquid temperature. The boiling heat transfer characteristics of a flat plate, two sintered screen samples, and a sintered powder sample were measured. All the porous samples had lower heat transfer coefficients than the flat plate. This was attributed to the premature occurrence of film boiling, caused by the entrapment of vapor bubbles in the wick matrix.

Axial heat transfer limits were determined for several heat pipe systems having the same outside dimensions but different wick configurations. Measurements were made at temperatures from 450 to 850°C by using potassium and sodium as working fluids. The wicks consisted of many axial channels, evenly spaced around the inside circumference of each container tube. Different size channels were studied, and in some tests, a layer of fine screen was used to cover the channels and separate them from the vapor passage. The experiments were chosen to show some possible methods for wick improvement and to check the validity of existing heat pipe equations. At higher test temperatures, good agreement was obtained between measured and calculated heat transfer limits. At low temperatures, however, heat transfer capability was below that predicted by theory, and startup difficulties were encountered with the open-channel systems. These problems appear due to an interaction between low-density, high-velocity vapor and returning liquid. The screen covering helped startup and substantially increased heat transfer capability at all operating temperatures.
Progress is reported in the development of two modules. Research on a water boiler heat sink module included testing of wick heat transfer, wick performance, and wicking height. Metal and nonmetal wicks were tested. A breakthrough analysis was performed on a water sublimator heat sink module, and capillary tubes were tested to verify analytical predictions. The effects of pore exit sharpness and contact angle on breakthrough pressure were determined. Porous plates were bench tested, and tabulated test results are presented for several specimens.

Axial heat transfer limits were determined as a function of temperature for some 3/4-inch OD x 12-inch long heat pipes. This information was obtained at temperatures from 450 to 850°C by using K and Na as working fluids. The wicks consisted of many axial channels cut into the inner wall of each tube. The vapor passage diameter was essentially 1.5 cm for all tests, but sizes of the capillary channels were varied both in width and depth. In some cases, one layer of fine screen was used to cover the channels and separate them from the vapor passage. Heat transfer limits were measured from 200 watts to 4000 watts as dictated by the heat removal system. Results obtained within this range show the effect of temperature, working fluid, channel size, and the use of screen. Startup problems and lower heat transfer rates than those predicted by theory were encountered at low temperatures. These problems appear due to an interaction between low density, high velocity vapor, and returning liquid. A layer of screen covering the liquid capillary return system helps startup and substantially increases the maximum heat transfer rate of a heat pipe throughout its useful temperature range.

Wicking material properties for the operation of a vapor-chamber fin or a heat pipe are considered. Materials studied are sintered metal screens, sintered metal powders, and sintered metal fibers, with porosities of 47.7 to 91.8%. The results of wick equilibrium height experiments and wick permeability experiments run on the three classes of wicking materials are presented. Both water and Freon 113 are used as working fluids in these experiments. These results are combined to yield the capillary pumping characteristics of wicking materials. Comparison of results with the heat transfer characteristics of a flat plate submerged in water indicate that equivalent or superior performance can be obtained with wick covered surfaces. However, the data also indicate that the entrapment of vapor bubbles in the wick matrix may cause premature film boiling in the porous material at relatively low heat fluxes, depending on the structure of the wicking material. The heat transfer characteristics of Freon 113 were poorer than those exhibited by water.

Wick boiler modules were tested to determine the relative performance of rectangular and triangular fins. A test module was designed and fabricated, and testing continued. Vertical and horizontal wicking rate tests were performed. Bench tests were performed on porous plates and a pressure drop correlation was developed. Single module sublimator tests were conducted to determine the performance of various porous plates. Preliminary panel designs were conceived and initial analyses begun.

The possibilities of producing heat pipes and, especially, the necessary capillary structures are discussed. Several types of heat pipes are made from stainless steel and tested at temperatures between 400 and 1055°C. The thermal power was determined...
by a calorimeter. Bubble-free evaporation of sodium from rectangular open channels is possible with a heat flux of more than 1,940 W/cm² at 1055°C. The temperature drop along the tube could be measured only at low temperatures. A subdivided heat pipe worked against the gravitational field. A heat pipe with a capillary structure made of a rolled screen supported by rings and bars operated at 250 W/cm² heat flux in the evaporating region.

68039 DETERMINING WICKING PROPERTIES OF COMPRESSIBLE MATERIALS FOR HEAT PIPE APPLICATIONS

Results of an experimental program to develop techniques for determining the wicking characteristics of nonrigid materials for potential use in heat pipes. The principal quantities of interest are effective pore size and permeability. Experiments were conducted with woven Refrasil sleeving to determine the wicking characteristics. The apparent permeability of the Refrasil increased with increasing height, while effective pore size decreased, except at relatively low heights, where these two quantities remained constant. It was concluded that the conventional maximum static pumping head provides little information useful in predicting the wicking capability of some fabric materials. It was also concluded that wicking properties of compressible materials can best be determined by conducting wicking rise tests and by verifying the results of such tests with evaporation tests.

68040 HIGH-PERFORMANCE HEAT PIPES

The heat transfer capability of a heat pipe depends to a large extent on the wick structure. Composite wicks are being investigated in heat pipes having several axial channels covered with screen. High heat transfer rates have been obtained with a very fine screen cover and relatively large channels. The fine screen cover provides a large capillary force for fluid circulation. It also suppresses liquid entrainment which might otherwise limit heat transfer. The protected channels provide a low impedance path for liquid return. It is shown that all of these wick functions are important and need to be considered in the design of high performance heat pipes.

69086 DETERMINATION OF WICKING PROPERTIES OF COMPRESSIBLE MATERIALS FOR HEAT PIPE APPLICATIONS, MARCH 1967-MARCH 1968

An experimental program was conducted to develop techniques for determining the wicking characteristics of nonrigid materials for potential use in heat pipes. The principal quantities of interest are effective pore size (to calculate a driving potential for capillary pumping of liquids) and permeability (to establish resistance to liquid flow). Compressible wicking materials do not readily lend themselves to some of the more conventional procedures used for determining flow properties as, e.g., in measuring permeability by forcing a liquid through a rigid, porous material after which flow rate and pressure drop measurements are used to calculate permeability. Consequently, other methods were investigated. Experiments were conducted with woven sleeving to determine the wicking characteristics mentioned above. Results of these tests are presented and compared with performance predicted from theory.

69087 EXPERIMENTAL DETERMINATION OF WICK PROPERTIES FOR HEAT PIPE APPLICATIONS
R. A. Freggens (Radio Corporation of America, Lancaster, Pa.). IN: AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, 4TH, WASHINGTON, D.C., SEPTEMBER 22-26, 1969, PROCEEDINGS. (A69-42236 23-03). Conference co-sponsored by the American Institute of Aeronautics and Astronautics, the American Nuclear Society, the American Society of Mechanical Engineers, the American Chemical Society, the Institute of Electrical and Electronics Engineers, and the Society of Automotive Engineers. New York, American Institute of Chemical Engineers, 1969, p. 888-897, Avail:TAC

The design of practical heat pipes requires exact knowledge of wick properties. Two of the most important wick properties are the "effective" pumping pore size and the permeability. A series of measurements was made to determine these values for three classes of wick materials. By expressing the velocity of fluid rise vs height of rise
against gravity, an equation is presented which relates wick pumping ability to power dissipation for reentrant heat pipe designs. A further heat pipe wick limitation, that of wick power density, was investigated for a sintered, porous wick material. The measurements were made using distilled water.

69088 DETERMINATION OF PROPERTIES OF CAPILLARY MEDIA USEFUL IN HEAT PIPE DESIGN

Description of heat-pipe data on wick permeabilities and burnout heat fluxes. For thick wicks, some variations of permeability with flow as measured with a forced flow device indicate that Darcy's law is not quite valid. Permeabilities of thin wicks (a single layer of screen) were determined with a sloping-wick device where friction is overcome by gravity. These permeabilities vary with depths of the menisci in the openings and consequently with the pressure difference between the liquid in the wick and the gas above it. Burnout heat fluxes were measured in a device where a small wick, supplied liquid by an artery to minimize pressure variations along the wick, is uniformly heated. The burnout heat fluxes were determined for three liquids as a function of temperature and of the pressure difference between the liquid in the wick and the gas above it.

69089 PERFORMANCE OF A WICK-LIMITED HEAT PIPE

Discussion of a heat pipe with variable dimensions designed for evaluating wick performance with a well defined fluid transfer length within the heat pipe. A simple horizontal isothermal wick experiment, developed for quantitative testing of various wicking materials outside the heat pipe, is also described. The maximum steady heat transfer capability or wick "burn-out" point was 10 W for an 81.9 cm long and 18.85 cm wide Refrasil C100-28 material, using water as the working fluid at a temperature of 26.7 (plus or minus 5) deg C. In practice, it was found possible to transfer considerably more heat than the burn-out point without damage to the system. However, when the heat input exceeded this value, the temperature continued rising, and temperature differences developed in the heat pipe. The time constant of the wicking chamber was found to be much shorter than that of the heater assembly, so that meaningful direct transient tests could not be performed.

69090 LIQUID TRANSPORT PROPERTIES OF SOME HEAT PIPE WICKING MATERIALS

A simplified analysis of heat pipe operation has indicated wick and fluid property parameters which are important in defining the maximum heat flux that a heat pipe can transport before failure due to capillary pumping limitations. These wick parameters were experimentally determined for a number of sintered metallic materials fabricated from felted fibers, powders, and screens. Considered as classes of materials, the fibrous materials were found to be best; the powder materials were next, and the screen materials were poorest. Both water and Freon 113 were used as working fluids to evaluate the effects of fluid properties.

70072 THE EFFECT OF WICK GEOMETRY ON THE OPERATION OF A LONGITUDINAL HEAT PIPE

Evaporative heat transfer limits were obtained and studied for an everted heat pipe with varying wick geometries. The wick geometries were a function of the wire mesh size and the total wick thickness. A nickel heat pipe was built and operated using both water and ethyl alcohol as the working fluids. The different wick materials used were 50 mesh, 80 mesh, and 150 mesh, plain weave, nickel wire cloth. The scope of the investigation included operating the pipe at 25 inches mercury vacuum, 10 inches mercury vacuum, and 5 pounds per square inch gage. The maximum heat transfer was found to increase as the mesh size was decreased, as the wick thickness was increased, or as the pressure was increased. The equipment used to obtain experimental data is described and experimental results and sample calculations are presented.
A STUDY OF WIRE MESH WICK CHARACTERISTICS IN A LONGITUDINAL HEAT PIPE

An everted, glass-enclosed, nickel heat pipe was operated at constant volume using a nickel wire mesh wick and distilled water. The performance of the pipe was evaluated under various combinations of wick parameters. The effect of the radial evaporator capillary radius, the radial condenser capillary radius, and the evaporator wetting angle were investigated at a pressure range of 27 to 24 inches of Mercury vacuum. The performance of the pipe was found to improve with decreasing radial evaporator capillary radius and decreasing amounts of non-condensables in the working fluid. A detrimental wick-aging effect which led to violent boiling and early dryout was observed. A discussion of observed behavior presents evidence that boiling and wick fin effect may play a significant part in heat pipe operation.

LIQUID TRANSPORT AND HEAT TRANSFER PROPERTIES OF HEAT PIPE WICKING MATERIALS

The purpose of this paper is to define and present the wicking material properties that are considered to be important to the operation of a heat pipe. Three classes of wicking materials are studied: sintered metal screens, sintered metal powders, and sintered metal fibers. The porosity of these sintered materials ranges from 47.7 to 91.8 percent. Two characteristics of the wicking material are considered to limit the operation of the heat pipe. These are: (1) the capillary pumping characteristics of a wick; and (2) the evaporative heat transfer characteristics of a liquid-saturated wick. To evaluate the effect of capillary pumping characteristics, a simplified analysis of a planar wick pipe is made. The result of this analysis gives the maximum operating length of a planar wick model in terms of the external boundary conditions, the heat pipe fluid properties, and the capillary pump characteristics of the wicking material. The capillary pump characteristics are found to be proportional to the equilibrium height to which the heat pipe liquid will rise in the wicking material divided by the wicking material friction factor. The latter is the reciprocal of the permeability for the wicking material. The results of wick equilibrium height experiments and wick permeability experiments run on the three classes of wicking materials are presented. Both water and Freon 113 are used in these experiments. These results are combined to yield the capillary pumping characteristics of each wicking material tested. To evaluate the effect of the evaporative heat transfer characteristics of wicks, experimental data on porous samples selected from the three classes of wicking materials is presented. These data result from evaporative heat transfer experiments run on planar wick samples saturated with water. All experimental results are compared with the heat transfer characteristics of a flat plate submerged in water. The data indicate that the entrapment of vapor bubbles in the wick matrix may cause the premature occurrence of film boiling in the porous material at relatively low heat fluxes, depending on the structure of the wicking material.
D.3 MATERIALS
Results are reported for studies on thermodynamic and transport properties of Cs, Rb, Li, and Na. Studies were made on Li and Na for heat pipe applications. The properties measured include PVT relations, vapor thermal conductivity, liquid viscosity, vapor viscosity, and specific heat for Cs and Rb and vapor pressure, surface tension and contact angle of the liquid and its vapor, liquid and vapor viscosity, and specific heat for Na and Li. Data are tabulated.

Developments in studies on the thermodynamic and transport properties of Rb, Cs, and K and thermodynamic and transport properties of alkali metals for heat pipe applications are described. Data are given on: PVT relations for K; vapor thermal conductivity of Rb; liquid viscosity of Li; and liquid thermal conductivity of Li and Na.

Calculation of the heat transfer in a heat-pipe requires many liquid and vapor data of the working fluid (metal) in the region of the boiling point. Measurements were made for the twelve most current metals of the vapor pressure and the surface tension. For calcium, strontium and barium density measurements were also made. The vapor pressure measurements were made with the new method of Bohdansky, using the heat-pipe effect in an open tube. Surface tension and density measurements were made by the maximum bubble pressure method. The vapor pressure measurements make it possible to evaluate the boiling point, the heat of vaporization and the vapor density. Data sheets are presented for surface tension, vapor pressure, and vapor density. Data sheets for density, viscosity, and vapor viscosity are also presented.

Ten working fluids and three high-temperature alloys have been investigated experimentally. A figure of merit is introduced, that is calculated from surface tension, liquid density, latent heat of vaporization and viscosity of the working fluid. This figure of merit is evaluated as a function of temperature for the working fluids and presented together with results on oxidation of the alloys.

A solution of heat pipe freeze up problems through the use of mixtures as heat pipe working fluid is presented. Data on the freezing point of mixtures of 1-propanol and water were experimentally obtained. Experimental gas emission tests of potential space suit heat pipe materials when exposed to both a vacuum environment and a water vapor environment were performed. A literature search was conducted to select film enclosure materials suitable for flexible heat pipe application with one of the desired film selection characteristics being impermeability to noncondensable gases. To reduce the thermal gradient from the heat pipe outer surfaces to the active wick surfaces, studies of the thermal conductivity of metallic wicking materials and methods of bonding wicks to substrates were performed. Techniques are described for the fabrication of an experimental heat pipe device which was used to demonstrate techniques applicable to extravehicular space suit controllable heat pipe devices for temperature control.

Study of the corrosion mechanism in high-temperature Nb-1 Zr/Li and Ta/Li heat pipes.

D.3-01
pipes, and measurements of the heat transfer. It is found that the corrosion of the heat pipes can be caused by the oxygen content of the wall material. Promising results on corrosion inhibition were obtained (1) by using as a wall material Nb-1 Zr which was deoxidized by a heat-pipe process to below 1 ppm O, (2) by adding Ca to a Nb-1 Zr/Li heat pipe, and (3) by using Ta with a small content of Y. The Nb-1 Zr/Li heat pipes withstood tests of 1000 hr at 1500°C without failure, but considerable loss of Zr occurred. Heat transfer measurements were made with a Li heat pipe about 50 cm long and with 0.46-cm² vapor flow area. At 1500°C, a maximum axial heat flux density of about 15 kW/cm² was measured.

70075 CORROSION STUDIES OF LIQUID METAL HEAT PIPE SYSTEMS AT 1000 TO 1800 C

Evaluation of the compatibility of heat pipe structural alloys with different working fluids, using reflux capsules. Capsule tests with refractory metal seamless tubing have been conducted in vacuum at temperatures of 1000 to 1800 C and at times to 1000 hours. Systems evaluated to date are: TZM with indium; Cb-12Zr with lead, calcium, and barium; and Ta-10W with indium, calcium, lead, thallium, and barium. The observed corrosion behavior of the various systems is associated with the nature of oxygen in the particular system. Severe attack has been observed in the lead and thallium systems, while calcium produces very little attack, especially in contact with Ta-10W. Corrosion occurring with calcium is mainly confined to very shallow intergranular penetration.

70076 MERCURY AS A HEAT-PIPE FLUID

In order to determine the feasibility of using mercury as a heat-pipe fluid, a mercury heat pipe was put on life test for 10,000 h at 330°C to study the wetting characteristics of mercury in a stainless-steel structure. A second pipe was built and operated to determine the heat-transfer capability of a mercury system and to compare its operational limitations with theoretical limitations. The results of the tests indicated that good wetting of wick structures could be attained and that long-term operation is possible without excessive corrosion. The heat-transfer test demonstrated that mercury behaves as a normal heat-pipe fluid with regard to its operational limitations and start-up dynamics. Construction of mercury heat pipes for high heat-transfer rates appears to be feasible for operation between 200 and 360°C.

70077 REACTOR, SYSTEM, AND COMPONENT ENGINEERING

CORROSION LOOPS--design of high temperature liquid lithium for heat pipe alloy testing
HEAT PIPES--fabrication technique development for 2000°C tungsten-molybdenum alloy
LOOPS--operation of low temperature liquid NaK, for testing reactor space power system pumps
MOLYBDENUM ALLOYS AND SYSTEMS--Mo-W, fabrication technique for 2000°C heat pipe
NUCLEAR AUXILIARY POWER SYSTEMS--design concepts for 300 kW(e) and 10 MW(e) space, using Rankine cycle power conversion --radiator designs for SPR-6, analysis of direct-condensing tube-fin and heat pipe
COOLANT OUTLET TEMPERATURE FOR MINIMUM, (T)
PUMPS--testing of reactor space power system, low temperature liquid NaK loop for RADIATORS--design concepts for SPR-6 system, analysis of direct-condensing tube-fin and heat pipe
REACTORS, POWER--design concepts for 300 kW(e) and 10 MW(e) space, using Rankine cycle power conversion

70078 COMPATIBILITY EVALUATION OF AN AMMONIA-ALUMINUM-STAINLESS STEEL HEAT PIPE

Tests were conducted to confirm the ability of an ammonia-aluminum-stainless steel heat pipe to operate for extended periods without failure either by fluid loss or by degradation of the energy transport mechanisms. Test conditions were chosen to accelerate the postulated failure mechanisms. The heat pipes were operated to simulate...
particular spacecraft lifetimes of 7 to 10 years. Post-test thermal performance was compared with pre-test performance and the heat pipes were sectioned for metallographic examination. Results of the performance tests and photomicrographs of the metallurgical specimens are presented.

70079 CORROSION IN HIGH TEMPERATURE LITHIUM HEAT PIPES WITH NIOBIUM-1 ZIRCONIUM AND TANTALUM AS WALL MATERIAL
C. A. Busse, Euratom 4298.e Corrosion Science 10, 65 (1970), Avail:TAC (32p)
In Nb-1Zr or Ta heat pipes with Li as working fluid, operated at temperatures of 1500°C or 1600°C, corrosion can cause a wall perforation in the heating zone within a few hours. Analysis of such heat pipes, together with fluiddynamic and thermodynamic considerations, leads to the conclusion that the corrosion is caused by the initial oxygen content of the wall material. The corrosion mechanism consists in the transition of oxygen from the wall material of the cooling zone to the liquid Li, the transport of the oxygen to the heating zone, the local increase of the oxygen concentration in the liquid Li by the evaporation process and finally the wall attack by this oxygen-rich Li. The corrosion can be strongly reduced or completely inhibited by deoxidation of the wall material, by the addition of Ca to the Li, or of Y to the Ta.
E. TESTING AND OPERATION
The "Grover Heat Pipe" is a self-contained, thermal conductance device that has no moving parts, utilizes the heat being transferred for its operation, has a thermal conductance higher than any known material, and conducts heat with essentially no temperature difference. Heat is transferred by means of mass flow of a fluid, utilizing the latent heat of a two-phase system. For high-temperature applications, two liquid metals have been tested and found suitable as heat pipe fluids: lithium and silver. Lithium heat pipes have been successfully operated up to 1300°C with heat input fluxes of 200 watts/sq cm and silver heat pipes up to 2000°C with input fluxes of over 400 watts/sq cm.

An observation was made during early heat pipe trials. An unwanted "non-condensible" gas was present in a heat pipe and it was observed that the non-condensible gas (hydrogen) was concentrated at the heat-output end of the pipe and that the amount of heat liberated over the intended output area was proportional to the amount of non-condensible gas present. This experimental finding seems to be susceptible to the following logical explanation. Assume that initially the hydrogen was uniformly distributed throughout the pipe. As heat is put into the device the working fluid (sodium) is boiled off and the resulting gas flows from the heat-input end to the heat-output end. The sodium gas flow sweeps the hydrogen to the heat-output end; as long as the heat pipe is operated any hydrogen molecules tending to migrate from the output end are returned by the continuing sodium gas flow. The equilibrium situation thus created is illustrated.
thermionic converter, and that it acts as a thermal transformer and provides high thermal heat transfer.

67058 ADVANCED REACTOR TECHNOLOGY (ART)

Installation of UHTREX plant and instrumentation systems is nearly complete. Analytical studies of the planned program of transient experiments have begun. Summaries are included concerning the development status of the reactor components. Work in the Na-cooled reactor program includes instrumentation testing and development, heat transfer investigations and formulation of computer programs for treating the dynamic response of entire reactor plants. Plasma thermocouple work was devoted to measurements of Cs vapor pressure, development of insulation for thermionic fuel rods, investigations of stability and fabrication of Tm0.3-Mo thermionic fuels, and calculations on performance of cylindrical diodes. Heat pipe tests were conducted using 80-cm-long pipes containing Na. A heat transfer limit of 5500 W at 850°C was determined. Fabrication methods for W heat pipes were investigated. A summary of investigations concerning thermal neutron effects on liquid Pu fuels is included. Fabrication and properties of Ta and Nb-base materials for Pu capsules were studied.

67059 A STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE

A stainless steel heat pipe was designed to obtain an understanding of the mechanisms involved in the operation of a heat pipe, to predict the operational characteristics, and to establish a procedure for the engineering design of heat pipes. Experiments were carried out with stainless steel beads to determine void fraction, permeability, and capillary rise height for various ranges of bead size. These characteristics are relevant to heat pipe operation.

67060 THERMAL MEASUREMENTS OF A THERMIONIC-CONVERTER/HEAT-PIPE SYSTEM

Description of the results of calorimetric measurements made on a converter, a prototype cylindrical device with an emitter area of 50 cm² designed expressly for operation from a heat pipe. The experimental method is discussed, and the results of the net electron cooling of the emitter, the effective thermal emissivity, the cesium conductance between emitter and collector, and the complete thermal balance are described. Unusually low-emitter cooling was observed in the obstructed mode of operation. The implications of such a low emitter cooling are discussed.

67061 ADVANCED REACTOR TECHNOLOGY (ART)

The various systems of UHTREX are discussed. The cold flow tests on the coolant system are described. Check-out of the computer systems, and programs for use in operation are mentioned. Estimates of reactivity worths of fuel mass and poison additions are discussed. Calculations of UHTREX transient responses are described. Reactivity calculations are tabulated. Fuel particle self-shielding calculations are compared for various types of analyses. The fuel elements, and tests planned for these, are discussed. The development of the fission-couple thermopile device for use as a neutron flux monitor is discussed. A method for nondestructive activation analysis for O in Ge is presented. Tests on vertical heat pipe operations are discussed.

67062 ADVANCED REACTOR TECHNOLOGY (ART), PART I

Cold critical experiments on UHTREX are discussed. Reactivity calibration of control rods and fuel elements are presented. Results of particle self-shielding calculations are evaluated. Stability and feedback calculations are discussed; results are tabulated. Heat pipe testing and evaluation are presented.

68043 THE EFFECT OF VIBRATION ON HEAT PIPE PERFORMANCE
A water heat pipe was operated while being subjected to typical sinusoidal and random vibrations encountered during a missile launch to determine the effect of vibration on heat pipe performance. The results of the experiment indicate that vibration tends to improve heat pipe performance as it promotes better wetting of the wick structure by the fluid.

68044 HEAT PIPE THERMIONIC CONVERTER DEVELOPMENT

Four heat pipe models, designated T/E-1 through T/E-4 were designed, fabricated, and subjected to a heat transfer test, a thermal cycling test, and a 100-hour run at maximum heat load. Model T/E-1 failed after the heat transfer test due to an embrittling reaction that occurred after assembly between the niobium heat pipe wall and its radiative coating. Model T/E-2 failed after the heat transfer test due to a faulty capillary assembly which caused overheating and a failure at the heat pipe-collector junction. Model T/E-3, fabricated with an emitter structure and operated as a converter, yielded valuable data on converter radiator heat load for accurate heat pipe sizing. This model completed the thermal cycling test and a 400-hour run at maximum load. Model T/E-4, without an emitter structure, had a larger radiator area than the other models and could accommodate an output current of 71.5 amperes at the optimum collector temperature. The model completed all the tests successfully, resulting in a heat pipe collector-radiator suitable for incorporation in the advanced SET converter.

68045 HEAT PIPE PERFORMANCE IN A SPACE ENVIRONMENT

The unusual thermal characteristics of the heat pipe indicate that it has great potential for the solution of heat transfer problems in satellites. In order to demonstrate that heat pipes will function normally under space conditions, a water heat pipe was launched into an earth orbit by an Atlas-Agena vehicle to determine the effect of a zero-gravity field on its operation. A second experiment was conducted in which a similar heat pipe was subjected to typical sinusoidal and random vibrations experienced by a satellite during the missile launch period. The results of the experiments indicate that heat pipes are suitable for space applications.

68046 HEAT PIPE STARTUP DYNAMICS

Transient modes of heat pipe startup are described. The heat flux-temperature states, the flow properties during startup, and the various mechanisms which may inhibit successful startup are discussed quantitatively.

68047 VAPOR CHAMBER FIN STUDIES. OPERATING CHARACTERISTICS OF FIN MODELS

This report presents the test results from experiments on two vapor-chamber fin (heat pipe) geometries and compares these results with a theory developed and presented in a prior report. Typical temperature distributions were obtained for heat pipe operation plus limiting heat flux data which was compared to the theory. This comparison indicated that the theory showed the correct trends at low levels of heat flux. An effect of working fluid inventory was found which was not included in the present theory. Tests with a noncondensable gas present in the chamber were found to result in complete mixing of this gas with the working fluid vapor.

68048 A STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE

The design of an experimental apparatus to study heat transfer to wetted porous beds at atmospheric and elevated pressures (up to 200 psi) has been completed and the apparatus is under construction. The solution technique for the distribution of pressure, mass flux, temperature and heat flux in a flat-plate heat pipe is discussed.

68049 STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE
Progress to date on two general experimental programs relating to the operating characteristics of the heat pipe is summarized. The apparatus that has been constructed, the experimental method employed, and the results obtained in the continuing study of heat transfer through porous media are described. Data are presented on the boiling characteristics of atmospheric pressure in an immersed bed of monel particles (40 to 50 mesh) supported on a stainless steel electrically heated surface. The equipment, experimental approach, and results obtained on the controlled environment heat pipe are described. Heat fluxes and temperature differences in the evaporator section of the apparatus were determined at atmospheric pressure using water in a capillary bed of the same particles. Angle of inclination of the capillary wick to the horizontal was the parameter of primary interest. A comparison of the results shows surprising similarities at low heat fluxes and small temperature differences.

A heat pipe is a sealed container in which a fluid is continuously evaporating and condensing, thereby establishing a two-phase system resulting in an essentially constant temperature throughout the length of the container. Heat addition into the evaporator section of the heat pipe is distributed throughout the other section by flow and condensation of vapor. Completion of the cycle is obtained with the return of the condensate to the evaporator by capillary action through a wick structure lining the container wall. Thus, large quantities of heat can be transferred with essentially no temperature difference and at a fraction of the weight of an equivalent solid heat conductor. By proper choice of fluids, heat pipes can be constructed for operating temperatures from below 0°C to 2000°C; they appear to have great potential for solution of heat transfer problems in space applications. An experiment was conducted to demonstrate that a heat pipe will operate normally in the absence of gravitational forces. The necessary evidence to substantiate this fact was considered to be isothermal operation of a water heat pipe while in an earth orbit. The satellite module, in which the heat pipe was mounted, was launched from Cape Kennedy April 5, 1967, on an Atlas-Agena vehicle.

Construction techniques and heat transfer results for annular return heat pipes are described. Tests were run to determine axial heat flow rates using potassium and sodium as working fluids in SS heat pipes with SS screens with exit temperatures up to 800°C. Indium was tested as a working fluid in a Re heat pipe with a W screen at 1950°C for 373 hr. Interdiffusion between Re and W occurred on the inner surface of the heat pipe. An incomplete test was made using phenyl ethyl as a working fluid in a SS heat pipe.

An experimental stainless steel heat pipe using water as the working fluid and 400 mesh stainless steel screen for a wick was designed and tested to determine the effect of gravity and nucleate boiling on heat pipe performance. The results of heat pipe operation at various angles of inclination in a gravity field are presented and compared with the existing theoretical predictions. The maximum heat flux obtained experimentally at angles of inclination less than 90 degrees was less than the predicted value.
by a factor of two or three. The maximum heat flux obtained for an angle of inclination greater than 90 degrees was much higher than that predicted. In addition, nucleate boiling noise was detected during operation at angles of inclination greater than 90 degrees.

68054 LOW TEMPERATURE HEAT PIPE RESEARCH
Phillips, E. C., Jr., Holmgren, J. S., Madsen, J. Donald 
Douglas Labs., Richland, Wash. 
(DAC-60752P) July 1968 
Avail:TAC (55p) 11 refs.

This report summarizes independent research and development (IRAD) effort including investigations of the use of arterial capillary flow passages in low temperature (250°F) water devices. The use of low temperature heat pipes to cool spacecraft electrical components, thermally control other components such as external sensors, hatches, or heat storage devices, and thermally equalize the outer shell of space vehicles were investigated. Preliminary performance analysis indicates the need for heat pipe operation over long distances, particularly for the case of thermal equalization of manned spacecraft. Thus, investigations proceeded with analysis and definition of bypass wick configurations including use of the artery. The feasibility and advantages of the artery have been successfully demonstrated by experimental tests.

68055 HEAT PIPE LIFETESTS AT 1600°C AND 1000°C
Avail:TAC

A series of life tests at 1600°C were performed with Li, Pb, Tl, Bi, and Ba as working fluids and ChI-Zr, Ta and SGS-Ta/Tl; in 1000°C region life tests with ChI-12r and Li (3570 hr at 1000°C), Na (1000 hr at 1100°C) and Cs (1000 hr at 1000°C) were made.

69093 DEVELOPMENT OF A VERSATILE SYSTEM FOR DETAILED STUDIES OF THE PERFORMANCE OF HEATPIPES
Avail:TAC

A heat pipe with variable dimensions was designed for the study of steady state and transient heat pipe performance using different fluids and wicking materials. An open ended dewar was designed and constructed for housing the heat pipe system. The maximum length of wicking material was 82 cm; this distance was considered the maximum length of heat transfer required in future space suits. Distilled water was the transfer medium used in the wicking chamber. The heat input to the dewar was supplied by electric heaters. Circulation of cool water was used to remove heat from the condenser end of the dewar. Approximately 45 thermocouple points were used for measuring important temperatures in the system. Throughout the entire wicking chamber, a maximum temperature variation of 1/2°C was encountered during normal heat pipe operation. No transient temperature lag from one end of the wicking chamber to the other end was observed during heat input changes. Apparently the time constants of the heat input changes were much larger than the temperature equalizing time constant of the wicking chamber.

69094 LOW-TEMPERATURE HEAT PIPE RESEARCH PROGRAM
Avail:TAC

Basic data for use in design and analysis has lagged for heat pipes operating in the range from +100°F to +200°F for thermal management of spacecraft. Of most importance are wick fluid flow and evaporator performance data. Wick permeabilities and capillary pressures were measured for wicks ranging in thickness from 0.005 to 0.100 in and structures ranging from square mesh screen to metal foams and felts. Permeabilities were also measured as a function of the menisci radii in the liquid/vapor interface. Forced flow and gravity flow measurement techniques were used. Results are presented in graphic form as a function of flow per unit area. Permeability data were found to deviate slightly from Darcy's law. Evaporator performance was determined by measuring maximum evaporator heat fluxes for metal screen, felt, and foam wick structures with water, methanol, and butanol. Heat fluxes were measured in the vapor and at the vapor pressure of the working fluid. Maximum heat fluxes at operating temperatures of approximately 100°F and 150°F in the vapor of the working fluid were found to be lower than those measured in air at atmospheric pressure. Heat pipe design procedures are outlined which make use of the wick permeability and evaporator heat flux data. Figures of merit for various potential working fluids are presented.
89095 AN EXPERIMENTAL AND ANALYTICAL STUDY OF WATER HEAT PIPES FOR MODERATE TEMPERATURE RANGES

Eight water heat pipes used as radiating fins and eight water heat pipes having an adiabatic section and a condenser were investigated while in or near a vertical position. Different heat inputs were applied to maintain steady-state operation of the heat pipes at temperatures of approximately 2000, 2500, 3000, and 3500 F. A data acquisition system was used to record heat inputs, surface temperatures, interior temperatures, and pressures of the heat pipes. The equations governing heat pipes were developed and programmed for a digital computer in order to study the effects of permeability, apparent contact angle, and length of the adiabatic section contained as parameters in the equation. The solutions for the equations and the parametric studies are presented in graphs. Design and fabrication of the heat pipes are described. A high-altitude simulation system was used for testing the water heat pipes as radiating fins. The analytical results were found to agree with experimental data in the temperature range from 2000 to 3500 F.

89096 EXPERIMENTS WITH A TWO-FLUID HEAT PIPE

The experimental performance of a two-fluid heat pipe, using methanol and water, was evaluated over a range of operating conditions. Temperatures along the heat pipe and condenser end vapor pressures were measured for two thermal power input conditions. Five ratios of working fluids were tested from 100 per cent water to 100 per cent methanol. The experimental results indicate that a two-fluid heat pipe is not isothermal. The two fluids separate into relatively isothermal regions with the more volatile fluid in the condenser end of the heat pipe. The location of the transition region depends on the mass ratio of the two fluids and on the operating temperature. Data indicate that the practical operating temperature range and heat transport rate capacity of a water heat pipe can be increased by the addition of a small quantity of methanol in the working fluid.

89097 PERFORMANCE MAP OF THE WATER HEAT PIPE AND THE PHENOMENON OF NONCONDENSIBLE GAS GENERATION
Assessment of a series of heat pipe performance curves which are an integral part of a performance map. The test heat pipe is cylindrical in shape and has stainless-steel components; water is the working fluid. The accumulation of free hydrogen, a noncondensable gas, was observed to occur in the heat pipe. A postulation of this phenomenon is presented, and conclusions are drawn.

89098 NEUTRON RADIOGRAPHIC EXAMINATION OF VAPOR BUBBLE FORMATION AS A LIMITATION ON PLANAR HEAT PIPE PERFORMANCE

An experimental study of the limiting heat transfer conditions in a planar heat pipe using water as a working fluid was conducted. The apparatus was designed to study the boiling processes that occur in the wick structure of a heat pipe. The vapor blanket which formed in the porous medium, i.e., the wick, during heat transfer was experimentally examined using neutron radiography. The neutron source for these experiments was the Industrial Reactor Laboratories' 5 megawatt reactor. The neutron radiographic system was composed of the following basic elements: a beam tube, the object (a planar heat pipe), a neutron image intensifier tube, and image recording cameras. Using the image intensifier, it was possible to quantitatively measure the thickness of water present to ±.006 inches for thicknesses up to .125 inches. The imaging system has a lateral resolution of .0135 inches. Two heat transfer models were postulated and analytically formulated. One model assumed that evaporation occurred only from the upper
surface of the wick, the second assumed that vapor was generated at the base of the wick and released solely from the sides of the wick. The data taken under conditions of varying heat transfer rate and angles of wick inclination demonstrated that, with a secondary assumption of variable pore size, the second model was more realistic than the first. The basis for the assumption of variable pore size is suspected to be a result of the "Leverett effect." The effects of wick cleaning, contact angle, and pore size distribution are also discussed.

70080 THE GEOS-2 HEAT PIPE SYSTEM AND ITS PERFORMANCE IN TEST AND ORBIT

The GEOS-2 Spacecraft is the first satellite to be equipped with a heat pipe as an integral part of the thermal design. The heat pipe, a device of extremely high effective thermal conductivity, is employed to minimize the temperature differences between transponders located in opposite quadrants of the spacecraft. Measured heat transfer rates through the pipe of as much as 64 watts, together with small temperature gradients on the outside of the heat pipe, are evidence of proper operation. Based on a 145-day observation period, transponder maximum and minimum temperatures show significant improvement over those of GEOS-1.

70081 PRELIMINARY PROGRAM PLAN HEAT PIPE PARAMETRIC DATA

A program is described which is designed to provide parametric heat pipe performance data which can be used by spacecraft designers, with only a limited knowledge of heat pipe theory, to perform tradeoff studies and generate preliminary system designs. The type of data to be generated and the basis for the selection of components and the range of parameters to be investigated are described. Parametric curves of thermal performance and weight are generated as a function of temperature and various other parameters such as length and thermal input profile. In addition, parametric data for controllable heat pipes are developed. Heat pipe operation is discussed where the basis for design data is shown. DWDL experience and facilities available for successful performance of this program are presented.

70082 THE PERFORMANCE OF A SODIUM HEAT PIPE

Experimental investigation of the ease of wick resetting, the reproducibility of the dryout limit, the ability of theories to predict dryout, and the sensitivity of the wick structure to premature dryout in a sodium heat pipe with a wick structure consisting of wire-wrapped rods. Continuous monitoring of the vapor temperature at any location that was flowing proved to be a sensitive means of determining both partial and total dryout of the evaporator region of the heat pipe. A wire wrap wick design, experimentally tested for the first time, is believed to be superior to a more conventional wick configuration. Unexpected operational characteristics were observed when all the heat pipe energy being transferred was concentrated into a small region. A large thermal gradient, accompanied by temperature oscillations, was observed. Calculations of the pressure drops in the vapor appear to greatly underestimate the actual driving force. Values of the pressure gradient obtained by relating the temperature differences to absolute pressure changes using the vapor pressure curve gave more rational results, but it is thought that these values may be too high.

70083 THE EFFECT OF LONGITUDINAL VIBRATION ON HEAT PIPE PERFORMANCE

An experimental heat pipe was constructed and performance tested while simultaneously being subjected to simple harmonic vibrations in the longitudinal direction. The frequency ranged from 0 to 580 cycles per second, and the acceleration from 0 to 12 g. Experimental tests were made to determine if the longitudinal vibration had significant effect on the performance of the heat pipe as indicated by failure of the capillary pump (drying of the wick). Secondary objectives were to determine what trends could be observed among varying frequency and acceleration of the imposed vibration. Results indicated that the vibrations caused the maximum heat transfer capacity of the heat pipe to decrease. The effect appears to be more severe at the lower test frequencies (60 cps and 120 cps) than at the higher test frequencies (240 cps and 580 cps).
severity of the reduction in maximum heat transfer capacity appears to increase as the
acceleration level of the imposed vibration increases.

70084 NEUTRON RADIOGRAPHIC STUDY OF LIMITING PLANAR HEAT PIPE PERFORMANCE
Moss, Richard A. (Massachusetts Inst. of Tech., Cambridge); Kelly, Arnold J. Int. J.
A condition limiting the maximum heat transfer rate attainable by heat pipes was
investigated experimentally. Using neutron radiographic techniques, a detailed inves-
tigation of the vaporization processes which occur interior to the wick structure of a
planar heat pipe employing water as a working fluid was conducted for a number of wicks
having different mean pore sizes and for several angles of inclination of the wick.
The neutron radiographic system employed permitted measurements of the liquid layer
thickness in the wick to be made with an accuracy of 0.006 in. for thicknesses up to
0.125 in. of water, and with a lateral resolution of 0.0135 in. Two models of the
heat transfer process occurring in planar heat pipes were postulated and analytically
formulated. The first model assumed that evaporation occurred only from the upper
surface of the wick whereas the second assumed that vapor was generated at the wick's
base and released solely from the sides of the wick. With a secondary assumption of
variable pore size, the second model proved to be more realistic for correlating the
test data than the first. The apparent variation of pore size, indicated by the data
to be a function of heat transfer rate, was interpreted as a manifestation of the
"Leverett effect."

70085 THE EXPERIMENTAL DESIGN AND OPERATION OF A ROTATING WICKLESS HEAT PIPE
70, 60p., Avail:TAC
An experimental rotating wickless heat pipe apparatus was designed and machined.
The apparatus includes a rotating heat pipe assembly, test stand, spray cooling as-
ssembly, safety shielding, and instrumentation. A revised condensing limit for the op-
eration of the rotating heat pipe was obtained by modifying Ballback's Nusselt film
condensation theory to include the effects of a thermal resistance in the condenser
wall and in the condenser outside surface cooling mechanism. Approximate results, ob-
tained for half-cone angles of 1, 2, and 3 degrees, show that less heat can be removed
than originally predicted by Ballback, and that the outside heat transfer coefficient
can significantly alter the condensing limit. An improved Nusselt theory was developed
which applies for all half-cone angles, and which includes the effects of the thermal
resistances in the condenser wall and in the condenser outside surface cooling mech-
anism. This formulation led to a second-order non-linear differential equation for the
film thickness which was numerically integrated using a free-overfall boundary condi-
tion at the condenser exit. Results obtained for a half-cone angle of 0 degrees are
substantially less than the results obtained from the approximate solution for half-
cone angles of 1, 2, and 3 degrees.

70086 CONSTRUCTION AND TEST OF A FLEXIBLE HEAT PIPE
Bliss, F. E., Jr., Clark, E. G., Jr., Stein, B. Sanders Associates Inc., Nashua, N.H.
(7p), 6 refs.
A flexible heat pipe was evaluated to determine its operating characteristics
(a) while stationary with varying degrees of bend and (b) while undergoing transverse
and longitudinal vibration in an unbent mode. The vibrational environments varied in
frequency from 5 to 1000 cps and accelerations up to 7 g's. The heat-pipe operation
changed somewhat due to bending and vibration, one effect being an increase in the max-
imum horizontal heat-transfer capacity. Also, a reduction was noted in the wick pump-
ing capacity when the heat pipe was operated with the evaporator above the condenser.

70087 STEADY-STATE AND TRANSIENT PERFORMANCE OF HOT RESERVOIR GAS-CONTROLLED HEAT
PIPES
Marcus, B. D., Fleischman, G. L. TRW Systems Group, Redondo Beach, Calif. (ASME 70-
5 refs.
The effects of working fluid, in either the liquid or vapor state, within the res-
ervoir of hot reservoir gas-controlled heat pipes were investigated. It is experi-
mentally shown that (a) the presence of liquid in the reservoir at start-up results in
temporary pressures and temperatures considerably in excess of design conditions and
(b) diffusion of working fluid vapor through the control gas plays a very large role
in the transient response of such heat pipes. A characteristic equation derived for
the steady-state operation of such heat pipes is based on a sharp front-no axial con-
duction model. Experimental results demonstrate that axial conduction is very im-
portant and should be included in the analysis. Although the no-conduction model
results in only a small error at the low end of the heat pipe's control range, this
error grows quite large at the higher end where the model seriously underestimates the
partial pressure of vapor within the reservoir.

70088 PERFORMANCE MAP OF AN AMMONIA (NH₃) HEAT PIPE
Schwartz, J. California Institute of Technology (ASME 70-HT/SpT-5. Space Technology

This paper presents a series of heat pipe performance curves, which are an integ-
ral part of a performance map. The test heat pipe is cylindrical and has stainless-
steel components; ammonia is the working fluid. The test data are compared to those
obtained for a similar heat pipe with the same physical dimensions, but with water as
its working fluid. A performance map comparison between both heat pipes indicates
that the ammonia pipe was more efficient in transporting thermal loads than the water
pipe, up to an operating temperature of approximately 30°F. Above this temperature, the
ammonia pipe’s relative advantage decreased rapidly until the onset of dryout at which
point the water pipe was able to transport 30 percent more thermal power than its am-
monia counterpart.

70089 DEMONSTRATION OF OPERATION OF ROTATING HEAT PIPE

Operation of a small, non-capillary, rotating heat pipe was successfully demon-
strated in a vertical mode working against gravity; water was used as test fluid, and
internal thermal conductance was found to be very high.

70090 UNSTEADY OPERATING BEHAVIOR OF HEAT PIPES
Groll, Manfred and Zimmerman, Peter Chem-Ing-Tech 1970, 42(16). Avail:TAC, 4p (Ger.)

The behavior of heat pipes (rate of change of temp., pressure conditions) when
brought into operation is described qual. Anal. solns. for the calcn. of the temp-
time relation are given for the case where a flow of vapor has been set up. Further,
irregular and steady changes in the heating performance were investigated for heat
pipes made of steel, of Cu, and of Al, assuming convective cooling.

71029 REEXAMINATION OF HEAT PIPE STARTUP
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio,
TM-X-52924) Avail:TAC

Visual observation in a lithium heat pipe of the high temperature profiles during
startup were made. Cotter’s model of the startup process is reassessed in the light
of these observations. The model is modified by moving the sonic point to the end of
the hot zone and including the opposing effects of wall friction and condensation on
the flow. Transient measurements have been made on a lithium heat pipe for startup to
temperatures in the range 1000 to 1400 C. As predicted by the theory, the temperature of
the hot zone is fairly independent of the power input to the evaporator until the
hot zone reaches the end of the pipe. The hot zone temperature predicted by the theory
is 50 to 80 C higher than the measured value with up to 30 C of the discrepancy attrib-
utable to the measurement.

71030 EXPERIMENTAL INVESTIGATION OF THE PERFORMANCE OF VARIOUS WICK CONFIGURATIONS IN
SINGLE AND TWO FLUID HEAT PIPES OPERATING IN THE GRAVITATIONAL FIELD
Illinois Univ., Urbana, Engineering Experiment Station, D. L. Hunsberger and J. C.
Avail:TAC

In one study, wicking material tests were made on 9 in. by 1 in. Refrasil strips.
Displacement-time curves were extrapolated for predicting the performance of a 21-3/4
in. heat pipe. In a second study, heat pipe tests were run with a well-defined wick
length of 21-3/4 in. and a total width of 7 in. The same Refrasil was the wicking ma-
terial. An open-ended dewar housed the heat pipe system which consisted of heat input,
mass transfer, and heat removal sections. Two electric heaters supplied heat input,
while circulating water was used for heat removal. Both studies showed water to be a
much better operating fluid than ethyl alcohol or 50 percent ethyl alcohol by weight.
Ethyl alcohol appeared to be only slightly better than the 50 percent mixture. At zero
degrees the maximum heat transfer capacities were 15, 4, and 2 watts, respectively, for
the three fluids. The predicted wattages in the first study were generally higher due
to greater ease in saturating the wicking material with fluid. A gap effect created
by sewing two layers of wicking material together greatly enhanced the heat pipe per-
formance. At zero degrees, water transferred over 80 watts, as compared to 15 watts
previously.
71031 MEASUREMENTS OF FILM CONDENSATION HEAT TRANSFER COEFFICIENTS ON VERTICAL TUBES FOR NITROGEN, HYDROGEN, AND DEUTERIUM

Experiments carried out with a Frigoduc or cryogenic heat pipe (i.e., a device composed of a boiler connected to a condenser by a pipe through which a cryogenic fluid flows) have made possible the study of heat exchange phenomena at the condenser wall. The condensation surface is made of vertical smooth stainless steel tubes containing a cryogenic liquid boiling under constant pressure. On the external surface, vapor of the same fluid coming from the boiler (except for deuterium, where liquid hydrogen was used to condense the vapor) is condensed under a pressure depending on the exchanged thermal power. After a brief review on the techniques used, tables and curves for nitrogen, hydrogen and deuterium heat fluxes are presented as a function of the temperature variation at bulk saturation, as well as heat transfer coefficients.

71032 SONIC LIMITATIONS AND STARTUP PROBLEMS OF HEAT PIPES

71033 INVESTIGATION OF HEAT AND MASS TRANSFER IN A HEAT PIPE WITH A SODIUM COOLANT

Results are presented of an experimental investigation of heat- and mass-transfer processes in a heat pipe. The experiments were carried out at temperatures of 600 to 800°C on a heat pipe with a wick of serge webbing (the length of the pipe was 500 mm, its inside diameter 25.5 mm). It was observed by measurement of the temperature fields in the vapor space of the pipe that the particular wick used is capable of generating a very high capillary pressure (higher than 0.07 bar).

71034 EXAMINATION OF NICKEL HEAT PIPES CONTAINING POTASSIUM

Three heat pipes constructed of pure nickel that contained potassium as a working fluid were examined after operation at 600°C for 6000 to 10,000 hr. These heat pipes had been designed and operated by the Electronic Components Division of the Radio Corporation of America and were shipped intact to ORNL for metallurgical analyses. No deterioration of the pipes was indicated during operation, and visual examination confirmed that no serious corrosion occurred under the test conditions. Metallographic examination did reveal local areas of the evaporator in which the capillary wick and adjacent pipe wall had been attacked and the attendant formation of a black oxide scale, which appeared to be a double oxide of the type Ni_xO_yK_z. Metallographic examination of the condenser area revealed no metallurgical changes other than grain growth. After the test, the potassium contained 50 to 120 ppM O and less than 50 ppM metal impurities.

71035 HEAT PIPE PERFORMANCE IN AN ARTIFICIAL GRAVITY FIELD

Elemental maximum energy transport formula are presented for the wick-limited heat pipe as a function of externally induced body forces. A water-screen wick heat pipe was constructed and subjected to controlled acceleration testing on a conventional laboratory centrifuge. The experimental results were compared with the predicted performance. It is shown that performance degrades stepwise starting at acceleration levels somewhat below the predicted levels.

71036 OPERATING CHARACTERISTICS AND LONG LIFE CAPABILITIES OF ORGANIC FLUID HEAT PIPES

A comprehensive test program on heat pipes using organic working fluids has demonstrated good performance for most cooling applications. These heat pipes have been effectively utilized to fill operating temperature gaps existing in the low and medium temperature ranges. The low thermal conductivity of the organic fluids had negligible effects on the evaporator temperature gradient between the heated surface and the saturated vapor. Additionally, life test compatibility results show very high reliability. This was further verified by a post test analysis of a 20,000-hour heat pipe which showed negligible internal mass transport, corrosion, and fluid property.
Heat transfer characteristics and heat transport capacity values are presented for two essentially similar grooved heat pipes. The pipes were made of 0.5 inch O.D. aluminum and had 30 internal longitudinal grooves. Tests were conducted with R-21, R-113, and ammonia working fluids, at various temperatures, charge levels, and tilt conditions. Some data also are presented with non-condensible gas added to provide variable conductance, as well as a limited amount of freezing-thawing data obtained with R-113. The grooved heat pipes are sensitive to gravity effects, but offer attractive performance coupled with a very simple and reliable construction.

Two sodium filled heat pipes were constructed and operated successfully. The principle of their operation is discussed, the method of construction is described, and the potential of these devices is assessed.
F. SUBJECT AND AUTHOR INDEX
F.1 BIBLIOGRAPHY
HEAT PIPE TECHNOLOGY

0010 ABU-ROMIA M
POSSIBLE APPLICATION OF ELECTRO-OSMOTIC FLOW PUMPING IN HEAT PIPES
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971 PAPER 71-423, AVAIL. TAC

00100 ACHENER P Y
ALKALI METALS EVALUATION PROGRAM
AEROJET - GENERAL NUCLEONICS, SAN RAMON, CALIFORNIA
QUART. PROG. RPT. 1 JULY 66 - 30 SEP 66, AVAIL. TAC
CONTRACT (AT (04-3)-368) (AGN-8202) 28 P.

00200 ACHENER P Y
ALKALI METALS EVALUATION PROGRAM
AEROJET - GENERAL NUCLEONICS, SAN RAMON, CALIFORNIA NUCLEAR PRODUCTS AND SERVICES GROUP, CONTRACT (AT(04-3)-368) (AGN-8222) 30P.
QUART. PROG. RPT. 1 JAN 67 - 31 MAR 67, AVAIL. TAC

00300 ADT R R JR
IRREVERSIBLE THERMODYNAMIC ANALYSIS OF THE AXIALLY HEATED HEAT PIPE
UNIV. OF MIAMI, DEPT. OF MECH. ENGRG., CORAL GABLES, FLORIDA 1969. (PAPER) AVAIL. TAC

00301 ALEACH C R
HEAT PIPE PRINCIPLE PUT TO USE
PROFESSIONAL ENGINEER, MARCH 1971, P. 21-23 AVAIL. TAC

00400 ALLEAVITCH J
VAPORIZATION HEAT TRANSFER FROM FLOODED WICK
DEPT. OF CHEM. ENGRG., NORTH CAROLINA STATE UNIVERSITY, RALEIGH, 1969. (PH. D. THESIS)

00600 ALLINGHAM WM D, MCENTIRE J A
DETERMINATION OF BOILING FILM COEFFICIENT FOR A HEATED HORIZONTAL TUBE IN WATER-SATURATED WICK MATERIAL
ASME J. OF HEAT TRANSFER, VOL. 83, NO. 1, FEB. 1961, PP. 71-76 AVAIL. TAC

00600 ALTIERI D, PARKER J JR
CONCEPTUAL DESIGN OF A RADIOISOTOPE HEAT-PIPE-THERMIONIC SPACE POWER SYSTEM
INTERSOCIETY ENERGY CONVERSION ENGRG. CONF., BOULDER, COLO. AUG. 13-17, 1968.

F. 1-01
HEAT PIPE TECHNOLOGY

00700 ANAND D K
ON THE PERFORMANCE OF A HEAT PIPE
J. OF SPACECRAFT AND ROCKETS, VOL. 3, NO. 5, MAY 1966, PP. 763-765. AVAIL. TAC

00800 ANAND D K
HEAT PIPE APPLICATION TO A GRAVITY-GRADIENT SATELLITE
ANNUAL AVIATION AND SPACE CONF., BEVERLY HILLS, CALIF., JUNE 16-19 1966, PP. 634-638. (ASME) AVAIL. TAC

00900 ANAND D K, DYBBS A Z
EFFECTS OF CONDENSER PARAMETERS ON HEAT PIPE OPTIMIZATION
J. OF SPACECRAFT AND ROCKETS, VOL. 4, NO. 5, MAY 1967, PP. 695-696. AVAIL. TAC

01000 ANAND D K, HESTER R B
HEAT PIPE APPLICATION FOR SPACECRAFT THERMAL CONTROL
TECH. MEMO OF JOHN HOPKINS APPLIED PHYSICS LAB. TG-922, AUG. 1967. AVAIL. TAC

01100 ANDEREN G B, KERN F R
GRIFFITH P
TWO-PHASE MOMENTUM FLUX AND DESIGN OF A HEAT PIPE
TID-22224, JUNE 30, 1965. AVAIL. TAC

01200 ANDERSON J L, LANTZ E
A NUCLEAR THERMIOMIC SPACE POWER CONCEPT USING ROD CONTROL
AND HEAT PIPES
LEWIS RESEARCH CENTER, CLEVELAND, OHIO, MAY 1969. NASA TN-D-5250. AVAIL. TAC

01300 ANDERSON J L, LANTZ E
THERMIOMIC HEAT PIPE SPACE POWER CONCEPT
TRANS. AMER. NUCL. SOC., 11 14 (JUNE 1968) AVAIL. TAC

01400 ARCELLA F G, DZAKOWIC G S
HEAT PIPES FUNCTION ISOTHERMALLY AND ADAPTABLE
SPACE AND AERONAUTICS, AUG. 1969, PP. 58-60. AVAIL. TAC

01500 ARMAND M, SHROFF A M
PRELIMINARY RESULTS OF A STUDY OF HEAT PIPES AT HIGH TEMPERATURE
PROCEEDINGS SECOND INTERN'L. CONF. ON THERMIOMIC ELECTRICAL POWER GENERATION (A69-29172 14-03), MAY 1968, PP. 557-563. AVAIL. TAC

F.1-02
HEAT PIPE TECHNOLOGY

EUR 4210, AVAIL. TAC

01600 BAFFR A  BURCK E
MÜFSCHMIDT W
LIQUID-VAPOR INTERACTION AND EVAPORATION IN HEAT PIPES
PROC. 2ND INT’L CONF. ON THERMIONIC ELECTRICAL POWER
GENERATION MAY 27-31, 1968, STRESA, ITALY EUR 4210 F, E P.
543-556, AVAIL. TAC

01700 BAINES W D  PETERSON E G
INVESTIGATION OF FLOW THROUGH SCREENS
ASME TRANSACTIONS, 1950, PP. 467-80. AVAIL. TAC

01800 BAINTON K F
EXPERIMENTAL HEAT PIPES
UNITED KINGDOM ATOMIC ENERGY AUTHORITY MEMO AERE-M1610,
HARWELL, ENGLAND, 1965. AVAIL. TAC

01900 BARNETT C S
AN OUT-OF-PILE HEAT PIPE THERMIONIC SPACE-POWER CONCEPT
TRAN. AMERICAN NUCLEAR SOCIETY, VOL. 9, NO. 2, NOV. 1966,
PP. 338-339. AVAIL. TAC

01901 BARSCH W O  SCHOENHALS R J
WINTER E R F  VISKANTA R
THE STUDY AND CLASSIFICATION OF TWO AND MULTI-COMPONENT HIGH
THERMAL CONDUCTANCE DEVICES
INTERIM REPORT, AUG. 20, 1970, CONTRACT NASA-24015, NASA-CR-
102943, 263 P., AVAIL. TAC

02000 BASIULIS A  DIXON J C
AN ELECTRICALLY INSULATED HEAT PIPE FOR DEPRESSED COLLECTORS
CONF. ON TUBE TECHNIQUES, 9TH, NEW YORK, SEPT. 17-18, 1968,
PP. 176-181, AVAIL. TAC

02100 BASIULIS A  DIXON J C
HEAT PIPE DESIGN FOR ELECTRON TUBE COOLING
ASME AND AICHE HEAT TRANSFER CONF., MINNEAPOLIS, MINN., AUG.
3-6, 1969. (ASME PAPER NO. 69-HT-25) AVAIL. TAC

02200 BASIULIS A
UNIDIRECTIONAL HEAT PIPES TO CONTROL TWT TEMPERATURE IN
SYNCHRONOUS ORBIT
THERMODYNAMICS AND THERMOPHYSICS OF SPACE FLIGHT
PROCEEDINGS OF SYMPOSIUM, PALO ALTO, CALIF., MARCH 23-25,
F.1-03
HEAT PIPE TECHNOLOGY

1970, P 165-173, CONT. NO. NAS-3-9719, AVAIL. TAC

02201 BASIULIS A FILLER M
OPERATING CHARACTERISTICS AND LONG LIFE CAPABILITIES OF ORGANIC FLUID HEAT PIPES
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971, PAPER 71-408, AVAIL. TAC

02300 BASIULIS A STARR M C
IMPROVED RELIABILITY OF TRAVELING-WAVE TUBES THROUGH THE USE OF A NEW LIGHT-WEIGHT REMOVAL DEVICE

02400 BIENERT W B LEVEADAHL W J
STREB A J

02500 BIENERT W B FRANK S HANNAH R PETERS J T
APPLICATION OF HEAT PIPES TO SNAP-29
IECEC 68 INTERSOCIETY ENERGY CONVERSION ENGRG. CONF., UNIV. OF COLO., BOULDER, COLO., AUG. 13-17, 1968, PP. 477-486. AVAIL. TAC

02501 BIENERT W B BRENNAN P J KIRKPATRICK J P
FEEDBACK CONTROLLED VARIABLE CONDUCTANCE HEAT PIPES
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971, PAPER 71-421, AVAIL. TAC

02600 BIENERT W
HEAT PIPES FOR TEMPERATURE CONTROL
PROC. OF 4TH INTERSOCIETY ENERGY CONVERSION ENGRG. CONF., WASHINGTON, D.C., SEPT. 22-26, 1969 (PAPER NO. 699128) PP. 1033-1041, AVAIL. TAC

02601 BILENAS J A HARWELL W
ORBITAL ASTRONOMICAL OBSERVATORY HEAT PIPE - DESIGN ANALYSIS TESTING
ASME PAPER 70-HT/SPT-9 AVAIL. TAC (9P.)
HEAT PIPE TECHNOLOGY

02700 BLISS F E JR, CLARK E G JR
STEIN B
CONSTRUCTION AND TEST OF A FLEXIBLE HEAT PIPE
SANDERS ASSOCIATES, INC., ASME PAPER 70-HT/SPT-13 AVAIL. TAC

02800 BOHDANSKY J
POWER FROM THERMIONIC CONVERTERS
ATOMWIRTSCHAFT, VOL. 13, NOV. 1968, PP. 548-549. (IN GERMAN)
AVAIL. TAC

02801 BOHDANSKY J
HEAT FLOW MEASUREMENTS IN A THERMIONIC CONVERTER
IEEE THERMIONIC CONVERSION SPECIALIST CONF., CARMEL, CAL.
OCT. 21-23, 1969, CONF. RECORD P. 517-520, AVAIL. TAC

02900 BOHDANSKY J, SCHINS H E J
THE SURFACE TENSION OF THE ALKALI METALS
J. INORG. NUCL. CHEM., 1967 VOL. 29 (2173-79) AVAIL. TAC

03000 BOHDANSKY J, SCHINS H E J
NEW METHOD FOR VAPOR-PRESSURE MEASUREMENTS AT HIGH
TEMPERATURE AND HIGH PRESSURE
J. OF APPL. PHYSICS VOL. 36, NO. 11 (36E3-4) NOV. 1965
AVAIL. TAC

03100 BOHDANSKY J, SCHINS H E J
THE VAPOR PRESSURE OF YTTERBIUM IN THE PRESSURE RANGE OF 40
TO 400 TORR
J. LESS-COMMON METALS 1967, VOL. 13 (248) AVAIL. TAC

03200 BOHDANSKY J, SCHINS H E J
VAPOR PRESSURE OF DIFFERENT METALS IN THE PRESSURE RANGE OF
50 TO 4000 TORR
J. OF PHYSICAL CHEMISTRY 1967, VOL. 71 (215-17) AVAIL. TAC

03300 BOHDANSKY J, SCHINS H E J
SURFACE TENSION AND DENSITY OF THE LIQUID EARTH ALKALINE
METALS MG, CA, SR, BA
J. INORG. NUCL. CHEM. 1968, VOL. 30 (2331-37) AVAIL. TAC

03400 BOHDANSKY J, SCHINS H E J
THE SURFACE TENSION OF AG, TL, PB, AND BI AT HIGH
TEMPERATURE
J. INORG. NUCL. CHEM. 1968, VOL. 30 (3362-65) AVAIL. TAC

P.1-05
HEAT PIPE TECHNOLOGY

03500 BOHDANSKY J  SALAMON K
VAN ANDEL E
INTEGRATED CS-GRAFITE RESERVOIR SYSTEM IN A HEAT PIPE THERMIONIC CONVERTER
DIRECT CONVERSION GROUP, EURATOM CCR, ISPRA, ITALY.
THERMIONIC CONVERSION SPECIALISTS CONF., PALO ALTO, CALIF.
OCT. 1967, P. 93-96, 8 REF., AVAIL. TAC

03600 BOHDANSKY J  SCHINS H E J
HEAT TRANSFER OF A HEAT PIPE OPERATING AT EMITTER TEMPERATURE
FIRST INTERN'L. CONF. ON THERMIONIC ELEC. POWER GENERATION,
ISPRA, ITALY, SEPT. 20-29, 1965, AVAIL. TAC

03700 BOHDANSKY J  BUSSE C A
GROVER G M
COOLING SYSTEM FOR NUCLEAR REACTORS

03800 BOHDANSKY J  STRUB H
VAN ANDEL E
HEAT TRANSFER MEASUREMENTS USING A SODIUM HEAT PIPE WORKING AT LOW VAPOR PRESSURE

03900 BOHDANSKY J  VAN ANDEL E
CALORIMETRIC MEASUREMENTS WITH A HEAT PIPE THERMIONIC CONVERTER
INTERN'L CONF. ON THERMIONIC ELEC. POWER GENERATION (A69-29172 14-03) 1968, PP. 989-996, AVAIL. TAC

04000 BOHDANSKY J  VAN ANDEL E
HEAT PIPE THERMIONIC CONVERTER WITH GRAPHITE ABSORPTION CESIUM RESERVOIR WORKING AT COLLECTOR TEMPERATURE

04001 BREITWIESER R  LANTZ E
A DESIGN STUDY OF A 350 KWE OUT-OF-CORE NUCLEAR THERMIONIC CONVERTER SYSTEM
NASA LEWIS RES. CNTR., CLEVELAND, OHIO (NASA-TM-X-52846), AVAIL. TAC

F.1-06
HEAT PIPE TECHNOLOGY

04004 BREITWIESER R
USE OF HEAT PIPES FOR ELECTRICAL ISOLATION
IEEE THERMIonic CONVERSION SPECIALIST CONF., MIAMI, FLA.
26-29 OCT., 1970 (NASA-TM-X-52928, E-6059) 8 P., AVAIL. TAC

04010 BRENNA N P J
STUDY TO EVALUATE THE FEASIBILITY OF A FEEDBACK CONTROLLED
VARIABLE CONDUCTANCE HEAT PIPE
AVAIL TAC

04100 BRESSLER R G WYATT P W
SURFACE WETTING THROUGH CAPILLARY GROOVES
AICHE PREPRINT 19, ASME-AICHE HEAT TRANSFER CONF.,
MINNEAPOLIS, MINN., AUG. 3-6, 1969. AVAIL. TAC

04200 BROSSENS P
HEAT PIPE THERMIonic CONVERTER DEVELOPMENT
THermoelectron ENGRG. CORP., WALTHAM, MASS., DEC. 1967.
NASA-CR 93664. AVAIL TAC

04300 BROSSENS P
THERMIonic CONVERTERS WITH HEAT-PIPE RADIATORS
ASME INTERSOCIETY ENERGY CONVERSION ENGRG. CONF., MIAMI
BEACH, FLA., AUG. 13-17, 1967, PP. 181-187. AVAIL TAC

04400 BROSSENS P
ADVANCED CONVERTER DEVELOPMENT
THermoelectron CORPORATION, WALTHAM, MASS., THERMIonic
CONVERSION SPECIALIST CONF., PALO ALTO, CALIF. OCT. 1967,
P. 68-73, 7 REF. AVAIL. TAC

04401 BURGES R T
DESIGN AND OPERATION OF A HEAT PIPE
MASTER'S THESIS, NAVAL POSTGRADUATE SCHOOL, MONTEREY, CALIF.
(44P.), AVAIL. TAC

04500 BUSSE C A
THEORY OF THE SONIC HEAT TRANSFER LIMIT OF HEAT PIPES
EURATOM CCR, 21020 ISPRA, ITALY (17P) AVAIL. TAC

04600 BUSSE C A
CORROSION IN HIGH TEMPERATURE LITHIUM HEAT PIPES WITH
NIOBium-IZIRCONIUM OR TANTALUM AS WALL MATERIAL
EUR 4298. (CORROSION SCIENCE 10, 65-84 (1970)) (IN GERMAN &
F.1-07
HEAT PIPE TECHNOLOGY

TRANSL.) AVAIL. TAC

04700 BUSSE C A
HEAT PIPE RESEARCH IN EUROPE
SECOND INTERN'L. CONF. ON THERMIonic ELEC. POWER GENERATION
AVAIL. TAC

04800 BUSSE C A
HEAT PIPE THERMIonic CONVERTER RESEARCH IN EUROPE
PROC. OF THE 4TH INTERSOCIETY ENERGY (AICHE) CONVERSION
ENGRG. CONF., WASHINGTON, D.C., SEPT. 22-26, 1969, PP. 861-872.
AVAIL. TAC

04900 BUSSE C A
OPTIMIZATION OF HEAT PIPE THERMIonic CONVERTERS FOR SPACE
POWER SUPPLIES
EUR 2534.E, 1965, AVAIL. TAC

05000 BUSSE C A
PRESSURE DROP IN THE VAPOR PHASE OF LONG HEAT PIPES
IEEE CONF. RECORD OF THE 1967 THERMIonic CONVERSION
SPECIALIST CONF., PALO ALTO, CALIF., OCT. 30-NOV. 1, 1967.
PP. 391-399, AVAIL. TAC

05100 BUSSE C A, CARON R
CAPPelleTTI C
PROTOTYPES OF HEAT PIPE THERMIonic CONVERTERS FOR SPACE
REACTORS
FIRST INTERN'L. CONF. ON THERMIonic ELECTRICAL POWER GENERATION,
LONDON, ENGLAND, SEPT. 20-24, 1965, AVAIL. TAC

05200 BUSSE C A, CARON R
GEIGER F, POETZSCHKE M
PERFORMANCE STUDIES ON HEAT PIPES
FIRST INTERN'L. CONF. ON THERMIonic ELECTRICAL POWER GENERATION,
LONDON, ENGLAND, SEPT. 20-25, 1965, AVAIL. TAC

05300 BUSSE C A, GEIGER F
STRUß H, POETZSCHKE M
KRAFT G
HIGH TEMPERATURE LITHIUM HEAT PIPES
INTERN'L. CONF. ON THERMIonic ELECTRICAL POWER GENERATION, PROC.
AVAIL. TAC

P.1-08
HEAT PIPE TECHNOLOGY

05400 RUSSE C A GEIGER F QUATAERT D POETZSCHKE W
HEAT PIPE LIFE TESTS AT 1600 DEGREES C AND 1000 DEGREES C
IEEE CONF. RECORD OF THE 1966 THERMIonic CONVERSION
SPECIALIST Conf., Houston, Texas, NOV. 3-4, 1966, PP. 149-158. AVAIL. TAC

05401 BYRO A W
HEAT PIPE THERMIonic DIODe POWER SYSTEM

05500 CALIMBAS A T HULETT R H
AN AVIONIC HEAT PIPE
ASME PAPER 69-HT-16, PROC. OF THE 4TH INTERSOCIETY ENERGY
CONVERSION ENGRG. CONF., WASHINGTON, D.C., SEPT. 22-26,
1969, PP. 1010-1015. AVAIL. TAC

05600 CALIMBAS A T HULETT R H
AVIONIC APPLICATION OF A HEAT PIPE
PROC. OF THE 4TH INTERSOCIETY ENERGY CONVERSION ENGRG. CONF.
WASHINGTON, D.C., SEPT. 22-26, PP. 1016-1024. AVAIL. TAC

05700 CAMPANA R J HOLLAND J W
STATUS REPORT ON HEAT PIPES
GULF GENERAL ATOMIC, INC., GA-5676, SEPT. 17, 1964. AVAIL.
TAC

05800 CARLSON G
HEAT PIPE RADIATOR DESIGN
LAWRENCE RAD. LAB., LIVERMORE, CALIF., SPACE POWER NOTE NO.
214, JUNE 15, 1967. AVAIL. TAC

05801 CARLSON G A HOFFMAN M A
EFFECT OF MAGNETIC FIELDS ON HEAT PIPES
PROC. ASME SPACE TECH. HEAT TRANSFER CONF., LOS ANGELES,
AVAIL. TAC

05900 CARNESALE A COSGROVE J H FERRELL J K
OPERATING LIMITS OF THE HEAT PIPE
PROC. OF JOINT ATOMIC ENERGY COMMISSIONS/SANDIA LAB HEAT
PIPE CONF., VOL. 1, OCT. 1966, SC-M-66-623. AVAIL. TAC

F.1-09
HEAT PIPE TECHNOLOGY

05901 CASAZZA S A  JOACHIN R J
A SURVEY OF COOLING TECHNIQUES FOR AIRCRAFT ELECTRONIC EQUIPMENT
IEEE EASTERN ELECTRONICS PACKAGING CONFERENCE, MASS. INST. TECH., CAMBRIDGE, MASS. JUNE 8-9, 1970 PROCEEDINGS (P. 5.2.1 -5.2.14), AVAIL. TAC

06000 CHATO J C  STRECKERT J H
PERFORMANCE OF A WICK-LIMITED HEAT PIPE
ASME 69-HT-20, 1969, AVAIL. TAC

06100 CHERKASSKII A KH
INDEPENDENT HEAT PIPES
AKAEMUYA NAUK, IZVESTIYA, ENERGETIKA I TRANSPORT, NO. 3, MAY-JUNE 1969, PP. 95-103. (IN RUSSIAN)

06200 CHEUNG H
HEAT PIPE OPTIMIZATION
LAWRENCE RAD. LAB., U. OF CAL., LIVERMORE, UCID-15531*
SPACE POWER NOTE NO. 264, DEC. 19, 1967. AVAIL. TAC

06300 CHEUNG H
A CRITICAL REVIEW OF HEAT PIPE THEORY AND APPLICATIONS
UNIV. OF CALIF., LAWRENCE RAD. LAB., UCRL-50453, JULY 15, 1968. AVAIL. TAC

06301 CHI S W
MATHEMATICAL MODELING OF CRYOGENIC HEAT PIPES
(GRANT NGR-09-005-071), NASA-CR-116175 SEPT. 1970, 123 P. AVAIL. TAC

06400 CHI S W  CYGNAROWICZ T A
THEORETICAL ANALYSIS OF CRYOGENIC HEAT PIPES
ASME PAPER 70-HT/SPT-6 AVAIL. TAC

06401 COLWELL G T  WILLIAMS C L
HSU J C  ZEVALLOS G E
A STUDY OF NONCONDENSIBLE EFFECTS IN A HEAT PIPE
NUCLEAR TECHNOLOGY, VOL. 10, MARCH 1971 P. 293-300, AVAIL. TAC

06410 CLAUSEN O W  MARCUS B D
PISEK W E  TURNER R C
CIRCUMFERENTIAL HEAT PIPE SYSTEMS FOR LARGE STRUCTURES

F.1-10
HEAT PIPE TECHNOLOGY

AVAIL. TAC

06500 CONWAY E C KELLEY M J
WILMARTH R W BEGGS J E
NONELECTRIC CATHODE HEATING
INST. OF ELECTRICAL AND ELECTRONICS ENGINEERS, CONF. ON
TUBE TECHNIQUES, 9TH, NEW YORK, NEW YORK, SEPT. 17, 18, 1968
CONFERENCE RECORD, P. 191-195. AVAIL. TAC

06600 CONWAY E C WILMARTH R W
COOLING OF A HIGH POWER ELECTRON TUBE IN A SPACE VEHICLE
IN IEEE CONF. ON TUBE TECH., 9TH N. Y., SEPT. 17, 18, 1968.
CONTRACT NAS12565, AVAIL. TAC

06700 CONWAY E C KELLEY M J
A CONTINUOUS HEAT PIPE FOR SPACECRAFT THERMAL CONTROL
ANNUAL AVIATION AND SPACE CONF., BEVERLY HILLS, CALIF., JUNE
16-19, 1968, PP. 655-658. (G.E.), AVAIL. TAC

06800 COSGROVE J H
ENGINEERING DESIGN OF THE HEAT PIPE
NORTH CAROLINA STATE UNIV., RALEIGH, 1967. (PH. D. THESIS)

06900 COSGROVE J H FERRELL J K
CARNESALE A
OPERATING CHARACTERISTICS OF CAPILLARY-LIMITED HEAT PIPES
JOURNAL OF NUCLEAR ENGERGY, JULY 1967, VOL.21,NO.7 (547-558)
AVAIL. TAC

07000 COSTELLO C P FREA W J
THE ROLES OF CAPILLARY WICKING AND SURFACE DEPOSITS IN THE
ATTAINMENT OF HIGH POOL BOILING BURNOUT HEAT FLUXES
UNIV. OF WASHINGTON, SEATTLE, WASH. A.I.CH.E. JOURNAL, VOL.
10, NO. 3, P. 393-8. (MAY 1964) AVAIL TAC

07100 COSTELLO C P REDEKER E R
BOILING HEAT TRANSFER AND MAXIMUM HEAT FLUX FOR A SURFACE
WITH COOLANT SUPPLIED BY CAPILLARY WICKING
CHEMICAL ENGINEERING PROGRESS SERIES, VOL. 41, 1963, P. 104-
113. AVAIL. TAC

07200 COTTER T P
HEAT PIPE STARTUP DYNAMICS
IEEE CONF. RECORD OF THE 1967 THERMIONIC CONVERSION
SPECIALIST CONF., PALO ALTO, CALIF., OCT. 30 - NOV. 1, 1967.
HEAT PIPE TECHNOLOGY

07300  COTTER T P
STATUS OF THE ENGINEERING THEORY OF HEAT PIPES
PROC. OF JOINT ATOMIC ENERGY COMMISSIONS/SANDIA LAB HEAT PIPE CONF., VOL. 1, OCT. 1966, AVAIL. TAC

07400  COTTER T P
THEORY OF HEAT PIPES
LOS ALAMOS SCI. LAB., LA-3246-MS, TID-4500 (37TH ED.), FEB. 23, 1965. AVAIL. TAC

07500  COTTER T P
DEVERALL J
ERICKSON G F
KEDDY E S
SALMI E W
STATUS REPORT ON THEORY AND EXPERIMENTS ON HEAT PIPES AT LOS ALAMOS
LOS ALAMOS SCI. LAB. REPORT LADC-7206, 1965, AVAIL. TAC

07501  SHELPUK B
CROUTHAMEL T A
CYGNAROWICZ T A
ICICLE - INTEGRATED CRYOGENIC ISOTOPE COOLING ENGINE SYSTEM
ASME PAPER 70-HT/SPT-30, AVAIL. TAC

07600  CYGNAROWICZ T A
MALONEY J A
WRIGHT P E
INTEGRATED CRYOGENIC ISOTOPE COOLING ENGINE SYSTEM - ICICLE
FEASIBILITY STUDY
FINAL REPORT, ADVANCED TECHN. LABS, DEFENSE ELECTRONIC PRODUCTS, CAMDEN, N.J., 08102 (CONTRACT NO NASS-21039)
AVAIL. TAC

07700  DAGEJARTSSON S
GROLL M
SCHLOERB D
PRUSCHEK R
AN IMPROVED OUT-OF-CORE THERMIONIC REACTOR FOR LOW POWER INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, ANNUAL THERMIONIC CONVERSION SPECIALIST CONFERENCE, 7TH, FRAMINGHAM, MASSACHUSETTS OCTOBER 21-23, 1966, CONFERENCE RECORD (A69-21806 09-03), NEW YORK, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC., 1968, P. 299-304. AVAIL. TAC

07701  DAILEY C C
MICROWAVE POWER RECEIVING ANTENNA
7P. AVAIL. TAC
HEAT PIPE TECHNOLOGY

07800 DALLAS D B
THE HEAT PIPE
ASTME STUDENT QUARTERLY FALL 1968. AVAIL. TAC

07900 DAY W R  LUCHSINGER T H
ANALYTICAL STUDY PROGRAM TO DEVELOP THE THEORETICAL DESIGN
OF SPACE BORN ELECTROSTATICALLY FOCUSED KLYSTRON
AMPLIFIERS
LITTON INDUSTRIES SAN CARLOS, CALIFORNIA, ELECTRON TUBE
DIV. CONTRACT NAS3-11515 (NASA-CR-72449), AVAIL. TAC

07901 DALEY T J
THE EXPERIMENTAL DESIGN AND OPERATION OF A ROTATING WICKLESS
HEAT PIPE
MASTER’S THESIS, NAVAL POSTGRADUATE SCHOOL, MONTEREY, CALIF.
JUNE 1970, (60P.), AVAIL. TAC

08000 DE TROYER A  NEVE DE MEVERGNIES E
BRABERS M J  DEJONGHE P
GAMMEL G  GROSS F
KOSKINEN M F  LANGPAPE R
DESIGN AND CHARACTERISTICS OF AN ACTINIUM FUELED THERMIonic
GENERATOR
INTERNATIONAL CONFERENCE OF THERMIonic ELECTRICAL POWER
GENERATION, 2ND, STRESA, ITALY, MAY 27-31, 1968, PROCEEDINGS
EUR NO. 4210 F,E 1969, P.305-306, 9 REFS, AVAIL TAC

08001 DEVAN J H  JANSEN D H
EXAMINATION OF NICKEL HEAT PIPES CONTAINING POTASSIUM
TAC

08100 DEVERALL J E
TOTAL HEMISPHERICAL EMISSIVITY MEASUREMENTS BY HEAT PIPE
METHOD
ANNUAL AVIATION AND SPACE CONFERENCE, BEVERLY HILLS,
AVAIL. TAC

08200 DEVERALL J E
THE EFFECT OF VIBRATION ON HEAT PIPE PERFORMANCE
LOS ALAMOS SCIENTIFIC LAB, LA-3758 OCT. 4, 1967. AVAIL. TAC

08300 DEVERALL J E  KEMME J E
HIGH THERMAL CONDUCTANCE DEVICES UTILIZING THE BOILING OF
LITHIUM OR SILVER

F.1-13
HEAT PIPE TECHNOLOGY

LOS ALAMOS SCIENTIFIC LAB REPORT, LA-3211, OCT. 1964, AVAIL. TAC

08400 DEVERALL J E  
MERCURY AS A HEAT PIPE FLUID  
LOS ALAMOS SCIENTIFIC LAB REPORT, LA-4300-MS, JAN. 1970.  
(ALSO ASME PAPER 70-HT/SPT-8) AVAIL. TAC

08500 DEVERALL J E  
KEMME J E  
SATELLITE HEAT PIPE  
LOS ALAMOS SCIENTIFIC LAB REPORT, LA-3278-MS, TID-4500 (39TH ED.), JAN. 1965. AVAIL. TAC

08501 DEVERALL J E  
KEMME J E  
FLORSCHUETZ L W  
SONIC LIMITATIONS AND STARTUP PROBLEMS OF HEAT PIPES  
CONTRACT W-7405-ENG-36, LA-4518, SEPT. 1970. 25 P. AVAIL. TAC

08600 DEVERALL J E  
SALMI E W  
HEAT PIPE PERFORMANCE IN A SPACE ENVIRONMENT  

08700 DEVERALL J E  
SALMI E W  
KNAPP R J  
HEAT PIPE PERFORMANCE IN A ZERO-G GRAVITY FIELD  
J. SPACECRAFT AND ROCKETS, VOL. 4, NO. 11, NOV. 1967, P. 1556-1557. AVAIL. TAC

08800 DEVERALL J E  
SALMI E W  
KNAPP R J  
ORBITAL HEAT PIPE EXPERIMENT  
LOS ALAMOS SCIENTIFIC LAB REPORT, LA-3714, JUNE 5, 1967. AVAIL. TAC

09000 DORNER S  
REISS F  
SCHREZMANN K  
EXPERIMENTAL INVESTIGATIONS ON SODIUM FILLED HEAT PIPES  
INSTITUT FUER NEUTRONENPHYSIK UND REAKTORTECHNIK, KERNFORSCHUNGSZENTRUM KARLSRUHE, GERMANY JAN. 1967 (IN GERMAN), AVAIL. TAC

09000 DUTCHER C H  
BURKE N R  
LA-3278-MS, TID-4500 (39TH ED.), JAN. 1965. AVAIL. TAC

P.1-14
HEAT PIPE TECHNOLOGY

APPLICATIONS OF HEAT PIPES IN ELECTRONIC EQUIPMENT
ELECTRONIC COMMUNICATIONS, INC. DEPT. NO. AER-69-0011 AVAIL. TAC

09100 DUTCHER C H JR BURKE M R
HEAT PIPES - A COOL WAY TO COOL CIRCUITRY
ELECTRONIC COMMUNICATIONS INC., ST. PETERSBURG, FLORIDA;
ELECTRONICS VOL. 43, FEB. 15, 1970 P. 94-100. AVAIL. TAC

09200 DZAKOWIC G S TANG Y S
ARCILLA F G
EXPERIMENTAL STUDY OF VAPOR VELOCITY LIMIT IN A SODIUM HEAT
PIPE
ASME 69-HT-21. AVAIL. TAC

09300 EASTMAN G Y
THE HEAT PIPE - A PROGRESS REPORT
PROC. 4TH INTERSOC. ENERGY CONV. ENGRG. CONF. WASHINGTON,
D.C. SEPT 22-26, 1969 (873-878) AVAIL TAC

09400 EASTMAN G Y
THE HEAT PIPE
SCI. AMERICAN. VOL. 218, MAY 1968, PP. 38-46. AVAIL. TAC

09500 EASTMAN G Y ERNST D M
HALL W B
REVIEW OF FOSSIL-FUEL-FIRED THERMIONIC ENERGY CONVERTERS
IEEE THERMIONIC CONVERSION SPECIALIST CONFERENCE, HOUSTON,
TEXAS 1966. AVAIL. TAC

09600 EASTMAN G Y
HEAT PIPE - SPACE SPINOFF FOR HEAT TRANSFER
SPEC POWER DEVICES ENGG. R.C.A. LANCASTER, PENNSYLVANIA;
HEATING, PIPING AIR COND. 1969 41 (12) 57-61 (ENG.) AVAIL.
TAC

09700 EBY R J
goldberg g i
A MILLIMETER WAVE PARABOLIC ANTENNA FOR COMMUNICATIONS WITH
A SYNCHRONOUS SATELLITE
FAIRCHILD HILLER CORP., SPACE AND ELECTRONICS SYSTEMS DIV.,
GERMANTOWN, MARYLAND, AEROSPACE STRUCTURES DESIGN CONFERENCE
SEATTLE, WASHINGTON, AUG. 4, 5, 1969 PROCEEDINGS SEATTLE,
WASHINGTON, SEATTLE PROFESSIONAL ENGINEERING EMPLOYEES
ASSOCIATION 1969 P. 2-1 TO 2-13. AVAIL. TAC

F.1-15
HEAT PIPE TECHNOLOGY

09701 FEGGERS P E SERKIZ A M
DEVELOPMENT OF CRYOGENIC HEAT PIPES
ASME WINTER ANNUAL MEETING, NEW YORK, N.Y., NOV. 29-DEC. 3, 1970, PAPER 70-WA/ENER-1, 8 P., AVAIL TAC

09710 EDELSSTEIN F HEMBACH R J
THE DESIGN, FABRICATION, AND TESTING OF A VARIABLE CONDUCTANCE HEAT PIPE FOR EQUIPMENT THERMAL CONTROL
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971, PAPER 71-422, AVAIL. TAC

09800 ERNST D M
EVALUATION OF THEORETICAL HEAT PIPE PERFORMANCE
THERMO ELECTRON CORP., WALTHAM, MASSACHUSETTS, 6TH THERMIonic CONVERSION SPECIALISTS CONFERENCE, PALO ALTO, CALIFORNIA, OCT. 1967 6P., 6 REFS. AVAIL. TAC

09900 ERNST D M EASTMAN G Y
TWO PIECE HEAT PIPE CONVERTER

09901 ERNST D M LEVY E K
SHEFSIEK P K
HEAT PIPE STUDIES AT THERMO ELECTRON CORPORATION

09902 EWALD R LACAZE A PERROUD P
FLOODING PHENOMENON IN A CRYOGENIC HEAT PIPE WITH VERTICAL COUNTERCURRENT TWO-PHASE FLOW
CONF-700522-1, (14P.) (IN FRENCH), AVAIL. TAC

09903 Ewers B J
A PARAMETRIC ANALYSIS OF A DEEP SEA RADIOISOTOPIC THERMOELECTRIC GENERATOR EMPLOYING A HEAT PIPE M.S. THESIS, NAVAL POSTGRADUATE SCHOOL, MONTEREY, CALIF. (AD-704790) (69 P.), AVAIL. TAC

09910 EWALD R PERROUD P
MEASUREMENTS OF FILM CONDENSATION HEAT TRANSFER COEFFICIENTS IN VERTICAL TUBES FOR NITROGEN, HYDROGEN AND DEUTERIUM CRYOGENIC ENGINEERING CONFERENCE, BOULDER, COLO. (CONF-700
HEAT PIPE TECHNOLOGY

628-1) 21 P., AVAIL. TAC

09920 FACKLER W C TRUMMEL J M
HEAT PIPE PERFORMANCE IN AN ARTIFICIAL GRAVITY FIELD
AIAA SIXTH THERMOPHYSICS Conf., APRIL 26-28, 1971 PAPER 71-419, AVAIL. TAC

10000 FARRAN R A STARNER K E
DETERMINATION OF WICKING PROPERTIES OF COMPRESSIBLE MATERIALS FOR HEAT PIPE APPLICATIONS
AIR FORCE REPORT NO. SAMSQ-TR-68-428, JULY 1968, AVAIL. TAC

10100 FARRAN R A STARNER K E
DETERMINING WICKING PROPERTIES OF COMPRESSIBLE MATERIALS FOR HEAT PIPE APPLICATIONS
ANNUAL AVIATION AND SPACE Conf., BEVERLY HILLS, CALIF., JUNE 16-19, 1968, PP. 659-669, AVAIL. TAC

10200 FELDMAN K T JR
ANALYSIS AND DESIGN OF HEAT PIPES

10300 FELDMAN K T JR WHITING G H
APPLICABILITY OF HEAT PIPES TO ENERGY CONVERSION SYSTEMS
SANDIA CORPORATION, AEROSPACE RADIOISOTOPE POWER, REPORT NO. SC-ARPIC-1012, JUNE 1969, AVAIL. TAC

10400 FELDMAN K T
WORKSHOP ON HEAT PIPE DESIGN AND ANALYSIS
UNIV. OF NEW MEXICO, APRIL 1968, AVAIL. TAC

10500 FELDMAN K T WHITING G H
APPLICATIONS OF THE HEAT PIPE
MECHANICAL ENGINEERING ASME, VOL. 90, NOV. 1968, PP. 48-53, AVAIL. TAC

10600 FELDMAN K T WHITLOW G L
EXPERIMENTS WITH A TWO-FLUID HEAT PIPE
PROC. OF THE 4TH INTERSOCIETY ENERGY CONVERSION ENG'G Conf.
WASHINGTON, D. C., PAPER NO. 699127, SEPT. 22-26, 1969, PP. 1025-1032, AVAIL. TAC

10700 FELDMAN K T WHITING G H

F.1-17
# Heat Pipe Technology

## The Heat Pipe

**Mechanical Engineering (ASME)**, FEB. 1967, pp. 30-33. Avail. TAC

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Authors</th>
<th>Title</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>10800</td>
<td>Ferrell J K, Johnson H R</td>
<td>The Mechanism of Heat Transfer in the Evaporator Zone of a Heat Pipe</td>
<td>ASME Paper 70-HE/SP/12, Avail. TAC</td>
</tr>
</tbody>
</table>
HEAT PIPE TECHNOLOGY

11600 FERRELL J K
Study of the Operating Characteristics of the Heat Pipe
9th Quarterly Progress Report (OR03411-9, Nov. 1, 1967)
Avail. TAC

11700 FERRELL J K
Study of the Operating Characteristics of the Heat Pipe
10th Quarterly Progress Report (OR03411-10, Feb. 20, 1968)
Avail. TAC

11800 FERRELL J K
Study of the Operating Characteristics of the Heat Pipe
11th Quarterly Progress Report (OR03411-11, April 1, 1968)
Avail. TAC

11900 FIEBELMANN P
Heat Pipes

12000 FIEBELMANN P
Neu H
RINALDINI C
A Heat Pipe Thermionic Reactor Concept
Proc. Second Intern'l Conf. on Thermionic Elec. Power
Generations, Stressa, Italy (A69-29172 14-03), May 27-31, 1968. Avail. TAC

12100 FLAHERTY R
Thermally Cascaded Thermoelectric Generator
(Patent Application) Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena,

12101 FORMAN R
Technique for the Direct Measurement of Thermal Conductivity
At High Temperatures by the Use of a Heat Pipe

12200 FRADKIN D B
Blackstock A W
ROEHLING D J
STRAITTON T F
WILLIAMS M
LIEWER K W
Experiments Using a 25kw Hollow Cathode Lithium Vapor Mpd
Arc Jet
HEAT PIPE TECHNOLOGY

12300 FRANK S SMITH J T TAYLOR K M HEAT PIPE DESIGN MANUAL MARTIN MARIETTA CORP. REPORT, MND-3288, FEB 1967 (DENVER, COLO.)

12400 FRANK S OPTIMIZATION OF A GROOVED HEAT PIPE ASME-ADVANCES IN ENERGY CONVERSION ENGRG., MIAMI, FLORIDA, AUG. 1967, PP. 833-842, AVAIL. TAC

12500 FRANK F G ANDERSON R C SMALL OUT-OF-PILE THERMIONIC CONVERTER LOS ALAMOS SCIENTIFIC LAB, NEW MEXICO 16 APRIL 1968 8 P. REFS (CONTRACT W-7405-ENG-36) (LA-3813), AVAIL. TAC


12700 FREIGGENS R A EXPERIMENTAL DETERMINATION OF WICK PROPERTIES FOR HEAT PIPE APPLICATIONS Proc. of th 4th INTERSOCIETY ENERGY CONVERSION ENGRG. CONF., WASHINGTON, D. C. SEPT. 22-26, 1968, PP. 888-897. AVAIL. TAC

12701 FREIGGENS R A ADVANCED HEAT PIPE THERMIONIC TECHNOLOGY - TOPICAL REPORT TASK 2 - DEVELOPMENT OF ADSORPTION RESERVOIR MARCH 1, 1969 - SEPT 30, 1969 (RCA CORP., LANCASTER, PA.) CONTRACT AT(30-1(-3979 (48P.) AVAIL TAC


12900 GALGWEN L S BARKER V A HEAT PIPE CHANNEL FLOW DISTRIBUTIONS ASME 69-HT-22 AVAIL. TAC

13101 GERRELS E E LARSON J W BRAYTON CYCLE VAPOR CHAMBER (HEAT PIPE) RADIATOR STUDY CONTRACT NAS3-10615, GESE-7030, FEB 1971, 279 P., AVAIL. TAC
HEAT PIPE TECHNOLOGY

13200 GILLOT R H NEU H
VAN ANDEL E
EURATOM'S ACTIVITY IN RADIOISOTOPE POWERED THERMOELECTRIC
AND THERMIONIC GENERATORS
INDUSTRIAL APPLICATIONS FOR ISOTOPIC POWER GENERATORS, PP.
461-82 PARIS, EUROPEAN NUCLEAR ENERGY AGENCY 1967. AVAIL.
TAC

13300 GRAUMANN D W
RESEARCH STUDY ON INSTRUMENT UNIT THERMAL CONDITIONING HEAT
SINK CONCEPTS
QUARTERLY PROGRESS REPORT JUNE 1 - AUG 31, 1966. CONTRACT
NAS8-11291 (NASA-CR82794, REPT. 66-1174, OPR-2) 24P. AVAIL.
TAC

13400 GRAUMANN D W
RESEARCH STUDY ON INSTRUMENT UNIT THERMAL CONDITIONING HEAT
SINK CONCEPTS
QUARTERLY PROGRESS REPORT, SEPT. 1 - NOV. 30, 1966 GARRETT
CORP., LOS ANGELES, CALIF. AIRESEARCH MANUFACTURING DIV.
CONTRACT NAS8-11291 (NASA-CR-89618, REPT-66-1491) 52 P.
AVAIL. TAC

13500 GRAY V H
THE ROTATING HEAT PIPE - A WICKLESS HOLLOW SHAFT FOR
TRANSFERRING HIGH HEAT FLUXES
ASME AND AIChE HEAT TRANSFER CONF., MINNIAPOLIS, MINN.,
(ASME PAPER 69-HT-19), AUG. 3-6, 1969. AVAIL. TAC

13501 GREGORY F C
AN INVESTIGATION OF NUCLEATE BOILING FROM MESH COVERED
SURFACES
M. S. THESIS, NAVAL POSTGRADUATE SCHOOL, MCINTEREY, CALIF.
(A0-709097) (64 P.), AVAIL. TAC

13600 GRIFFON E C
PINKEL B
GASEOUS-CORE REACTOR CONCEPT FOR ELECTRICAL POWER GENERATION
NUCLEAR APPLICATIONS AND TECHNOLOGY V. 8 NO. 4 APRIL 1970,
P. 355-70. AVAIL. TAC

13700 GROLL M
ZIMMERMANN P
PARAMETERS FOR THE ASSESSMENT OF HEAT CARRIERS IN HEAT PIPES
INST. KERNENERG, UNIV. STUTTGART, STUTTGART, GERMANY, CHEM.
-ING.-TECH. 1969, 41(24), 1294-1300 (GERMAN) AVAIL. TAC

13701 GROLL M
ZIMMERMANN P

F.1-21
HEAT PIPE TECHNOLOGY

MAXIMUM HEAT TRANSPORT OF OPTIMALLY DESIGNED HEAT PIPES
CHEMIE - ING. - TECHNIK 1970, 42 (15), 977-81 (IN GERMAN)
AVAIL TAC

13702 GROLL M ZIMMERMANN P
UNSTABLE OPERATING BEHAVIOR OF HEAT PIPES
CHEMIE - ING. - TECH. 1970, 42(16), 1031-4 (IN GERMAN)
AVAIL TAC

13800 GROSSE A V CAHILL J A
HIGH TEMPERATURE INORGANIC CHEMISTRY
TEMPLE UNIVERSITY RESEARCH INST., PHILADELPHIA, PENNSYLVANIA
CONTRACT (AT(30-1)-2082), (RTIV-1966-18, APRIL 8, NYO-2082-5
AVAIL. TAC

13900 GROVER G M
EVAPORATION-CONDENSATION HEAT TRANSFER DEVICE
U.S. PATENT NO. 3,229,759, JAN. 18, 1966

13901 GROVER G M BUSSE C A
CORON R J
THERMIONIC CONVERTER DEVICE
PATENT USA 3441752, 23 OCT. 1965 PUBLISHED 29 APRIL 1969.

14000 GROVER G M BOHDANSKY J
BUSSE C A
NUCLEAR REACTOR WITH THERMIONIC CONVERTER

14100 GROVER G M BOHDANSKY J
BUSSE C A
THE USE OF A NEW HEAT REMOVAL SYSTEM IN SPACE THERMIONIC
POWER SUPPLIES
EUROPEAN ATOMIC ENERGY COMMUNITY-EURATOM, REPORT NO. EUR
2229.E, 1965 AVAIL. TAC

14200 GROVER G M COTTER T P
ERICKSON G F
STRUCTURES OF VERY HIGH THERMAL CONDUCTANCE
AVAIL. TAC

14300 GROVER G M KEMME J E
KEDDY E S
ADVANCES IN HEAT PIPE TECHNOLOGY

P.1-22
HEAT PIPE TECHNOLOGY


14400 HALL W B
HEAT PIPE EXPERIMENTS
IEEE CONF. RECORD OF THE 1965 THERMIonic CONVERSION
AVAIL. TAC

14500 HALL W B, KESSLER S W
ADVANCES IN HEAT PIPE DESIGN
PROC. OF THE 20Th ANNUAL POWER SOURCES CONF., FORT MONMOUTH,
NEW JERSEY, MAY 1966, AVAIL. TAC

14501 HALL W B, KESSLER S W
THE DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE
WITH THERMIonic ENERGY CONVERTERS
RCA DIRECT ENERGY CONVERSION DPT. QUART. TECH. RPT. NO. 2,
MAY 1966.

14502 HALL W B, KESSLER S W
THE DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE
WITH THERMIonic ENERGY CONVERTERS
RCA DIRECT ENERGY CONVERSION DPT. QUART. TECH. RPT. NO. 3
JULY 1966

14503 HALL W B, KESSLER S W
THE DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE
WITH THERMIonic ENERGY CONVERTERS
RCA DIRECT ENERGY CONVERSION DPT. FINAL RPT., SEPT. 1966

14600 HALLER H C
ANALYSIS OF A DOUBLE FIN-TUBE FLAT CONDENSER-RADIATOR AND
COMPARISON WITH A CENTRAL FIN-TUBE RADIATOR
NASA TN D-2558, 1964, AVAIL. TAC

14700 HALLER H C, LIEBLEIN S
FEASIBILITY STUDIES OF SPACE RADIATORS USING VAPOR CHAMBER
FINS
PROC. OF JOINT ATOMIC ENERGY COMMISSIONS/SANDIA LAB. HEAT
PIPE CONF., VOL. 1, OCT. 1966, AVAIL. TAC

14800 HALLER H C, LIEBLEIN S
LINDOW B G
ANALYSIS AND EVALUATION OF A VAPOR-CHAMBER FIN-TUBE RADIATOR
FOR HIGH-POWER RANKINE CYCLES

F.1-23
# Heat Pipe Technology

NASA Lewis Research Center, NASA TN D-2836, Cleveland, Ohio, May 1965. Available TAC

## 14900 HALLER H C LINDOW B G

**Analysis of Low-Temperature Direct-Condensing Vapor-Chamber Fin and Conduction Fin Radiators**

Lewis Research Center, NASA TN D-3103, Cleveland, Ohio, May 1965. Available TAC

## 15000 HAMPEL V E KOOPMAN R P

**Reactivity Self-Control on Power and Temperature in Reactors Cooled by Heat Pipes**


## 15100 HARBAUGH W E

**The Development of an Insulated Thermionic Converter Heat Pipe Assembly**


## 15101 HARBAUGH W E

**Development of an Insulated Thermionic Converter Heat Pipe Assembly**

Quarter. Tech. Rpt. No. 2

## 15102 HARBAUGH W E

**Development of an Insulated Thermionic Converter Heat Pipe Assembly**

Quarter. Tech. Rpt. No. 3

## 15103 HARBAUGH W E

**Development of an Insulated Thermionic Converter Heat Pipe Assembly**

Quarter. Tech. Rpt. No. 4

## 15104 HARBAUGH W E

**Development of an Insulated Thermionic Converter Heat Pipe Assembly**


## 15200 HARBAUGH W E EASTMAN G Y

**Experimental Evaluation of an Automatic Temperature**

F.1-24
HEAT PIPE TECHNOLOGY

CONTROLLED HEAT PIPE
INTERSOCIETY ENERGY CONVERSION ENGRG. CONF., BOULDER, COLO.,
AUG. 13-17, 1968.

15300 HARBAUGH W E LONGSDERFF R W
THE DEVELOPMENT OF AN INSULATED THERMIONIC CONVERTER - HEAT
PIPE ASSEMBLY
IEEE CONF. RECORD OF THE 1566 THERMIONIC CONVERSION
SPECIALIST CONF., HOUSTON, TEXAS, NOV 3-4, 1966, PP.
139-143. AVAIL. TAC

15400 MARKNESS R E
THE GEOS-2 HEAT PIPE SYSTEM AND ITS PERFORMANCE IN TEST AND
IN ORBIT
APPLIED PHYSICS LAB., JOHN HOPKINS UNIV., REPORT NO. NASA-CR
107686, APRIL 1., 1968. AVAIL. TAC

15500 MARKNESS R E
PERFORMANCE OF THE GEOS-2 HEAT PIPE SYSTEM
APL TECHNICAL DIGEST, VOL. 9, MY, JN 1969, P 14-49. AVAIL.
TAC

15600 HASKIN W L
CRYOGENIC HEAT PIPE
AIR FORCE FLIGHT DYNAMICS LAB., WRIGHT-PATTERSON AFB, OHIO,
JUNE 1967. (FINAL REPORT) AVAIL TAC

15700 HEATH C A LANTZ E
A REACTOR CONCEPT FOR SPACE POWER EMPLOYING THERMIONIC
DIODES AND HEAT PIPE
AIAA, AERO. SCI. MEETING, 5TH, PAPER NO. 66-122, NEW YORK,

15800 HEATH C A LANTZ E
NUCLEAR THERMIONIC SPACE POWER SYSTEM CONCEPT EMPLOYING HEAT
PIES
LEWIS RESEARCH CENTER, NASA TN D-4299, CLEVELAND, OHIO,
MARCH 1968. AVAIL. TAC

15801 HICKOX O J
A STUDY OF WIRE MESH WICK CHARACTERISTICS IN A LONGITUDINAL
HEAT PIPE
M.S. THESIS, NAVAL POSTGRADUATE SCHOOL, MONTEREY, CALIF.
(AD-709108) (71 P.), AVAIL. TAC

P.1-25
HEAT PIPE TECHNOLOGY

15900 HINDERMAN J D MADSSEN J
WATERS E D
AN ATS-E SOLAR CELL SPACE RADIATOR UTILIZING HEATPIPES
AIAA, THERMO PHYSICS CONF. 4TH SAN FRANCISCO, CALIF. JUNE 16-
18, 1969 PAPER 65-630 7P., AVAIL. TAC

15901 HINDERMAN J D WATERS E D
KASER R V
DESIGN AND PERFORMANCE OF NONCONDENSIBLE GAS CONTROLLABLE
HEAT PIPES
AIAA SIXTH THERMO PHYSICS CONF., APRIL 26-28, 1971, PAPER 71-
4208 AVAIL. TAC

15910 HOLM F W
THERMAL SCALE MODELING OF A HEAT PIPE
PHD THESIS 1969, KANSAS STATE UNIVERSITY, MANHATTAN, KANSAS,
82 P., AVAIL. TAC

16000 HOLM F W MILLER P L
THERMAL SCALE MODELING OF A HEAT PIPE
ASME PAPER 70-HT/SPT-14 AVAIL. TAC

16001 HOLMGREN J S
PRELIMINARY PROGRAM PLAN HEAT PIPE PARAMETRIC DATA
MCDONNEL-DOUGLAS CO., RICHLAND, WASH. DONALD W. DOUGLAS LABS,
AUG. 1969 (22 P.), AVAIL. TAC

16100 HUFSCHEIDT W BURCK E
DIOLA G HOFFMANN H
LIQUID-VAPOR INTERACTION IN HEAT PIPES
WAERME-UND STOFFUEBERTRAGUNG VOL. 2 (1969) P. 222-239 (IN
GERMAN) AVAIL. TAC

16101 HUNSBERGER D L CHATO J C
EXPERIMENTAL INVESTIGATION OF THE PERFORMANCE OF VARIOUS
WICK CONFIGURATIONS IN SINGLE AND TWIN FLUID HEAT PIPES
OPERATING IN THE GRAVITATIONAL FIELD
GRANT NGR-14-005-103 (NASA-CR-111760, ME-TR-187), OCT. 1970,
46 P., AVAIL. TAC

16110 IVANOVSKII M N SOROKIN V P
SUBBOTIN V I SHUSTOV N V
INVESTIGATION OF HEAT AND MASS TRANSFER IN A HEAT PIPE WITH
A SODIUM COOLANT
HIGH TEMPERATURE (USSR, ENGL. TRANSL) VOL. 8, MAR.-APRIL
1970, P. 299-304, AVAIL. TAC
<table>
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<tr>
<th>HEAT PIPE TECHNOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>16200 JANSSEN M</td>
</tr>
<tr>
<td>VISCOS FLOW IN A RECTANGULAR CHANNEL HEAT PIPE WICK</td>
</tr>
<tr>
<td>LAWRENCE RAD. LAB., LIVERMORE, CALIF., UCID-15518 ALSO SPACE POWER NOTE NO. 105, NOV. 4, 1966. AVAIL. TAC</td>
</tr>
<tr>
<td>16300 JEFFERIES N P</td>
</tr>
<tr>
<td>FABRICATION AND TEST OF AN ALUMINUM HEAT PIPE</td>
</tr>
<tr>
<td>GENERAL ELECTRIC MEMO. REPORT HTC-7, GENERAL ELECTRIC CO., CINCINNATI, OHIO, FEB. 1967. AVAIL. TAC</td>
</tr>
<tr>
<td>16400 JOHNSON G D</td>
</tr>
<tr>
<td>COMPATIBILITY OF VARIOUS HIGH-TEMP. HEAT PIPE ALLOYS WITH WORKING FLUIDS</td>
</tr>
<tr>
<td>16600 JOHNSON G D</td>
</tr>
<tr>
<td>CORROSION STUDIES OF LIQUID METAL HEAT PIPE SYSTEMS AT 1000 TO 1800°C</td>
</tr>
<tr>
<td>METALLURGICAL SOCIETY OF AI ME, FALL MEETING, PHILADELPHIA, PA., OCT. 13-16, 1969. PAPER F69.2, 17P. AVAIL. TAC</td>
</tr>
<tr>
<td>16700 JOY P</td>
</tr>
<tr>
<td>OPTIMUM CRYOGENIC HEAT PIPE DESIGN</td>
</tr>
<tr>
<td>ADVANCED TECHNOLOGY LABS - DEFENCE ELECTRONIC PRODUCTS, RCA CAMDEN, N.J., ASME PAPER 70-HT/SPT-7. AVAIL. TAC</td>
</tr>
<tr>
<td>16800 JUDGE J F</td>
</tr>
<tr>
<td>RCA TEST THERMAL ENERGY PIPE</td>
</tr>
<tr>
<td>MISSILES AND ROCKETS, FEB. 21, 1966, PP. 36-38. AVAIL. TAC</td>
</tr>
<tr>
<td>16801 KALKBRENNER R W</td>
</tr>
<tr>
<td>HEAT TRANSFER DEVICE</td>
</tr>
<tr>
<td>16900 KATZOFF S</td>
</tr>
<tr>
<td>HEATPIPES AND VAPOR CHAMBERS FOR THERMAL CONTROL OF SPACECRAFT</td>
</tr>
<tr>
<td>PROC. OF THE AIAA THERMOPHYSICS SPECIALISTS CONF., AIAA PAPER NO. 67-310, NEW ORLEANS, LOUISIANA, APRIL 17-20, 1967. AVAIL. TAC</td>
</tr>
<tr>
<td>17000 KATZOFF S</td>
</tr>
</tbody>
</table>

F.1-27
HEAT PIPE TECHNOLOGY

NOTES ON HEAT PIPES AND VAPOR CHAMBERS AND THEIR APPLICATION TO THERMAL CONTROL OF SPACECRAFT
PROC. OF JOINT ATOMIC ENERGY COMMISSIONS/SANDIA LAB. HEAT PIPE CONF., VOL. I, OCT. 1966. AVAIL. TAC

17100 KEMME J E
HEAT PIPE CAPABILITY EXPERIMENTS
PROC. OF JOINT ATOMIC ENERGY COMMISSION/SANDIA LAB. HEAT PIPE CONF., VOL. I, ALBUQUERQUE, NEW MEXICO, OCT. 1966. AVAIL. TAC

17200 KEMME J E
HEAT PIPE CAPABILITY EXPERIMENTS
LOS ALAMOS SCIENTIFIC LAB. NEW MEXICO CONTRACT W-7405-ENG-36 (LA-3596-MS) AVAIL. TAC

17300 KEMME J E
HEAT PIPE CAPABILITY EXPERIMENTS

17400 KEMME J E
HIGH PERFORMANCE HEAT PIPE

17500 KEMME J E
HEAT PIPE DESIGN CONSIDERATIONS
LOS ALAMOS SCI. LAB. REPORT, LA-4221-MS, AUG 18 1969. AVAIL. TAC

17600 KEMME J E
ULTIMATE HEAT PIPE PERFORMANCE
IEEE THERMIIONIC CONVERSION SPECIALIST CONF., (7TH), FRAMINGHAM, MASS., OCT. 21-23, 1968, PP. 717-723. (IEEE TRANS. ELECTR DEV. AUG. 69) AVAIL. TAC

17700 KILMARTIN H E JR
THE EFFECT OF WICK GEOMETRY ON THE OPERATION OF A LONGITUDINAL HEAT PIPE
NAVAL POSTGRADUATE SCHOOL, M. S. THESIS, MONTEREY, CALIF., JUNE 1969. AVAIL. TAC

P.1-2R
HEAT PIPE TECHNOLOGY

17710 KIRKPATRICK J P MARCUS B D
A VARIABLE CONDUCTANCE HEAT PIPE FLIGHT EXPERIMENT
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971, PAPER 71-411, AVAIL. TAC

17800 KOEPPE A
EXPERIMENTS FOR SIMULATING HEAT TRANSFER FROM A REACTOR SURFACE TO CESIUM VAPOR CONVERTERS
STUTTGART UNIVERSITY (WEST GERMANY) FEB. 15, 1968, 17P, (IN GERMAN), AVAIL. TAC

17900 KOLACH T A
INVESTIGATION OF HEAT EXCHANGE WITH BOILING WATER DELIVERED TO THE HEATING SURFACE BY A CAPILLARY POROUS BODY AT LOW PRESSURES
17 DEC. 1969 18 P. REFS. TRANSL. INTO ENGLISH FROM INZH - FIX ZH. (MOSCOW), V. 14, JUNE 1958 P. 975-982. IN ENGLISH AND RUSSIAN (NLL-CE-TRANS-5048-(9022-09)) AVAIL. TAC

17901 KROEGER E W

17910 KOSOWSKI N KOSSON R
EXPERIMENTAL PERFORMANCE OF GROOVED HEAT PIPES AT MODERATE TEMPERATURES
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971, PAPER 71-409, AVAIL. TAC

18000 KUCHEROV R Y RIKENGLAZ L E
ON HYDRODYNAMIC BOUNDARY CONDITIONS FOR EVAPORATION AND CONDENSATION
SOVIET PHYSICS JETP VOL. 37 (10) NO. 1, JAN. 1960, P. 88-9 AVAIL. TAC

18100 KUNZ H R LANGSTON L S
HILTON B H WYDE S S
NASHICK G H
VAPOR-CHAMBER FIN STUDIES - TRANSPORT PROPERTIES AND BOILING CHARACTERISTICS OF WICKS
PRATT AND WHITNEY AIRCRAFT, NASA CR-812, EAST HARTFORD, CONN JUNE 1967, AVAIL. TAC

18200 KUNZ H R WYDE S S
F.I-29
HEAT PIPE TECHNOLOGY

NASHICK G H, BARNES J F
VAPOR-CHAMBER FIN STUDIES - OPERATING CHARACTERISTICS OF FIN MODELS
PRATT AND WHITNEY AIRCRAFT, NASA CR-1139, PWA-3154, EAST HARTFORD, CONN., JULY 1967. AVAIL. TAC

18201 Kuo S C Y
THERMOELECTRIC - BIOMEDICAL HEAT PIPE

18300 LANGSTON L, KUNZ H R
VAPOR-CHAMBER FIN STUDIES

18400 LANGSTON L S, KUNZ H R
LIQUID TRANSPORT AND HEAT TRANSFER PROPERTIES OF HEAT PIPE WICKING MATERIALS

18500 LANGSTON L S, KUNZ H R
LIQUID TRANSPORT PROPERTIES OF SOME HEAT PIPE WICKING MATERIALS
ASME AND AICHE HEAT TRANSFER CONF., MINNEAPOLIS, MINN., ASME PAPER 69-HT-17, AUG. 3-6, 1969. AVAIL. TAC

18600 LANGSTON L S, SHERMAN A
HILTON B H
VAPOR CHAMBER FIN STUDIES

18700 LANGSTON L S, SHERMAN A
HILTON B H
VAPOR-CHAMBER FIN STUDIES

18800 LARKIN B S
HEAT TRANSFER IN A TWO-PHASE THERMOSYPHON TUBE
CANADA NATIONAL RESEARCH COUNCIL, DIVISION OF MECHANICAL ENGINEERING
HEAT PIPE TECHNOLOGY

ENGINEERING AND NATIONAL AERONAUTICAL ESTABLISHMENT,
QUARTERLY PUBLICATION, NO. 3, 1967 P. 45-53, AVAIL TAC

18900 LAUE J H MCGINNESS H D
RECIRCULATION OF A TWO-PHASE FLUID BY THERMAL AND CAPILLARY PUMPING

19000 LAZARIDIS L J PANTAZELOS P G
TESTS ON FLAME HEATED THERMIONIC DIODE
PROC. ANNUAL POWER SOURCES CONF., 1966, AVAIL. TAC

19100 LEE J D WERNER R W
CONCEPT OF A GAS BUFFERED ANNULAR HEAT-PIPE FUEL IRRADIATION CAPSULE
UCRL-71889 (CONF-690910-1) 32 P., AVAIL. TAC

19200 LEE J D WERNER R W
CONCEPT OF A GAS BUFFERED ANNULAR HEAT PIPE FUEL IRRADIATION CAPSULE
LAWRENCE RADIATION LAB., REPORT NO. UCRL-50510, LIVERMORE, CALIF. 1968, AVAIL. TAC

19300 LEEFER B I
NUCLEAR-THERMIONIC ENERGY CONVERTER
NASA PROC. 20TH ANNUAL POWER SOURCES CONF., 1966, P. 172-175, AVAIL. TAC

19401 LEVEDAHLL W J
THERMIONIC CONVERTER ASSEMBLIES
BRITISH PATENT 1,182,799 (4 MAR. 1970) PRIORITY DATE 7 NOV. 1966 U.S.

19500 LEVY E K
THEORETICAL INVESTIGATION OF HEAT PIPES OPERATING AT LOW VAPOR PRESSURE
ANNUAL AVIATION AND SPACE CONF., BEVERLY HILLS, CALIF., JUNE 16-19, 1968, PP. 671-676, AVAIL. TAC

19501 LEVY E K CHOU S
VAPOR COMPRESSIBILITY EFFECTS IN HEAT PIPES
PROGRESS RPT. NO. 1, MAY 1970 (DPT MECH. ENGRG., LEHIGH UNIV., BETHLEHEM, PA) CONTRACT AT(30-1)-4095 TAC (NYO-4095-1), AVAIL. TAC

F.1-31
HEAT PIPE TECHNOLOGY

19510 LEVY E K
EFFECTS OF FRICTION ON THE SONIC VELOCITY LIMIT IN SODIUM HEAT PIPES
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971, PAPER 71-407, AVAIL. TAC

19600 LOEWE W E
INVESTIGATION OF PERFORMANCE OF AN OUT-OF-CORE THERMIONIC SPACE POWER SYSTEM
CALIF. UNIV., LIVERMORE, LAWRENCE RADIATION LAB. 18 MARCH 1968, 24 P. REFS. (UCRL-70984 CONF. 680802-5) AVAIL. TAC

19700 LOEWE W E
ANALYSIS OF AN OUT-OF-CORE THERMIONIC SPACE POWER SYSTEM
CALIF. UNIV., LIVERMORE, LAWRENCE RADIATION LAB., LIVERMORE CALIF. IEEE TRANSACTIONS ON AEROSPACE AND ELECTRONIC SYSTEMS VOL. AES-5, JAN. 1969, P. 58-65. 19 REFS. AVAIL. TAC

19800 LOEWE W E
OUT-OF-CORE THERMIONIC SPACE POWER
CALIF. UNIV., LIVERMORE, LAWRENCE RADIATION LAB., MARCH 8, 1968. CONTRACT W-7405-ENG.-48, 10 P. (CONF-680508-1), AVAIL. TAC

19900 LONGSDERFF R W
DEVELOPMENT OF THREE CONVERTER HEAT PIPE - THERMIONIC MODULE
IEEE TRANS. ON ELECT. DEVICES V. ED-16 N. 2, FEB. 1969, P. 259. AVAIL. TAC

20000 LONGSDERFF R W
ADVANCED HEAT PIPE THERMIONIC TECHNOLOGY - DEVELOPMENT OF HIGH VOLTAGE MODULE
RADIO CORP. OF AMERICA, REPORT NO. NYO-3979-1, LANCASTER, PA., FEB. 28, 1969, AVAIL. TAC

20001 LONGSDERFF R W
ADVANCED HEAT PIPE THERMIONIC TECHNOLOGY
DEVELOPMENT OF HIGH VOLTAGE MODULE
FINAL TECH. RPT. 1 MAY 1969 - 30 SEPT. 1969, RCA LANCASTER, PA. CONTRACT AT(30-1)-3979, (NYO-3979-3) (47P.), AVAIL. TAC

20100 LOPER D J
THE HEAT PIPE AND SOME POTENTIAL NAVAL APPLICATIONS
HEAT PIPE TECHNOLOGY

21000 MILLER P L HOLM F W
INVESTIGATION OF CONSTRAINTS IN THERMAL SIMILITUDE
VOL. 1, FINAL RPT SEPT. 1967 - SEPT. 1969 CONTRACT F33615-
68-C-1017 (AD700392, AFFDL-TR-69-91-VOL. 1) (107P.), AVAIL.
TAC

21001 MILLER P L HOLM F W
INVESTIGATION OF CONSTRAINTS IN THERMAL SIMILITUDE
VOL. 2, FINAL RPT SEPT. 1967 - SEPT. 1969 CONTRACT F33615-
68-C-1017 (AD700767, AFFDL-TR-69-91-VOL. 2) (100P.), AVAIL.
TAC

21100 MILLER P R JR WIEBELT J A
HEAT PIPES AND VAPOR CHAMBERS FOR THERMAL CONTROL OF
SPACECRAFT
NASA OFFICE OF TECH. UTILIZATION, JAN. 1968. (EDUCATIONAL
MONOGRAPH HT-8-67) AVAIL. TAC

21200 MILLERON W WOLGAST R
CRYOPUMPING OMNITRON ULTRA-VACUUM SYSTEM USING HEAT PIPES
AND METAL CONDUCTORS
IEEE TRANS. ON NUCLEAR SCIENCES V. NS-16 NO. 3, JUNE 1969
941-4 AVAIL. TAC

21300 MORITZ K
HEAT PIPE OF NEW CONSTRUCTION - THREADED ARTERY HEAT PIPE
CHEMIE-INGENIEUR-TECHNIC, VOL. 41, NO. 1-2, JAN. 17, 1969,
PP. 37-40. (IN GERMAN, TRANSL. AVAIL.) AVAIL. TAC

21400 MORITZ K PRUSCHEK P
LIMITATIONS OF ENERGY TRANSPORT IN HEAT PIPES
CHEMIE-INGENIEUR-TECHNIK, VOL. 41, NO. 1-2, JAN. 17, 1969,
PP. 30-37, (IN GERMAN, TRANSL. AVAIL.) AVAIL. TAC

21401 MORITZ K
ON THE EFFECTS OF CAPILLARY GEOMETRY ON OPTIMAL HEATING
SURFACE LOADS IN HEAT PIPES
PH.D. THESIS, TECHNISCHE HOCHSCHULE STUTTGART (WEST GERMANY)
27 OCT. 1969 (IN GERMAN TRANSL. AVAIL.) (107 P.), AVAIL. TAC

21500 MOSKVIN Y V FILLINNOV Y N
HEAT TUBES
HIGH TEMPERATURE, V. 7, N. 4, JULY - AUG. 1969, P 704-713
AVAIL TAC

F.1-34
HEAT PIPE TECHNOLOGY

21600 MOSS R A
NEUTRON RADIOGRAPHIC EXAMINATION OF VAPOR BUBBLE FORMATION
AS A LIMITATION ON PLANAR HEAT PIPE PERFORMANCE
THESIS (PRINCETON UNIVERSITY 1968)

21601 MOSS R A  KELLY A J
NEUTRON RADIOGRAPHIC STUDY OF LIMITING PLANAR HEAT PIPE
PERFORMANCE
INT. J. HEAT MASS TRANSFER, 13 491-502 (MAR. 1970) AVAIL. TAC

21700 MOUSSEZ C  MIHAIL A
THE HEAT PIPE AND THE THERMOSYPHON FOR COOLING GAS TURBINE
BLADES
SOCIETE NATIONALE D'ETUDE ET DE CONSTRUCTION DE MOTEURS
D'AVIATION, DIVISION ATOMIQUE, DEPARTEMENT ETUDES THERMIQUES,
PARIS, FRANCE, ENTROPIE SEP.-OCT 1966, P 102-109, AVAIL TAC

21800 KEAL L G
AN ANALYTICAL AND EXPERIMENTAL STUDY OF HEAT PIPES
TRW SYSTEMS REPORT NO. 99900-6114-R000 REDONDO BEACH,
CALIF., JAN. 1967, AVAIL. TAC

21900 NEU H
HEAT PIPES AND THEIR APPLICATION FOR NUCLEAR POWER SUPPLIES
IN SPACE
ATOMPRAXIS 12, APRIL - MAY 1966, PP. 220-224 (IN GERMAN)
AVAIL. TAC

21901 NEU H
HEAT PIPE - A NEW HEAT TRANSFER SYSTEM
SCHWEIZERISCHE TECHNISCHE ZEITSCHRIFT, VOL. 67, DEC. 17,
1970, P. 996-1001 (IN GERMAN), AVAIL. TAC

21910 NIEDERAUER G  LANTZ E
A SPLIT-CORE HEAT PIPE REACTOR FOR SPACE POWER APPLICATIONS
THERMIONIC CONVERSION SPECIALIST CONF., MIAMI, FLA., 26-29

22000 PARKER G H  HANSON J P
HEAT PIPE ANALYSIS
WESTINGHOUSE ELECTRIC CORP., INTERSOCIETY ENERGY CONVERSION
ENGRE CONF., MIAMI, 1967 ASME-ADVANCES IN ENERGY
CONVERSION ENGRE, AUG. 1967, PP. 647-857, AVAIL. TAC

22100 PEDERSEN E S

F.1-35
HEAT PIPE TECHNOLOGY

NEUTRONIC DESIGN OF A REACTOR CORE CONTAINING HEAT PIPES FOR APPLICATION TO A NUCLEAR AIRPLANE


23000 QUAST A THEORETICAL CONSIDERATIONS ON A VAPORIZATION COOLING SYSTEM WITH CAPILLARY DISTRIBUTOR DEUTSCHE VERSUCHSANSTALT FUR LUFT-UND RAUMFAHRT, BRUNSWICK (WEST GERMANY) INST FUR STRAHLANTRIEBE, DEC. 1967 23 P. REFS. IN GERMAN ENGLISH SUMMARY (DLR-FB-67-85), AVAIL. TAC


23200 RANKEN W A SUMMERS C S ISOTHERMAL IRRADIATION ASSEMBLY FOR STUDY OF FAST NEUTRON DAMAGE TO CERAMICS THERMIONIC CONVERSION SPECIALIST CONF., PALO ALTO, CALIF. 1967. AVAIL. TAC

23400 REICHLE L THE EFFECT OF GRAVITY ON HEAT TRANSFER IN HEAT PIPES DEUTSCHE GESELLSCHAFT FUR LUFT UND RAUMFAHRT, JAHRESTAGUNG, BREMEN, WEST GERMANY, SEPT. 22-24, 1969, PAPER 44. 21 P. 12 REFS. ALSO RAUMFAHRTFORSCHUNG V. 14, JAN.-FEB. 1970 P. 13-17, IN GERMAN, AVAIL. TAC

23401 REIMERS E CAPACITOR ENERGY STORAGE IMPROVEMENT BY MEANS OF HEAT PIPE 24TH POWER SOURCES SYMPOSIUM, ATLANTIC CITY, N.J. MAY 19-21, 1970, PROCEEDINGS P. 118-122, AVAIL. TAC
HEAT PIPE TECHNOLOGY

23500 REISS F SCHRETMANN K
PRESSURE BALANCE AND MAXIMUM POWER DENSITY AT THE
EVAPORATION GAINED FROM HEAT PIPE EXPERIMENTS:
PROC. SECOND INT. CONF. ON THERMIONIC ELECTR. POWER GENERATION
STRESA, ITALY, 1968, PP. 507-513. (EURNO. 4210 F E) AVAIL. TAC

23600 ROBERTS J J CROKE E J
DESIGN OF A 1 KWE FAST REACTOR POWER SUPPLY
ARGONNE NATIONAL LABORATORY, ARGONNE, ILL. IN ADVANCES IN
ENERGY CONVERSION ENGINEERING AMERICAN SOCIETY OF
MECHANICAL ENGINEERS INTERSOCIETY ENERGY CONVERSION
ENGINEERING CONF., MIAMI BEACH, FLA., AUGUST 13-17, 1967,
PAPERS. (A6742485 24-03) NEW YORK, AMERICAN SOCIETY OF
MECHANICAL ENGINEERS, 1967 P. 576-586. 25 REFS. AVAIL. TAC

23700 ROBERTS J J CROKE E J
CARTER R P NORDC J E
A HEAT-PIPE COOLED FAST REACTOR SPACE POWER SUPPLY
ARGONNE NATIONAL LAB., ILL REACTOR ENG. DIV. CONTRACT W-31
-109-ENG-38 (ANL-7422), AVAIL TAC

23800 ROBERTS J J CROKE E J
COMPACT POWER CONCEPT FEATURES A FAST REACTOR, HEAT PIPES,
AND DIRECT CONVERTERS
REACTOR FUEL-PROCESS TECH., VOL. 11, FALL. 1968, PP. 187-
200. AVAIL. TAC

23810 ROUKIS J ROGOVIN J
SWERDLING B
HEAT PIPE APPLICATIONS TO SPACE VEHICLES
AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971, PAPER 71-
410, AVAIL. TAC

23820 ROUSAR D C
HEAT PIPE TECHNOLOGY FOR ADVANCED ROCKET THRUST CHAMBERS
AEROJET LIQUID ROCKET CO., SACRAMENTO, CALIF., DEPT OF
ENGINE COMPONENTS, INTERIM RPT. 3 JAN. 1969 - 2 MAY 1970,
(CONTRACT NAS7-697), NASA-CR-110735, RPT. -697-1) (178 P.)
AVAIL. TAC

23821 ROUSAR D C
HEAT PIPE COOLED THRUST CHAMBERS FOR SPACE STORABLE
PROPELLANTS
AIAA PROPULSION JOINT SPECIALIST CONF., 6TH. SAN DIEGO JUNE
15-19, 1970, PAPER 70-942 (7 P.), AVAIL. TAC

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<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Authors</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>23900</td>
<td>Employment of Heat Pipes for Thermionic Reactors</td>
<td>RUEHLE R, STEINER D, DAGBJARTSSON S</td>
<td>ATOMKERN ENERGIE 10, SEPT.-OCT. 1965, PP. 399-404 (IN GERMAN) AVAIL. TAC</td>
</tr>
<tr>
<td>24000</td>
<td>A Study of a Nuclear Thermionic Propulsion System</td>
<td>SALMI E W</td>
<td>LOS ALAMOS SCIENTIFIC LAB., NEW MEXICO (1967) &amp; P. PRESENTED AT THE AM. INST. OF AERON. AND ASTRONAUTICS MEETING, NEW YORK (CONTRACT W-7405-ENG-36) (LA-DC-8482 CONF-670111-1) AVAIL. TAC</td>
</tr>
<tr>
<td>24200</td>
<td>Space Experiment Thermal Design</td>
<td>SCHACH M</td>
<td>NASA GODDARD SPACE FLIGHT CENTER. GREENBELT, MARYLAND. AVAIL. TAC</td>
</tr>
<tr>
<td>24300</td>
<td>Theoretical Considerations on Heat Transfer in Heat Pipes</td>
<td>SCHINDLER M, WOESSNER G</td>
<td>ATOMKERN ENERGIE, 10, SEPT.-OCT. 1965 (P. 395-398) (IN GERMAN) AVAIL. TAC</td>
</tr>
<tr>
<td>24400</td>
<td>Liquid Metals for Heat Pipes, Properties, Plots and Data Sheets</td>
<td>SCHINS H E J</td>
<td>EUROPEAN ATOMIC ENERGY COMMUNITY, EUR-3653, ISPRA, ITALY, SEP. 1967. AVAIL. TAC</td>
</tr>
<tr>
<td>24500</td>
<td>Determination of Loss of Pressure in Capillary Media Capable of Being Used in Heat Pipes</td>
<td>SCHMIDT E</td>
<td>CENTRE D'ETUDES NUCLEAIRES, NOTE TT NO. 265, APRIL 27, 1967. AVAIL. TAC</td>
</tr>
<tr>
<td>24600</td>
<td>Theoretical and Experimental Determination of the Limiting Heat Power Transported by Sodium Heat Pipes</td>
<td>SCHMIDT E, SEMERIA R</td>
<td>PROC. SECOND INT. CONF. ON THERMIONIC ELECT. POWER GENERATION, STRESA, EUR 4210, 1968, P. 515. (IN FRENCH), AVAIL. TAC</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
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<tr>
<td></td>
<td></td>
<td>CALIF. UNIV., LOS ALAMOS SCIENTIFIC LAB., LOS ALAMOS, NEW MEXICO AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS, PROPULSION JOINT SPECIALIST CONF. 3RD, WASHINGTON, D.C., JULY 17-21, 1967, PAPER 67-498, 7P. AVAIL. TAC</td>
<td></td>
</tr>
<tr>
<td>24800</td>
<td>SCHULMAN F</td>
<td>ISOTOPES AND ISOTYPE THERMOELECTRIC GENERATORS</td>
<td>67027 B.3-01</td>
</tr>
<tr>
<td></td>
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<td>IN NASA LEWIS RES. CENTRE SPACE POWER SYSTEMS ADVANCED TECHNOLOGY CONF. 1966, P. 73-93. AVAIL. TAC</td>
<td></td>
</tr>
<tr>
<td>24900</td>
<td>SCHWARTZ J</td>
<td>PERFORMANCE MAP OF AN AMMONIA HEAT PIPE</td>
<td>70088 E-09</td>
</tr>
<tr>
<td></td>
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<td>JET PROPULSION LAB., CALIF. INST. TECH., PASADENA, CALIF. ASME PAPER 70-HT/SPT-5 AVAIL. TAC</td>
<td></td>
</tr>
<tr>
<td>25000</td>
<td>SCHWARTZ J</td>
<td>THE HEAT PIPE AND ITS OPERATION</td>
<td>69005 A-03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JET PROPULSION LAB., CALIF. INST. OF TECH., PASADENA, CALIF. REPT 701-21, JAN. 31, 1969. AVAIL. TAC</td>
<td></td>
</tr>
<tr>
<td>25100</td>
<td>SCHWARTZ J</td>
<td>PERFORMANCE MAP OF THE WATER HEAT PIPE AND THE PHENOMENON OF NONCONDENSIBLE GAS GENERATION</td>
<td>69097 E-06</td>
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<td>ASME 69-HT-15. AVAIL. TAC</td>
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<tr>
<td></td>
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<td>AIAA SIXTH THERMOPHYSICS CONF., APRIL 26-28, 1971, PAPER 71-412, AVAIL. TAC</td>
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<tr>
<td>25200</td>
<td>SEMERIA R</td>
<td>HEAT PIPES FOR THERMIonic CONVERTER WITH ISOTOPIC FUEL</td>
<td>67020 B.2-05</td>
</tr>
<tr>
<td></td>
<td>SCHMIDT E</td>
<td>INDUSTRIAL APPLICATIONS FOR ISOTOPIC POWER GENERATORS. EUROPEAN NUCLEAR ENERGY AGENCY, PARIS, FRANCE, 1967, PP. 399-409. (IN FRENCH) AVAIL. TAC</td>
<td></td>
</tr>
<tr>
<td>25300</td>
<td>SEMERIA R</td>
<td>ANALYTICAL AND EXPERIMENTAL STUDY OF SODIUM HEAT PIPES</td>
<td>69054 C.1-04</td>
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<td>25400</td>
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<td>SHISHINA V</td>
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<td></td>
</tr>
</tbody>
</table>
HEAT PIPE TECHNOLOGY

(TERMOREGUL-IROVANIE) AVIATSIIA I KOSMONAVTIKA - JAN. 1970, P. 26-27. AVAIL. TAC

25500 SHEFSIEK P K THERMAL MEASUREMENTS ON A THERMIONIC-CONVERTER - HEAT PIPE SYSTEM THERMIONIC CONVERSION SPECIALIST CONF., HOUSTON, TEXAS, 1966. AVAIL. TAC

25600 SHEFSIEK P K ERNST D M HEAT PIPE DEVELOPMENT FOR THERMIONIC APPLICATIONS PROC. OF THE 4TH INTERSOCIETY ENERGY CONVERSION ENGRG. CONF., WASHINGTON, D.C. SEPT. 22-26, 1969, PP. 879-887. AVAIL. TAC


25800 SHLOSINGER A P HEAT PIPES FOR SPACE SUIT TEMPERATURE CONTROL ANNUAL AVIATION AND SPACE CONF., BEVERLY HILLS, CALIF., JUNE 16-19, 1968, PP. 644-648. AVAIL. TAC

25900 SHLOSINGER A P ADVANCEMENTS OF SPACE SUIT TEMPERATURE CONTROL TECHNOLOGY BY APPLICATION OF MODIFIED HEAT PIPES AIAA THERMOPHYSICS CONF. 4TH SAN FRANCISCO, CALIF., JUNE 16-18, 1969. PAPER 69-619 9P. AVAIL. TAC

26000 SHLOSINGER A P HEAT PIPE DEVICES FOR SPACE SUIT TEMPERATURE CONTROL RESEARCH REPORT 30 JUNE 1966 1 SEPT. 1968, TRW SYSTEMS GROUP REDONDO BEACH, CALIF., CONTRACT NO. NAS2-3817 NASA-CR-1400, TRW-046462-6005-R0-00 AVAIL. TAC

26100 SHLOSINGER A P STUDY OF PASSIVE TEMPERATURE AND HUMIDITY CONTROL SYSTEMS

F.1-41
HEAT PIPE TECHNOLOGY

FOR ADVANCED SPACE SUITS
TRW SYSTEMS REPORT NO. 06462-6002-R000, CONTRACT NO. NAS 2-3817. (NASA CR-73168) AVAIL. TAC

26101 SHLOSINGER A P WOOD W CAFARO C BENTILLA E W
TECHNOLOGY STUDY OF PASSIVE CONTROL OF HUMIDITY IN SPACE SUITS
79 P. AVAIL. TAC

26200 SHROFF A M ARMAND M
THE HEAT PIPE
REVIEW TECHNIQUE THOMPSON CSF VOL. I, DEC. 69, P. 611-648.
(IN FRENCH), AVAIL. TAC

26300 SILVERSTEIN C C
A STUDY OF HEAT PIPE APPLICATIONS IN NUCLEAR AIRCRAFT PROPULSION SYSTEMS
AVAIL. TAC

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HEAT PIPE GAS TURBINE REGENERATORS
ASME PAPER 68-WA/GT-7 WINTER ANNUAL MEETING
AVAIL. TAC

26500 SILVERSTEIN C C
PRELIMINARY EVALUATION OF GAS TURBINE REGENERATORS EMPLOYING HEAT PIPES
FINAL TECH. REPORT AD-671-028, APRIL 1968. AVAIL. TAC

26501 SOCKOL P M FORMAN R
REEXAMINATION OF HEAT PIPE STARTUP

26600 SOLIMAN M M GRAUMANN D W BERENSON P J
EFFECTIVE THERMAL CONDUCTIVITY OF DRY AND LIQUID-SATURATED SINTERED FIBER METAL WICKS
AIRSEARCH MANUF. CO., LOS ANGELES, CALIF., ASME PAPER 70-HT/SPT-40 AVAIL. TAC

26700 STENGER F J

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EXPERIMENTAL FEASIBILITY STUDY OF WATER-FILLED CAPILLARY-PUMPED HEAT TRANSFER LOOPS

26800 STEPHANOU S E WARD T E HOLMGREN J S
APPLICATION OF HEAT PIPE TECHNOLOGY TO ROCKET ENGINE COOLING
AMER. INST. OF AER. AND ASTRO. PROPULSION JOINT SPECIALIST
5TH U. S. AF ACADEMY, PAPER NO. 69-582, COLO. SPRINGS, COLO. (J. SPACECRAFT & ROCKETS 7 748-50, JUNE 1970) AVAIL. TAC

26900 STRATTON A A WALKER W N
A SHORT STUDY OF CAPILLARY ACTION IN BOILING WATER HEAT TRANSFER THROUGH POROUS MEDIA
CENTRAL ELECTRICITY GENERATION BOARD, LONDON, ENGLAND.
RESEARCH AND DEVELOPMENT DEPT., JULY. 1969 17 P. (RD/B/N-1356) AVAIL. TAC

27000 STRECKERT J H CHATO J C
DEVELOPMENT OF A VERSATILE SYSTEM FOR DETAILED STUDIES ON THE PERFORMANCE OF HEAT PIPES
NASA CR-100725, AVAIL. TAC

27100 THURMAN J L INGRAM E H
APPLICATION OF HEAT PIPES TO REDUCE CRYOGENIC BOIL-OFF IN SPACE
J. OF SPACECRAFT & ROCKETS, VOL. 6, NO. 3, MARCH 1969, PP. 319-321, AVAIL. TAC

27101 THURMAN J L MEI S
APPLICATION OF HEAT PIPES TO SPACECRAFT THERMAL CONTROL PROBLEMS
BROWN ENGRG CO., INC., HUNTSVILLE, ALA. RES. LABS. CONTRACT NAS8-20073, NASA-CR-109991, TN-AST-275, (102P.), AVAIL. TAC

27200 TIEN C L
TWO-COMPONENT HEAT PIPES
AIAA THERMOPHYSICS CONF., AIAA PAPER NO. 69-631, BERKELEY, CALIF., JUNE 1969. AVAIL. TAC

27300 TURNER R C
THE CONSTANT TEMPERATURE HEAT PIPE - A UNIQUE DEVICE FOR THE THERMAL CONTROL OF SPACECRAFT COMPONENTS

F.1-43
HEAT PIPE TECHNOLOGY

AIAA THERMOPHYSICS CONF., 4TH, PAPER NO. 69-632 SAN FRANCISCO, CALIF., JUNE 16-18, 1969. AVAIL. TAC

27400 TURNER R C
DESIGN OF A 50000 WATT HEAT PIPE SPACE RADIATOR
ANNUAL AVIATION AND SPACE CONF., BEVERLY HILLS, CALIF., JUNE 16-19, 1968. PP. 639-643. AVAIL. TAC

27500 VAN ANDEL E
HEAT PIPE DESIGN THEORY
INTERN'L CONF. ON THERMONIC FLEC. POWER GENERATION, 2ND, PROC. A69-29172 14-03, STRESA, ITALY, MAY 27-31, 1968. AVAIL. TAC

27600 VIDAL C P
HEAT PIPE OVEN - A NEW WELL-DEFINED METAL VAPOR DEVICE FOR SPECTROSCOPIC MEASUREMENTS
NATIONAL BUREAU OF STANDARDS, BOULDER, COLORADO 80302 J. OF APPL. PHYSICS, VOL. 40, NO. 8, JULY 1969, P. 3370-3374. AVAIL. TAC

27700 WATERS F D
COMPATIBILITY EVALUATION OF AN AMMONIA-ALUMINUM-STAINLESS STEEL HEAT PIPE
DONALD W. DOUGLAS LAB., MCDONEL DOUGLAS CORP., RICH, WASH. ASME PAPER 70-HT/SPT-15 AVAIL. TAC

27800 WATTS J L
A HEAT-PIPE OPTIMIZATION CODE, LAW2
LAWRENCE RAD. LAB., UCID-15462, UNIV. OF CALIF., LIVERMORE, CALIF. ALSO SPACE POWER NOTE 159, APRIL 2, 1969. AVAIL. TAC

27900 WATTS J L
ANNUAL HEAT PIPE THEORY
LAWRENCE RAD. LAB., UCID-15519, UNIV. OF CALIF., LIVERMORE, CALIF. ALSO SPACE POWER NOTE NO. 163, NOV. 17, 1966. AVAIL. TAC

28000 WEAVER C V
RANKEN W A
DEVELOPMENT AND FEASIBILITY TESTS OF ISOThERMAL IRRADIATORS
LOS ALAMOS SCIENTIFIC LAB., NEW MEXICO, (CONF-690910 - PP. 184-96). AVAIL. TAC

P.1-44
HEAT PIPE TECHNOLOGY

29100 WERNER R W
THE MODULE APPROACH TO BLANKET DESIGN - A VACUUM WALL FREE BLANKET USING HEAT PIPES
CALIF. UNIV., LIVERMORE, LAWRENCE RAD. LAB., AUG. 13, 1969. 38 P. REF. (UCRL-71758 CONF-690901-2) AVAIL. TAC

28200 WERNER R W
CARLSON G A
HEAT PIPE RADIATOR FOR SPACE POWER FOR A 50-MWT SPACE POWER PLANTS
LAWRENCE RAD. LAB., UCRL-50294, LIVERMORE, CALIF., JUNE 1967
AVAIL. TAC

28300 WERNER R W
CARLSON G A
HEAT PIPE RADIATOR FOR SPACE POWER PLANTS
IEEE TRANSACTIONS ON AERO. & ELEC. SYSTEMS, PAPER NO. 689068
NEW YORK, NEW YORK, Aug. 1568, PP. 487-503. (ALSO UCRL-71004, MAY 16, 1968, AVAIL. TAC

28400 WERNER R W
SOME OPERATING LIMITS ON HEAT PIPES
LAWRENCE RAD. LAB., UNIV. OF CALIF., LIVERMORE, SPACE POWER NOTE NO. 293, APRIL 3, 1968, AVAIL. TAC

28401 WHITEHURST C A
WHITEHOUSE G D
RICHARDSON J W
THE EFFECT OF LONGITUDINAL VIBRATION ON HEAT PIPE PERFORMANCE
J. OF THE ASTRONAUTICAL SCIENCES, VOL. 17, MAR-APRIL 1970
(P.249-266) AVAIL. TAC

28410 WILLIAMS R M
A DESIGN OPTIMIZATION OF AN OUT-OF-CORE THERMIonic CONVERTER

28500 WILSON A J
ADVANCED RANKINE CYCLE PROVIDES BASIC TECHNOLOGY FOR OTHER POWER PLANTS AS WELL
AICF, INTERSOCIETY ENERGY CONVERSION ENGG. CONFERENCE, 4TH WASHINGTON DC, SEPT. 23-26, 1965, PAPER 11 C. 15 P. AVAIL.
TAC

28501 WILSON W E
AN ANALYSIS OF THE HEAT PIPE AS A HEAT SINK FOR SOLID-STATE RADIOFREQUENCY SOURCES

F.1-45
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IEEE TRANSACTIONS ON ELECTRONIC DEVICES VOL. ED-17, NO. 11, NOV. 1970 P. 1013-1014 AVAIL. TAC

28600 WOO W
STUDY OF PASSIVE TEMPERATURE AND HUMIDITY CONTROL SYSTEMS FOR ADVANCED SPACE SUITS
MATERIALS RESEARCH REPORT 1 JULY 1967-1 SEPT., 1968, TRW SYSTEMS GROUP, REDONDO BEACH, CALIF. CONTRACT NAS23817 (NASA -CR-73271, TRW-06462-6007-R000) 72 P., AVAIL. TAC

28800 WYATT T
A CONTROLLABLE HEAT PIPE EXPERIMENT FOR THE SE-4 SATELLITE
APPLIED PHYSICS LAB., REPORT 5DO-1134, JOHN HOPKINS UNIV., MARCH 1965, AVAIL. TAC

28900 YINGST T E
HIGH POWER GRIDDED TUBES - 1968
RCA ELECTRONIC CORPORATION, LANCASTER, PA. AVAIL. TAC

29000 ZIELENBACH W J MILLER N E
ACHIEVING UNIFORM SPECIMEN TEMPERATURES IN AN IRRADIATION CAPSULE USING HEAT PIPES
BATTLE MEMORIAL INST., COLUMBUS, OHIO CONF.-690910-, PP. 157-64, AVAIL. TAC

29001 ZIMMERMANN P GROLL M
HEAT PIPES IN SATELLITE TECHNOLOGY
RAUMFAHRTFORSCHUNG VOL. 14, SEPT.-OCT. 1970 P. 189-192 (IN GERMAN), AVAIL. TAC

29100 ZWICK F B
SECONDARY POWER SPACE/AERONAUTICS VOL. 52, JULY 69, PP. 143-148, 150, AVAIL. TAC

29200 ADVANCED REACTOR TECHNOLOGY QUARTERLY STATUS REPORT - ART LA-3244-MS FOR PERIOD ENDING JANUARY 31, 1965, AVAIL. TAC

29300 ADVANCED REACTOR TECHNOLOGY QUARTERLY STATUS REPORT - ART LA-3316-MS FOR PERIOD ENDING APRIL 30, 1965, AVAIL. TAC

29400 ADVANCED REACTOR TECHNOLOGY QUARTERLY STATUS REPORT - ART LA-3370-MS FOR PERIOD ENDING JULY 31, 1965, AVAIL. TAC

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29500 ADVANCED REACTOR TECHNOLOGY QUARTERLY STATUS REPORT - ART LA-3431-MS FOR PERIOD ENDING OCTOBER 31, 1965. AVAIL. TAC
66019 C.1-01

29600 ADVANCED REACTOR TECHNOLOGY QUARTERLY STATUS REPORT - ART LA-3482-MS FOR PERIOD ENDING JANUARY 31, 1966. AVAIL. TAC
66020 C.1-01

29700 ADVANCED REACTOR TECHNOLOGY QUARTERLY STATUS REPORT - ART LA-3524-MS FOR PERIOD ENDING APRIL 30, 1966. AVAIL. TAC
66021 C.1-02

29800 ADVANCED REACTOR TECHNOLOGY QUARTERLY STATUS REPORT - ART LA-3625-MS FOR PERIOD ENDING OCTOBER 31, 1966. AVAIL. TAC
67058 E-02

29900 ADVANCED REACTOR TECHNOLOGY QUARTERLY STATUS REPORT - ART LA-3708-MS FOR PERIOD ENDING APRIL 30, 1967. AVAIL. TAC
67061 E-02

30000 ADVANCED REACTOR TECHNOLOGY QUARTERLY STATUS REPORT - ART LA-3760-MS FOR PERIOD ENDING JULY 31, 1967. AVAIL. TAC
67062 E-02

30100 ADVANCED SPACE NUCLEAR POWER PROGRAM
QUART. RPT. JULY - SEPT. 1967. LAWRENCE RAD. LAB. CALIF. UNIV., LIVERMORE. (UCRL-50004-67-31), AVAIL. TAC
68022 B.4-01

30200 APPLICATION OF HEAT PIPES TO THE SNAP-19 HEAT REJECTION SYSTEM
MARTIN MARIETTA CORP., REPORT NO. MND-5181, BALTIMORE, MARYLAND. OCT. 1966. AVAIL. TAC
66016 B.3-01

30400 CASCaded THERMoelectric TEST GENERATOR
PHASE 2 QUART. PROGRESS RPT., 1 DEC. 1968 - 28 FEB. 1969.
WESTINGHOUSE ELECTRIC CORP., PITTSBURGH, PA., ASTRONUCLEAR LAB. 28 FEB. 1969 18 P. PREPARED FOR JPL (CONTRACTS NAS7-100 JPL-952196) (NASA-CR-107775, WANL-PD (DDD)-005) AVAIL. TAC
69013 B.2-08

30500 DEMONSTRATION OF OPERATION OF ROTATING HEAT PIPES
NASA LEWIS RESEARCH CENTER BULLETIN (4/16/70) AVAIL. TAC
70099 E-09

30600 DESIGN AND FABRICATION OF ADVANCED THERMIONIC CONVERTERS
FINAL REPORT THERMO ELECTRON ENG. CORP., WALTHAM, MASS., NOV. 1968. 408 P. PREPARED FOR JPL. (CONTRACTS NAS7-100, JPL-951239) (NASA-CR-165322, 7E4055-65-69) AVAIL. TAC
69016 B.2-09

F.1-47
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30700 DEVELOPMENT OF A FLAME FIRED THERMIONIC GENERATOR
SUMMARY TECH. REPORT 15 MARCH 1965 - 15 APRIL 1966. ERDL-9987-2, AD 634538, AVAIL. TAC

30800 HEAT PIPE THERMIONIC CONVERTER DEVELOPMENT
THERMO ELECTRON ENG. CORP., WALTHAM, MASS. QUARTERLY REPORT, JUN 16-OCT. 12, 1967. (CONTRACTS NAS7-100, JPL-951465) (NASA-CR-91437; TE-4067-44-68) AVAIL. TAC

30900 HEAT PIPE THERMIONIC CONVERTER DEVELOPMENT

31000 HEAT PIPE TRANSFERS HEAT WITH NEARLY UNIFORM TEMPERATURE
WESTINGHOUSE R & D LETTER, MARCH 69. AVAIL. TAC

31100 HEAT PIPE - A UNIQUE AND VERSATILE DEVICE FOR HEAT TRANSFER APPLICATIONS
RADIO CORP. OF AMERICA, DIRECT ENERGY CONVERSION DEPT., LANCASTER, PA., RFF. 994-615. (17 P) AVAIL TAC

31200 INTERNATIONAL CONFERENCE ON THERMIONIC ELECTRICAL POWER GENERATION

31301 ISOTOPE KILOWATT PROGRAM
ORNL QUART. PROC. RPT. JUNE 30, 1970. CONTRACT W-7402-ENG-26 (268P.), AVAIL. TAC

31402 LARGE TELESCOPE EXPERIMENT PROGRAM - LTFP

31500 MACCAP

31600 PROCEEDINGS OF JOINT ATOMIC ENERGY COMMISSION - SANDIA LAB

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HEAT PIPE CONFERENCE
VOL. 1, SPACE ISOTOPE POWER DEPT., SANDIA LAB., OCT. 1, 1966
AVAIL. TAC

31700 RADIOISOTOPE THERMOELECTRIC GENERATOR EMPLOYS HEAT PIPE
WESTINGHOUSE ENGINEER, MAY 1969. AVAIL. TAC

31800 REACTOR, SYSTEM AND COMPONENT ENGINEERING
CALIF. UNIV., LIVERMORE (LAWRENCE RAD. LAB.) UCRL-50004-67-1
PP. 47-82. AVAIL. TAC

31900 SOLAR THERMIonic GENERATOR DEVELOPMENT
THERMO ELECTRON ENG. CORP., WALTHAM, MASS. QUARTERLY REPORT,
MARCH 1-MAY 31, 1968 CONTRACTS NASA-100, JPL-951263, 32P.
NASTA-CR-95980, TE-4055-176-68 QR-10). AVAIL. TAC

32000 SPACE ELECTRIC POWER RESEARCH AND DEVELOPMENT
LOS ALAMOS SCIENTIFIC LABORATORY REPORT, NEW MEXICO
LA-3881-MS FOR PERIOD ENDING JANUARY 31, 1968. AVAIL. TAC

32100 SPACE ELECTRIC POWER RESEARCH AND DEVELOPMENT
LA-3941-MS FOR PERIOD ENDING APRIL 30, 1968. AVAIL. TAC

32200 SPACE ELECTRIC POWER RESEARCH AND DEVELOPMENT
LA-3986 FOR PERIOD ENDING JULY 31, 1968. AVAIL. TAC

32300 SPACE ELECTRIC POWER RESEARCH AND DEVELOPMENT
LA-4039 FOR PERIOD ENDING OCT 31, 1968. AVAIL. TAC

32400 SPACE ELECTRIC POWER RESEARCH AND DEVELOPMENT
LA-4109-MS FOR PERIOD ENDING JANUARY 31, 1969. AVAIL. TAC

32501 SPACE ELECTRIC POWER R AND D PROGRAM
QUART. STATUS RPT., 31 JAN 1970, (CONTRACT W-7405-ENG-36)
LA-4374; LOS ALAMOS SCIENT. LAB. (SP.), AVAIL. TAC

32602 SPACE ELECTRIC POWER R AND D PROGRAM
QUART. RPT. APRIL 30, 1970 (PARTI) LASL CONTRACT W-7405-ENG-36 (LA-4446), (SP.), AVAIL. TAC

32700 SPACECRAFT POWER
JET PROPULSION LAB., CALIF. INST. OF TECH. PASADENA SPACE

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PROGRAMS SUMMARY NO. 37-45 VOL. 4  30 JUNE 1967 P. 22-41
AVAIL. TAC

32800  THE DEVELOPMENT OF A FLAME FIRED THERMICNIC GENERATOR
INTERIM TECHNICAL REPORT NO. 1, 15 MAR. - 15 OCT. 1965.
RADIO CORP. OF AMERICA, LANCASTER, PA., DIRECT ENERGY
CONVERSION DEPT., (1965) 76 P. REFS. (CONTRACT DA-44-009-AMC-
998(T)) (ERDL-998T-1 AD629762), AVAIL. TAC

32900  THE GEOS-2 HEAT PIPE SYSTEM AND ITS PERFORMANCE IN TEST AND
IN ORBIT
CONTRACT NOW-62-0604-C), NASA-CR-94565, S2P-3-25, 29 APRIL
1968, 30 P. AVAIL. TAC

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05400 PE LIFE TESTS AT 1500 DEGREES C AND 1000 DEGREES C = HEAT PI
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03300 UID EARTH ALKALINE METALS MG, CA, S, BA = VENITITY OF THE LIQ
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11400 PE = STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE 67041 C.4-02
11600 PE = STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE 68048 E-03
11100 PE = STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE 70051 C.2-02
11700 PE = STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE 68029 C.3-01
11800 PE = STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE 68049 E-03
11300 PE = STUDY OF THE OPERATING CHARACTERISTICS OF THE HEAT PIPE 67059 E-02
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18100 NSPORT PROPERTIES AND BoILING CHARACTERISTICS OF WICKS = /TRA 67053 D.2-02
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14600 E FLAT CONDENSER-RADIATOR AND COMPARISON WITH A CENTRAL FIN- 65003 B.1-01
27700 AMMONIA-ALUMINUM-STAINLESS COMPATIBILITY EVALUATION OF AN 70078 B.3-02
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19100 LAR HEAT PIPE FUEL IRRADIATION CONCEPT OF A GAS BUFFERED ANN 69053 B.4-03
01200 UCLEAR THERMIIONIC SPACE POWER CONCEPT USING ROD CONTROL AND 69014 B.2-08
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04010 FEEDBACK CONTROLLED VARIABLE CONDUCTANCE HEAT PIPE= /Y OF A
02501 FEEDBACK CONTROLLED VARIABLE CONDUCTANCE HEAT PIPE= /Y OF A
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09710 ON, AND TESTING OF A VARIABLE CONDUCTANCE HEAT PIPE FOR EQUI
14200 RUCTURES OF VERY HIGH THERMAL CONDUCTANCE=
14900 DENSING VAPOR-CHAMBER FIN AND CONDUCTION FIN RADIATORS= /CON
12101 DIRECT MEASUREMENT OF THERMAL CONDUCTIVITY AT HIGH TEMPERATU
26600 -SATURATED/ EFFECTIVE THERMAL CONDUCTIVITY OF DRY AND LIQUID
21200 FM USING HEAT PIPES AND METAL CONDUCTORS= /ULTRA-VACUUM SYST
31200 RICAL POWER GE/ INTERNATIONAL CONFERENCE ON THERMIONIC ELECT
31600 ISSION - SANDIA LAB HEAT PIPE CONFERENCE= /THERMIONIC ENERGY COMM
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23000 ON COOLING SYSTE/ THEORETICAL CONSIDERATIONS ON A VAPORIZATI
24300 R IN HEAT PIPES= THEORETICAL CONSIDERATIONS ON HEAT TRANSFE
17500 HEAT PIPE DESIGN CONSIDERATIONS=
27300 - A UNIQUE DEVICE FOR T/ THE CONSTANT TEMPERATURE HEAT PIPE
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21001 INVESTIGATION OF CONSTRAINTS IN THERMAL SIMILIT
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02700 HEAT PIPE= HEAT PIPE OF NEW CONSTRUCTION - THREADED ARTERY
22000 CNIC DESIGN OF A REACTOR CORE CONTAINING HEAT PIPES FOR APPL
08001 MATION OF NICKEL HEAT PIPES CONTAINING POTASSIUM= EXA
06700 CRAFT THERMAL CONTROL= A CONTINUOUS HEAT PIPE FOR SPACE
01200 SPACE POWER CONCEPT USING ROD CONTROL AND HEAT PIPES= /CNIC
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25700 THEIR APPLICATION TO THERMAL CONTROL OF HUMIDITY IN SPACE S
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16900 ND VAPOR CHAMBEPS FOR THERMAL CONSTRUCTION AND TEST OF A FLE
27101 T PIPES TO SPACECRAFT THERMAL CONTROL PROBLEMS= /ION OF HEA
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02600 HEAT PIPES FOR TEMPERATURE CONTROL=
25400 HEAT PIPE
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25100 SYSTEM FOR SPACECRAFT THERMAL CONTROL= HEAT PIPE
26000 ES FOR SPACE SUIT TEMPERATURE CONTROL=
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09710 AT PIPE FOR EQUIPMENT THERMAL CONTROL= /ABLE CONDUCTANCE HEA
15901 ORMANCE OF NONCONDENSIBLE GAS CONTROLLABLE HEAT PIPES= /PERF
28600 ENT FOR THE SE-4 SATELLITE/ A CONTROLLABLE HEAT PIPE EXPERIM
15200 N OF AN AUTOMATIC TEMPERATURE CONTROLLED HEAT PIPE= /ALUATIO
02501 E HEAT PIPES= FEEDBACK CONTROLLED VARIABLE CONDUCTANC
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10300 ILITY OF HEAT PIPES TO ENERGY CONVERSION SYSTEMS= APPLICAB
15300 NT OF AN INSULATED THERMIONIC CONVERTER - HEAT PIPE ASSEMBLY

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30900 HEAT PIPE THERMIONIC CONVERTER DEVELOPMENT= 67043 D-1-01
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04200 HEAT PIPE THERMIONIC CONVERTER DEVELOPMENT= 68044 E-03
13901 THERMIONIC CONVERTER DEVICE= 69028 B-2-12
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15103 NT OF AN INSULATED THERMIONIC CONVERTER HEAT PIPE ASSEMBLY= / 66006 B-2-03
15101 NT OF AN INSULATED THERMIONIC CONVERTER HEAT PIPE ASSEMBLY= / 65008 B-2-01
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17800 ACTOR SURFACE TO CESIUM VAPOR CONVERTERS= /TRANSFER FROM A RE 68023 B-4-02
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05901 T ELECTRONIC EQU/ A SURVEY OF COOLING TECHNIQUES FOR AIRCRAF 70039 B-5-02
02100 PIPE DESIGN FOR ELECTRON TUBE COOLING= /HEAT 69058 B-5-02
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16600 TAL HEAT PIPE SYSTEMS AT 100/ CORROSION STUDIES OF LIQUID ME 70075 D.3-02
09902 GENIC HEAT PIPE WITH VERTICAL COUNTERCURRENT TWO-PHASE FLOW= 70064 C.4-05
13501 RF NUCLEATE BOILING FROM MESH COVERED SURFACES = ESTIMATION 70058 C.3-02
11000 AT TRANSFER FROM FLOODED WICK COVERED SURFACES = RIZATION HE 69070 C.3-02
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21200 UUM SYSTEM USING HEAT PIPES / CRYOPUMPING DMNTRON ULTRA-VAC 69011 B.1-04
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05400 TS AT 1600 DEGREES C AND 1000 DEGREES C= HEAT PIPE LIFE TEST 68055 E-05
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30500 ROTATING HEAT PIPES= DEMONSTRATION OF OPERATION OF 70039 E-09
23500 URE BALANCE AND MAXIMUM POWER DENSITY AT THE EVAPORATION GAI 69066 C.2-01
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07000 CAPILLARY WICKING AND SURFACE DEPOSITS IN THE ATTAINMENT OF 64002 C.2-01
02000 CALLY INSULATED HEAT PIPE FOR DEPRESSED COLLECTORS= ELECTRI 69054 B.5-01
28100 HE MODULE APPROACH TO BLANKET DESIGN = A VACUUM WALL FREE BL 70033 B.4-03
02601 MILICAL OBSERVATORY HEAT PIPE = DESIGN ANALYSIS TESTING = 70059 D.1-06
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30600 NCED THERMIONIC CONVERTERS= DESIGN AND FABRICATION OF ADVA 69016 B.2-09
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04401 PIPE= DESIGN AND OPERATION OF A HEAT 68053 E-04
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23600 POWER SUPPLY= DESIGN OF A 1 KWE FAST REACTOR 67033 B.4-01
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22601 LEAR-ELECTRIC SPA/ CONCEPTUAL DESIGN OF A 2-MWT (375KWE) NUC 71015 B.4-04
27400 PE SPACE RADIATOR= DESIGN OF A 50000 WATT HEAT PI 69048 B.3-07
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25700 N OF GAS TURBINE REGENERATORS EMPLOYING HEAT PIPES = /ALUMINUM
15700 ACTOR CONCEPT FOR SPACE POWER EMPLOYING THERMIONIC DIODES AN
23900 HERMIONIC REACTORS EMPLOYING HEAT PIPES FOR TPIPE = RADIOISOTOPIC
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31600 PROCEEDINGS OF JOINT ATOMIC ENERGY COMMISSION - SANDIA LAB
31500 APPLICATION OF HEAT PIPES TO ENERGY CONVERSION SYSTEMS = A
12800 EE KW FLAME HEATED THERMIONIC ENERGY CONVERTER = /FIRE THERMIONIC
19300 PIPE HEATING SYSTEMS = NUCLEAR THERMIONIC ENERGY CONVERTER=
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15800 TER CYROGENIC ISOTOPIC COOLING ENGINE SYSTEM - ICICLE FEASIBILITY
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08600 PCA TEST THERMAL ENERGY PIPE =
23400 MEANS OF HEAT PIPE/ CAPACITOR ENERGY STORAGE IMPROVEMENT BY
21400 = LIMITATIONS OF ENERGY TRANSPORT IN HEAT PIPES
26800 HEAT PIPE TECHNOLOGY TO ROCKET ENGINE COOLING = /LICATION OF HEAT PIPES
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31800 REACTOR, SYSTEM AND COMPONENT ENGINEERING =
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04700 HEAT PIPE RESEARCH IN EUROPE =
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04010 FEEDBACK CONTROLLED/ STUDY TO EVALUATE THE FEASIBILITY OF A
14800 FIN-TUBE RADIATOR ANALYSIS AND EVALUATION OF A VAPOR-CHAMBER
27700 MU-M-STAINLESS /COMPATIBILITY EVALUATION OF AN AMMONIA-ALUMINUM
15200 PERATURE CONTROL/ EXPERIMENTAL EVALUATION OF AN AUTOMATIC THERMI
17901 HERMIONIC CO/ FABRICATION AND EVALUATION OF AN OUT-OF-CORE T
26500 NERATORS EMPLOY/ PRELIMINARY EVALUATION OF GAS TURBINE REGENERATION
09800 PIPE PERFORMANCE = EVALUATION OF THERMIONIC HEAT PIPE
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18000 IC NAMIC BOUNDARY CONDITIONS FOR EVAPORATION AND CONDENSATION=
23500 MAXIMUM POWER DENSITY AT THE EVAPORATION GAINED FROM HEAT PIPE
01600 LIQUID-VAPOR INTERACTION AND EVAPORATION IN HEAT PIPES =
13900 TRANSFER DEVICE = EVAPORATION-CONDENSATION HEAT
10800 ANIS OF HEAT TRANSFER IN THE EVAPORATOR ZONE OF A HEAT PIPE
08001 ES CONTAINING POTASSIUM = EXAMINATION OF NICKEL HEAT PIPE
21600 RMATION/ NEUTRON RADIOGRAPHIC EXAMINATION OF VAPOR BUBBLE FORMATION
17900 LIVER/ INVESTIGATION OF HEAT EXCHANGE WITH BOILING WATER DENSITY
26800 T/ A CONTROLLABLE HEAT PIPE EXPERIMENT FOR THE SE-4 SATELLITE
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20800  UDY OF WATER HEAT PIPES F/ AN EXPERIMENTAL AND ANALYTICAL STUDY 69905  E-06
07901  ION OF A ROTATING WICKLE/ THE EXPERIMENTAL DESIGN AND OPERATIONAL 70085  E-08
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24600  THE LIMITING/ THEORETICAL AND EXPERIMENTAL DETERMINATION OF AN 69709  D.1-04
15200  AUTOMATIC TEMPERATURE CONTROL/ EXPERIMENTAL EVALUATION OF AN 71043  B.1-05
26700  OF WATER-FILLED CAPILLARY-P/ EXPERIMENTAL FEASIBILITY STUDY 66024  C.4-01
01800  EXPERIMENTAL HEAT PIPE= 71045  E-11
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17100  HEAT PIPE CAPABILITY EXPERIMENTS= 67052  D.2-02
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15300  MINUM HEAT PIPES= FABRICATION AND TEST OF AN ALU 67032  B.3-03
30600  ONIC CONVERTERS= DESIGN AND FABRICATION OF ADVANCED THERMI 69016  B.2-09
09710  VARIABLE CONDUCT/ THE DESIGN, FABRICATION, AND TESTING OF A 71028  D.1-08
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08700  RFORMANCE IN A ZERO-G GRAVITY FIELD= HEAT PIPE PE 68050  E-04
09920  ANCE IN AN ARTIFICIAL GRAVITY FIELD= HEAT PIPE PERFORM 71035  E-10
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18100 TIES AND ROIL/ VAPOR-CHAMBER FIN STUDIES - TRANSPORT PROPER

18300 VAPOR-CHAMBER FIN STUDIES

18700 VAPOR-CHAMBER FIN STUDIES

18600 VAPOR-CHAMBER FIN STUDIES

14600 OR AND / ANALYSIS OF A DOUBLE FIN-TUBE FLAT CONDENSER-RADIAT

14800 EVALUATION OF A VAPOR-CHAMBER FIN-TUBE RADIATOR FOR HIGH-POW

14600 AND COMPARISON WITH A CENTRAL FIN-TUBE RADIATOR - /RADIATOR

14700 RADIATORS USING VAPOR CHAMBER FINS - VILIETY STUDIES OF SPACE

14503 DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE WITH T

14502 DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE WITH T

13070 DEVELOPMENT OF A FLAME FIRED THERMIONIC GENERATOR

32800 THE DEVELOPMENT OF A VAPOR-CHAMBER FIN-TUBE RADIATOR FOR HIGH-POW

14600 AND COMPARISON WITH A CENTRAL FIN-TUBE RADIATOR - /RADIATOR

14800 EVALUATION OF A VAPOR-CHAMBER FIN-TUBE RADIATOR FOR HIGH-POW

14503 DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE WITH T

14502 DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE WITH T

13070 DEVELOPMENT OF A FLAME FIRED THERMIONIC GENERATOR

32800 THE DEVELOPMENT OF A VAPOR-CHAMBER FIN-TUBE RADIATOR FOR HIGH-POW

14600 AND COMPARISON WITH A CENTRAL FIN-TUBE RADIATOR - /RADIATOR

14800 EVALUATION OF A VAPOR-CHAMBER FIN-TUBE RADIATOR FOR HIGH-POW

14503 DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE WITH T

14502 DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE WITH T

13070 DEVELOPMENT OF A FLAME FIRED THERMIONIC GENERATOR

32800 THE DEVELOPMENT OF A VAPOR-CHAMBER FIN-TUBE RADIATOR FOR HIGH-POW

14600 AND COMPARISON WITH A CENTRAL FIN-TUBE RADIATOR - /RADIATOR

14800 EVALUATION OF A VAPOR-CHAMBER FIN-TUBE RADIATOR FOR HIGH-POW

14503 DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE WITH T

14502 DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE WITH T

13070 DEVELOPMENT OF A FLAME FIRED THERMIONIC GENERATOR

32800 THE DEVELOPMENT OF A VAPOR-CHAMBER FIN-TUBE RADIATOR FOR HIGH-POW

14600 AND COMPARISON WITH A CENTRAL FIN-TUBE RADIATOR - /RADIATOR

14800 EVALUATION OF A VAPOR-CHAMBER FIN-TUBE RADIATOR FOR HIGH-POW

14503 DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE WITH T

14502 DEVELOPMENT OF A FOSSIL FUEL FIRED HEAT PIPE FOR USE WITH T

13070 DEVELOPMENT OF A FLAME FIRED THERMIONIC GENERATOR

32800 THE DEVELOPMENT OF A VAPOR-CHAMBER FIN-TUBE RADIATOR FOR HIGH-POW
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13100 AS BUFFERED ANNULAR HEAT-PIPE FUEL IRRADIATION CAPSULE = A G
25200 IONIC CONVERTER WITH ISOTOPIC FUEL = HEAT PIPES FOR THERMIONIC CONVERSION
09800 HARMONICS OF ACTINUM FUELED THERMIONIC GENERATOR = / HEAT PIPES FOR THERMIONIC CONVERSION
01400 TABLY = HEAT PIPES FUNCTION ISO-TEMPERALLY AND ADAPTED TO THE THERMAL LOAD
23500 ER DENSITY AT THE EVAPORATION GAINED FROM HEAT PIPE EXPERIENCE
19200 FUEL IRRADIATION CONCEPT OF A GAS BUFFERED ANNULAR HEAT PIPE
19100 FUEL IRRADIATION CONCEPT OF A GAS BUFFERED ANNULAR HEAT PIPE
15901 PERFORMANCE OF NONCONDENSABLE GAS CONTROLLABLE HEAT PIPES / HEAT PIPE THERMIONIC CONVERTER WITH ISOTOPIC FUEL,
25100 PHENOMENON OF NONCONDENSABLE GAS GENERATION = PIPE AND THE CONCEPT FOR ELECTRICAL POWER GENERATION=
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26500 YI/ PRELIMINARY EVALUATION OF PERFORMANCE OF THE GEOS-2 HEAT PIPE SYSTEM AND IT.
26400 HEAT PIPE GAS TURBINE REGENERATORS EMPLOY THE THERMOSYPHON FOR COOLING GAS TURBINE BLADES / PIPE AND THE
20400 PERFORMANCE OF HOT RESERVOIR GAS-CONTROLLED HEAT PIPES = AN ARTIFICIAL GRAVITY FIELD = HEAT PIPE
13600 OR ELECTRICAL POWER GENERATION/
25100 CONCEPT FOR ELECTRICAL POWER GENERATION = ISO-CORE REACTOR
13600 THERMIONIC ELECTRICAL POWER GENERATION = THERMIONIC CONCEPT FOR ELECTRICAL POWER
31200 N N THERMIONIC ELECTRICAL POWER GENERATION = /ONAL CONFERENCE ON ELECTRICAL POWER GENERATION=
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30400 CASCaded THERMIONIC TEST GENERATOR = THERMIONIC GENERATOR EMPLOYING A HEAT PIPE
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08000 AN ACTINUM FUELED THERMIONIC GENERATOR = CHARACTERISTICS OF
24800 E S AND ISO-CORE THERMIONIC ELECTRIC GENERATORS = ISOTOPIC GEOMETRY ON OPTIMAL HEATING SUCCESSSFUL
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16200 FLOW IN A RECTANGULAR CHANNEL HEAT PIPE WICK= VISCOUS
18500 TRANSPORT PROPERTIES OF SOME HEAT PIPE WICKING MATERIALS= / A
18400 D HEAT TRANSFER PROPERTIES OF HEAT PIPE WICKING MATERIALS= / A
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G. HEAT PIPE RELATED PATENTS
HEAT PIPE RELATED PATENTS

00100 GAY F W
COOLING SYSTEM FOR UNDERGROUND ELECTRIC TRANSMISSION LINES
U.S. PATENT 1754314
APRIL 15, 1930

00200 BISSELL R E
COOLING CAPSULE FILLED VALVE
U.S. PATENT 1786285
DEC 23, 1930

00300 SCHLUMROHM P
METHOD OF COOLING INDIRECTLY
U.S. PATENT 1975868
OCT 9, 1934

00400 MULSE G F
REFRIGERATION
U.S. PATENT 2010431
AUG 6, 1935

00500 FIENF M E
CONSTANT TEMPERATURE DEVICE
U.S. PATENT 2026423
DEC 31, 1935

00600 VERNET S
CAR HEATER
U.S. PATENT 2028260
JAN 21, 1936

00700 BAILEY E G
LIQUID VAPORIZING TUBE
U.S. PATENT 2279548
APRIL 14, 1942

00800 GAUGLER R S
HEAT TRANSFER DEVICE
U.S. PATENT 2350348
JAN 6, 1944

00900 GAUGLER R S
CAPILLARY HEAT TRANSFER DEVICE FOR REFRIGERATION APPARATUS
U.S. PATENT 2448261
AUG 31, 1948

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HEAT TRANSFER PANEL
U.S. PATENT 3018087
JAN 23, 1962

02000 SNEILLING C D
FLUORESCENT LAMP FIXTURE
U.S. PATENT 3112490
DEC 3, 1963

02100 WYATT T
SATellite Temperature Stabilization System
U.S. PATENT 3152774
OCT 12, 1964

02200 LONG E L
MEANS FOR MAINTAINING PERMfrost Foundations
U.S. PATENT 3217791
NOV 26, 1965

02300 RODGERS J S
Steam Condenser of the Water Tube Type
U.S. PATENT 3217799
NOV 16, 1965

02400 TALCOTT P C
Electron Tube Comprising Beryllium Oxide Ceramic
U.S. PATENT 3227905
JAN 4, 1966

02500 GROVER G M
Evaporation - Condensation Heat Transfer Device
U.S. PATENT 3229759
JAN 18, 1966

02600 HEEREN H
Internally Finned Condenser Tube
U.S. PATENT 3273599
SEPT 20, 1966

02700 MCCORMICK H L
COOLED GAS TURBINE VANES

G.1-03
HEAT PIPE RELATED PATENTS

03600 BOHDANSKY J ET AL
HEAT PIPES
U.S. PATENT 3402767
SEPT 24, 1968

03700 FIEBELMANN P
NUCLEAR REACTOR
U.S. PATENT 3403075
SEPT 24, 1968

03800 SWET C J
CONTROLLABLE HEAT PIPE APPARATUS
U.S. PATENT 3402761
SEPT 24, 1968

03900 HALL W R ET AL
VAPORIZABLE MEDIUM TYPE HEAT EXCHANGER FOR ELECTRON TUBES
U.S. PATENT 3405299
OCT 6, 1968

04000 ANAND D K
HEAT PIPE CONTROL APPARATUS
U.S. PATENT 3414050
DEC 3, 1968

04100 FIEBELMANN P
HEAT PIPES
U.S. PATENT 3414475
DEC 3, 1968

04200 RIFNERT W B
HEAT PIPES FOR NON-WETTING FLUIDS
U.S. PATENT 3435889
APRIL 1, 1969

04300 RASPE D
CASCADED THERMIonic - THERMOELECTRIC DEVICES UTILIZING HEAT PIPES
U.S. PATENT 3437847
APRIL 8, 1969

04400 LEVEDAHL W J
HEAT PIPES WITH UNIQUE RADIATOR CONFIGURATION IN COMBINATION WITH THERMIonic CONVERTER
U.S. PATENT 3457436

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HEAT PIPE RELATED PATENTS

JULY 22, 1969

04500 DIFNEERT W R
      LEVEADAHL W J
      STREE A J
      THERMAL CONTROL AND POWER FLATTENING FOR RADIOISOTOPIC
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      U.S. PATENT 3465813
      AUG 6, 1969

04600 BROWNBERG R ET AL
      METHOD OF AND MEANS FOR INCREASING THE HEAT TRANSFER
      CAPABILITY OF A HEAT PIPE
      U.S. PATENT 3465813
      SEPT 9, 1969

04700 LEVEADAHL W J
      HEAT PIPES WITH PREFABRICATED GROOVED CAPILLARIES AND
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      U.S. PATENT 3498369
      MAR 3, 1970

04800 LEVEADAHL W J
      THERMIONIC CONVERTER ASSEMBLIES
      U.S. PATENT 342709
      MAR 4, 1970

04900 SCHOSINGER A P
      MEANS FOR REGULATING THERMAL ENERGY TRANSFER THROUGH A HEAT
      PIPE
      U.S. PATENT 3502138
      MAR 24, 1970

05000 BYRD A W
      HEAT PIPE THERMIONIC DIODE POWER SYSTEM
      U.S. PATENT 3509386
      APRIL 28, 1970

05100 KEISER J T
      HEAT PIPE WITH CONTROL
      U.S. PATENT 3516497
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05200 WYATT T
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      U.S. PATENT 3517730

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HEAT PIPE RELATED PATENTS

JUNE 30, 1970

05300 MILTON R M
HEAT EXCHANGE SYSTEM
U.S. PATENT 3523577
AUG 11, 1970

05400 LEVEDAHL W J
HEAT PIPE FOR LOW THERMAL CONDUCTIVITY WORKING FLUIDS
U.S. PATENT 3528494
SEPT 15, 1970

05500 HAMMITT A G, BROADWELL J C
HIGH PERFORMANCE HEAT PIPE
U.S. PATENT 3532159
OCT 6, 1970

05600 BYRD A W
POWER SYSTEM WITH HEAT PIPE LIQUID COOLANT LINES
U.S. PATENT 3537515
NOV 3, 1970

05700 LEVEDAHL W J
HEAT PIPE FOR LOW THERMAL CONDUCTIVITY WORKING FLUIDS
U.S. PATENT 3537514
NOV 3, 1970

05800 EASTMAN G Y
HEAT EXCHANGER FOR HIGH VOLTAGE ELECTRONIC DEVICES
U.S. PATENT 3543841
DEC 1, 1970

06000 SHLOSINGER A P
MULTI-CHAMBER CONTROLLABLE HEAT PIPE
U.S. PATENT 3543839
DEC 1, 1970

06100 BYRD A W
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U.S. PATENT 3548930
DEC 22, 1970

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ANAND D K
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BAILEY E G
BIENERT W B
BIENERT W B
BISELLE R E
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BOHDA NSKY J ET AL
BROADWELL J E
BROMBERG R ET AL
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U.S. PATENT 3509386=
U.S. PATENT 3516487=
U.S. PATENT 3517730=
U.S. PATENT 3523577=
U.S. PATENT 3526494=
U.S. PATENT 3532159=
U.S. PATENT 3537514=
U.S. PATENT 3537515=
U.S. PATENT 3543839=
U.S. PATENT 3543841=
U.S. PATENT 3548930=

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