SODIUM TECHNOLOGY

1948-1961

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INTRODUCTION

This bibliography on sodium technology has been published in two parts. Part I covers the literature cited in *Nuclear Science Abstracts (NSA)* from 1948 (Volume 1) through 1961 (Volume 15). Part II covers the period 1962 (Volume 16) through March 31, 1972 (issue 6 of Vol. 26).

The subject of the search was defined to be metallic sodium and NaK technology. The search was limited to *NSA* and, therefore, the main emphasis of the literature covered is sodium as applied to reactor coolant technology and closely related subjects.

Abstracts are grouped by *NSA* volumes and are arranged in ascending order by the original *NSA* abstract number. This places them in roughly chronological order. The subject index at the end of the bibliography refers to these abstract numbers.

All the literature cited is publicly available. The scientific and technical journals in which much of the literature appears are available in many libraries throughout the United States. The report literature is on file in microfiche form at the libraries listed on the inside front cover of this publication.

The reports listed herein (*NSA* Vols. 1-15) can be purchased from Microsurance, Inc., P. O. Box 3522, Oak Ridge, Tennessee, 37830. Prices are currently 11¢ per page of hard copy and 30¢ per microfiche. (Each microfiche can contain up to 60 pages of copy.) Price quotations for any report cited may be obtained by writing the above address.

If there are any problems encountered in obtaining journals or reports, assistance will be provided by the U. S. Atomic Energy Commission, Technical Information Center, P. O. Box 62, Oak Ridge, Tennessee, 37830.

Volume 2, Jan.-June, 1949

- 161 Quarterly Progress Report No. 8 on the Development of the Physical and Chemical Properties of the Sodium-Potassium Alloy. Curtis T Ewing, Robert E Seebold, Joseph A Grand and Harold B Atkinson, Jr. Naval Research Laboratory Report NRL-C-3330 Aug 9, 1948 8p.

The report presents the status of active property measurements of sodium-potassium alloys. Three pieces of apparatus are described which are used in measurements of specific heat, thermal conductivity, and surface tension respectively. A preliminary report of the determination of surface tension of sodium-potassium alloys by the bubble-pressure method is also included.

- 590 Liquid Sodium Heat Transfer. F. C. Bennett. Dow Chemical Company Report No. 14854. Oct. 1948. 23p. (NP-514)

Information derived from previous operation of a plant and later experimental work is combined to give the following conclusions. Liquid sodium metal is found to be an excellent heat transfer medium if properly handled. Only pure sodium can be used in a heat transfer system if trouble is to be avoided. Distilled metal should be used without any exposure to the atmosphere. Heat transfer systems employing sodium should be protected by freeze traps which will precipitate and remove any dissolved solids. Sodium hydroxide, iron oxide, sodium hydride, or sodium oxide will cause plugs to form in a sodium system if present either singly or collectively.

Volume 3, July-Dec., 1949

- 342 Preliminary Report on Viscosity Determinations on a Potassium-Sodium Alloy. R. Ruskin, C. T. Ewing, and R. R. Miller. Naval Research Laboratory Report NRL-P-2931, Aug. 14, 1946. 10p.

An Ostwald-type viscometer has been used to measure values of viscosity on a potassium sodium alloy which was 43.4% potassium by weight. Viscosity of the alloy at 72°C was 1.267 relative to water at the same temperature. The values at higher temperatures were calculated from the volumes of alloy flowing per second at those temperatures, and the constant was determined for the apparatus at 72°C.

- 696 Specific Heat of Sodium Between 0° and 900°C, the Melting Point and Heat of Fusion. D. C. Ginnings, T. B. Douglas, and Anne F. Ball. AECD-2639, June 7, 1949. Decl. July 6, 1949. 22p.

Using an improved ice calorimeter and furnace, the enthalpy changes of two samples of pure sodium have been accurately measured by a drop method at a number of temperatures between 0° and 900°C. Equations are derived to fit the data, and values of enthalpy and entropy, based on zero values at 0°C, as well as the specific heat, are tabulated for both the solid and the liquid. Sources of significant experimental error are examined critically, and some theoretical implications of the results are discussed qualitatively. 16 references.

- 1675 Forced Convection Heat Transfer Theory and Experiments with Liquid Metals. Richard N. Lyon. AECU-419(ORNL-361) Aug. 19, 1949. 109p.

A theoretical development is described which leads to the following equation for an ideal tubular system in forced convection:

$$\frac{1}{Nu} = 2 \int_0^1 \frac{[\int_0^{S_q} V S dS]^2}{S_q \frac{K}{k}} dS_q$$

Nu is the Nusselt modulus; V is the relative velocity; S, the relative distance from the center of the tube; k the molecular conductivity of heat; and K is the total conductivity (molecular plus eddy). This equation may be applied to any fluid in either turbulent or viscous flow. Application of the analogy between fluid friction and heat transfer leads to the equation:

$$\frac{1}{Nu} = 2 \int_0^1 \frac{[\int_0^{S_q} V S dS]^2}{S_q \left(1 + \alpha \Pr \frac{\epsilon_M}{\nu} \right)} dS_q$$

where α is the ratio of the eddy diffusivities of the momentum and heat; ϵ_M is the eddy diffusivity of momentum; Pr is the Prandtl modulus; and ν is the kinematic viscosity. This equation, when used with other experimental data, leads to numerical results which may be roughly generalized by the equation: $Nu = 7 + 0.025(\alpha Pe)^{.8}$ where Pe is the Peclet modulus. Similarly the theoretical results of Harrison and Menke for an asymmetrically heated parallel plate system are shown to approximate: $Nu = 4.9 + 0.0175(\alpha Pe)^{.8}$. Experiments with sodium-potassium alloy are described which appear to support these generalizations where the parallel plate equation is applied to narrow annuli and α is assumed to be unity.

Volume 4, 1950

- 1964 The D. C. Electromagnetic Pump for Liquid Metals
J. Woodrow. Atomic Energy Research Establishment Report No. AERE E/R-452, Dec. 1949. 14p.

The general theory of an ideal pump is developed, expressions being derived for the current and flux distributions, pressure developed, and the efficiency. The efficiency is found to depend on three nondimensional parameters. A very important special case is the pump developing maximum pressure at the outlet. The theory is applied to the case of a pump for liquid sodium. (auth)

- 3430 Film Heat Transfer Coefficients for Liquid Potassium-Sodium Alloys; Supplement No. 2. R. C. Werner and E. C. King. Mine Safety Appliances Company Preliminary Report No. 4, June 24, 1948. 59p. (AEC File No. NP-1412.)

A graphical method is presented whereby the individual film heat-transfer coefficients may be determined and correlated from the data obtained on a figure of eight type double pipe heat exchanger. The method overcomes the previous limitation of constant exponents in the Nusselts type of equation. This method with results is applied to two NaK alloy compositions of 44 and 78 wt.% K through a temperature range of 300 to 1200°F and a flow rate of 1.5 to 12 ft/sec velocity in the center stream giving film heat-transfer coefficients as high as 5500 Btu/(hr)(ft²)(°F) at 800°F, which is approximately 2 times that of water at 120°F. The results are out of necessity reported in graphical form which indicates a trend similar to that reported by Martinelli (Trans. Am. Soc. Mech. Engrs. 69, 947(1947)) for the relationships between the Stanton number, the Reynolds number, and temperature for liquid metals. Results are also reported on the specific heat of NaK alloy from data collected on the main heater when used as a flow calorimeter. Values were obtained 10 to 30% lower than those reported by Bidwell (NRL Report No. C-3152, July 1947). (auth)

- 5901 Thermodynamic Diagrams for Sodium. T. H. Inatomi and W. C. Parrish. NAA-SR-62, July 13, 1950. 54p.

Temperature-entropy and Mollier charts for sodium, based on available data from the literature, are presented, and the method used for their construction is described. In the absence of constants for the more exact equations of state, the vapor phase was assumed to obey the perfect gas law. Subsequent checks with compressibility-factor data indicate that

the assumption of ideality holds reasonably well for pressures as high as 103 atm. Corrections for dimerization in the vapor phase were included in the present work, although there is considerable uncertainty in the extrapolated value of the equilibrium constant for the dimerization reaction. If used in the light of these limitations, the charts should serve as a useful first approximation in thermodynamic cycle analysis. (auth)

- 6123 The Relative Thermal Conductivities of Liquid Lithium, Sodium, and Eutectic NaK, and the Specific Heat of Liquid Lithium. F. L. Yaggee and Samuel Untermyer. ANL-4458, Apr. 21, 1950. 27p.

Determinations of the relative thermal conductivities of liquid lithium, sodium, and eutectic NaK under similar conditions show that lithium is not as efficient a heat-transfer medium as sodium, and is more efficient than eutectic NaK. Determinations were made in a simple conductivity apparatus. For a mean liquid temperature of 190°C to 200°C the value obtained for the thermal conductivity of sodium is in fair agreement with published values. The relative conductivities of lithium and NaK are roughly ½ and ¼ that of sodium at ~250°C. The values for the specific heat of liquid lithium show an increase in the specific heat of liquid lithium with an increase in temperature, although the numerical values are of the same order of magnitude as those reported from other sources. These specific heat values were calculated from a comparison of the cooling rates in air of aluminum-filled and lithium-filled stainless steel capsules. The numerical values reported for lithium are believed to have an accuracy of about ±10%.

- 6137 Temperature Variation of the Compressibility of Molten Sodium. T. E. Pochapsky and S. L. Quimby. Phys. Rev. 79, 892(1950) Sept. 1 (Letter to the editor).

A modification of the standard pulse method for the measurement of sound velocity permits the measurement of the temperature coefficient of this quantity for molten sodium with an accuracy better than 1%. Measurements made on singly and triply distilled sodium are indistinguishable. The velocity of sound at the melting point (97.6°C) is found to be $252,600 \pm 500$ cm/sec, and the temperature coefficient between this and 272°C, which is constant, to be -52.4 ± 0.3 cm/sec/deg. Values of the adiabatic compressibility of the material computed with these data and those of Rinck (Ann. Chim. Phys. 18, 395 (1932)) on the density of molten sodium are given.

Volume 5, 1951

118

THE APPLICATION OF CHEMICAL THERMODYNAMICS TO THE STUDY OF METALLIC ALLOY FORMATION. QUARTERLY PROGRESS REPORT FOR APRIL 1, 1950-JULY 1, 1950. R. S. Craig, W. E. Wallace, T. M. Buck, D. A. Edwards, E. E. Ketchen, C. B. Satterthwaite, and F. A. Trumbore. July 3, 1950. 9p. (NYO-606)

Continuation and status of work on the investigations of the heat of formation of Na-K and Cd-Mg alloys are reported. Heat of formation studies and free energies of the formation of Cd-Mg alloys are considered. Specific heat studies (Cd-Mg system) and the apparatus, calibration, preparation of sample, etc., are described. Data are tabulated.

120

THE DETERMINATION OF THE VISCOSITY OF MOLTEN METALS. M. R. Hopkins and T. C. Toye. Proc. Phys. Soc. (London) 63, 773-82(1950) Oct. 1.

A method is described for the measurement of the viscosity of molten metals at temperatures up to about 900°C. The metal is contained in a cylindrical crucible which is allowed to oscillate about its axis under the control of the torsion in a suspension wire. The theory of the method is considered. The viscosity of zinc has been determined in the temperature range 430°C to 480°C and the results are given. 11 references. (auth)

127

THERMODYNAMICS OF LIQUID METALLIC SOLUTIONS. John Chipman and John F. Elliott. Trans. Am. Soc. Mech. Engrs. 42a, 102-43(1950). (See also NSA 4-4892).

This paper reviews the principal experimental methods which have been used in determining the thermodynamic functions, free energy, enthalpy, and entropy, in liquid metallic solutions. Computational methods for these and the derived quantities, the thermodynamic potential, activity and activity coefficient, are illustrated. A bibliography is included. 139 references. (auth)

400

Argonne National Laboratory
RESISTANCE OF MATERIALS TO ATTACK BY LIQUID METALS. LeRoy R. Kelman, Walter D. Wilkinson, and Frank L. Yaggee. July 1950. 139p. (ANL-4417)

Tabular data and descriptive material are presented concerning the resistance of materials to attack by Na and Na-K alloys, Li, Hg, Pb, Bi, alloys of Pb and Bi, Mg, Cd, Ti, In, Ga, Al, Sn, Zn, and Sb.

604

National Bureau of Standards
HEAT CAPACITY OF POTASSIUM AND THREE POTASSIUM-SODIUM ALLOYS BETWEEN 0° AND 800°C. Thomas B. Douglas, Anne F. Ball, and Defoe C. Ginnings. [nd.] 30p. (AECU-1017)

Using the drop method and an ice calorimeter, as with earlier experiments with sodium, measurements have been made of the changes in enthalpy in the range 0 to 800°C of potassium and three sodium-potassium alloys containing approximately 45, 54, and 78% by weight of potassium. The measurements on the first two alloys were of precision inferior to the 0.05% or better usually obtained with this apparatus, owing to the complication of a solid-phase transformation in the process of cooling. The heat capacities of solid and liquid potassium, the heat of fusion of potassium, and the heat capacities of the three alloys in the liquid state were derived from the enthalpy measurements. The heat capacities of the liquid alloys were found to correspond very closely at each temperature between 100 and 800° with those calculated additively from the values found for pure liquid potassium and sodium. As reported earlier for liquid sodium, all the liquids show a minimum in heat capacity at 500 to 600°C. (auth)

1015

University of Pittsburgh
PROGRESS REPORT FOR JULY 1, 1950-OCTOBER 1, 1950. W. E. Wallace and E. E. Ketchen. Oct. 9, 1950. 19p. (NYO-750)

Heats of reaction of pure potassium, pure sodium, and fine sodium-potassium with water at 25°C have been measured. From these data the heats of formation of the alloys were computed. Comparison of the data obtained with expectations based on Hildebrand's theory (Hildebrand and Wood, J. Chem. Phys. 1, 304(1935)) of regular solutions and the quasi-chemical theory of Guggenheim and Rushbrooke (Guggenheim, Proc. Roy. Soc. (London) 148A, 304(1935) and Rushbrooke, ibid. 166A, 296(1938)) reveals appreciable discrepancies between theory and experiment. 11 references. (auth)

1260

Knolls Atomic Power Laboratory
METHOD AND RESULTS OF SODIUM WETTING TESTS. H. H. Winkler and L. B. Vandenburg. Dec. 27, 1949. 9p. (KAPL-P-231)

This report presents the method used and the results of 43 tests made to determine the relation between sodium wetting temperatures and surface conditions of various materials. (auth)

2161

LIQUID METAL HEAT-TRANSFER COEFFICIENTS.
Richard N. Lyon. *Chem. Eng. Progress* 47, 75-9(1951)Feb.

In a discussion of the use of liquid metals as heat-transfer media a qualitative diagram of temperature distribution in fluids of various Prandtl moduli is presented as the current concept of turbulent flow in a tube. A general equation for the heat-transfer coefficient in tubes is developed for the following specifications: steady state, constant physical properties of fluid, no end effects, system symmetrical about tube axis, and constant heat flux along the tube wall in one direction. Comparisons of theoretical and experimental values for liquid-metal heat transfer are made. 15 references.

2802

VISCOSITY OF THE SODIUM-POTASSIUM SYSTEM.
Curtis T. Ewing, Joseph A. Grand, and R. R. Miller. *J. Am. Chem. Soc.* 73, 1168-71(1951) Mar.

A closed viscometer technique was developed and applied to reactive metals with unusually high surface-tension ranges. Viscosities were measured for Na, K, and several alloys from 60°C (or the m.p.) to 200°C. The values for the alloys were observed to vary uniformly between those for the metals, and a mixture equation was applied to satisfy the data. It was also shown that the temperature variation of the viscosity values could be adequately expressed by the equation set forth by Andrade. (auth)

4411

Oak Ridge National Lab.
HEAT TRANSFER IN NONCIRCULAR DUCTS; PART I.
H. C. Claiborne. May 14, 1951. 44p. (ORNL-985)

This is the first of a planned series of reports on the analytical treatment of heat transfer to noncircular ducts with emphasis on liquid-metal systems. This report is concerned only with results for systems with fully developed hydrodynamic and thermal boundary layers; i.e., away from entrance effects. Analytical solutions for velocity distributions in the case of laminar or viscous flow are presented for rectangular, equilateral triangular, right isosceles triangular, elliptical and circle sector ducts. Analytical solutions are given for the temperature distribution in the case of slug flow in the type ducts mentioned for heat transfer at constant wall temperature and at uniform wall heat flux. In addition, the general right triangular duct problem is solved for the case of uniform wall flux. The applicability of these results to liquid-metal systems for a region of the turbulent regime is indicated. At uniform wall flux the average Nusselt modulus for slug flow was found to be 6, 4, 3, and 2 for rectangular, equilateral triangular, right isosceles triangular, and 30-deg right triangular ducts, respectively. (auth)

4677

North American Aviation, Inc.
MOLECULAR FORM OF VAPORIZING SODIUM. M. H. Feldman. May 21, 1951. 18p. (NAA-SR-123)

The vaporization of sodium is considered. The heat of vaporization, the rate of dimerization, the molecular form of sodium at the time of vaporization, and the effects of extreme pressure are considered from the point of view of the absolute reaction rates theory. Liquid sodium is composed of monatomic ions; vaporization is by way of monatomic sodium atoms; these atoms subsequently dimerize to a degree dependent on the temperature and the pressure. (auth)

4735

Knolls Atomic Power Lab.
SODIUM; A NONCORROSIVE COOLANT. R. F. Koenig and S. R. Vandenberg. [nd] 17p. (AECU-1495)

A general description of the corrosive properties of Na is presented, and several corrosion tests are described. Examples of five types of attack on containers by liquid metals are mentioned. The steps followed in making a static corrosion test are discussed, and descriptions of four types of dynamic tests are included, namely, rotating specimen (whirligig), thermally circulated loops (harps), forced-circulation loops, and surveillance coupons in operating heat-transfer systems. Four methods of determining the effect of Na immersion on mechanical properties of construction materials are outlined. Eight forms of test apparatus are illustrated by photographs or diagrams.

4766

Knolls Atomic Power Lab.
AN EXPERIMENT ON THE RISE OF LIQUID SODIUM IN CAPILLARY GROOVES. R. L. Cummerow and J. H. Read. Apr. 24, 1951. 31p. (KAPL-508)

Results of experiments on the rise of Na in vertical grooves on an unoxidized stainless-steel rod in a He atmosphere at 300 to 600°C are correlated with theory. The capillary rise is shown to be amenable to exact analysis. The dependence of the behavior of the liquid on small irregularities in the groove profile is demonstrated. The theory and experiment presented provide a first step for approximate and semiempirical descriptions of liquids on machined and ground surfaces.

5125

North American Aviation, Inc.
THE REMOVAL OF SMALL AMOUNTS OF POTASSIUM FROM SODIUM. W. C. Ruebsamen. July 27, 1951. 9p. (NAA-SR-139)

A method for the removal of small amounts of K from Na metal by digestion with graphite at elevated temperatures is described. Residual K in the Na is about 0.003 wt. %. (auth)

5175

Knolls Atomic Power Lab.
HEAT TRANSFER MEASUREMENTS AT SODIUM-STAINLESS STEEL INTERFACE. J. W. Moyer and W. A. Riemen. June 1, 1951. 19p. (KAPL-567)

Experiments have been performed to measure the heat-transfer coefficient at the interface between liquid Na and type-347 stainless steel as a function of the temperature of the Na from 100 to 500°C. Clean surfaces (degreased and sometimes polished) were outgassed thoroughly under high vacuum conditions and the contact made with triply distilled Na. In two of the three experimental arrangements it was possible to make visual observations of the progress of wetting. Diagrams of the apparatus are shown. The only evidence of thermal impedance of the interface came with preliminary measurements in the first apparatus. In view of the lack of substantiation of the earlier observed effect, one is forced to conclude that under the conditions of these experiments wetting plays little, if any, part in the heat transfer at the sodium-stainless-steel interface.

5640

Knolls Atomic Power Lab.
ENGINEERING ASPECTS OF THE USE OF LIQUID METALS FOR HEAT TRANSFER; by T. Trocki. Sept. 8, 1951. 14p. (AECU-1608)

The advantages of liquid metals in heat-transfer systems are shown by comparing the tabulated thermal properties at high temperature and required pumping power of Na, NaK, heat-transfer salt ($\text{NaNO}_2\text{-NaNO}_3\text{-KNO}_3$), Dowtherm A, Hg,

Pb, Pb-Bi eutectic, Li, and H₂O. Problems of liquid-metal handling and safety, construction of piping and heat exchangers, pumping methods, and purification requirements are discussed.

6189

Metallurgical Lab., Univ. of Chicago
SOME PROBLEMS IN EDDY DIFFUSION; by William Karush. Aug. 15, 1945. Decl. Sept. 24, 1951. 19p. (AECD-3244)

Several problems involving the diffusion of heat by eddy motion in turbulent streams are considered. Diffusion normal to the walls is estimated from Nikuradse's curves and applied to the calculation of the heat transfer coefficient for fluids of high thermal conductivity, such as liquid metals. Sidewise diffusion parallel to the walls of a flat stream is treated; an application to the rib effect is made. (auth)

6213

SURFACE TENSION OF LIQUID METALS. R. A. Weale. *Nature* 168, 343(1951) Aug. 25.

A comparison is made between two mathematical expressions in the literature for the surface tension of liquid metals. The fact that both expressions are roughly satisfied is probably due to the inaccuracy of the experimental data, or to the fact that they are only different forms of the one given by Wen Po (*Phil. Mag.* 23, 33(1937)).

6725

Columbia Univ.
NATURAL CONVECTION TRANSFER PROCESSES; I. HEAT TRANSFER TO LIQUID METALS AND NON-METALS AT HORIZONTAL CYLINDERS; by Seymour C. Hyman, Charles F. Bonilla, and Stanley W. Ehrlich. [nd] 30p. (NYO-564)

Heat transfer by natural convection from a ½-in. diam horizontal cylinder to liquids was investigated. Fourteen liquids were employed, including the Pb-Bi eutectic, Hg, Pb, Bi, Na, and Na-K alloy. The Prandtl number of the liquids ranged from 0.0075 to 300. Both streamline and turbulent modes of flow were observed and equations to represent both were derived. Surface wetting had no appreciable effect on the heat transfer coefficient. A method for measuring the average surface temperature without interference with heat or fluid flow involved electroplating two different metals over the surface and measuring the thermoelectric potential developed between them.

6755

North American Aviation, Inc.
THE THERMODYNAMIC PROPERTIES OF SODIUM VAPOR; by T. H. Inatomi and A. Benton. Issued Oct. 8, 1951. 36p. (NAA-SR-141)

The calculated free-energy functions, the enthalpy functions, the entropies, and the specific heats for both the monatomic and diatomic sodium vapor, and entropies, enthalpies, and equilibrium constants for equilibrium mixtures of the two species, are tabulated for the temperature range 100 to 2600°K. These values were obtained for a pressure of 1 atm by the methods of statistical mechanics, assuming the vapors to be ideal gases.

6756

National Bureau of Standards
A CRYOSCOPIC STUDY OF THE SOLUBILITY OF URANIUM IN LIQUID SODIUM AT 97.8°C; by Thomas B. Douglas. Mar. 12, 1951. Decl. Oct. 16, 1951. 13p. (AECD-3254)

With an average reproducibility of approximately $\pm 0.001^\circ\text{C}$, measurements were made of the equilibrium temperatures, at various stages of melting from 70 to 100% complete, of three samples of Na. One sample contained U in bulk form and one sample contained finely divided U. A Ag-core furnace was used to provide an environment of constant and uniform temperature. Impurities present in all the samples lowered the freezing point by 0.035°C . As compared with the Na containing no U, that containing finely divided U had a freezing point higher by 0.005°C , an effect attributed to a partial purification of the Na by the U. The Na containing bulk-form U was found, however, to have an average freezing point lower than without U by 0.001 to 0.003°C , corresponding to approximately 0.007% by weight of U in solution. It is concluded that if solubility equilibrium was obtained in these experiments, the solubility of U in liquid Na at 97.8°C does not exceed a few hundredths of 1% by weight, and may actually be many times smaller. (auth)

6769

SURFACE TENSION OF LIQUID METALS. N. R. Mukherjee. *J. Applied Phys.* 22, 1215-16(1951) Sept. (Letter to the editor)

The surface tension of liquid metals at the melting point was found to be approximately proportional to their molar latent heat of fusion. The empirical relation obtained from this study is $\sigma = 365 Q_f$, where σ is the surface tension in dynes/cm and Q_f is the molar latent heat of fusion in kilocal/gram atom.

Volume 6, 1952

232

Naval Research Lab.

LIQUID METALS; THERMAL CONDUCTIVITY MEASUREMENTS; by Curtis T. Ewing. Oct. 23, 1951. 9p. (NP-3481; 3230-135A/51)

Results are presented of experimental measurements and calculations of thermal conductivity of stainless steel (type 304), Na, and Na-K alloy (56.5 wt. % K) at temperatures from 200 to 815°C.

580

THE TEMPERATURE VARIATION OF THE COMPRESSIBILITY OF MOLTEN SODIUM. T. E. Pochapsky. *Phys. Rev.* 84, 553-8(1951) Nov. 1.

The present method for the determination of the adiabatic compressibility of molten sodium depends in the first instance upon the measurement of the velocity of propagation of a short train of ultrahigh frequency compressional acoustic waves in the material. This figure is then combined with the best available value of the density to yield the compressibility, on the assumption that the rigidity of the liquid is zero. The wave trains are produced and detected by a piezoelectric transducer, and the resultant signal is exhibited on the screen of an oscilloscope whose sweep circuit is time-calibrated to permit the measurement of the transit time of a train over a known path length in the medium. A novel acoustic interferometer is employed, with which small changes in velocity can be measured with high precision. The velocity of compressional waves in molten sodium at the freezing point, 97.6°C, is $252,600 \pm 500$ cm/sec, and its temperature coefficient remains constant at the value -52.4 ± 0.3 cm/sec°C at least to 545°C. The adiabatic compressibility is 16.85×10^{-12} cgs at 97.6°C, and its temperature coefficient increases from 0.012×10^{-12} cgs at this temperature to 0.013×10^{-12} cgs at 545°C. The relations between these quantities and other elastic and thermal properties of solid and liquid sodium are discussed. (auth)

1017

TOTAL REACTION CROSS SECTIONS FOR Be, C, N, AND Na FOR FAST 2- TO 3.7-MEV NEUTRONS. R. Ricamo and W. Zünti. *Helv. Phys. Acta* 24, No. 4, 302(1951) Sept. 20. (In German)

Some results of measurements of total cross sections in the 2- to 3.7-Mev neutron-energy region are reported briefly. Be was found to have a single, broad, unsymmetrical maximum of 3.3 barns at 2.75 Mev. A new peak was found for C at 2.08 Mev with a half width of only 50 kev; the cross section ranges from 1.6 to 2.4 barns. Maxima were found for N at 2.22, 3.1, and 3.55 Mev. A complex structure was found for the Na cross section, with abrupt oscillations between 2.0 and 3.4 barns.

1127

THERMAL PROPERTIES OF THE ALKALI METALS. II. THE HEATS OF FORMATION OF SOME SODIUM-POTASSIUM ALLOYS AT 25°. Eugene E. Ketchen and W. E. Wallace. *J. Am. Chem. Soc.* 73, 5812-14(1951) Dec.

The heats of formation of several Na-K alloys are pre-

sented. These data are based upon the measured heats of reaction of the alloys and the two pure metals with water. Heat effects are reported for the alloying of the solid metals and the undercooled liquids. The latter data are compared with results to be expected from Hildebrand's theory of regular solutions and the quasi-chemical theory. Substantial disagreement between experiment and both theories is evident. The disagreement can be explained qualitatively by assuming the exothermal formation of the previously observed intermetallic compound Na_2K . (auth)

1237

Naval Research Lab.

SOLUBILITY OF OXYGEN IN POTASSIUM METAL AND SODIUM-POTASSIUM ALLOYS; by Dale D. Williams. Dec. 19, 1951. 18p. (NRL-3894)

The oxides resulting from the incomplete reaction of potassium metal and sodium-potassium alloys with dry oxygen have been isolated and identified as the monoxides of potassium and sodium, respectively. The equilibrium oxide in a sodium-potassium-oxygen system is sodium monoxide exclusively.

The solubility of potassium monoxide in potassium has been determined and is expressed by $\text{Wt. \% O}_2 = 0.0865 - 0.0006089t + 0.000007714t^2$ where t equals °C for the range 65-310°C. The solubility of sodium monoxide in potassium and in sodium-potassium alloys has been determined and is expressed by $\text{Wt. \% O}_2 = 0.0012 - 0.00000871t + 0.000000128t^2$ where t equals °C for the range 50-360°C. Potassium metal may be freed of its oxide by distillation or by reaction with a quantity of sodium metal equivalent to its oxide content followed by filtration.

1444

THERMAL CONDUCTIVITY OF LIQUID SODIUM AND POTASSIUM. C. T. Ewing, J. A. Grand, and R. R. Miller. *J. Am. Chem. Soc.* 74, 11-14(1952) Jan. 5.

Conductivity coefficients were measured for liquid Na and K metals with a longitudinal heat flow apparatus—sodium to 510°C and potassium to 610°C. A description of an apparatus for accurate measurement of high-boiling metals to 600°C is presented. The ideality of the pure liquid-metal media is shown by the conformation of the conductivity values to empirical and theoretical postulations. (auth)

1670

Columbia Univ.

QUARTERLY PROGRESS REPORT; THERMODYNAMIC PROPERTIES OF SODIUM VAPOR, by W. A. Selke, C. H. Muendel, and H. Y. Krinsky. Jan. 1, 1952. 5p. (NYO-3097)

An apparatus for obtaining vapor-pressure data for sodium in the range 0.1 to 5 atmospheres absolute pressure is described. Materials of construction, heating requirements, pressure measurements, and temperature control are discussed. This apparatus is currently being constructed.

2088

Columbia Univ.

QUARTERLY PROGRESS REPORT; THERMODYNAMIC PROPERTIES OF SODIUM VAPOR, by W. A. Selke, Herman Krinsky, and Carl Muendel. Oct. 1, 1951. (NYO-3096)

Using data from the literature, an incomplete temperature-entropy diagram was prepared for sodium vapor in the mixed phase and superheated region from 900 to 1600°K. This diagram differs from the previous ones principally because the entropy of dimerization was included in the calculations. Work has started on construction of apparatus of experimental determination of properties, including vapor pressure, degree of dimerization, and apparent heat capacity at constant pressure. (auth)

3229

Babcock and Wilcox Co.

THE DETERMINATION OF CARBON IN SODIUM-POTASSIUM ALLOYS, by Kenneth G. Stoffer and J. H. Phillips. Nov. 20, 1950. Decl. June 1, 1950. 32p. (NP-3722; Report No. ES401-14; R&D-5036; U62448)

A method has been described for the determination of carbon in sodium-potassium alloy. It is a modification of the classical microcombustion method and involves the ignition of a 100 mg sample at very high temperatures to decompose all carbon compounds which might be present. The carbon is converted to CO₂ which is absorbed and weighed. Results are accurate within tolerances acceptable in microcombustion analysis. The method described also covers the problem of sampling hot Na-K from a dynamic system, weighing it, and transferring it to the analytical apparatus by means of specially designed equipment. The possibility of analyzing for hydrogen simultaneously with carbon is considered. (auth)

3276

Knolls Atomic Power Lab.

HOMOPOLAR GENERATOR PUMP FOR LIQUID METALS, by Leonard B. Vandenberg. Aug. 13, 1951. Decl. Apr. 18, 1952. 83p. (AECD-3368; KAPL-590)

This report presents the results of combining a homopolar generator and a simple d-c electromagnetic liquid metal pump in one unit. An experimental pump proved the feasibility of such a combination, and it also proved that compact pumps of high efficiency can be built. The problems usually presented by bearings, seals, heavy bus-bar connections, lead losses, and bulky power-conversion equipment, which are associated with the pumping of liquid metal, are largely eliminated. (auth)

3560

Knolls Atomic Power Lab.

VORTICITY HEAT TRANSFER IN MOLTEN METALS, by R. G. Kennison. Apr. 11, 1952. 27p. (AECU-2010)

The transfer of heat is assumed analogous to the transfer of vorticity for turbulent fluid flow in a long straight pipe. Nusselt numbers are found and compared with other theoretical and experimental information. A simple and purely experimental velocity profile equation providing good correspondence with experimental information down to the laminar sublayer is also found. (auth)

3572

North American Aviation, Inc.

PREPARATION OF DROSS-FREE SODIUM AND OTHER LOW MELTING METALS AND ALLOYS BY THE UNDER POUR METHOD, by L. Silverman. Issued Apr. 1952. 8p. (NAA-SR-178)

An apparatus has been designed to prepare dross-free Na metal from the manufacturer's sample. The apparatus, which may also be used for other low-melting elements and for alloys, comprises a "ladle" or reservoir having pouring spouts leading from below the liquid surface.

4476

Argonne National Lab.

ELECTROMAGNETIC FLOWMETER, by A. Barnes, G. K. Whitham, and F. A. Smith. (EXCERPTS FROM ANL-4092; PROGRESS REPORT FOR MARCH 1 - NOVEMBER 30, 1947.) [nd] Decl. June 18, 1952. 5p. (AECD-3407)

An adaptation of an electromagnetic flowmeter for measuring the flow of NaK alloy is described. A schematic drawing and calibration curve are included.

4477

General Engineering Lab.

ALTERNATE VALVE STUDIES, by H. J. McLean and R. W. Wirta. Apr. 15, 1952. 45p. (GEL-53; R52GL18)

A summary is presented of an investigation conducted on alternate valving techniques for handling liquid metal. The requirements investigated were alternate valve closure mechanisms, positive seal between the internal valve mechanism and the external driving force, and mechanical override mechanism.

4482

Oak Ridge National Lab.

FORCED CONVECTION HEAT TRANSFER IN THERMAL ENTRANCE REGIONS; PART II, by H. F. Poppendiek and L. D. Palmer. Issued June 11, 1952. 22p. (ORNL-914)

Mathematical solutions pertaining to convective heat transfer in thermal entrance regions of parallel plates and pipe-duct systems with uniform wall temperatures containing flowing liquid-metals with turbulent velocity profiles (previously derived in Part I) are evaluated. The analyses were based on the postulate that all heat was transferred by means of the conduction mechanism and hence are valid only for the low Reynolds modulus range. A method of extending these conduction solutions for the case where the eddy diffusivity is small but not negligible compared to the molecular diffusivity (to higher Reynolds moduli) is proposed. (auth)

4492

Brookhaven National Lab.

A METHOD OF EVALUATING CORROSION TEST RESULTS, by M. A. Cordovi. Brookhaven National Lab. and Babcock and Wilcox Co. [nd] 13p. (BNL-1176)

A report is presented on the work of measuring the extent of liquid-metal corrosion of metals in order to determine the service life that may be expected from various construction materials and to quantitatively evaluate the results by direct measurement of penetration after a period of exposure. The test procedures are described.

5117

Columbia Univ.

QUARTERLY PROGRESS REPORT [ON] THERMODYNAMIC PROPERTIES OF SODIUM VAPOR, by W. A. Selke, C. H. Muendel, and H. Y. Krinsky. Mar. 1, 1952. 2p. (NYO-3098)

An apparatus for measuring the vapor pressure of radium in the range 500° to 1200°C has been designed and is now being completed. The method to be used consists essentially of boiling radium under argon at a known pressure and measuring the temperature at a point of vapor-liquid equilibrium. The data will be used to extend the experimentally known areas of the T-S and H-S diagrams for radium. Since the dimer content of radium increases with temperature along the boiling point curve, the data will also be used to determine the validity of the standard vapor pressure equations for this case with a possible view toward extrapolation into higher temperature regions. The apparatus is described in detail in a previous report, NYO-3097 (NSA 6-1670). (Entire report)

5366

Knolls Atomic Power Lab.

MECHANICAL LIQUID METAL PUMPS IN THE ALPLAUS

(GENIE) HEAT TRANSFER SYSTEM, by P. M. Clark. Nov. 1, 1951. 31p. (KAPL-635)

The design and operation of the mechanical liquid metal pumps in the Alphas (Genie) heat-transfer system are described. The pumps are centrifugal pumps with long overhung rotors. The pumping elements are contained in drain tanks which return pump leakage to the storage tanks. The drain tanks, which are pressurized with an inert gas, are sealed at the pump shaft with a face-type rotary shaft seal. The development of the seal is described. The highest liquid-metal operating temperature at the pump has been 800°F.

5376

Knolls Atomic Power Lab.

SAMPLING OF HIGH TEMPERATURE ALKALI METALS, by W. H. Bruggeman and G. Billuris. [nd] 16p. (AECU-2143)

The development history of sampling procedures used for determining the O content of Na and other alkali metals is presented. The KAPL sampling device, which is adaptable to a variety of sampling applications, is described in detail. (auth)

5391

THE DIFFRACTION OF X-RAYS BY LIQUID ALLOYS OF SODIUM AND POTASSIUM. N. S. Gingrich and R. E. Henderson. J. Chem. Phys. 20, 1117-20(1952) July.

Monochromatic x-ray diffraction patterns were taken of liquid alloys of sodium and potassium of seven different compositions at 115°C. Contrary to previous results, the present work does not show in a plot of position of main peak vs. composition an inflection which had been taken as evidence for the existence of Na₂K molecules in the liquid. Fourier analyses made for five of the alloys gave distribution curves which prove that there are no compact molecules in these liquid alloys, though they do not rule out the possibility that there may be weakly associated groups of atoms. (auth)

6031

THE TEMPERATURE DEPENDENCE OF THE VISCOSITY OF LIQUIDS. F. Gutmann and L. M. Simmons. J. Applied Phys. 23, 977-8(1952) Sept.

The equation $\log \eta = A + B/(T + C)$ is obtained as a simple modification of Andrade's viscosity equation by treating the activation energy as a function of temperature, A, B, and C being free parameters. This is shown statistically to express adequately the temperature dependence of viscosity over substantial ranges of temperature for all the liquids examined viz., n-heptane; n-nonane; n-undecane; n-tridecane; n-

heptadecane; benzene; viscous mineral oil; ethanol; 1,2-dibromopropane; water; mercury; molten gallium; potassium; sodium; sodium nitrate; silver bromide; lead chloride; bromine; 98 to 100% sulfuric acid. (auth)

5587

Naval Research Lab.

THERMAL CONDUCTIVITY OF SODIUM-POTASSIUM ALLOY (77.7 WT. % POTASSIUM), by Curtis T. Ewing and Robert E. Seebold. Aug. 12, 1952. 7p. (NRL-Memo-47)

The thermal conductivity of Na-K alloy, 77.7 wt. % K, has been determined between 157 and 676°C. The conductivity curve of this alloy increases from 0.2393 watts/cm-°C at 157°C to a maximum of 0.2618 at 445°C and then decreases to 0.2563 at 676°C. A graphic correlation of these results with those of two other previously reported Na-K alloys is presented. (auth)

6603

Cambridge Univ. (England)

INTERACTIONS BETWEEN SOLID AND LIQUID METALS AND ALLOYS; SECOND ANNUAL TECHNICAL REPORT, by V. W. Eldred. Sept. 1951. 72p. (AERE-X/M-85)

A method has been developed for bringing clean surfaces of fully annealed metals in contact with filtered and degassed liquid metals and keeping them in contact for long periods, without oxide contamination, so that the rate and nature of the attack by the molten metal may be investigated. The method can be used with many of the lower melting point metals at temperatures below 500°C and may be extended to higher temperatures. Tests have been carried out at temperatures up to 400°C on pure metal systems in which little attack was anticipated. A few tests have also been included on systems in which severe attack was expected. The interpretation and practical application of the results are discussed. (auth)

6604

Committee on the Basic Properties of Liquid Metals, Office of Naval Research

LIQUID-METALS HANDBOOK, by Richard N. Lyon, ed. June 1952. 276p. (NAVEXOS-P-733(Rev.))

This second edition of the Liquid-Metals Handbook incorporates suggested improvements and additional releasable data. It offers a reasonably complete compilation of information on liquid metals covering the physical properties, industrial utilization, corrosive effects on materials, heat transfer properties, heat transfer systems, heat transfer system components, and availability for production of low-melting-point alloys.

Volume 7, 1953

133

Knolls Atomic Power Lab.

DESCRIPTION AND TEST RESULTS OF A 400-GPM LIQUID METAL INDUCTION PUMP, by J. F. Cage, Jr. and E. H. Schoch. Oct. 23, 1951. Decl. Nov. 6, 1952. 93p. (AECD-3459; KAPL-619)

This report is a description of a round, 400-gpm, a-c electromagnetic pump which was manufactured and tested to determine the feasibility of its mechanical design and the accuracy of the theoretical analysis. The objective was to provide a pump, without bearings, packing, shaft seals, or moving parts of any kind, which would be capable of pumping 750°F sodium at flows up to 400 gpm against a head of approximately 40 psi for extended periods of time without leakage or other cause for maintenance. (auth)

134

Knolls Atomic Power Lab.

TEST OF 1200-GPM LINEAR A-C ELECTROMAGNETIC PUMP, by John Barnard and G. D. Collins. May 23, 1951. Decl. Nov. 6, 1952. 65p. (AECD-3460; KAPL-568)

Design and performance data are given for a straight-line, a-c induction electromagnetic pump to be used for pumping 1250-gpm of liquid Na at a pressure of 38 psi at temperatures up to 750°F are described. (J.E.D.)

135

Knolls Atomic Power Lab.

ELECTROMAGNETIC PUMPS FOR HIGH TEMPERATURE LIQUID METAL, by J. F. Cage, Jr. [nd] 31p. (AECU-2282)

A summary report is presented describing electromagnetic pumps for liquid metals. The pumps vary in size and application from small-scale laboratory pumps to those suitable for circulating liquid metal in a nuclear reactor power plant. The design and performance characteristics of the a-c and d-c Faraday types, helical-flow induction type, and the linear induction pump are described. (J.E.D.)

566

North American Aviation, Inc.

MOLYBDENUM CORROSION BY SODIUM, by R. Cygan and E. Reed. Issued Nov. 20, 1951. Decl. with deletions Dec. 1, 1952. 15p. (AECD-3473; NAA-SR-161)

Investigations of corrosion with both liquid Na and Na vapor, carried out at low temperatures, have shown Mo to be one of the most promising of the refractory metals. This report gives the results of the first corrosion test on Mo in Na vapor at 1500°C that has been successfully completed. In addition to the usual grain growth, the Mo showed some intergranular-type attack with a maximum penetration of less than 1 mil. (auth)

813

North American Aviation, Inc.

THE CORROSION OF REFRACTORY MATERIALS IN SODIUM, by R. L. Loftness, W. C. Ruebsamen, and T. A.

Coultas. Issued Nov. 20, 1951. Decl. with deletions Dec. 1, 1952. 41p. (AECD-3472; NAA-SR-126)

The corrosion of refractory materials in liquid sodium and sodium vapor at 900°C for periods of time up to 1 month was studied under static conditions. Vacuum-distilled sodium was used in all but a few instances. Changes in weight, appearance, and metallographic structure were observed, and post-run chemical analyses of the sodium were made. In general the rates of corrosion were higher in liquid sodium than in sodium vapor. The presence of excessive oxygen in the sodium increased the corrosion rates. In order of decreasing resistance to corrosion by sodium at 900°C the materials are: molybdenum, tungsten, Haynes Stellite-25 (Co, Cr, W, Ni alloy), type 347 stainless steel, Kennametal-138A (TiC + Co), tantalum, and titanium. Graphite, copper, platinum, spinel, alumina, magnesia, and zirconia showed poor resistance. Silicon carbide, molybdenum silicide, and thoria showed good resistance to corrosion. Synthetic sapphire and single-crystal magnesia had good resistance. Experimental procedures and equipment are described. Analytical methods for the presence of the following substances in sodium are described: oxygen, potassium, calcium, magnesium, silicon, aluminum, nickel, niobium, chromium, iron, molybdenum, tantalum, titanium, tungsten, zirconium, carbon, and sodium carbide (evidenced by acetylene formation). (auth)

1233

NEUTRON TOTAL CROSS SECTIONS. E. R. Hodgson, J. F. Gallagher, and E. M. Bowey. *Proc. Phys. Soc. (London)* A65, 992-4(1952) Dec.

The neutron total cross sections of Be, Na, Mo, and Hg have been measured in the energy region 1 ev to 10 kev, and of Th between 1 ev and 1 kev, using the Harwell linear accelerator time-of-flight spectrometer. The energy resolution is better than in previously reported work on these elements, and several resonances have been more clearly resolved. (auth)

1231

TOTAL NEUTRON CROSS SECTION OF SODIUM. P. H. Stelson and W. M. Preston. *Phys. Rev.* 88, 1354-7(1952) Dec. 15.

The total neutron cross section of sodium has been measured over the energy range 120 to 1000 kev using resolutions of 2.5 to 5 kev. A number of resonances, corresponding to excited states in the compound nucleus Na^{24} were investigated. In some cases it is possible to assign J and l values and to compute the effective level spacings D_J^l . Evidence is given to show that the D_J^l , which are a measure of the complexity of a state, differ by a factor of 8 for two states of the same type and at approximately the same excitation energy (7.5 Mev) in the Na^{24} nucleus. An anomalous S-wave resonance at 300 kev suggests that the potential scattering may be spin dependent. (auth)

1610

Illinois Inst. of Tech.

STUDIES OF FAST REACTIONS WHICH EVOLVE GASES. THE REACTION OF SODIUM-POTASSIUM ALLOY WITH WATER IN THE PRESENCE AND ABSENCE OF OXYGEN, by Martin Kilpatrick, Louis L. Baker, Jr., and C. Dana McKinney, Jr. Oct. 1952. 27p. (NP-4215; Technical Report No. 6; U-25213)

An improved apparatus has been developed for following simultaneously the pressure and ignition of reactions evolving gases. Both the early technique and the improved method have been applied to the reaction of Na-K alloy with H₂O in the presence and absence of O₂. It has been found that if O₂ is present there is an interesting example of ignition delay which explains the second pressure rise reported previously. When the excess of H₂O relative to the alloy is reduced sufficiently, ignition takes place on contact and only one maximum is recorded, corresponding to the second pressure rise. In the absence of O₂ a single maximum is recorded, corresponding to the first pressure rise reported previously. The improved apparatus permits the contacting of one ml of each of the reactants in 2 msec. A possible limitation to the speed with which chemical reactions may be followed by measuring their pressure is discussed. The reaction of Na-K alloy with ethanol, the hydrolysis of Al borohydride, and the hydrolysis of triethyl dialane are reported. (auth)

1688

SELF-DIFFUSION IN THE ALKALI METALS. D. K. C. MacDonald. *J. Chem. Phys.* 21, 177-8(1953) Jan.

The following activation energies for self-diffusion in the solid alkali metals have been determined from the "excess" electrical resistance (an exponential rise in resistance starting well below the melting point) and an assumption of an equilibrium number of lattice vacancies: Li, 9.3 ± 0.35 ; Na, 9.1 ± 0.1 ; K, 9.1 ± 0.1 kcal/mole. The figures for Li and Na are in good agreement with those of Gutowsky and McGarvey (NSA 6-6445). The constancy of the three values is remarkable in view of the variation in latent heat of vaporization: Li, 32.6; Na, 23; K, 19.3 kcal/mole. No exponential resistance rise was observed in Rb and Cs, in accord with their lower melting points. (G.Y.)

2307

Oak Ridge National Lab.

A SIMPLE ELECTROMAGNETIC FLOWMETER FOR LIQUID METALS, by R. M. Carroll. Issued Mar. 4, 1953. 19p. (ORNL-1461)

A method of construction of electromagnetic flowmeters from stainless steel or inconel tubing has been developed for the measurement of the flow rate of liquid Na. The experimental results of the calibration of the flowmeters have corresponded, within the limits of experimental error, to a general theoretical equation. With reasonable care in construction, the flowmeter should correspond to the formula to within 3%. (auth)

2312

LIQUID METAL CORROSION. Anton de S. Brasunas. *Corrosion* 9, 78-84(1953) Mar.

In many instances, liquid-metal corrosion is simply a solubility rate and extent of solubility. However, solubility and diffusion barriers may be developed from the components or impurities in the form of intermetallic compounds, metal oxides, nitrides, and other surface films. This paper does not discuss in detail the desirability or formation of these films, but recognizes their existence and discusses the nature and extent of interaction between a variety of metals of relatively high melting point and low melting metals which are arbitrarily referred to as "liquid metals." Such metals and alloys are those which melt below 400 or 500°C. (auth)

2351

Columbia Univ.

QUARTERLY PROGRESS REPORT [ON] AN APPARATUS FOR THE DETERMINATION OF THE CRITICAL TEMPERATURE OF SODIUM, by W. A. Selke and M. M. Makansi. Oct. 1, 1952. 11p. (NYO-3099)

A design of an apparatus for the determination of the critical temperature of Na is presented. The method is based on the difference between the electrical resistivities of Na vapor and Na liquid as a function of temperature. This difference should decrease as the critical point is approached and vanish when the critical is reached. Construction of the apparatus has started. (auth)

2726

Argonne National Lab.

NEUTRON RADIOBIOLOGY, RADIUM TOXICITY, EXPERIMENTAL PATHOLOGY, AND CLINICAL INVESTIGATION. Howard H. Vogel, Jr., John W. Clark, Donn L. Jordan, Robert J. Hasterlik, Miriam P. Finkel, Hermann Lisco, Austin M. Brues, Asher J. Finkel, Earl A. Hathaway, and Elaine J. Katz. p.8-25 of QUARTERLY REPORT [FOR] AUGUST, SEPTEMBER, AND OCTOBER 1952; DIVISION OF BIOLOGICAL AND MEDICAL RESEARCH. Austin M. Brues, ed. 18p. (ANL-4932(p.8-25)).

The eyes of mice exposed to fast neutrons, γ rays from a Co⁶⁰ source, and a 50-50 mixture of these two radiations, were examined approximately 5 months after irradiation. Data on pathologic changes are presented in tabular form. Fast neutrons were found to be much more effective than Co⁶⁰ γ rays in producing complete cataracts. Data on the response of mouse spleen and thymus to 90-min exposure to fast neutrons are presented graphically. Clinical studies on two patients containing Ra are discussed. Data are presented on the survival and gross pathological changes in rats following administration of Pu²³⁹. Studies reported to be in progress are designed to test the efficacy of protective substance against NaK burns of the skin and the therapeutic effects of various types of treatment of such skin burns. Following the accidental exposure of four laboratory members to γ rays and neutron radiation at levels below 200 r, urinary amino-acid excretion was studied by means of paper partition chromatography. All four patients showed a consistent daily increase in the amounts of amino acids excreted after the accident. The possibility is discussed that aminoaciduria may be a significantly sensitive early indicator of radiation exposure. (C.H.)

2825

Columbia Univ.

A METHOD FOR THE MEASUREMENT OF THE SPECIFIC HEAT OF SODIUM VAPOR: [PROGRESS REPORT]. M. M. Makansi and W. A. Selke. Apr. 1, 1953. 21p. (NYO-3100)

A method for the measurement of the specific heat of Na vapor at one atmosphere in the range of 200°C superheat, is presented. This method can be extended to include a wider range of temperatures and pressures; it also can be used for the determination of the specific heats of various other fluids of very high boiling point. The method is suitable at temperatures where the heat loss to the surroundings is appreciable compared to the sensible heat which can be transferred to a fluid stream in test equipment. (auth)

3452

Naval Research Lab.

THE SOLUBILITY OF IRON IN SODIUM METAL, SODIUM-SODIUM OXIDE, AND SODIUM-SODIUM OXIDE-SODIUM HYDROXIDE. Andrew D. Bogard. Mar. 9, 1953. 10p. (NRL-4131)

The solubility of Fe in Na metal has been determined across the temperature range 236°–540°C in a static system using 46.3-day Fe⁵⁹ as a tracer. The solubility of Fe in Na metal follows the expression: $\text{wt.}\% \text{ Fe} = 2.88 \times 10^{-7} - 1.63 \times 10^{-9} T + 5.63 \times 10^{-12} T^2$, where T is the temperature in degrees-centigrade. Sodium monoxide, across a similar temperature range increases the solubility of Fe in Na metal by a factor of approximately 10. The solubility at any temperature between 200 and 560°C may be calculated from: $\text{wt.}\% \text{ Fe} = 3.17 \times 10^{-6} - 1.71 \times 10^{-8} T + 3.51 \times 10^{-11} T^2$. The combined effect of Na monoxide and Na hydroxide increases the solubility by another factor of approximately 10 across the temperature range 250–560°C. The curve follows the expression: $\text{wt.}\% \text{ Fe} = 8.23 \times 10^{-8} T - 1.30 \times 10^{-5}$. It was found that impurities in the Fe undetectable by chemical or spectroscopic methods appeared in the sodium metal. A stainless-steel and Ni apparatus was used, in which a sample of Na was distilled onto the radioactive Fe, and the sample was removed after saturation at a given temperature and stored in a sample receiver until a series of determinations had been completed. The Fe dissolved in the Na was determined radiometrically. (auth)

3471
DETERMINATION OF THE THERMODYNAMIC ACTIVITY OF CONSTITUENTS OF MOLTEN SYSTEMS FROM THE SOLIDIFICATION DIAGRAMS. M. Maurice Rey. Translated from *Compt. rend.* **228**, 473-5(1949). 2p. (AEC-TR-2024)

3775
[Brush Beryllium Co.]
APPLICATION OF VIBRATIONS TO MOLTEN METALS: A REVIEW OF THE LITERATURE. R. G. O'Rourke. [1951]. 7p. (AECU-2535)

A survey is made of work on sonic and supersonic vibrations as applied to molten metals, and of their effects on grain size, melting point, homogeneity, etc. 19 references. (J.S.R.)

3874
TOTAL CROSS SECTIONS OF CHLORINE, SODIUM, TITANIUM, AND BROMINE FOR FAST NEUTRONS. H. R. Dvorak and R. N. Little, Jr. *Phys. Rev.* **90**, 618-22(1953) May 15.

Relatively new liquid scintillation counter methods were adapted to detect fast neutrons with a heretofore unattainable efficiency of about 19%. The geometry obtained was the so-called "good" geometry, which was a half angle at the counter of 2.7°. With the more efficient counter reasonable counting times could be obtained with the detector subtending a half angle of only 2.7° from the target. The neutrons were obtained by using a modified Cockcroft-Walton linear accelerator of 100-kev bombarding energy. The neutron energy range was 2.15 to 2.82 Mev. A C cross-section curve was obtained as a check on this method, and agreement with previously reported values was excellent. The Cl and Na cross sections were found to be about $3 \times 10^{-24} \text{ cm}^2$, as determined indirectly by using CCl_4 and NaCl . The Ti cross section was found to be about $4.1 \times 10^{-24} \text{ cm}^2$ by using powdered Ti metal. The Br cross section was found to be about $3.7 \times 10^{-24} \text{ cm}^2$, by using a sample of liquid Br. No large resonances were found in the energy region available. Data were also taken on the angular distribution of the number of neutrons with respect to the forward direction of the incident deuteron beam and were found to agree well with theory. (auth)

4461
COOLANTS. O. J. Woodruff, Jr., W. J. McShane, and W. J. Purcell. *Nucleonics* **11**, No. 6, 27-34(1953) June.

The nuclear, thermal, and fluid properties of coolants are reviewed. Water, liquid metals, and gases are the three types of coolants discussed. The system design and components of each type are given, and the advantages and disadvantages of each are discussed. (J.S.R.)

4802

Oak Ridge National Lab.

DISSOLUTION OF NaK. J. C. White, C. K. Talbott, and L. J. Brady. Dec. 2, 1952. Decl. June 11, 1953. 9p. (AECD-3538; ORNL-1453)

A rapid yet safe method for the dissolution of Na-K alloys prior to chemical or instrumental analysis has been devised. The alloy is submerged beneath the surface of an inert organic reagent and dissolved at a controlled rate by adding methanol drop-by-drop. A blanket of inert gas is maintained over the reaction flask. The procedure has been successfully used to dissolve samples of NaK in the range of 0.05 to 25 g. (auth)

5332

Atomic Energy Research Establishment, Harwell, Berks (England)

A. C. LIQUID METAL PUMPS FOR LABORATORY USE. D. A. Watt. Mar. 19, 1953. 27p. (AERE-CE/R-1089)

Two types of single-phase a-c electromagnetic pump for liquid metals are described, a leakage reactance model and a combined pump and transformer. The NaK-alloy test rig is briefly described, and methods of pump construction are detailed. Test results and curves for pumping the NaK alloy at temperatures below 70°C are included, and it is shown that the combined form is the more effective pump. One of these models, with a single loop secondary winding, had a maximum efficiency of 11% with an output of 10 gpm at 13 psi pressure rise, and an input of 650 watts, 9.0 to 7.5 amps at 180 to 195 volts. A maximum pressure rise of nearly 30 psi is recorded for the first model of this form. (auth)

5709

Knolls Atomic Power Lab.

DISSOLVING SODIUM-POTASSIUM ALLOYS. L. P. Pepkowitz. Aug. 12, 1953. 7p. (KAPL-976)

Na-K alloys can be added to solvents without any explosion hazard if the alloy is frozen on dry ice. The solid is cut into small pieces and added to an alcohol-dry ice slurry. The rate of reaction can be controlled by adding more dry ice to the slurry. The CO_2 blanket and the low temperature prevent any reaction with the O in the air. (J.S.R.)

5990

Pesco Products Div., Borg-Warner Corp.

DESIGN OF LIQUID COOLANT PUMPS; DESIGN REPORT 22463-D2. PARTS 1 AND 2. Norman B. Dewees. Apr. 30, 1951. 113p. (NEPA-1855)

Design and theoretical data are presented for a lightweight pump to be used for Na in an operating temperature range of 705 to 1200°F at a flow rate of 1600 gpm at 950°F for a 108-psi head. Engineering requirements are summarized, and detailed theory and calculations are included. (E.S.)

6217

TOTAL REACTION CROSS SECTIONS OF THE ELEMENTS N, Na, Al, AND Si FOR 1.9 TO 3.8 MEV NEUTRONS. R. Meier, R. Ricamo, P. Scherrer, and W. Züntli. *Helv. Phys. Acta.* **26**, 451-64(1953) Sept. 15. (In German)

Total neutron cross sections of N, Na, Al, and Si have been measured by means of transmission experiments in the range 1.9 to 3.8 Mev. Monoenergetic neutrons were obtained from the D-D reaction in a thin heavy-ice target with a spread in energy between 20 and 50 kev. Many new excited levels of N^{16} , Na^{24} , Al^{28} , and Si^{29} were found. A level in N^{16} , excited with 2.25-Mev neutrons, has been analyzed and is proposed to be a $J = \frac{1}{2}$, odd parity state. (auth)

6497

SURFACE TENSION AND HEAT OF VAPORIZATION OF METALS. S. N. Zadumkin. *Doklady Akad. Nauk S.S.S.R.* **92**, 115-18(1953) Sept. 1. (In Russian)

The surface tension and heat of vaporization of Ni, Na, K, Li, Cs, Rb, Zr, and Hf were determined experimentally. The results were in fair agreement with theory. (J.S.R.)

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227

Argonne National Lab.

RESISTIVITY OF NaK. P. G. Drugas, I. R. Rehn, and W. D. Wilkinson. Issued Oct. 2, 1953. 11p. Contract W-31-109-eng-38. (ANL-5115)

Resistivity measurements of two liquid NaK alloys containing 44.8 and 80% K by weight were made. The method consisted of passing a measured current through a calibrated inconel tube containing NaK alloys, heating the central portion to a uniform temperature over a length of 12 in., and measuring the potential drop across the heated length. The measurements were made over a temperature range of 30 to 720°C. The resistivity curve for the 44.8-wt. % K alloys appeared to consist of two straight lines with a break at 220°C. The curve for the 80-wt. % alloy was uniformly curved. (J.S.R.)

517

HEAT TRANSFER AT HIGH-POWER DENSITIES. John S. Hickey, Jr. *J. Appl. Phys.* 24, 1312-17(1953) Oct.

The power densities that liquid metal cooling is capable of are explored. The advantages of liquid metals over conventional water cooling are shown. The presentation is such that one can choose between the available coolants for any particular application with a minimum of background. The work done at the General Research Laboratory in developing a vacuum tube anode capable of handling 5 kw/cm² is covered. (auth)

1039

Atomic Energy Research Establishment, Harwell, Berks (England)

THE THEORY OF THE D.C. ELECTROMAGNETIC FLOW-METER FOR LIQUID METALS. J. A. Shercliff. Nov. 1952. 31p. (AERE-X/R-1052)

In practical electromagnetic flowmeters the ratio of voltage output to flow quantity times field intensity is not a simple constant. This report investigates theoretically the variations of this ratio due to wall conductivity, contact resistance, the shortness of magnet pole faces, and the distortion of the velocity profile by electromagnetic forces in tubes of circular and rectangular section. Several points are still obscure, particularly the behavior of turbulence. Some recent tests are examined in the light of the theory, and the influence of dimensionless groups is discussed. It is shown that the design of an accurately predictable flowmeter is possible, although such a meter would be uneconomic for routine use. (auth)

*1079

Knolls Atomic Power Lab.

CORROSION OF ZIRCONIUM AND ITS ALLOYS IN LIQUID METALS. R. F. Koenig. Oct. 1, 1953. 14p. Contract W-31-109-eng-52. (KAPL-982)

The results of corrosion tests of Zr and Zr alloys in various liquid metals under static, isothermal conditions are

summarized. Stress-rupture tests of Zr alloys in filtered Na at 1000°F are tabulated. (J.E.D.)

2341

SOME PROPERTIES OF SODIUM AND POTASSIUM NEAR THEIR MELTING POINTS. L. G. Carpenter (Royal Aircraft Establishment, Farnborough, Hants., England). *J. Chem. Phys.* 21, 2224-5(1953) Dec.

An examination of how far the resistance, diffusion, and specific heat phenomena of Na and K near their melting point can be interpreted in terms of a common model is reported. (J.A.G.)

2442

Iowa Engineering Experiment Station

THERMAL CONDUCTIVITY OF MOLTEN MATERIALS. PROGRESS REPORT NO. 1 [FOR] QUARTER ENDING

MARCH 31, 1952. Apr. 3, 1952. 6p. Contract AF 33(616)-11. (NP-5093)

*2824

Oak Ridge National Lab.

SODIUM PLUMBING. A REVIEW OF THE UNCLASSIFIED RESEARCH AND TECHNOLOGY INVOLVING SODIUM AT THE OAK RIDGE NATIONAL LABORATORY. William B. Cottrell and Leland A. Mann. Aug. 14, 1953. 82p. Contract W-7405-eng-26. (ORNL-1688)

The research data and the development experience relevant to sodium obtained during the period 1950 to 1953 at the Oak Ridge National Lab. are summarized. Methods for testing the corrosion resistance of structural metals in sodium and the results of such tests are presented. The developmental work that has been done on the various components of sodium systems is described, and the relative merits of commercially available components are discussed. Cleaning, assembly, leak testing, and operating techniques and precautions are given. (auth)

2827

HEAT TRANSFER MEASUREMENTS AT SODIUM-STAINLESS STEEL INTERFACE. James W. Moyer and William A. Riemen (Knolls Atomic Power Lab., Schenectady, N. Y.). *J. Appl. Phys.* 25, 400-2(1954) Mar.

Experiments to measure the heat-transfer coefficient at a Na-type-347 stainless steel interface are described. The temperature range is 100 to 500°C. It is concluded that wetting does not play a significant role in the heat transfer. (auth)

2836

STABILITY OF REFRACTORIES IN LIQUID METALS.

E. L. Reed (North American Aviation, Inc., Downey, Calif.). *J. Am. Ceram. Soc.* 37, 146-53(1954) Mar.

Present technological developments are making more extensive use of liquid metals as heat transfer agents. Their stable and relatively noncorrosive character makes

them especially adaptable for high-temperature applications. The compatibility of various liquid metals with refractories has been investigated in the past over a temperature range up to several hundred degrees centigrade. To extend this information to much higher temperatures, corrosion experiments were carried out utilizing liquid sodium, tin, and bismuth. Tests were conducted in the range 800 to 1500°C using molybdenum, tantalum, tungsten, graphite, alumina, zirconia, and other materials. The experimental apparatus and procedures employed in conducting both static and dynamic tests are described, and significant results are summarized. (auth)

4038

Mine Safety Appliances Co.
HEAT TRANSFER WITH SODIUM-POTASSIUM LIQUID ALLOYS. Robert C. Werner, Earle C. King, and Robert A. Tidball. Dec. 5, 1949. 45p. (NP-5169)

Over-all heat-transfer coefficients of 1000 to 2100 Btu/(hr) (ft²) (°F) were measured in a double-pipe heat exchanger using a 44 and a 77 wt. % K alloy of sodium and potassium. The data cover a temperature range of 300 to 1200°F and a velocity range of 1.5 to 12 fps in the center tube. A method is presented for separating the over-all coefficients into individual film coefficients. The coefficients calculated by this method, with the aid of the physical properties of sodium-potassium alloys presented, are then compared with the theoretical coefficients for liquids of low Prandtl number with very favorable results. Values of the individual film heat-transfer coefficients are found to vary from 2000 to 6000 Btu/(hr) (ft²) (°F) for the temperatures and velocities used. At temperatures up to about 1400°F, alloys of sodium and potassium will serve as excellent heat-transfer media because of their low vapor pressures, low viscosities, high thermal stability, high thermal conductivities, and melting points below room temperature. (auth)

4283

Knolls Atomic Power Lab.
EVALUATION OF FERRITIC SUBSTITUTES FOR THE AUSTENITIC STAINLESS STEELS. 1. RESISTANCE TO ATTACK BY SODIUM. E. G. Brush and R. F. Koenig. Apr. 22, 1954. 47p. Contract W-31-109-Eng-52. (KAPL-1103)

The ferritic chromium-iron alloys have several advantages which make them attractive substitutes for the austenitic stainless steels in sodium-cooled nuclear power plants where primary coolant temperatures will not exceed 1000°F. The principal advantages are lower cost, greater availability, lower thermal expansion, and higher thermal conductivity. The resistance of the chromium-iron alloys to attack was evaluated in sodium at temperatures of 500 and 700°C in a series of static and dynamic laboratory tests. Results indicated that steels containing 12% chromium are as resistant to attack by solution and mass transfer in filtered sodium at 500°C as the austenitic stainless steels, do not decarburize in filtered sodium at 500°C, and are more susceptible to corrosion in sodium containing more than 0.01% by weight of oxygen at 500°C than the austenitic stainless steels. The results further indicated that the 12% chromium-iron alloy decarburized at a rate of 0.04 mil/hr in continuous immersion (2160 hr) in sodium containing 0.01% oxygen at 700°C, but did not decarburize in intermittent immersion in sodium at 649°C containing between 0.003 and 0.015% oxygen. Additional tests are in progress to determine the effects of stress and local oxide contamination on the corrosion of the chromium-iron alloys at 500°C in filtered sodium, to evaluate decarburization up to 800°C in sodium containing 0.003% oxygen, and finally to evaluate diffusion welding behavior. The operation of a large-scale 12% chromium-iron alloy heat transfer sodium system is desirable to substantiate laboratory data, which

show the 12% chromium-iron alloy to have promise as a construction material for sodium service at temperatures up to 1000°F. (auth)

4314

MAGNETO-HYDRODYNAMIC WAVES IN LIQUID SODIUM. Bo Lehnert (Royal Institute of Technology, Stockholm, Sweden). *Phys. Rev.* **94**, 815-24(1954) May 15.

Liquid sodium, because of its higher electrical conductivity and lower density, is more suitable than mercury for magneto-hydrodynamic experiments. Torsional waves in liquid sodium have been generated in a cylindrical vessel with the axis parallel to a homogeneous magnetic field, and resonance phenomena have been investigated at constant frequency and variable magnetic field strength. The agreement between theory and experiment is satisfactory. It is shown that even with sodium, damping plays an important role under laboratory conditions. The calculations of this paper are also used to improve the results of earlier investigations with mercury. (auth)

4318

A NEW SEMI-AUTOMATIC APPARATUS FOR MEASUREMENT OF SPECIFIC HEATS AND THE SPECIFIC HEAT OF SODIUM BETWEEN 55 AND 315°K. T. M. Dauphinee, D. K. C. MacDonald, and H. Preston-Thomas (National Research Council, Ottawa, Canada). *Proc. Roy. Soc. (London)* **A221**, 267-76(1954) Jan. 21.

An apparatus has been developed for the semi-automatic measurement of specific heats from room temperature to the liquid-hydrogen range. A dynamic system, involving continuous heat input to the sample, is made possible by the use of a relatively small sample together with a large effective surface area for the heaters. Adiabatic conditions can then be maintained automatically. All data relevant to the specific heat determination (time, power input, and temperature) are recorded on a single chart. The operator is required only for periodic switching, which could in principle also be automatic. The specific heat of sodium has been studied between 55 and 315°K with this apparatus. The predicted limits of accuracy ($\pm 0.1\%$) appear to be approached rather closely. A small anomaly, showing some hysteresis effects, appears in the region of 200°K. (auth)

4567

Knolls Atomic Power Lab.
FREE CONVECTION IN NARROW VERTICAL SODIUM ANNULI. D. P. Timo. Mar. 5, 1954. 31p. Contract W-31-109-Eng-52. (KAPL-1082)

An engineering approach to the solution of a troublesome free-convection problem in the narrow vertical sodium annuli of the SIR Mark A rotating plugs is presented. Very high heat transfer rates (in the order of 2000 Btu/hr/ft of periphery) were observed in annuli approximately 0.1 in. wide, 30 in. high, and of varying diameters, with vertical ΔT 's of the order of 200°F. An approximate analysis of the heat transfer in these annuli is made, based chiefly on the assumption that the maximum ΔT between the hot and cold convecting legs of the tangential convection loops is equal to the vertical ΔT . (The hot leg is at the heat source temperature, and the cold leg is at the heat sink temperature.) An expression giving the heat transfer due to free convection in a narrow annulus is derived, and a simple relationship between the Nusselt, Grashof, and Prandtl Numbers is obtained. The effectiveness of peripheral flow barriers or "piston rings" in reducing free-convection heat transfer in an annulus at higher ΔT 's is conservatively evaluated. Preliminary experimental results provide a rough check on the analysis. This analysis, while made specifically for the case of convecting sodium, is applicable to other fluids, if film thermal resistances are taken into account. (auth)

5200

Oak Ridge National Lab.

FORCED CONVECTION HEAT TRANSFER IN THERMAL ENTRANCE REGIONS. PART 3. HEAT TRANSFER TO LIQUID METALS. William B. Harrison. 74p. Contract W-7405-eng-26. (ORNL-915)

The heat transfer to liquid metals in turbulent flow within the thermal entrance region of circular tubes having uniform wall temperature was explored. Since liquid metals are characterized by high thermal conductivity, emphasis has been placed on analytical conduction solutions which neglect the contribution to heat transfer that is made by the eddy motion of a fluid in turbulent flow. Three solutions, which differ only in the postulated velocity distribution of the fluid, have been selected for comparison. The postulated velocity distributions are: (1) uniform, (2) parabolic, and (3) velocity proportional to distance from the channel wall raised to the one-seventh power. Other related entrance region solutions are briefly surveyed. In view of the important role played by the molecular thermal conductivity in heat transfer to liquid metals in a direction normal to a tube wall, the influence of thermal conductivity on heat transfer parallel to a tube wall has been examined. Experimental work performed in connection with this study consisted of taking heat transfer data to mercury and sodium in tubes of $\frac{1}{16}$ in. and $\frac{1}{8}$ in. length in combination with diameters of $\frac{1}{16}$ in. and $\frac{1}{8}$ in. The mercury heat transfer data for three different test sections compare favorably with the conduction solution for a postulated velocity distribution according to the one-seventh power law. These data were taken over a range of Reynolds modulus from 20,000 to 200,000, and heat transfer coefficients up to 66,300 Btu/hr · ft² · °F were achieved. Sodium data were erratic and low when compared with the mercury data or the conduction solutions. In an effort to explain this observation, it has been shown that, if a nonwetted condition existed, the small test section diameter and the high thermal conductivity of sodium would combine to maximize the effects on the heat transfer. An attempt was made to corroborate the hypothesis of non-wetting with an experimental study of interfacial electrical resistance, but the results were inconclusive. (auth)

5204

Naval Engineering Experiment Station, Annapolis
BASIC INFORMATION ON THE BEARING PROPERTIES OF VARIOUS MATERIALS IN LIQUID METALS. W. J. Greenert and M. R. Gross. July 2, 1954. 23p. (EES-090014B)

The report deals with the operation of aluminum thrust and journal bearings in NaK at ambient temperatures of 80 to 400°F. The thrust bearings, at 75-lb load, showed little wear or deterioration after 11,000 hr of exposure and intermittent operation in contaminated NaK. The journal bearings failed at these conditions under 20-lb load. (auth)

5497

ON THE ELECTROLYSIS OF POTASSIUM-SODIUM ALLOYS. Robert Kremann and Rudolf Gruber von Rehenburg. Translated from *Z. physik. Chem.* 110, 559-71(1924). 8p. (AEC-tr-1845)

5549

Mine Safety Appliances Co.

UNDERWATER DISPOSAL OF MOLTEN SODIUM. R. C. Andrews and E. C. King. July 30, 1954. 18p. Contract NObs-65426, Technical Report No. 29. (NP-5261)

Sodium at 350°F was discharged under 10 ft of water through an open end annulus (free area of 0.226 sq in.) at flow rates of approximately 90 lbs/min. The reactions resulted in little sodium oxide smoke and no hydrogen fires, showing that large quantities of sodium can be disposed of under water with little surface reaction, provided a minimum depth of 10 ft is maintained. (auth)

5684

RESONANCE OF NEUTRONS IN SODIUM. D. Popovic (Joint Establishment for Nuclear Energy Research, Kjeller, Norway). *Nuovo cimento* (9) 12, 143-4(1954) July. (In Italian).

The cadmium ratio of Na was measured relative to that of B, a known 1/v absorber. The results were $CdR_B = 48.1 \pm 0.25$ and $CdR_{Na} = 41.5 \pm 0.8$. The integral resonance absorption for Na was calculated to be $\Sigma_a = 0.037$ barn. (J.S.R.)

5825

Mine Safety Appliances Co.

EMERGENCY SEAL FOR LIQUID SODIUM. V. K. Heckel and E. C. King. Aug. 13, 1954. 10p. Contract NOas-65426, Technical Report No. 30. (NP-5292)

A valveless emergency seal for sodium can be formed by freezing the leaking fluid in small tubing. Tests with a 0.035-in. wall, 0.125-in. OD tube have shown that ambient temperature is the determining factor in sodium travel before freezing. Sodium temperatures and pressures ranged from 400 to 1030°F and 25 to 125 psig. Ambient temperatures ranged from 72 to 180°F, giving a maximum sodium travel of 16.6 ft at the highest temperature. (auth)

5849

Culcheth Labs., Research and Development Branch, Dept. of Atomic Energy (England)

THE SOLUBILITY OF OXYGEN IN SODIUM AND SODIUM-POTASSIUM ALLOY. J. D. Noden and K. Q. Bagley. July 20, 1954. 18p. (RDB(C)-TN-80)

The solubility of oxygen in sodium has been determined in the temperature range 130 to 540°C and of oxygen in sodium-potassium alloy in the range 20 to 176°C, using apparatus in both glass and stainless steel. The results suggest that the solution formed approximates to an ideal solution but that the partial heat of solution changes abruptly at 260 to 270°C. Sources of error encountered during the use of the glass apparatus have been investigated. (auth)

6147

Atomic Energy Research Establishment, Harwell, Berks (England)

HOMOPOLAR GENERATORS AND LIQUID METAL BRUSHES. A BIBLIOGRAPHY. M. Greenhill. 1954. 6p. (AERE-Inf/Bib-92)

This bibliography on homopolar generators and liquid metal brushes includes 64 references taken from the Harwell report indexes, Nuclear Science Abstr. up to volume 7(1953), Science Abstr. B up to volume 56(1953), Eng. Index 1939 to 1952, and Ind. Arts Index 1947 to 1952. (J.A.G.)

6981

Mine Safety Appliances Co.

NATURAL CIRCULATION WITH NaK-56 IN FOUR VERTICAL UNBAFFLED HEAT EXCHANGERS. M. J. McGoff and J. W. Mausteller. Sept. 30, 1954. 54p. Contract NObs 65426, Technical Report No. 32. (NP-5350)

Natural convection cooling of tubes by NaK 56 was investigated in four vertical un baffled heat exchangers. Three multitube exchangers contained either 0.125 or 0.250 in. OD tubes, and one exchanger contained a single 0.500 in. OD tube. The same exchangers were also tested under forced convection conditions. Natural circulation shell-side film coefficients ranged from 360 to 2,860 Btu/hr/ft² · °F, with corresponding Reynolds numbers of 475 to 19,500. A general correlation of natural circulation and forced circulation points was made for the three multitube exchangers. Natural circulation data for the single tube exchanger do not lie on the curve. (auth)

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Atomic Energy Research Establishment, Harwell, Berks (England)

THE SURFACE TENSION OF LIQUID METALS AND ALLOYS. J. W. Taylor. May 4, 1954. 62p. (AERE-M/TN-24)

Existing information on the surface tensions of liquid metals and alloys is reviewed. Methods of measurement are discussed critically to permit the selection of most accurate experimental values. Interpretations of surface tension data in terms of the molecular form of the liquid metal state are presented, and the limitations and inaccuracies of these analyses are indicated. Several physico-mathematical treatments of the surface energies of liquid metals are considered, and the calculated surface tensions are compared with the experimental values for a number of metals. It is shown that such treatments can in general only indicate the order of magnitude of the surface tension for the majority of metals. A number of empirical relationships between the surface tension of metals and other physical properties are presented, and the theoretical basis for these correlations are established. (auth)

229

LIQUID METALS. PART I. THE SURFACE TENSION OF LIQUID SODIUM: THE VERTICAL-PLATE TECHNIQUE. C. C. Addison, D. H. Kerridge, and J. Lewis (Nottingham Univ., Nottinghamshire, England). *J. Chem. Soc.*, 2861-6(1954) Aug.

This paper describes the determination of the surface tension of liquid Na in an atmosphere of pure argon, from measurements on plates of Zn, Cu, and Mo suspended, and partly immersed, in liquid Na. In the temperature range 100-100° Zn can be fully wetted by Na, but Cu and Mo are not wetted; the technique employed for contact angles of 0° and 180° is described. The surface tension is found to be 195 dynes/cm. at the melting point, and the temperature coefficient is 0.1 dyne/cm./degree. (auth)

605

Mine Safety Appliances Co.

SODIUM LEAK DETECTION IN VERTICAL PIPING. W. Millich and E. C. King. Nov. 19, 1954. 22p. Contract NObs-65426, Technical Report No. 34. (NP-5417)

The leak detecting tape previously developed for application on horizontal piping operated satisfactorily for leaking sodium at 850°F and 80 psig. At 350°F and 50 psig the tape was not satisfactory for use on vertical or horizontal piping. It has been shown that the tape can be used for 350°F, 50-psig sodium leak detection on vertical piping, provided sumps are cut into the insulation at the nearest horizontal section. The leaking sodium collects in the

sumps and shorts out bare wires set in ceramic spacers.

Bare wires in 2-hole ceramic spacers have been tested and recommended instead of the woven electrical insulation leak detector tape. A leak in vertical pipe was not satisfactorily detected until the sodium reached a bend and horizontal pipe section. (auth)

672

THE SURFACE ENERGY OF SODIUM. Allen B. Scott (Univ. of Bristol, England). *Phil. Mag.* (7) 45, 1173-6(1954) Nov.

The surface energy of sodium, calculated by the use of the free-electron model, is modified by considering the increased electrostatic energy in the surface if the positive charge is assumed to be localized in the planes of the atomic nuclei instead of distributed uniformly. While the theoretical surface energy is increased significantly, the theory does not yet account for the energy observed experimentally. (auth)

943

THE DESIGN OF TOTALLY ENCLOSED MECHANICAL PUMPS WITH PARTICULAR REFERENCE TO A 50 H.P. SODIUM PUMP. P. Fortescue (Atomic Energy Research Establishment, Harwell, Berks, England). *J. Nuclear Energy* 1, 5-23(1954) Aug.

An analysis is first made of the influence of design factors on performance of sheathed induction motors, the results being presented in the form of simple general working formulas with the case of the motor for a proposed 50-hp sodium pump worked out in detail by way of example. The general conclusion is that motors for this duty should have a large ratio of length to diameter and should work at lower magnetic loading and higher electric loading than is normal practice for unsheathed motors. The maintenance of an adequate reserve of pull out torque constitutes a major design limitation in these circumstances. With the design presented, having a 6-in. diameter motor, 25-in. long and employing a 0.03-in. thick nichrome sheath, 50 hp should be obtainable at 1,500 rpm at an over-all efficiency of 80 per cent. Increasing sheath thickness to 0.045 in. would drop efficiency by about 3 per cent. Use of a solid rotor and permitting the liquid metal to penetrate the rotor-sheath gap would involve no serious additional loss. An analysis of the problems of bearing design for use in liquid metals is then made, results being presented in the form of generalized performance charts and a discussion of their implication. The conclusion is that a vertical shaft arrangement with hydrostatic journals and a hydrodynamic thrust bearing offers great advantage. A general arrangement drawing incorporating the previously discussed recommendations in a particular design of a pump is shown. (auth)

948

Mine Safety Appliances Co.
THE INFLUENCE OF OXYGEN ON THE CORROSION OF ARMCO IRON AND TYPE 347 STAINLESS STEEL IN 1000 F SODIUM. E. F. Batutis, S. J. Rodgers, and J. W. Mausteller. Nov. 29, 1954. 14p. Contract NObs-65426, Technical Report 33. (NP-5433)

The corrosion of Type 347 stainless steel and Armco iron was studied as a function of oxygen content in sodium in a nickel system. The corrosion rate of Armco iron varied from 0.20 mg/cm²/month at 0.005 wt. % oxygen to 60.0 mg/cm²/month at 0.066 wt. % oxygen. Type 347 stainless steel showed a weight gain below 0.036 wt. % oxygen and a weight loss above 0.036 wt. % oxygen; the corrosion rate varied from -1.6 mg/cm²/month at 0.008 wt. % O₂ to +2.4 mg/cm²/month at 0.080 wt. % O₂. (For preceding report in series see NP-5350.) (auth)

1080

Atomic Energy Research Establishment, Harwell, Berks (England)
LIQUID METAL COOLANTS. BIBLIOGRAPHY. J. E. Terry and N. B. Skeats. July 1954. 21p. (AERE-Inf/Bib-94)

A bibliography of unclassified reports and literature references supplementing, A.E.R.E., Inf./Bib. 89 and A.E.R.E. Inf./Bib. 89 (Supplement 1) and containing references up to mid-June, 1954 on liquid metal coolants is presented. (auth)

CORROSION

1254

Mine Safety Appliances Co.
REPORT NO. 7, MARCH 1, 1954 THRU MAY 7, 1954 TO THE DETROIT EDISON COMPANY. J. R. Taylor, S. J. Rodgers, and H. J. Williams. July 25, 1954. 37p. (NP-5449)

A 30-day test on Zr tubing produced a metallic deposit on a large portion of the outer or NaK contacting surface. The deposit was found to be very magnetic, and a chemical analysis showed that it was 75% Fe. The deposit formation was believed to have been caused by a form of mass transfer due to the coexistence of a temperature differential and metals (type-316 stainless steel) having temperature-dependent solubilities in NaK. Weight and dimensional determinations made on the specimen tube before and after exposure showed no appreciable gain or loss of weight nor change in wall thickness. A metallurgical examination of the exposed Zr specimen showed the presence of black needle-like spider-web constituent which appeared to be at the grain boundaries penetrating to as much as half the thickness of the tube from the Na contacting side. This constituent was thought to be Zr hydrides. An examination by polarized light showed that recrystallization took place in all sections of the tube. A change in grain structure on the Na contacting surface was also evident with polarized light. An examination of the type-347 stainless steel IHX tube showed no erosion or corrosion and the tube structure was normal. An average concentration of 1.8 ppm of Zr at the sampling temperature was found in metal samples taken from the Na stream during the test. A total of less than 1 mg of Zr was found in Na and NaK cold traps analyzed at the conclusion of the tests, indicating that the amount of tube material lost to the liquid metals during the 30-day test was negligible. (J.A.G.)

1277

VISCOSITY OF THE SODIUM-POTASSIUM SYSTEM. C. T. Ewing, J. A. Grand, and R. R. Miller (Naval Research Lab., Washington, D. C.). *J. Phys. Chem.* 58, 1086-8(1954) Dec.

Viscosity coefficients in the low-temperature range from 60° (or the mp) to 200° for sodium, potassium, and several alloys have recently been published. A nickel viscometer of the Ostwald type has been used to substantiate these measurements and to extend results to 700°. For each metal and alloy, the extended coefficients also exhibited normal temperature variation which is adequately expressed by an equation set forth by Andrade. The coefficients at higher temperatures were intended for engineering application, and no attempt was made to duplicate the precision of the results measured in glass. A composite curve of isotherms representing both sets of measurements can be drawn from which the viscosity-temperature curve for any alloy in the sodium-potassium system can be derived. (auth)

1806

Mine Safety Appliances Co.
FLOW DECAY IN A SODIUM HEAT TRANSFER SYSTEM. R[obert] A. Tidball and F. L. Mangold. Jan. 11, 1955. 24p. Contract NObs-65426, Technical Report No. 35. (NP-5491)

Isothermal flow decay studies were made on the sodium side of the 1000 kw steam generating system, and the results compared with decays calculated by an analytical technique developed for SIR emergency cooling predictions. A total of eleven tests were run: seven at 800 to 850°F sodium temperature and four at 580°F sodium temperature. Initial flow rates of 75 and 50 gpm were used for each condition. In all cases there was a more rapid decay than predicted—at one second the flow was about 55% of the predicted flow. (auth)

1897

Mine Safety Appliances Co.
MONTHLY REPORT NO. 1, JULY 1953, TO DETROIT EDISON COMPANY. Aug. 11, 1953. 10p. (NP-5477)

Corrosion tests with liquid Na on a group of special fuel alloy test specimens are conducted in two corrosion harps. The design of the harps is emphasized. (K.S.)

1898

Mine Safety Appliances Co.
MONTHLY REPORT NO. 2, OCTOBER 1953, TO DETROIT EDISON COMPANY. Nov. 2, 1953. 19p. (NP-5478)

Final corrosion loop design is presented for the study of liquid-Na corrosive effects. (K.S.)

1899

Mine Safety Appliances Co.
MONTHLY REPORT NO. 3, NOVEMBER 1953, TO DETROIT EDISON COMPANY. [Dec.] 1953. 16p. (NP-5479)

Completion of the liquid-Na corrosion test loop is reported. Initial procedures for starting test runs on globe-iron samples were established. (K.S.)

1900

Mine Safety Appliances Co.
MONTHLY REPORT NO. 4, DECEMBER 1953, TO DETROIT EDISON COMPANY. Jan. 4, 1954. 12p. (NP-5480)

Initial operation of a corrosion loop for testing the corrosive effects of liquid Na on samples of globeiron tubing are described. The thermal and hydrodynamic characteristics of the loop system were determined. (K.S.)

1901

Mine Safety Appliances Co.
MONTHLY REPORT NO. 5, JANUARY 1954, TO DETROIT
EDISON COMPANY. R. H. Jones. Feb. 16, 1954. 18p.
(NP-5481)

Test results are evaluated for a 7-day run on the corrosion of globeiron tubing by liquid Na. A slight grain growth was the only indicated change in the material. (K.S.)

1902

Mine Safety Appliances Co.
MONTHLY REPORT NO. 6, FEBRUARY 1954, TO
DETROIT EDISON COMPANY. R. H. Jones. Mar. 11,
1954. 21p. (NP-5482)

Test results are evaluated for a 30-day run on the corrosion of globeiron tubing by liquid Na. A slight grain growth was the only indicated change in the material. (K.S.)

1903

Mine Safety Appliances Co.
REPORT NO. 8, MAY 8, 1954 TO JULY 1, 1954, TO
DETROIT EDISON COMPANY. J. R. Taylor, S[heridan]
J. Rodgers, and H. J. Williams. Sept. 10, 1954. 38p.
(NP-5483)

A detailed analysis was made of globeiron tubing exposed for 30 days in a liquid Na corrosion loop. Parts of the loop and samples of Na were examined in order to estimate the effects of corrosion. (K.S.)

1904

Mine Safety Appliances Co.
REPORT NO. 9, JULY 1, 1954 TO SEPTEMBER 1, 1954,
TO DETROIT EDISON COMPANY. J. R. Taylor,
S[heridan] J. Rodgers, and H. J. Williams. Sept. 30, 1954.
26p. (NP-5484)

Liquid sodium corrosion tests are described for two Ti tube specimens. Both specimens failed by oxide formation along grain boundaries with erosion of TiO_2 at the hot end of the corrosion loop where turbulence was greatest. O_2 was absorbed from the liquid Na and NaK. (K.S.)

2280 EES-9C(4)966861

Naval Engineering Experiment Station, Annapolis
BASIC INFORMATION ON THE BEARING PROPERTIES
OF VARIOUS MATERIALS IN LIQUID METALS. M. R.
Gross and W. J. Greenert. [Includes appendix: CALCULATION OF STRESSES IN CONTACT ROLLER TEST.
Watt V. Smith]. Nov. 20, 1952. 63p.

Bearing properties of various materials exposed to a liquid metal environment are presented. Results on the rolling contact behavior of SAE 52100 steel under various conditions of viscosity and temperature are discussed. These variations were accomplished by substituting hydrocarbons for the liquid metal environment. The data indicate that viscosity and temperature are critical factors influencing the load carrying capacity of SAE 52100 in liquid metal. It is concluded that the inherent difference in load carrying capacity between materials of similar composition and structure are intensified by reduced viscosity and/or increased temperature of the test environment. Also, standard antifriction bearings were found to be sensitive to dissolved atmospheric gases in low viscosity hydrocarbons. In addition to a discussion of the mechanism of failure, the report contains a appendix describing the method of stress calculation. (auth)

2340

THE SURFACE TENSION OF SODIUM. J. W. Taylor
(Atomic Energy Research Establishment, Harwell, Berks,
England). *J. Inst. Metals* 83, 143-52(1954) Dec.

A redetermination has been made of the surface tension of sodium, and its temperature coefficient has been established over the range 98 to 450°C. The maximum-bubble-pressure method of measurement was employed. The surface tension at the melting point, relative to an argon atmosphere, is 190.8 dynes/cm and the temperature coefficient over the range studied is -0.1 dyne/cm/°C. The presence of an oxide film on the sodium surface increases the surface tension, and this effect may account for the discrepancy between the present and previous data. The surface-tension values are in keeping with several empirical relationships existing between this property and other physical constants of liquid metals. A comparison of the values obtained by experiment with those calculated theoretically does nothing to substantiate the validity of the former owing to the uncertainty in the latter; likewise the experimental result does not indicate which theoretical treatment is the most accurate. (auth)

2799

SELF-DIFFUSION IN SODIUM NEAR THE MELTING POINT.
Robert E. Meyer and Norman H. Nachtrieb (Univ. of Chicago).
J. Chem. Phys. 23, 405(1955) Feb.

The rate of self diffusion in both states of Na within 0.1°C of the melting point was measured to determine whether a "pre-melting" phenomenon occurs. Results of four runs show agreement with calculated results within experimental limits. Diffusion coefficients were also measured from 98.0 to 226°C by the capillary reservoir technique, and results may be represented by the equation: $D = 1.10 \times 10^{-3} \exp(-2450/RT)$. It appears that the transition from the rate of solid-state self diffusion to the rate of liquid state self diffusion is as discontinuous in Na as the melting point, itself. (L.M.T.)

3125 NACA-TN-3336
Lewis Flight Propulsion Lab., NACA
REVIEW OF EXPERIMENTAL INVESTIGATIONS OF
LIQUID-METAL HEAT TRANSFER. Bernard
Lubarsky and Samuel J. Kaufman. [Nov. 4,
1954]. 115p.

Experimental data of various investigators of liquid-metal heat-transfer characteristics were reevaluated using as consistent assumptions and methods as possible and then compared with each other and with theoretical results. The reevaluated data for both local fully developed and average Nusselt numbers in the turbulent flow region were found still to have considerable spread, with the bulk of the data being lower than predicted by existing analysis. An equation based on empirical grounds which represents most of the fully developed heat-transfer data is $N = 0.625 Pe^{0.4}$ where Nu represents the Nusselt number and Pe the Peclet number. The theoretical prediction of the heat transfer in the entrance region was found to give lower values, in most cases, than those found in the experimental work. (auth)

3386 WADC-TR-53-308(Pt.1)

Cincinnati Univ.
DENSITY AND VISCOSITY OF MOLTEN MATERIALS.
PART 1. DENSITY OF SODIUM AND SODIUM HYDROXIDE.
M. Nishibayashi. Nov. 1953. 53p. Contract AF33(616)-
9. (AD-26029)

The densities of molten sodium and sodium hydroxide were measured over the temperature range of 254 to 860°C, and 447 to 736°C, respectively. The determinations were made by Kohlrausch's hydrostatic weighing method utilizing the Archimedes principle. The apparatus used was a refinement of the commonly known Mohr-Westphal balance where a chainomatic analytical balance was used as the weighing mechanism for increased accuracy. The equations, $d_{Na} = (0.9378 \pm 0.0086) - (0.000268 \pm 0.000018)(t - 97.5)$ and $d_{NaOH} = (1.753 \pm 0.002) - (0.000565 \pm 0.000008)(t - 318.4)$ were derived by the method of least squares from the data accumulated. (auth)

3443 AERE-X/R-1381

Atomic Energy Research Establishment, Harwell, Berks (England)

A REPORT ON THE PROCEEDINGS OF THE LIQUID METAL UTILIZATION CONFERENCE HELD IN ABINGDON, MAY 16, 1953. C. G. Banister, C. J. Heming, N. F. Goodway, and B. L. Tozer, eds. Mar. 26, 1954. 130p.

Papers on the following are included: design and operation of an apparatus for handling liquid Na and similar fluids; electromagnetic pumping of liquid metals, including reasons for adoption over mechanical forms, basic principles of operation, design of a small single-phase pump capable of handling Na of 200 to 500 kev, and a few notes regarding the large-scale pumping of liquid metals; use of liquid metals for high-temperature heat transfer, including properties, advantages as high-temperature media, design of heat exchangers, and application of liquid metals to nuclear power production and gas turbines; heat-transfer experiments with liquid Na; design and construction of a Na-steam superheater test plant; a study of Na-heated steam generating plant; and the application of liquid metals to reheating in a steam turbine plant. (J.A.G.)

3501 ANL-5359

Argonne National Lab.

EQUIPMENT AND PROCEDURES FOR STUDYING THE EQUILIBRIUM SOLUBILITY OF IRON IN NaK. P. G. Drugas and L. R. Kelman. Sept. 4, 1953. 29p. Contract W-31-109-Eng-38.

This study of the equilibrium solubility of Fe in NaK was part of a program to investigate the mechanisms whereby solid metals are attacked by liquid metals in engineering systems. Careful consideration was given to several experimental solubility methods, and the equipment and procedures are described in detail. A trial run of the most promising method was made, and the equilibrium solubility of Fe in NaK at 700°C was found to be 15 ± 3 ppm. The solubility methods that were devised made no provision for particles of Fe that might remain suspended in NaK upon precipitation from saturated solutions on cooling. In tests that were performed to determine the degree to which this phenomenon occurred, little, if any, tendency for suspension was found. (auth)

3643

ROLE OF LIQUID METALS IN NUCLEAR POWER DEVELOPMENT. J. W. Taylor (Atomic Energy Research Establishment, Harwell, Berks, England). Research (London) 8, 102-5(1955) Mar.

Liquid metals have potential application in reactor technology as coolants and heat exchange media, carrier media for nuclear fuel, and extraction agents in processing spent fuel. The advantages and disadvantages of liquid metals as

coolants are discussed, and the other applications for liquid metals are reviewed briefly. Solutions to fundamental questions on corrosion mechanisms and structure and properties of liquid metals are necessary before the full potentialities of liquid metals in nuclear power can be realized. (M.P.G.)

3827 NP-5583

Mine Safety Appliances Co.

EFFECT OF OXYGEN ON MASS TRANSPORT OF STAINLESS STEEL COMPONENTS IN SODIUM. J. W.

Mausteller and E. F. Batutis. Mar. 18, 1955. 18p.

Contract NObs-65426, Technical Report 36.

The transport of some radioactive type-347 stainless steel constituents in 925°F sodium has been studied in isothermal systems operated at oxygen contents of 0.010, 0.005 and 0.003 wt. % O₂. Ratios of the transfer rate of the parent stainless steel at high and low oxygen contents were 54/1, 17/1, 5/1 and 4/1, based on transport of Co⁶⁰, Fe⁵⁹, Ta¹⁸², and Mn⁵⁴ respectively. Transport rates of the stainless steel at high oxygen level, based on transport of the source isotopes were 12, 541, 58 and 272 μg ss/cm² active stainless steel/mo. Concentrations of tantalum, antimony and cobalt in 925°F sodium were 7.7×10^{-3} , 0.33 and 3.0×10^{-4} ppm at 0.010 wt. % O₂. In sodium containing 0.003 wt. % O₂ the concentrations dropped by a factor of five. (auth)

4175 NP-5601

Mine Safety Appliances Co.

PROGRESS REPORT NO. 27 FOR FEBRUARY AND

MARCH 1955. J. W. Mausteller, ed. Apr. 22, 1955. 62p. Contract NObs-65426.

Tests on the Mark B 3000-Kw steam generator are described, including a circulating cold trap and plugging indicator, system cleaning, pump performance, NaK furnace tube failure, boiler water analysis, and heat transfer. Engineering studies are summarized on vent and drain line closures, NaK cross flow exchanger, development of EM pumps, pressure gages, wetting with alkali liquid metals, thermal shock, bellows testing, valve cleaning and testing, and thermal insulation tests in liquid Na. The depression of Na₂O solubility in Na by K is discussed. Further studies on inhibition of mass transfer of radioactive stainless steel constituents in Na are described. The removal of residual radioactive Na with Na flushes was studied. Further results on radioactive leak contamination and the reactions of molten Zr in water are reported. (For preceding period see NP-5536.) (L.M.T.)

4179 NP-5614

Mine Safety Appliances Co.

LIQUID METAL TECHNOLOGY. FINAL REPORT.

(A review of the work from May 1949 to May 1954 with abstracts of reports issued). R. C. Werner. Mar. 29, 1955. 77p. Contract N9onr-85801.

A final summary is presented of the various activities which have been carried out on liquid Na and NaK plumbing systems. Results on heat transfer, flow properties, corrosion tests, accessibility, Na cleaning, and tests on valves, bellows, pumps, etc. are included. Approximately half of the report consists of abstracts of the various technical reports and memos which have been issued under the contract. (For preceding progress report see NP-5601.) (L.M.T.)

4231 RDB-(W)/TN-197

Research and Development Branch, Industrial Group, Windscale Works, United Kingdom Atomic Energy Authority, Windscale, Cumb. (England)

A LIQUID METAL LEVEL INDICATOR. G. Bottomley. Mar. 1955. 12p.

Details are given of a level indicator suitable for use with liquid metals. A bifilar wound transformer is inserted into a stainless steel tube fitted along the axis of the tank containing the liquid metal. An alternating voltage across one winding produces an output voltage from the second winding which varies with the metal level. Over the range tested the instrument was found to be linear. A circuit diagram and list of components are included. (auth)

4702 NRL-Memo-424

Naval Research Lab., Washington, D. C.

THE SOLUBILITY OF IMPURITIES IN METALLIC SODIUM.

D. D. Williams, J. A. Grand, and R. R. Miller. Feb. 1, 1955. 22p.

The solubilities of NaH and Na_2CO_3 in metallic Na were determined for temperature ranges of 240 to 255°C and 150 to 385°C, respectively. The solubility of NaCl in metallic Na at 400°C was approximated. (auth)

4989 NP-5670

Mine Safety Appliances Co., Callery, Penna.

UNDERWATER DISPOSAL OF SODIUM WITH EB NOZZLE.

W. Milich and E. C. King. June 14, 1955. 12p. Contract NObs-65426, Technical Report No. 39.

Sodium at 350°F and 50 psig nitrogen pressure was discharged through a nozzle of the current EB design (free area of approximately 0.103 sq in.) at a water depth of 5 ft with a maximum flow rate of approximately 45 lb/min. The reaction resulted in some hydrogen flames at intervals among the waves near the surface with very little sodium oxide smoke. Based on the results of this test it appears feasible to safely dispose of such quantities of sodium under 5 ft of water without any immediate danger of surface reactions or detonations. (auth)

5251 AEC-tr-2171

METAL DEPOSITS FROM AMALGAM. I. DETERMINATION OF THE EQUILIBRIUM DIAGRAM OF THE NaOH-NaBr-NaI SYSTEM. T. S. Okada, S. R. Yoshizawa, and N. Y. Watanabe. Translated from J. Chem. Soc. Japan Ind. Chem. Sect. 56, 79-81(1953). 8p.

A study was made of the equilibrium diagram for the electrolytic system necessary for the production of metallic Na from Na amalgam by electrolysis of fused salts. (auth)

5318 NP-5689

Mine Safety Appliances Co., Callery, Penna.

TEST OF A PISTON OPERATED VALVE FOR SODIUM

SERVICE. R. A. Tidball and T. A. Ciarlariello. June 9, 1955. 28p. Contract NObs-65426, Technical Report No. 38

An 8-in. piston operated split gate valve, fabricated by the Chapman Valve Mfg. Co. for water service, was re-modeled for sodium service and tested by exposure to 850°F sodium for 1152 hours during 4520 operating cycles. Seat leakages varied but were always below 0.4 cu ft/hr. Disassembly by the manufacturer showed no damage other than a blackening of the Malcolmized surfaces, but with no loss in hardness, and a slight deformation on the back of the gates. These tests showed that piston operated valves are suitable for sodium service. Changes are recommended to reduce the seat leakage and pumping power required for operation. (auth)

5647

CONSTRUCTION MATERIALS FOR LIQUID SODIUM SYSTEMS. E. G. Brush (Knolls Atomic Power Lab., Schenectady, N. Y.). Corrosion 11, 299t-303t(1955) July.

In pure sodium, engineering alloys may be subject to mass transport effects, preferential solution of alloying constituents and diffusion welding of mating surfaces. Trace amounts of impurities which are difficult to remove result in damaging oxidation and also act to accentuate preferential solution phenomena, particularly decarburization and intergranular attack. The resistance of alloys to attack by sodium has been investigated in static and dynamic laboratory tests and in pilot plant heat transfer systems. Extensive laboratory data and service performance indicate that the design engineer has a wide selection of materials of construction that will give satisfactory service in high temperature sodium systems. (auth)

5657 NP-5690

Mine Safety Appliances Co., Callery, Penna.

PROGRESS REPORT NO. 28 FOR APRIL AND MAY 1955.

J. W. Mausteller, ed. June 21, 1955. 70p. Contract NObs-65426.

Tests on the Mark B 3000-Kw steam generator were continued. Engineering studies are summarized on vent and line closures, cross flow exchanger, electromagnetic pumps, pressure gages, liquid metal leakage, alkali liquid metal surface wetting, corrosive effects and waste disposal of Na, and testing of Mark A and B bellows, valves, and apparatus for thermal shock measurements. The changes in the solubility of Na_2O in liquid Na due to the addition of Na or K were investigated. Mass transfer inhibition was examined. The removal of radioactive Na by flushing was investigated. Loop tests and pipe-flushing tests and pipe-flushing tests were continued. The radiation hazards arising from leaks in the water cooling system of a reactor and the possible chemical reactions between water and molten metals were studied. (For preceding period see NP-5601.) (C.W.H.)

6247 NP-5727

Mine Safety Appliances Co., Callery, Penna.

HEAT TRANSFER AND PRESSURE DROP WITH NaK-56 FLOWING PERPENDICULAR TO VERTICAL TUBES.

Memo Report No. 87. M. J. McGoff and J. W. Mausteller. July 29, 1955. 17p. Contract NObs-65426.

A cross-flow heat exchanger has been tested with liquid metal (NaK-56) as the heat transfer fluid. The heat exchanger consisted of twenty-five $\frac{1}{2}$ in. OD tubes arranged on a $\frac{1}{8}$ in. equilateral triangular pitch; five rows longitudinal and five rows transverse to flow. Operation was up to 900°F at Reynolds numbers of 3,000 to 80,000. Heat transfer coefficients varied to the 0.8th power of the Reynolds number and were higher than have been reported for mercury or pressurized water. Friction factors agreed with those obtained for the more common fluids. (auth)

6251

HEAT TRANSFER EXPERIMENTS WITH SODIUM AND

SODIUM POTASSIUM ALLOY. W. B. Hall and A. E. Jenkins. J. Nuclear Energy 1, 244-63(1955) June.

The theoretical approach to the problem of heat transfer in liquid metals is briefly reviewed. The difference between this approach and that used in the case of fluids with a high Prandtl number is due to the fact that the thermal conductivity of a liquid metal may be so high as to swamp the "eddy conductivity" in a turbulent stream. A description

is given of experiments in which the heat-transfer coefficients between two annuli, each carrying a flow of liquid metal, were measured. Whilst a direct comparison with results obtained with a circular tube is not possible, the results are in quite good agreement with the theoretical values given by Lyon (1951). In the course of the work it was found that there were significant variations in temperature around the annuli carrying the liquid metal in the heat exchanger. It is thought that these variations were due to slight eccentricity of the exchanger tubes. An approximate theoretical treatment indicates that such variations are likely to be greater (when expressed as a fraction of the overall temperature difference) in the case of liquid metals than in the case of fluids with a higher Prandtl number. In these experiments, where the heat flux was about 50 watts per sq cm, the temperature variations were quite small, but if full advantage is taken of the liquid metal to obtain high heat fluxes, they might be so large as to produce serious thermal stresses and distortion of the heat exchanger. (auth)

6664 TID-5277

Atomic Energy Commission, Washington, D. C. and Bureau of Ships.

LIQUID METALS HANDBOOK. SODIUM-NaK SUPPLEMENT. Carey B. Jackson, ed. July 1, 1955. 452p.

This supplement to the Liquid Metals Handbook includes information specifically on Na and Na-K alloys. Discussions are presented on chemical and physical properties, heat transfer, chemical engineering aspects, heat transfer systems and components, and safety measures. Specific applications of Na and Na-K alloys as heat-transfer agents are outlined. (C.W.H.)

6668

LIQUID METALS. PART II. THE SURFACE TENSION OF LIQUID SODIUM: THE DROP-VOLUME TECHNIQUE.

C. C. Addison, W. E. Addison, D. H. Kerridge, and J. Lewis (Univ. of Nottingham, England). *J. Chem. Soc.* 2262-4(1955) July.

The surface tension of liquid Na in an atmosphere of pure A has been measured over the temperature range 110 to 220°C by a drop-volume method. The temperature coefficient of tension is 0.1 dyne/cm/degree, and extrapolation of results to the melting point of Na gives $\gamma = 202$ dynes/cm. Results are compared with those obtained by the vertical-plate method. (Part I appears in *J. Chem. Soc.*, 2861-6(1954) Aug.) (auth)

6872 KAPL-1398

Knolls Atomic Power Lab., Schenectady, N. Y. SOLUBILITY OF BARIUM METAL AND BARIUM OXIDE IN SODIUM. J. R. Gould. Sept. 1, 1955. 17p. Contract W-31-109-Eng-52.

Because of the interest in barium metal as an inhibitor of mass transport in liquid sodium systems, the following properties of barium in sodium were determined. The solubility of barium in sodium varied from 1 to 3.8 wt. % in the temperature range of 250 to 700°C. The variation in the solubility ($S = \text{wt.}\%$) of barium with temperature ($^{\circ}\text{K}$) may be expressed as: $\ln S = 2.76 - 1.39 \times 10^3/T$. The heat of solution of barium in sodium is approximately 2800 cal/mole of barium. Barium monoxide solubility in sodium at 500°C is $<0.05 \text{ wt.}\%$. (auth)

6953 NP-5751

Mine Safety Appliances Co., Callery, Penna. FINAL REPORT ON THE 1000 KW AIR COOLED, LIQUID METAL HEAT TRANSFER LOOP. R. A. Tidball, F. L. Mangold, S. N. Tower, and T. A. Ciarlariello. Aug. 16, 1955. 129p. Project NR-031-364. Contracts N9onr-85801 and NObs-65426, Technical Report No. 39.

A 1000-Kw liquid metal heat transfer system has been designed and operated at 1500°F. The system used sodium-potassium alloy to transmit heat from a gas fired furnace to an intermediate heat exchanger. Sodium was used to transmit the heat from the intermediate heat exchanger to an air heat sink. The maximum heat load on the system was 3,500,000 Btu/hr with the NaK temperature at the heater outlet of 1500°F. (See also NP-5491.) (auth)

6999 NP-5739

Mine Safety Appliances Co., Callery, Penna. PROGRESS REPORT NO. 29 FOR JUNE AND JULY 1955. J. W. Mausteller, ed. Aug. 19, 1955. 53p. Contract NObs-65426.

Tests at cyclic conditions were initiated on the Mark B 3000-kw steam generator; the extent of NaK heat failures and water carry-over in the boiler was determined. Studies were continued on the natural circulation of liquid metal system components around heated vertical cylinders and about the heat transfer characteristics of liquid metals in cross flow. Modifications and improvements were made on the electromagnetic pumps, liquid level gages, and pressure gages. The effect of pretreatment of the surfaces on the wetting of surfaces with liquid Na was investigated. Testing continued on the valve welds and the Mark A bellows. The studies of radiation hazards arising from reactor cooling system leaks and from chemical reactions between steam and reactor molten metals were continued. The removal of residual radioactive Na using sodium flushes was shown to be dependent upon the degree of mixing of the flush and residual sodium. (For preceding period see NP-5690.) (C.W.H.)

7282

THERMODYNAMIC PROPERTIES OF THE ALKALI METALS. William H. Evans, Rosemary Jacobson, Thomas R. Munson, and Donald D. Wagman. *J. Research Natl. Bur. Standards* 55, 83-96(1955) Aug.

The available data on the thermodynamic properties of the elements lithium, sodium, potassium, rubidium, and cesium have been analyzed, and selected values of these properties are presented in tabular form. The tables include values of the free-energy function, $(F^{\circ} - H_0^{\circ})/T$; heat-content function, $(H^{\circ} - H_0^{\circ})/T$; entropy, S° ; heat content, $(H^{\circ} - H_0^{\circ})$; heat capacity, C_p° ; heat formation, ΔH_f° , free energy of formation, ΔF_f° ; and logarithm of the equilibrium constant of formation, $\log K_f$, for the solid, the liquid, and the monatomic and diatomic gases as a function of temperature from 0°K to high temperatures. (auth)

7349 NP-5752

Mine Safety Appliances Co., Callery, Penna. SODIUM PLUGGING OF VENT LINES. E. C. King and V. K. Heckel. Sept. 7, 1955. 11p. Contracts N9onr-85801 and NObs-65426, Technical Report No. 42.

The distance sodium will travel in a copper or stainless steel pipe or tube of inside diameter between 0.180 to 0.622 in. can be calculated to within an accuracy of ± 3 ft from the equation: $S = (4 k_w d / k_w - 8.9 + 4 k_w d) (1020 d / 208 - T_a +$

$18.08 d - 3059/d - 0.1258$) where S is the distance of sodium travel in ft, k_w is the thermal conductivity of the tube wall in Btu/hr-sq ft-°F/ft, d is the inside diameter of tubing in in., and T_a is the ambient temperature in °F surrounding the tube, or the tube wall temperature. (auth)

7438

THE DETECTION OF THE LEVEL OF LIQUID SODIUM IN STAINLESS STEEL TUBES. E. W. Pulsford (Atomic Energy Research Establishment, Harwell, Berks, England). J. Sci. Instr. **32**, 362-3(1955) Sept.

The level of liquid Na in a stainless steel tube can be determined by observing the change in inductance of a narrow coil of wire wound around the tube as the liquid

surface passes through it. Two similar coils are used connected in a standard inductance bridge circuit. An abrupt change in the state of balance of the bridge indicates when the liquid is treading one of the coils. A circuit diagram is given. (M.P.G.)

7534

PUMPS FOR REACTOR COOLANTS. Nucleonics **13**, No. 7, 78-80(1955) July.

A tabulation of pumps for liquid nuclear reactor coolants has been prepared from a survey of pump manufacturers. Mechanical and electromagnetic pumps are listed, and suppliers and pump characteristics given. (D.E.B.)

Volume 10, 1956

120 NP-5779

Mine Safety Appliances Co., Callery, Penna.
PROGRESS REPORT NO. 30 FOR AUGUST AND SEPTEMBER 1955. W. J. Posey, ed. Oct. 11, 1955. 78p. Contract NObs-65426.

The results of tests on models of the Submarine Intermediate Reactor Mark B 3000-kw steam generators are reported. Data from steady state and cyclic operation have been obtained. The system has been shut down for cleaning, inspection, and repairs. Heat transfer with liquid metals flowing perpendicular to tube bundles is being studied, and some performance data are presented. An induction pump for liquid metals has been designed using the principle of the watt-hour meter. Tests are being performed to determine conditions influencing the low temperature wetting of surfaces with alkali liquid metals. The testing of valves and bellows for use in the SIR sodium system is described. Mockups have been constructed of the expansion tank and other components in the Mark B Na system. Tests are being performed on them to determine the effects of the use of impure N containing 2 vol. % O as a cover gas for the Na system. Methods of leak plugging are being studied for water to mercury leaks in the Mark A steam generating system. The removal of residual radioactive Na from a cooling system by means of Na flushes is being studied using Au^{198} as a tracer. The study of radiation hazards arising from leaks in a simulated contaminated water cooling system of a nuclear reactor is continuing. (For preceding period see NP-5739.) (M.P.G.)

206

LIQUID METALS. PART III. THE INFLUENCE OF OXIDE FILMS ON THE SURFACE TENSION OF LIQUID SODIUM. C. C. Addison, W. E. Addison, and D. H. Kerridge (Univ. of Nottingham, England). *J. Chem. Soc.*, 3047-50(1955) Sept.

The drop-volume technique has been used to determine the changes in surface tension of liquid sodium which occur when dry air is introduced into the argon atmosphere surrounding the metal drops. At 180°C, the surface tension decreases linearly with partial pressure of oxygen, from 194 to 186 dynes/cm. A minimum occurs at an oxygen partial pressure of 2×10^{-4} atm., after which the tension can increase to very high values. The tension minimum is related to the change from a soluble to an insoluble film of sodium oxide at the metal surface. (For preceding report in series see *J. Chem. Soc.* 2262-4(1955) July.) (auth)

576 NP-5811

Mine Safety Appliances Co., Callery, Penna.
WETTING WITH SODIUM. Technical Report No. 43.
M. H. Wahl. Nov. 7, 1955. 13p. Contract NObs-65426.

Certain pretreatments (aqua regia, NaOH, electropolish, and Na_3PO_4) have been shown to enhance wetting of stainless steel by molten Na at low temperatures. Wetting was neither speeded nor retarded by contact with cover gas (98% N_2 -2% O_2). (C.W.H.)

1063

THE SIGNIFICANCE OF WETTING IN REACTOR TECHNOLOGY. J. W. Taylor (Atomic Energy Research Establishment, Harwell, Berks, England). *J. Nuclear Energy* 2, 15-30(1955) Aug.

The fundamental forces responsible for the spreading of a liquid metal on a solid (or a liquid) surface are discussed, and a number of interfacial tension and spreading studies are analyzed in terms of the theoretical considerations. In the light of these, methods of modifying the interfacial tension in any given application are suggested. The significance of interfacial effects in the following technological processes is outlined: liquid metal corrosion and intergranular penetration; heat transfer; mass transfer and zone melting; liquid metal slurry properties and stability; and extraction metallurgy. (auth)

1775 NP-5840

Mine Safety Appliances Co., Callery, Penna.
PROGRESS REPORT NO. 31 FOR OCTOBER AND NOVEMBER 1955. W. J. Posey, ed. Dec. 12, 1955. 72p. Contract NObs-65426.

Testing of the 3-Mw steam generators was continued. Level indicators for liquid Na, combined valve connect and disconnect, and AC induction pumps for liquid metals are described. Microfissure propagation has been observed as a result of quenching heated weld specimens with liquid Na. The feasibility of using impure N_2 as a cover gas for sodium systems was demonstrated. Investigations were continued on the corrosion of Zr by liquid Na, the removal of Hg from sodium systems by amalgamation with Cu, and the radiation hazards arising from leaks in liquid metal systems. (For preceding period see NP-5779.) (C.W.H.)

2054 BNL-2446

Division of Engineering, AEC. and Brookhaven National Lab., Upton, N. Y.
REACTOR HEAT TRANSFER INFORMATION MEETING HELD AT BROOKHAVEN NATIONAL LABORATORY, OCTOBER 18-19, 1954. Dec. 1955. 195p.

The following unclassified papers were presented at the Reactor Heat Transfer Information Meeting in October, 1954: Heat Transfer Rates to Cross-Flowing Mercury in a Staggered Tube Bank; Specific Heat of Liquid Metal and Salt Mixtures; The Effect of Gas Entrainment on the Heat Transfer Characteristics of Liquid Mercury; Flow in

a Thermal Convection Harp in the Grashof Modulus Range From 10^4 to 10^6 ; Theoretical and Experimental Investigation of Heat Transfer by Laminar Natural Convection Between Parallel Plates; Remarks on Forced Heat Convection in Cylindrical Channels; Potential and Parabolic Velocity Distributions; High Temperature Liquids; Heat Transfer to Boiling Water Forced Through an Electrically Heated Tube; Boiling Density Studies in Multiple Rectangular Channels; Measurement and Prediction of Density Transients in a Volume-Heated Boiling System; Heat Transfer and Corrosion Tests for a Sodium-Cooled Fast Breeder Reactor; and Free Convection in Narrow Vertical Liquid Metal Annuli. (M.P.G.)

2089

THERMAL DIFFUSION IN LIQUID METALS. F. R. Winter and H. G. Drickamer (Univ. of Illinois, Urbana). *J. Phys. Chem.* 59, 1229-30(1955) Dec.

Thermal diffusion measurements have been made on a series of liquid metal mixtures. The results are totally consistent with a previously presented theory. The separations depend on the "activation energy density" $\Delta U \ddagger / V$ of the components. It is also shown that the quantity $X(\partial\mu/\partial X)$ in the denominator is important for quantitative prediction of the separation. Results also are presented and discussed for three ternary mixtures. (auth)

2092 KAPL-828

Knolls Atomic Power Lab., Schenectady, N. Y. THEORY AND APPLICATION OF SLIDING CONTACT OF METALS IN SODIUM. L. F. Coffin, Jr. (Paper Presented at Liquid Metals Information Meeting October 9, 1952). Decl. Oct. 6, 1955. 39p. Contract W-31-109-Eng-52.

Metallic friction, wear, and surface damage during metallic sliding are generally believed to be due to the welding of surface asperities and the immediate breaking of these welds. This report considers in greater detail the nature of these welds. It is concluded that wear and surface damage are principally dependent on the alloying tendency between the metals in the couple. A sliding couple, having considerable mutual solubility of forming an intermetallic compound, should undergo serious surface damage. In the case of a very low solubility couple which forms no intermetallic compound, the surface damage is slight. A study of the surface damage to many different couples, which results when a rotating disk of one metal is rubbed against a fixed rider of a second metal in air, under severe loads, for some 100 revolutions, conclusively proves this hypothesis. Thrust-bearing tests have been performed in sodium for two couples selected by the solubility hypothesis. These couples exhibit the property of extreme wear-in, so that, following high coefficients of friction upon initial load applications, hydrodynamic operation of the bearing ensues. This has been found true for bearing pressures up to 200 psi at temperatures up to 400°C. Marked temperature sensitivity of these bearings has been noted and is due to the extremely thin film of sodium between the bearing faces. (auth)

2648 AECU-3142

[Argonne National Lab., Lemont, Ill.] REACTION OF GRAPHITE WITH SODIUM. G. L. Montet. June 19, 1952. Decl. Jan. 17, 1956. 3p. Contract [W-31-109-eng-38]. (ANL-GRH-16). \$1.80(ph OTS); \$1.80(mf OTS).

The literature on the reaction of graphite with Na was reviewed. From the evidence gathered it seems probable that pure graphite and pure liquid Na will react only slowly at moderate temperatures. However, liquid Na rapidly attacks amorphous C, so that incompletely graphitized graphite would probably be more susceptible to attack. Since irradiation is known to produce electron acceptors in graphite it seems likely that irradiated graphite should react more readily with liquid Na than unirradiated graphite. In view of the conflicting evidence available, the use of graphite in direct contact with liquid Na is not recommended except under very mild conditions of temperature and irradiation, and then only with very pure Na and completely graphitized graphite. (C.H.)

3061

ELECTROMAGNETIC CENTRIFUGAL PUMP. K. O. Donelian and J. R. Menke (to U. S. Atomic Energy Commission). U. S. Patent 2,730,951. January 17, 1956.

An apparatus is described for pumping electrically conductive fluids such as alloys of Na and K by whirling the fluid within a pump chamber. The fluid is introduced into the center of a flat disk shaped chamber, where the interaction of a rotating magnetic field with the currents induced in the conducting liquid by the rotating field causes the fluid to follow a circular path at high velocity and then to be thrown outward by the resulting centrifugal force into an annular peripheral chamber from which the liquid exits through an outlet passage at the periphery. (auth)

3198 KAPL-337

Knolls Atomic Power Lab., Schenectady, N. Y. INVESTIGATION OF ALPLAUS ATMOSPHERIC PRESSURE SODIUM STILL. E. E. Baldwin. July 6, 1950. Decl. Nov. 22, 1955. 30p. Contract W-31-109-Eng-52.

As a result of two fires in the sodium still, an extensive investigation was made to determine the type and extent of damages and their cause. Results indicate that the external erosion and pitting was caused by action of the products of combustion of the Na fires, the argon line plug was due to localized oxygen contamination of the Na, and the internal surface damages were negligible. (C.W.H.)

3368 NAA-SR-268

North American Aviation, Inc., Downey, Calif. SOLID STATE AND IRRADIATION PHYSICS QUARTERLY PROGRESS REPORT FOR APRIL-JUNE 1953. F. E. Faris and E. C. Crittenden, Jr., ed. Aug. 21, 1953. Decl. Nov. 16, 1955. 51p. \$0.35(OTS).

The specific heat of graphite was investigated by a computation of the inplane vibrational modes, with a Born-von Karman model. The thermal and electrical conductivities of graphitized lampblack were determined as a function of temperature (10 to 300°K) and neutron irradiation (up to 460 Mwd/ct). Changes in Peierls' diamagnetism and paramagnetism from interstitials in graphite were evaluated as a function of neutron irradiation up to 1534 Mwd/ct. Measurements of radiation damage as a function of depth were obtained for AWG graphite by noting changes in the resistivity and thermoelectric power with depth for cyclotron-irradiated samples. A scatter in the plot of the normalized resistivity in graphite is so great that correlations may be made with annealing temperatures as well as activation temperatures. Proton irradiation effects on AuCu₃ alloy were studied. Other data indicate that the Debye temperature of ordered AuCu₃ is about 175°K, in-

creasing on ordering to 200°K. Indentation tests on the surface hardness changes of X Cu irradiated by 1-Mev electrons are reported, together with data on the thermal annealing of radiation induced hardness in KCl and NaCl. An experimental arrangement is described for measuring the mass transfer of radioactivity in a Na-stainless steel corrosion loop. (K.S.)

3857 AECD-3709

Knolls Atomic Power Lab., Schenectady, N. Y.
THE THERMODYNAMICS OF REDUCIBILITY OF FISSION PRODUCT OXIDES BY SODIUM AND OTHER ELEMENTS. Leo F. Epstein and Joanne Nigriny. Apr. 27, 1948. Decl. Nov. 3, 1955. 20p. Contract W-31-109-Eng-52. (MEMO-LFE-1) \$0.20(OTS).

Thermodynamic data on the free energies of formation of 58 oxides from the constituent elements are computed at 25, 500, and 1000°C. Reducibility by Na, H₂, and C are shown in tabular form. The application of these computations to the depletion of liquid Na in pile designs using UO₂ fuel and liquid Na coolant in sealed units is discussed, and it is concluded that, if the kinetics of the reaction are favorable, only 7% of the Na will be lost by conversion to Na₂O after 10% burn-up in a system initially containing one atom of Na per molecule of UO₂. (auth)

3929 KAPL-1502

Knolls Atomic Power Lab., Schenectady, N. Y.
ELECTRICAL CONTACT RESISTANCE BETWEEN SODIUM AND STAINLESS STEEL. L. B. Vandenberg. Feb. 14, 1956. 39p. Contract W-31-109-Eng-52. \$0.30 (OTS).

Electrical contact resistance between sodium and stainless steel is investigated experimentally. Results predict the amount of contact resistance that can be expected for varying conditions of temperature, current density, solid surface conditions, and liquid metal purity. It is concluded that for the normal standards of cleanliness now practiced in liquid metal coolant work, electrical contact resistance is in the order of 0.037 micro-ohms/in.² in a 0 to 7000 amp/in.² range. Such resistance can therefore be ignored in the calculation and design of such devices. (auth)

4184 KAPL-612

Knolls Atomic Power Lab., Schenectady, N. Y.
INTERIM REPORT ON COLD TRAP INVESTIGATIONS. B. G. Voorhees and W. H. Bruggeman. Oct. 1, 1951. Decl. Jan. 5, 1956. 36p. Contract W-31-109-eng-52. \$4.80 (ph OTS); \$2.70(mf OTS).

Recent tests of cold trapping have demonstrated the feasibility of this method for the removal of sodium oxide from sodium in a circulating system. A summary of work to date is presented with a description of test equipment, test procedures, and test results. Operating theories are discussed, and a brief outline of future development work is included. (auth)

4262 AECD-3831

North American Aviation Inc., [Downey, Calif.].
ISOTHERMAL PUMP LOOP. R. Keen. Oct. 22, 1952. Decl. Dec. 5, 1955. 10p. Contract [AT-11-1-GEN-8]. (NAA-SR-Memo-469). \$3.30(ph OTS); \$2.40(mf OTS).

A centrifugal pump built entirely of graphite and capable of handling liquid metals in the temperature region of 1000°C is described. The pump was designed to meet the requirements of a high-temperature reactor. (J.E.D.)

4686

SELECTING MATERIALS FOR LIQUID SODIUM SYSTEMS. R. F. Koenig and E. G. Brush (Knolls Atomic Power Lab., Schenectady, N. Y.). *Materials and Methods* 42, No. 6, 110-14(1955) Dec.

In selecting materials for liquid Na systems, corrosion resistance to Na and Na impurities, known transfer characteristics, radioactivity transfer, and mechanical properties must be considered. These considerations are discussed, and the known data for some ferrous metals, Ni and Ni alloys, Cu and Cu alloys, refractory materials, and other metals and non-metals are tabulated. (D.E.B.)

5358 AECD-4025

Knolls Atomic Power Lab., Schenectady, N. Y.
REACTOR PHYSICS, SECTION II [OF] PROGRESS REPORT NO. 39 [FOR] OCTOBER 1-31, 1949. Nov. 30, 1949. Decl. with deletions Jan. 10, 1956. 36p. Contract W-31-109-eng-52. \$6.30(ph OTS); \$3.00(mf OTS).

Theoretical work in calculating adjoint functions and fluxes at Mn, Au, and In resonances in the KAPL Intermediate Power Breeder Critical Experiments (SAPL) is summarized. Values for Pu alpha have been confirmed. Alpha experiments are being continued in the SAPL preliminary pile assembly; accepted values are given for ν , danger coefficients, and α . Measurements of the Doppler effect in U²³⁵ in the intermediate spectrum are underway. An optical fringe method for determination of O₂ in He is described briefly. Tests are being conducted on friction and leakage of "O" ring seals. Data on creep of Na on inside walls of cylinders having various finishes are tabulated. (G.Y.)

5583 NP-5886

Mine Safety Appliances Co., Callery, Penna.
PROGRESS REPORT NO. 32 FOR DECEMBER 1955 AND JANUARY 1956. W. J. Posey, ed. Feb. 9, 1956. 72p. Contract NObs-65426.

Tests were continued on the 3-Mw steam generator. Progress is reported on the following: heat-transfer-system component development; resistance of reactor components to thermal shock; removal of entrained gas; nitriding of loop materials in Na systems; organic coolants in reactor systems; and stainless steel corrosion by NaK. The corrosion and solubility of Zr in sodium was determined as a function of oxygen concentration. Radiation hazards arising from leaks in reactor cooling systems and the effects of wall surface on mass transport of steel by Na were also investigated. (For preceding period see NP-5840.) (C.W.H.)

5596 NP-5872

Mine Safety Appliances Co., Callery, Penna.
REPORT NO. 1 ON 1000 KW SYSTEM. Memorandum Report No. 49. R. A. Tidball, F. L. Mangold, and S. N. Tower. Oct. 15, 1953. 14p.

The 1000-kw heat transfer system was designed to test pilot plant size liquid metal system components at temperatures to 1400°F. The test program was divided into phases: transferring heat to air and transferring heat to boiling water. Two liquid metal systems to prevent exposing the tubes of the liquid metal heater to full steam pressure in event of a failure of the steam generating equipment were used. The air cooled system is shown schematically. The NaK was circulated by a rotary magnet pump, through a flow meter into the NaK heater. The discharge from the heater was piped to the tube side of the intermediate heat exchanger, and returned to the pump. Sodium was circulated by a DC conduction pump, through the flow meter, the shell side of the intermediate heat

exchanger, a swing check valve to the sodium cooler. Discharge of the sodium cooler passed through a stop valve, an a-c conduction pump to the suction of the d-c pump. The sodium was cooled by an air blast over finned tubes. Both NaK and sodium systems were fitted with diffusion type cold traps, expansion tanks, and emergency dump tanks. The sodium piping was fitted with tubular heaters (strapped to the outer surface) to preheat the piping before charging. Tests of the major components of this unit at various loads and temperatures are reported. (auth)

5605

SOME ENGINEERING APPLICATIONS OF MAGNETO-HYDRODYNAMICS. J. A. Shercliff (Univ. of Cambridge, England). *Proc. Roy. Soc. (London)* **A233**, 396-401(1955) Dec. 29.

The sensitivity of an electromagnetic flowmeter depends on the form of the velocity profile, which is affected by upstream conditions and, when the fluid is a highly conducting liquid metal, by magneto-hydrodynamic forces. The steady state of the velocity profile and the distance necessary for it to be reached are predicted and compared with experiment. Other results concern the settling of the motion in a flowmeter downstream of an obstruction. (auth)

5615 AERE-ED/R-1844

Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.

A SINGLE PHASE ANNULAR INDUCTION PUMP FOR LIQUID METALS. D. A. Watt. Jan. 21, 1953. Decl. Jan. 17, 1956. 44p.

This is a declassified version of AERE-CE/R-1090.

An electrodeless single-phase a-c liquid metal pump with combined transformer is described. The principle of operation is discussed and mathematical theory deduced. A design study for a pump producing 60 ft head rise in a sodium circuit at 400°C with a flow rate of 1100 gpm is included. This will have an annular pumping channel of nearly 12 ins. mean diameter, 1/2 in. internal width and length 2 1/2 ins. An electrical efficiency of 30 to 35% can be expected with an over-all efficiency of 20 to 25%. The pump is designed to be operated from 415-volt single-phase mains; about 110 kva will be required with an over-all power factor near 0.5. A note is appended on the general theory of a-c conduction pumps. (auth)

5627 NAA-SR-Memo-557

North American Aviation, Inc., [Downey, Calif.]
COMPATIBILITY OF SODIUM AND VARIOUS MATERIALS OF INTEREST IN REACTOR CONSTRUCTION. F. E. Bowman. Jan. 5, 1953. Decl. June 6, 1956. \$1.80(ph OTS); \$1.80(mf OTS).

Available data relative to the compatibility of Na and various materials of interest in reactor construction are summarized. (J.E.D.)

5791 AECU-3171

General Electric Co. General Engineering Lab., Schenectady, N. Y.

A REPORT ON THE CALIBRATION OF TWO EIGHT-INCH MAGNETIC FLOWMETERS—MARK 1-2 AND MARK II. Eugene R. Astley. Nov. 10, 1954. 31p. (R54GL303).

Methods of calibration were explained for verification of the theoretical performance of 8-in. magnetic flowmeters used in other than ideal entry conditions. The flowmeter should have a calibration accuracy within ±3% of the full scale of 3400 gal/min. (F.S.)

6359 AECD-3925

Argonne National Lab., Lemont, Ill.

EXPERIMENTAL BREEDER PROJECT REPORT FOR THE PERIOD MARCH 1, 1949 THROUGH JANUARY 31, 1950.

H. V. Lichtenberger. Mar. 13, 1950. Decl. with deletions Dec. 14, 1955. 31p. Contract W-31-109-eng-38. \$6.30 (ph OTS); \$3.00(mf OTS).

The report covers the status of EBR construction; measurements of Co⁶⁰, Na²⁴, and fission-product γ-ray attenuation in concrete; examination of NaK-filled fuel rods and ball check rods for temperature distribution and NaK evaporation; examination of various EBR component mock-ups after operation; heat-transfer characteristics of vertical composite tube (NaK-H₂O) falling-film-type steam generator and water heater; tests of a rotating liquid seal for a liquid metal pump with a totally enclosed motor; and an experiment on the effects of pile irradiation on a U slug immersed in NaK. (G.Y.)

6526 NP-5898

Mine Safety Appliances Co., Callery, Penna.

SOLUBILITY OF SODIUM MONOXIDE IN NaK. Technical Report No. 47. S. J. Rodgers and J. W. Mausteller. Mar. 15, 1956. 9p. Contract NObs-65426.

The concentration of oxygen (added as Na₂O) in NaK-24 (24 wt.% potassium) and NaK-44 was studied as a function of temperature. Oxygen concentrations are higher for lower potassium NaK compositions, and are higher at higher temperatures. Curves are presented for oxygen concentration versus temperature and potassium content for NaK-24, NaK-44, and NaK-78. Up to 550°F, the oxygen concentrations are independent of potassium content of the sodium, but above 550°F the curves diverge to reach oxygen saturations at 1000°F of 0.20, 0.15, 0.085, and 0.050 wt. % O₂, respectively, for sodium, NaK-24, NaK-44 and NaK-78. These data can be applied to the problem of oxide precipitation by a leak from a third-fluid NaK system to a sodium system high in oxygen content. Below 0.010 wt.% O₂ in the sodium there would be no problem. Above this value precipitation would depend on the potassium content, temperature, and oxygen content, but the effect would be of little consequence in a well-designed sodium system. (auth)

6631

PURITY CONTROL IN SODIUM-COOLED REACTOR SYSTEMS. Warren H. Bruggeman (Knolls Atomic Power Lab., Schenectady, N. Y.). *A.I.Ch.E. Journal* **2**, 153-6 (1956) June.

Recent advances in purity control in sodium systems are covered. Emphasis is placed on results from the prototype SIR system as well as other unpublished data. Included are chemical and nuclear activation analyses of sodium, filtration data, and details and operation of cold traps and plugging indicators. (auth)

6663

FUNDAMENTALS OF LIQUID METAL CORROSION. W. D. Manly (Oak Ridge National Lab., Tenn.). *Corrosion* **12**, 336t-42t(1956) July.

The corrosion of structural metals in liquid metals is for the most part the result of solubility of the various constituents of the metal or alloy in the liquid metal. The manner in which this solution manifests itself gives rise to many types of attack, ranging from a simple solution type attack to a deep intergranular attack with the preferential leaching of one constituent of an alloy. Examples of the many types of corrosion experienced with solid metal-liquid metal systems are illustrated. The role of impurities on

the corrosion is discussed. In addition to the solution stage, which would soon disappear in a static one metal system on reaching a solubility limit, the corrosion of metals can be continued through the removal of materials from solution in the liquid metal with a temperature gradient or by dissimilar metal transfer. The transfer of metal in a plumbing system by the mechanisms of mass transfer—temperature gradient and dissimilar—will greatly increase the amount of corrosion as compared to the results obtained in static systems. Examples of temperature gradient mass transfer and dissimilar metal transfer are reviewed, and factors governing the occurrence of these phenomena are outlined. (auth)

6696 NAA-SR-Memo-1115

North American Aviation, Inc., [Downey, Calif.].
THE INVESTIGATION OF THE EFFECTS OF SODIUM ON
SRE CORE MATERIALS. F. E. Bowman. Oct. 4, 1954.
Decl. June 6, 1956. 5p. \$1.80(ph OTS); \$1.80(mf OTS).

An experimental program to investigate Na effects at elevated temperatures on Zr in order to establish the feasibility of using Zr in a Na system at temperatures above 1000°F was proposed and outlined. (F.S.)

6751 NP-5990

Mine Safety Appliances Co., Callery, Penna.
THIRD FLUID TUBE SHEET HAZARD TEST. Memo
Report 101. W. Milich, E. A. Schultz, E. C. King, and
R. E. Lee. Dec. 28, 1955. 9p. Contract NObs-65426.

Tests were made to determine the extent of the hazard in event of tube failure between water and third fluid NaK in an evaporator. Three tests were made simulating as closely as possible a third fluid NaK-to-water break at the tube sheet. The tests were run in a horizontal and 30 pitch either way, forcing the 200°F water into the 700°F NaK under 200 psig driving pressure. There was no immediate hazard or reaction of explosive violence during the runs. At the time of rupturing the disc between the NaK and water, the pressures on both sides equalized almost instantly and continued to hold for some time. (auth)

7249 CT-3726

Argonne National Lab., Lemont, Ill.
EFFECT OF SODIUM-POTASSIUM ALLOY ON VARIOUS
MATERIALS AT ELEVATED TEMPERATURES. LeRoy
R. Kelman. Dec. 1, 1946. Decl. Dec. 20, 1955. 26p.
Contract W-31-109-eng-38. \$0.25(OTS).

The corrosive effects of Na-K alloys were investigated at temperatures up to 800°C. Uranium, Th, Be, and Nb showed extremely good resistance to pure Na-K alloy. The presence of O in the Na-K alloy appeared to effect the corrosion resistance of these metals. Pure Fe and low-carbon steels showed good resistance to Na-K alloys and appeared to be suitable metals for the construction of equipment to handle Na-K where structural strength and air corrosion resistance at elevated temperatures are not necessary. The presence of Cr and high-Cr alloys appeared to greatly accelerate the rate of attack of steel by Na-K alloy. Nickel and high-Ni alloys showed extremely good resistance to Na-K alloy. Type 302 stainless steel showed irregular corrosion when tested in Na-K alloy. In general, Cu and its alloys, C, Si, Ag, and Pt were found to be extensively attacked by Na-K. (C.H.)

7251 KAPL-M-WW-2

[Knolls Atomic Power Lab., Schenectady, N. Y.]
THERMAL STRESS IN A BERYLLIUM WASHER. Warren
F. Witzig and William A. Riemen. July 1, 1949. Decl.

Feb. 8, 1956. 17p. Contract [W-31-109-eng-52]. \$3.30 (ph OTS); \$2.40(mf OTS).

Thermal stress was produced by a large radial heat flux in a Be washer immersed in a NaK alloy. After 7,000 cycles of thermal stress, the washers maintained its principle dimensions but developed small radial cracks. There was a 2 mg wt gain despite obvious corrosion. (F.S.)

7348 ORNL-360

Oak Ridge National Lab., Tenn.
A DISCUSSION OF LIQUID METALS AS PILE COOLANTS.
A. S. Kitzes. Aug. 10, 1949. Decl. Jan. 5, 1956. 41p.
Contract W-7405-eng-26. \$0.30(OTS).

Criteria given for evaluating liquid metal coolants are corrosion, nuclear properties, availability and cost, radiation stability, heat-transfer properties, and health hazards. Lithium, Na, NaK, Pb-Bi and Ga were considered as the liquid metals most suitable to be studied as coolants. (F.S.)

7622 KAPL-P-1511

Knolls Atomic Power Lab., Schenectady, N. Y.
RECLEANING SODIUM HEAT TRANSFER SYSTEMS.
W. H. Bruggeman, H. F. Karnes, and F. C. Hanny. [1956].
31p. Contract [W-31-109-Eng-52]. \$6.30(ph OTS);
\$3.00(mf OTS).

Both steam and alcohol are useful techniques for the removal of sodium residues from piping systems and components. The principal disadvantage of steam recleaning is the possibility of high temperature excursions due to the low heat capacity of the steam. Tests have been conducted in which these temperature rises are minimized by dilution of the steam with an inert gas. This humid gas technique is recommended for recleaning operations where the use of steam would be preferable to alcohol and where local over-temperature could result in system equipment damage. (auth)

7639 NP-5912

Mine Safety Appliances Co., Callery, Penna.
CALCULATION OF DEVELOPED PRESSURE AND FLUID
POWER IN LINEAR POLYPHASE INDUCTION LIQUID
METAL PUMPS. Technical Report No. 48. R. S. Baker.
Mar. 24, 1956. 67p. Contract NObs-65426.

The following factors which affect the performance of linear polyphase induction liquid metal pumps are discussed: frequency of the power source; speed of the traveling field; electrical power losses due to harmonic losses of the traveling magnetic field; and "end effects" due to the stationary fields at each end of the pump. Formulas are given for calculating the pressure developed in liquid metal, by the action of a traveling magnetic field in a linear polyphase induction pump, and the electrical power loss in the liquid metal caused by the traveling field. Equations for obtaining maximum shut-off pressure by varying pump dimensions are also presented. An example of the application of these equations to pump design is included. (auth)

7640

FREEZE-SEAL VALVES AND PUMPS. R. Cygan and A. M. Stelle (North American Aviation, Inc., Canoga Park, California). *Chem. Eng. Progr.* 52, 157-9(1956) April.

Freeze seals have been developed for sealing stationary and rotating shafts affording a simple means of adapting commercial equipment for use in high-temperature liquid-metal systems. Several designs for sealing sodium at temperatures up to 1200°F have been satisfactorily tested. Under different operating conditions cooling loads, torque,

and temperature distribution were measured. Locating the freeze seal away from the high-temperature region allows the formation of an annulus of frozen metal around the shaft with small cooling loads. (auth)

7656 NP-5936

Mine Safety Appliances Co., Callery, Penna.
CORROSION OF ZIRCONIUM IN 1000 F SODIUM. Memo Report No. 110. S. J. Rodgers and J. W. Mausteller. Apr. 23, 1956. 5p. Contract NObs-65426.

The corrosion of Zr was studied as a function of oxygen concentration in 1000 F sodium flowing at 3 fps in a Ni system. The corrosion rate varied from 0.8 mg/cm²-mo at 0.005 wt % O₂ to 1.0 mg/cm²-mo at 0.036 wt % O₂. Samples were covered with a black film and all showed weight gains. (auth)

7696 AERE-X/R-1806

Cambridge [Univ.], England.
INTERACTIONS BETWEEN SOLID AND LIQUID METALS AND ALLOYS. V. W. Eldred. 1953. 242p.

This report was written in the early part of 1953 and was based on work carried out at Cambridge in the preceding three years.

A technique for carrying out long-term corrosion tests is described. It has been applied to the investigation of over forty systems involving pure metals in contact with liquid Bi, Cd, Pb, Hg, K, Na, Sn and Zn at temperatures up to 550°C for periods of contact up to 300 hr. A series of ferrous and non-ferrous alloys has also been investigated under similar conditions in contact with the same liquid metals. The types of attack observed are described and discussed. Criteria for the classification of combinations of solid and liquid metals and alloys according to their corrosive behavior are put forward and applied to the systems investigated. The factors controlling the rate of solution of a solid metal in a liquid metal under various conditions are discussed theoretically in the light of the experimental results. The knowledge at present available with regard to metals and alloys manifesting a high corrosion resistance to liquid metals is considered and the characteristics of such systems are discussed. A method of predicting further systems of a similar character is suggested. (auth)

7746

AN INVESTIGATION OF THE SODIUM-POTASSIUM EQUILIBRIUM DIAGRAM. D. K. C. MacDonald, W. B. Pearson, and Lois T. Towle (National Research Council, Ottawa, Canada). *Can. J. Phys.* 34, 389-94(1956) April.

The study of fundamental properties such as specific heat and electrical resistivity in pure metals has made it very important to know the influence of small amounts of impurity. This has led the authors to undertake a detailed investigation of the Na-K equilibrium diagram. Previous work had indicated zero solid solubility at each limit (100% Na; 100% K) but the present investigation shows in particular that solubility extends to a few per cent from either limit. (auth)

7779 NP-5921

Mine Safety Appliances Co., Callery, Penna.
PROGRESS REPORT NO. 33 FOR FEBRUARY AND MARCH 1956. W. J. Posey, ed. Apr. 9, 1956. 57p. Contract NObs-65426.

Progress is reported on the tests made on models of the S2G steam generators. Modifications of a 1000 kw test unit were made to permit adequate testing of the 3000-kw generators. The cyclic test program for the S2G is outlined. Typical Na flow data are given for the cyclic testing of the

S2G evaporator. The operational history of this evaporator is also discussed. Progress is also reported on research pertaining to liquid metal system components, including fundamental heat transfer studies and component development and testing. Diagrams are given of the steam generators and tube joints. Operating characteristics of the liquid metal system are tabulated. The ability of transition welds to withstand the rapid temperature changes anticipated during scram conditions was studied. The suitability of stainless steel bellows for use in 8-in. S2G sodium valves was also studied. Results are given of 14 runs to determine the minimum velocity necessary to remove entrained gas by forcing it downward through the 5½-ft vertical leg for separation in the lower expansion tank. The nitriding of metals in Na is also discussed. The weight losses of Be specimens in 900°F Na are shown. A study was made of the characteristics of water-NaK leaks and applicable sealing methods. Data are given on the corrosion rate of Cr-Mo steel samples in NaK. It was found that the solubility of O₂ in NaK is dependent on K concentration. A study was made of radiation hazards arising from hole and valve gland leaks in a simulated, contaminated H₂O cooling system of a nuclear reactor. A schematic diagram is given of an inpile loop for testing proposed reactor organic moderator-coolants. Operational data for the loop containing isopropyl diphenyl are included. Tests were made to determine the extent of the hazard resulting from mixing hot diphenyl and H₂O. (B.J.H.)

7988 NP-6037

Mine Safety Appliances Co., Callery, Penna.
REMOVAL OF ENTRAINED GAS FROM A SODIUM SYSTEM. Technical Report No. 50. K. R. Barker and J. W. Mausteller. July 12, 1956. 14p. Contract NObs-65426.

An efficient method for removal of entrained gas in a Na system similar to the S2G primary coolant system is described. A study of the behavior of air-water mixtures in a glass loop showed how gas moved through the system and gave a better understanding of two-phase flow. Air could be held up at various points depending on the velocity: down-stream end of upper horizontal run at 0.25 fps, in the vertical downward leg at 0.25 to 0.50 fps, and at the bottom of the vertical downward run at 0.50 fps. Entrained gas in the Na system caused erratic flowmeter and pump performance and flow stoppage at low velocities. An expansion tank located above the loop will remove gas at any flow condition great enough to transport gas to the vent. If it is necessary to transport gas downward to the expansion tank a minimum velocity must be exceeded. This was found to be between 1.5 and 2.3 fps in a 1 in. line 6 ft long. Gas removal rate is a function of velocity in the expansion tank line, but is independent of the main loop velocity. Entrained gas can be removed if liquid velocities are kept above 2 ft/sec and a normal separator is used in a by-pass line. (auth)

8101

FILTER WITH FRACTIONAL CRYSTALLIZATION MEANS. W. H. Bruggeman and B. G. Voorhees (to U. S. Atomic Energy Commission). U. S. Patent No. 2,745,552, May 15, 1956.

A cold-trap-type filter has been used to remove Na₂O crystals from a molten Na heat exchanger system. Oxygen entering such a system through leaks will combine with Na to form Na₂O which will deposit in cooler portions of the system and choke the flow. This filter installed in a by-pass will remove the Na₂O and other solid impurities that may be present in the molten sodium. The by-passed stream is cooled to 400° then to 350°F in the filter, at which temperature the crystals are formed and then forced

through steel wool which collects and holds the crystals and other impurities. The Na is then reheated to system temperature utilizing the heat extracted in the cooling steps. The holdup time required for Na passage is 5 min and the capacity is 7500 lbs/hr. The cooling surfaces must be periodically cleaned of deposits and the steel wool renewed as needed. (auth)

8350 NP-5935

Mine Safety Appliances Co., Callery, Penna.
NITROGEN CONTAINING TWO PER CENT OXYGEN AS A SODIUM SYSTEM COVER GAS. Technical Report No. 49. E. F. Batutis, J. W. Mausteller, and C. A. Palladino. Apr. 10, 1956. 22p. Contract NObs-65426.

Nitrogen containing 2 vol. % O₂ is not recommended as a cover gas for sodium systems. Nitriding was general throughout the loop that was tested and plugged gas and drain lines were also found. (F.S.)

8357 NP-6050

Mine Safety Appliances Co., Callery, Penna.
TWO INCH STOP VALVE TESTS WITH SODIUM. Memo Report 107. G. E. Kennedy and E. C. King. Mar. 5, 1956. 5p. Contract NObs-65426.

The integrity of the bellows of the 2 in. stop valve on the S2G drain system was determined during freezing and thawing of sodium following a dump operation into the hold tanks. The valve was so positioned that a minimum of sodium should be held up in it. The test was run three times to determine whether subsequent freezing and thawing of the residual sodium would cause failure of the bellows. The valve performed satisfactorily. (auth)

8358

NUCLEAR METALLURGY—A SYMPOSIUM ON BEHAVIOR OF MATERIALS IN REACTOR ENVIRONMENT, FEBRUARY 20, 1956. New York, American Institute of Mining and Metallurgical Engineers, 1956. 94p. \$3.75.

The following papers describing the peculiar problems and fields of application of commercial metallurgical materials were read: applications of materials in reactor environments; material behavior in liquid metals; application of materials in low-temperature water power reactor; corrosion of materials in fused hydroxides. (F.S.)

8373 NP-6051

Mine Safety Appliances Co., Callery, Penna.
CORROSION OF LOW ALLOY STEEL IN HOT NaK. Memo Report 109. W. Milich and E. C. King. Mar. 30, 1956. 6p. Contract NObs-65426.

Consideration is being given to the use of low alloy steels due to the difficulties encountered in the use of type 347 stainless steel for steam generating equipment. As a preliminary experiment, to check the corrosion of such steels by liquid metals, a type 304 stainless steel loop was revised to accommodate a section of 1 in. OD tubing composed of 2 1/4% Cr-1% Mo steel. NaK (56 wt. % K) at 850°F was circulated at approximately 8 ft/sec. through this tubing for four months. Four small samples (1/4 in. weighed sections of the tubing) placed in an in-stream expansion tank were removed after 1, 2, 3, and 4 months immersion time and showed penetration of 0.19, 0.09, 0.07, and 0.06 mils/yr respectively. The section of test tubing showed no detectable weight loss after the 4 month period. With the temperature of the NaK at 850°F the oxygen content was found to be 0.032 wt. % O₂. All results of the test run isothermally at 850°F indicated a rate of attack less than one mil per year. (auth)

8398 AECU-3143

Knolls Atomic Power Lab., Schenectady, N. Y.
GUIDE TO ALKALI METALS HANDLING. Liquid Metals Safety Committee Manual LMSC-1. W. W. Kendall, L. H. B. Peer, W. J. Scheiber, and F. C. Steiner. July 1, 1954. 33p. Contract W-31-109-Eng-52. \$0.25(OTS).

8510 AD-83639

General Electric Co. Electronics Div., Syracuse, N. Y.
NUCLEAR INSTRUMENTATION STUDIES. Final Development Report covering the period August 1, 1952 to June 1, 1955. June 4, 1955. 378p. Contract NObsr-57409.

Design philosophy, data, and experimental results are presented on a second harmonic type d-c to a-c converter and transistor amplifier. This combination was able to amplify d-c currents ranging from 10⁻⁷ to 10⁻⁴ amp over a temperature range of 0 to 50°C. The description and performance of an experimental pressure transmitter for use with liquid metals is presented. The development of a temperature detector for use with liquid Na up to 1000°F is reported. The design, development, construction, and testing of experimental models of transistorized d-c linear amplifiers, d-c logarithmic amplifiers, and derivative amplifiers are given. A transistor logarithmic response pulse rate computer design is presented. Neutron-sensitive phosphors and photovoltaic detectors were studied for adaptability to neutron flux measurement. Photovoltaic detectors appear quite satisfactory at flux levels above 10¹⁸; neutron phosphors are destroyed at fluxes greater than 10¹⁴. (D.E.B.)

8876 KAPL-197

Knolls Atomic Power Lab., Schenectady, N. Y.
REPORT ON SODIUM RESISTANT BRAZING ALLOYS. J. P. Frandsen and R. S. Zeno. June 30, 1949. Decl. Aug. 26, 1952. 17p. Contract W-31-109-Eng-52. \$3.30(ph OTS); \$2.40(mf OTS).

An investigation was made on the effect of Na corrosion on the mechanical properties of brazed Type 347 stainless steel. Brazes of Ni-Mn, Ni-Mo, Ni-P, and Fe-P were exposed to Na at a temperature of 500°C. for a period of two weeks. It was found that none of the brazes were attacked by Na. On the basis of shear strength alone the Ni-Mn braze was found preferable, followed by Ni-Mo, Fe-P, and Ni-P in that order. (auth)

8877 KAPL-M-NGN-1

Knolls Atomic Power Lab., Schenectady, N. Y.
DYNAMIC CORROSION TEST OF TYPE-347 STAINLESS STEEL IN SODIUM. N. G. Mills and R. F. Koenig. Oct. 6, 1950. Decl. Feb. 9, 1956. 9p. Contract W-31-109-Eng-52. \$1.80(ph OTS); \$1.80(mf OTS).

As part of the program to compare various sodium purification treatments, a six-month dynamic corrosion test employing thermal circulation was made with aged and filtered sodium to determine the corrosion and erosion resistance of type 347 stainless steel. The temperature relationships were observed for indications of plugging by metal or oxide deposition. No plugging was encountered although there appeared to be some iron deposited immediately downstream from the cooling fins and in the annulus around the specimen. The results showed that type 347 stainless steel was very resistant to corrosion and erosion in aged and filtered sodium at 500°C (932°F). It was also shown that such a system can be operated with moderate flow rates (0.3 ft/sec) and relatively small openings (3/16 in.) without difficulty. (auth)

8939 IDO-16276

Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.

TOTAL NEUTRON CROSS SECTIONS OF SODIUM, POTASSIUM, AND RUBIDIUM IN THE 0.03 TO 10 EV REGION. E. G. Joki, L. G. Miller, and J. E. Evans. Apr. 22, 1955. Contract AT(10-1)-205. (PPC-149). \$3.30(ph OTS); \$2.40(mf OTS).

Transmission measurements were made with the MTR crystal spectrometer on Na, K, and Rb metal samples 8.73 cm (8.48 g/cm²), 30.0 cm (26.1 g/cm²) and 5.04 cm, respectively. The free atom scattering cross sections, as determined from these data, are 3.2 ± 0.1 b for Na, and 2.04 ± 0.1 b for K. The Rb data are to be corrected for a 5 wt. % Cs contamination in the sample. (auth)

8954 CF-3746

Argonne National Lab., Lemont, Ill.

PILE RESEARCH & DEVELOPMENT DIVISION REPORT FOR JULY 1946-FEBRUARY 1947. Feb. 28, 1947. Decl. Dec. 20, 1955. 74p. Contract W-31-109-eng-38. \$12.30 (ph OTS); \$4.50(mf OTS).

9254 NP-6062

Mine Safety Appliances Co., Callery, Penna.

THE USE OF IMPURE INERT GAS WITH SODIUM. Memo Report No. 81. R. C. Werner. Apr. 14, 1955. 5p. Contract NObs-65426.

Before the purity specification of the inert gas is relaxed it is recommended that studies be made on the effect of local corrosion resulting from high oxygen concentration formed on draining, on the effect these sludge formations can have on valve seats, bellows valves, and other moving parts and on determining the ratio of corrosion between the walls of the main loop and the cold trap based on the operational schedule and rate of oxide removal of the cold trap. The purification specifications of the inert gas may then be relaxed following the knowledge on the extent of the resulting problems. (auth)

9258 AECU-3291

Knolls Atomic Power Lab., Schenectady, N. Y.

NATURAL CONVECTION HEAT TRANSFER IN NARROW VERTICAL LIQUID METAL ANNULI. C. F. Bonilla. Aug. 26 and Oct. 21, 1954. 16p.

Experiments on natural convection heat transfer from the bottom to the top of a rigid narrow annulus or vertical slot with insulating walls yield and approximate correlation $Nu_L = UL/k = q/kP \Delta t = 2.0 \pm 1.0$. (auth)

9260

THE USE OF SODIUM AND OF SODIUM-POTASSIUM ALLOY AS A HEAT-TRANSFER MEDIUM. I. W. B. Hall and T. I. M. Crofts (United Kingdom Atomic Energy Authority, Sellafield, England). *Atomics* 7, 167-72(1956) May.

The applications of liquid metals in heat-transfer problems are discussed, and comparisons are drawn between those metals whose melting points are sufficiently low to make them of interest in this respect. A number of Na and Na-K circuits which have been built and operated over the past three years are described; some of these were built in order to gain experience in handling the liquid metals, while others were for heat-transfer experiments. A general discussion on the design and construction of liquid metal circuits and the components which are commonly used in them is given. A brief discussion of forced-convection heat-transfer with liquid metals follows, and the results of some work on cavitation in Na-K eutectic flowing through a constriction in a pipe are summarized. (auth)

9284 NRL-Memo-591

Naval Research Lab., Washington, D. C.

THE TRANSFER RATES OF RADIOACTIVE STAINLESS STEEL COMPONENTS IN SODIUM CONTAINING BARIUM. Final Report. R. A. Baus, A. D. Bogard, J. A. Grand, L. B. Lockhart, and D. D. Williams. Apr. 17, 1956. Project No. NS 200-021.

The effect of Ba on the transfer rates of Fe, Co, Ta, Mn and impurities in radioactive stainless steel at 425°C was measured with 0, 0.1, 1, and 10 wt. % Ba added to the Na. Type 347 stainless steel apparatus and radioactive sources were used. The presence of less than 1 wt. % Ba in Na containing 0.001 to 0.003 wt. % O₂ is effective in reducing the transfer rates of Fe⁵⁹, Ta¹⁸¹, and Co⁶⁰. The transfer rate of Mn⁵⁴ was not significantly reduced. (auth)

9395

THERMAL AND ELECTRICAL CONDUCTIVITIES OF THE ALKALI METALS AT LOW TEMPERATURES. D. K. C. MacDonald, G. K. White, and S. B. Woods (National Research Council, Ottawa, Canada). *Proc. Roy. Soc. (London)* A235, 358-74(1956) May 8.

9770 KAPL-M-SCT-4

Knolls Atomic Power Lab., Schenectady, N. Y.

FREE CONVECTION THROUGH PARALLEL RISERS. F. C. Steiner. June 1, 1955. 20p. Contract W-31-109-Eng-52. \$4.80(ph OTS); \$2.70(mf OTS).

Preliminary data, demonstrating the manner in which free convection distributes flow between parallel risers having unequal heat generation, cover that phase of the tests in which steady-state data were obtained when applying heat to two parallel risers of equal cross sectional areas. It was found that temperatures at the top varied by less than 25°F or about 5% of the outlet temperature when applying heat differing by a factor up to 8, to the risers. (F.S.)

9776 KAPL-M-SCT-8

Knolls Atomic Power Lab., Schenectady, N. Y.

MARK B PUMP CLEANING REPORT. R. Demers. Oct. 7, 1955. 12p. Contract W-31-109-Eng-52. \$3.30(ph OTS); \$2.40(mf OTS).

Sodium cleaning of the Mark B Pumps was successfully completed without incident. However, an additional step, (a tri-NaHPO₄ flush) had to be incorporated into the cleaning procedure to remove an oily-type film which was deposited after Na cleaning. This T.S.P. did not remove all of the residue and localized swabbing with acetone on all accessible parts of the pump interior was necessary. Analysis of the residue indicated that the oily film could have been deposited by the methyl isobutyl ketone, one of the cleaning agent's constituents. The ketone apparently undergoes a condensation reaction to form a water insoluble soap-like compound. In view of the above, SIR Systems Development has suggested that an alcohol which does not contain this constituent be employed in future pump cleaning operations. If the oil film deposit is still evident after the use of absolute alcohol, it is suggested that the final water rinse be followed by a cold acetone flush in place of the T.S.P. solution. This would ensure maximum cleanliness of the inaccessible expansion joint. Residual acetone could be readily removed by hot gas purging. (auth)

9785 KAPL-M-EGB-16

Knolls Atomic Power Lab., Schenectady, N. Y.

ALUMINUM BEARING ALLOYS IN SODIUM. Report No. 2 ON EVALUATION OF THE BEHAVIOUR OF ALUMINUM IN SODIUM. Problem No. 28. E. G. Brush. Apr. 6,

1954. 15p. Contract W-31-109-Eng-52. \$3.30(ph OTS); \$2.40(mf OTS).

Simulated bearing tests have shown that certain Al base alloys have attractive bearing properties for service in Na and NaK. Previous corrosion tests have shown that the behaviour of Al in Na is greatly influenced by the presence of stainless steel. To study this influence under simulated bearing conditions, non-rotating sleeve and journal tests were run in Na at 300, 400 and 500°C. Additional tests were made to determine the solubility of Al in Na as a function of temperature. The tests reaffirm previous findings that at temperatures above 400°C, the high corrosion rate of Al base alloys prohibits their use in Na-stainless steel systems. (auth)

9885 KAPL-M-DPT-2

Knolls Atomic Power Lab., Schenectady, N. Y.
FLOW VELOCITY IN SECONDARY PLENUM OF SANDWICH PLATES. Dominic P. Timo. [1953]. 21p. Contract W-31-109-Eng-52. \$4.80(ph OTS); \$2.70(mf OTS).

The radial Na velocity distribution in the secondary plenum of the sandwich plates at the bottom of the SIR Mark A rotating plug was calculated, and a curve is given showing the variation of radial velocity in the secondary plenum with radius on a radial line normal to the outlet pipes centerline. This velocity is an average of the radial velocity in the secondary plenum. (F.S.)

10135 NP-6087

Mine Safety Appliances Co., Callery, Penna.
TESTS OF A FILLING PROCEDURE FOR THIRD FLUID SYSTEM OF COMBUSTION ENGINEERING EVAPORATOR. Memo Report 118. V. K. Heckel and E. C. King. Aug. 27, 1956. 13p. Contract NObs-65426.

During preparation for installing the Combustion Engineering evaporator, it was discovered that the third fluid passages of many of the tubes were restricted to such an extent that it was questionable that they could be completely filled with NaK. Tests were devised to determine a method of filling the third fluid passages and determine the voids remaining after filling. The relative degree of restriction and volume of each of the 10 third fluid passages were successfully filled and the tests indicate that it should be possible to fill the evaporator by this method even though some of the third fluid passages are partially plugged. (auth)

10136

THE USE OF SODIUM AND OF SODIUM-POTASSIUM ALLOY AS A HEAT-TRANSFER MEDIUM. II. W. B. Hall and T. I. M. Crofts (U. K. Atomic Energy Authority, Sellafield, England). *Atomics* 7, 189-93(1956) June.

The applications of liquid metals in heat-transfer problems are discussed, and comparisons are drawn between those metals whose melting points are sufficiently low to make them of interest in this respect. A number of sodium and sodium-potassium circuits which have been built and operated over the past three years are described; some of these were built in order to gain experience in handling the liquid metals, while others were for heat-transfer experiments. A general discussion on the design and construction of liquid metal circuits and the components which are commonly used in them is given. A brief discussion of forced-convection heat-transfer with liquid metals follows, and the results of some work on cavitation in sodium-potassium eutectic flowing through a constriction in a pipe are summarized. (auth)

10218

THE USE OF SODIUM AND OF SODIUM-POTASSIUM ALLOY AS A HEAT-TRANSFER MEDIUM. III. W. B.

Hall and T. I. M. Crofts (U. K. Atomic Energy Authority, Sellafield). *Atomics* 7, 271-3 & 290(1956) Aug.

The applications of liquid metals in heat-transfer problems are discussed, and comparisons are drawn between those metals whose melting points are sufficiently low to make them of interest in this respect. A number of sodium and sodium-potassium circuits which have been built and operated over the past three years are described; some of these were built in order to gain experience in handling the liquid metals, while others were for heat-transfer experiments. A general discussion on the design and construction of liquid metal circuits and the components which are commonly used in them is given. A brief discussion of forced-convection heat-transfer with liquid metals follows, and the results of some work on cavitation in sodium-potassium eutectic flowing through a constriction in a pipe are summarized. The first parts of these articles appeared in the May and June issues of *ATOMICS*. (auth)

10505 AERE-T/M-65

Gt. Brit. Atomic Energy Research Establishment,
Harwell, Berks, England.

THE EFFECT OF Na COOLING ON A BARE U^{235} -Be UNDERMODERATED THERMAL REACTOR. M. E. Mandl. Aug. 1952. 17p.

For one core composition of a bare homogeneous U^{235} -Be intermediate reactor, the effect of adding one given proportion of Na upon the critical radius has been calculated. Comparing the result with the critical radius and median energy of the uncooled reactor suggests that the slowing down in the Na produces almost negligible effect upon the energy spectrum and that the change in critical radius is entirely due to the volume effect upon the slowing-down length. Assuming that this represents the effect of Na cooling, graphs of critical radii and weights of U^{235} required for various amounts of Na present were prepared. Calculations indicate that the reactor can be assembled safely with its coolant spaces empty. (auth)

10699 KAPL-722

Knolls Atomic Power Lab., Schenectady, N. Y.
STATIC PRESSURE DUE TO SODIUM-WATER REACTIONS IN CLOSED VESSELS. W. S. Horton. Mar. 26, 1952. Decl. Dec. 7, 1955. 20p. Contract W-31-109-Eng-52. \$0.20(OTS).

The reaction between H_2O and Na, followed by reaction of the liberated H_2 with air, in a closed vessel is treated as a thermodynamic problem at constant volume. The results for reaction of stoichiometrically equivalent amounts of Na and H_2O for varying size of vessel are found to follow the equation: $P = 3.44 + 45.64 R - 7.97 R^2$ where P is the final pressure in pounds per square inch gauge, and R is the ratio of Na (in hundreds of cubic feet measured at 350°F) to dry air (in millions of cubic feet at 77°F). This equation is satisfactory when the final temperature is above the melting point of NaOH (591°K). (auth)

10708 CF-55-7-16

Oak Ridge National Lab., Tenn.
EFFECT OF PRE-CLEANING OF GLASS SAMPLERS ON THE OXYGEN CONTENT OF SODIUM. J. C. White. July 5, 1955. Decl. Apr. 4, 1956. 3p. Contract W-7405-eng-26. \$1.80(ph OTS); \$1.80(mf OTS).

Molten Na flushing exerts a cleansing action on glass Na sampling tubes. The O_2 content of the Na used in this study was so high that the results are not conclusive for the chromic acid cleansing. (T.R.H.)

10768 KAPL-M-JRG-2

Knolls Atomic Power Lab., Schenectady, N. Y.
REMOVAL OF MERCURY FROM SIR COOLANT (E-3

EXPERIMENTS). John R. Gould and J. G. Gratton. Oct. 17, 1955. 5p. Contract W-31-109-Eng-52. \$1.80(ph OTS); \$1.80(mf OTS).

The removal of Hg from Na (SIR coolant) by precipitation as a Ca-Hg compound was studied. No evidence of a Ca-Hg reaction was observed over a period of 10 hr. at 700°K; however, the reaction goes to completion within 1/2 hr at 870°K. The solubility of Hg_xCa_y in a Na solution is approximately 0.1 to 0.3 wt. % at 870°F. (C.W.H.)

10821 KAPL-877

Knolls Atomic Power Lab., Schenectady, N. Y. SUMMARY OF JOURNAL BEARING TESTS WITH COPPER BEARINGS AND TUNGSTEN CARBIDE JOURNALS OPERATING IN SODIUM-POTASSIUM ALLOY. D. B. Vail. Feb. 3, 1953. Decl. Jan. 10, 1956. 27p. Contract W-31-109-Eng-52. \$4.80(ph OTS); \$2.70(mf OTS).

Tests were performed on two 2 3/8-inch-diameter hydrodynamic journal bearings with sodium-potassium alloy as a lubricant. The first test was made with an electrolytically copper-plated bearing and 18-4-1 high speed, tool-steel guide bearings operated against a tungsten carbide journal. The second test was run with an electrolytically copper-plated bearing and tough pitch copper guide bearings operated against a tungsten carbide journal. Tests were run with speeds of 1200 and 1700 rpm and with liquid metal temperatures from 100 to 500°F. The duration of the respective tests was 376 hours and 1483 hours. Data are tabulated. (auth)

10822 KAPL-M-HLT-1

Knolls Atomic Power Lab., Schenectady, N. Y. WEAR AND GALLING TESTS OF PLUG SEAL TUBING. Report No. 1. E. G. Brush and H. L. Tymchyn. Feb. 25, 1954. 16p. Sub-Project No. 27. Contract W-31-109-Eng-52. \$3.30(ph OTS); \$2.40(mf OTS).

To determine the effect of Cr plating on the wear and galling characteristics of the plug seal tubing laboratory tests simulating the sliding action of the rotating plug during raising and lowering operations have been completed in Na at 500°F. Cr plated and as drawn tubing sections, loaded to deflections of 15 and 30 mils, were drawn over plates representing the container wall under conditions simulating 355 plug raising and lowering operations. Results indicate that seizing due to galling is unlikely in SIR and that for deflections in the range of 0 to 20 mils as drawn tubing has satisfactory resistance to wear and scoring. Above 20 mil deflections Cr plating will reduce the amount of scoring and wear experienced by both tubing and container wall. (auth)

10823 KAPL-M-PMC-1

Knolls Atomic Power Lab., Schenectady, N. Y. FREEZE SEALS. P. M. Clark. July 14, 1952. 6p. Contract W-31-109-Eng-52. \$1.80(ph OTS); \$1.80(mf OTS).

Results are presented from tests on an air-cooled freeze seal suitable for use in the Submarine Thermal Reactor service lines. The seal consists of a finned pipe section for freezing the sodium and a trap for retaining sufficient sodium in the seal for freezing. The seal is considered a one way freeze seal because it will pass gas in one direction only without emptying the liquid from the seal. The test arrangement is illustrated and performance data are summarized. (C.H.)

10825 KAPL-M-SCT-5(Rev. 1)

Knolls Atomic Power Lab., Schenectady, N. Y. CALIBRATION OF 8" MAGNETIC FLOWMETER BY USE

OF A CALIBRATED ORIFICE. E. J. Duffy and J. J. Marguin. May 24, 1955. 34p. Contract W-31-109-Eng-52. \$6.30(ph OTS); \$3.00(mf OTS).

A calibrated, sharp-edged orifice was installed and used for the calibration of the Mark I-1 eight-inch magnetic flowmeter. This flowmeter is one of the two being used for performance testing of Mark B electromagnetic pumps, both prototype and production models. Repeatable data was obtained throughout the entire calibration period of eleven days. As a result, it is now possible to establish the relationship between this magnetic flowmeter output signal and sodium flow which, to date, has been in question. From the test it is now certain that the relationship between flowmeter output and flow does deviate from linearity above the higher flow rates (1800 gpm and over). Pump performance, based on flow measurements derived from magnetic flowmeters, has been affected to such an extent that, because of this deviation, it has not been possible to establish the rated voltage or accurate performance curves on the electromagnetic pumps. (auth)

10832 CF-55-6-24

Oak Ridge National Lab., Y-12 Area, Tenn. EXAMINATION OF INCONEL-316 STAINLESS STEEL-SODIUM PUMP LOOPS 4689-5 AND 4689-6. G. M. Adamson and R. S. Crouse. June 2, 1955. Decl. Apr. 4, 1956. 12p. Contract W-7405-eng-26. \$3.30(ph OTS); \$2.40(mf OTS).

The findings of a metallographic examination of the loops confirm the fact that excessive mass transfer occurs in Inconel pump loops in which Na is circulated at 1500°F. The use of 316 stainless steel in the cold leg of the loops does not appear to increase mass transfer. (T.R.H.)

10835 KAPL-M-EGB-14

Knolls Atomic Power Lab., Schenectady, N. Y. RESISTANCE OF TITANIUM CARBIDE BEARING MATERIALS TO CORROSION IN SODIUM. Report No. 5 [on] EVALUATION OF THE BEHAVIOR OF VARIOUS MATERIALS IN SODIUM. (Problem No. 21). E. G. Brush. Apr. 15, 1953. 6p. Contract W-31-109-Eng-52. \$1.80(ph OTS); \$1.80(mf OTS).

The corrosion resistance of four titanium carbide ceramals was determined in Na at 500°C and was found to be of the same order of magnitude as Carboloy 55A and 779 (tungsten carbides). (auth)

10865 KAPL-M-LFE-7

Knolls Atomic Power Lab., Schenectady, N. Y. ESTIMATED CRITICAL CONSTANTS, EXTRAPOLATED VAPOR PRESSURE, AND EQUATION OF STATE OF SODIUM. Leo F. Epstein. Sept. 20, 1951. 14p. Contract W-31-109-Eng-52. \$3.30(ph OTS); \$2.40(mf OTS).

Critical constants, vapor pressure, and equation of state of Na were extrapolated from low-temperature data and evaluated for high-temperature use. (F.S.)

10954 KAPL-M-EGB-21

Knolls Atomic Power Lab., Schenectady, N. Y. PRELIMINARY EXPERIMENTS ON THE NITRIDING OF REACTOR MATERIALS IN SODIUM. E. G. Brush and C. R. Rodd. Sept. 22, 1955. 9p. Contract W-31-109-Eng-52. \$1.80(ph OTS); \$1.80(mf OTS).

The use of N_2 as a cover gas in the SIR Mark B primary coolant system poses the problem of possible nitriding to reactor structural materials. Preliminary tests have been conducted at KAPL and in the MTR in sodium under a pressurized N_2 blanket. Results show that at 900 and 1100°F the

ferrous alloys and Be readily nitride under these test conditions. The thermodynamics of the reaction indicate that transport of N_2 in Na (diffusion, entrainment, or Ca_2N_2 as a carrier) may be the rate controlling factor. Further experiments must therefore be performed to evaluate the problem under conditions more closely resembling those of actual reactor operation. (auth)

10956 KAPL-M-FCS-3

Knolls Atomic Power Lab., Schenectady, N. Y.
NATURAL CONVECTION IN SODIUM IN AN 8" HORIZONTAL PIPE. F. C. Steiner. Dec. 6, 1954. 22p. Contract W-31-109-Eng-52. \$4.80(ph OTS); \$2.70(mf OTS).

In connection with the problem of thawing out the reactor by the application of heat on the sodium piping, it was established that melting in a horizontal pipe is accomplished with the aid of free convection. Data were obtained regarding the rate of heat transfer by convection as a function of the temperature difference between the top and bottom of the horizontal pipe. Steady-state heat transfer and heat loss data were obtained using a water-cooled heat exchanger. It was established that complete melting of a 10 foot long, 8" pipe section containing about 230 lbs of sodium can be accomplished in 50 minutes when using 14 KW of external heat applied in a 14" length at one extreme end of the piping system. (auth)

10958 KAPL-M-FNS-6

Knolls Atomic Power Lab., Schenectady, N. Y.
USE OF A D-C ELECTROMAGNETIC PUMP AS A THROTTLING DEVICE IN A SODIUM SYSTEM. F. N. Schell. Aug. 13, 1953. 11p. Contract W-31-109-Eng-52. \$3.30(ph OTS); \$2.40(mf OTS).

Operation of a d-c pump as a dynamic brake (magnetic drag) in a Na system proved successful. The Na flow from the 60 gpm test pump was reduced by 26 percent and the pressure at the inlet of the test pump was lowered from 15 psia to 2.7 psia. A comparison between the performance of the d-c unit as a pump and as a generator is presented. (auth)

10960 KAPL-M-HFK-3

Knolls Atomic Power Lab., Schenectady, N. Y.
HYDROGENOUS LOOP: WATER INJECTION TEST SDT-3 [on] RUN NO. W.I.-1. H. F. Karnes. Sept. 12, 1955. 15p. Contract W-31-109-Eng-52. \$3.30(ph OTS); \$2.40(mf OTS).

Six grams of H_2O were injected into the 1-inch hydrogenous loop at a temperature of 500°F. The pressure rise within the loop was more than 17 psi for at least $\frac{3}{4}$ second and then decreased to 7.5 psi. Approximately 10% of the injected hydrogen was collected as gas in the surge tank. The balance is assumed to be in the form of NaOH and NaH. The plugging temperature of the Na increased from less than 300°F to 630°F after injection. Although the loop temperature was approximately 500°F, no flow restrictions were noted in the circulating system until flow was diverted to the plugging section. Cold trapping was successful in reducing the saturation temperature to 310°F. Hydrogen analysis of the Na confirmed the relative changes in plugging temperatures. (auth)

11171 AERE-ED/R-1856

Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
A.C. LIQUID METAL PUMPS FOR LABORATORY USE. D. A. Watt. Mar. 19, 1953. Revised Jan. 24, 1956. 33p.
Two types of single phase a-c electromagnetic pump for liquid metals are described, a leakage reactance model and a combined pump and transformer. The NaK alloy test rig

is briefly described and methods of pump construction detailed. Test results and curves for pumping NaK alloy at temperatures below 70°C are included, and it is shown that the combined form is the more effective pump. One of these models with a single loop secondary winding had a maximum efficiency of 11% with output 10 gals/min. at 13 lb/in.² pressure rise, input 650 watts, 9.0/7.5 amps at 180/195 volts. A maximum pressure rise of nearly 30 lb/in.² is recorded for the first model of this form. (auth)

11493 NAA-SR-1622

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

SODIUM GRAPHITE REACTOR QUARTERLY PROGRESS REPORT [FOR] JANUARY-MARCH 1956. SECTION A. L. E. Glasgow, ed. SECTION B. J. C. Cochran, ed. July 15, 1956. 88p. Contract AT(04-3)-49. \$13.80(ph OTS); \$4.80(mf OTS).

Reactivity and flux perturbation studies for SRE are reported. Additional experiments were conducted to determine the behavior of Zr in liquid Na. Weight gain as a function of time and temperature is plotted. Tests were made on Hf-free Zr which show the effects of surface oxide on the fatigue and rupture properties and the effects of temperature on tensile properties. These functions are plotted. Analog computer studies of convective flow in the SRE after shutdown indicate satisfactory heat removal. Coolant flow decay for the case of simultaneous pump failure and scram is plotted. Moderator can fabrication and stress studies resulted in revised fabrication techniques and a reconsideration of can stress tolerances. Previously obtained fuel element orifice calibration data were translated to show pressure drop-flow rate and discharge coefficient-Reynold's number relationships. Results of tests on control rod drive mechanism components are reported and discussed. Excessive wear continues to appear. The status of various shielding studies is reviewed. (For preceding period see NAA-SR-1582.) (D.E.B.)

11852

THE SURFACE TENSIONS OF LIQUID-METAL SOLUTIONS. J. W. Taylor (Atomic Energy Research Establishment, Harwell, Berks, England). *Acta Met.* 4, 460-8 (1956) Sept.

Two analytical methods are presented for the calculation of the surface tensions of binary liquid-alloy mixtures. Calculated surface tension-composition relationships are compared with the corresponding experimental values for ten binary systems. For six simple eutectic systems the agreement is good. Three systems, showing intermediate phase formation in the solid state, exhibited considerable discrepancies between the calculated and experimental relationships. It is suggested that in these systems the surface has not the simple monolayer structure assumed in the analysis. In one system of peritectic form, the agreement was intermediate between the above two extremes. It was not found possible to invert the analysis to calculate activity-composition relationships from surface tension data, although this is theoretically possible. (auth)

12026 NAA-SR-1690

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

SODIUM GRAPHITE REACTOR QUARTERLY PROGRESS REPORT [FOR] APRIL-JUNE 1956. L. E. Glasgow, ed. Sept. 15, 1956. 67p. Contract AT(04-3)-49. \$0.40(OTS).

Technology of the Sodium Graphite Reactor. Nuclear parameters were calculated for a lattice having cylindrical moderator cans. Design, development, and fabrication

progress on SRE hot cells are reviewed. Solid and hollow U-Mo fuel slug fabrication experience is reported. Breeder material and graphite studies were continued. Additional information on the behavior of Zr and Zr-Ti alloys in liquid Na is given. Sodium Reactor Experiment. Core tank stresses as a function of time after shutdown were plotted. The status of plant construction is shown. Cooling system component testing was continued. Test equipment and results are shown. Further testing of the control rod mechanism is reported. Calculated values of required shield thicknesses are plotted. (For preceding period see NAA-SR-1622.) (D.E.B.)

12150

HEAT-EXCHANGER PUMP. L. B. Vandenberg (to U. S. Atomic Energy Commission). U. S. Patent No. 2,748,710, June 5, 1956.

A combined heat exchanger and liquid metal pump suitable for use as the connecting means between the primary liquid metal and secondary liquid or gas cooling systems of a nuclear reactor was designed. The two fluids flow through banks of adjacent interspersed tubes which are connected to headers, the interstices being filled with a good heat conductor such as Cu. The Na tubes are so designed that thermocouples are created, connected in series so that sufficient current is generated to set up an electromotive force acting upon the liquid metal resulting in circulation of the primary coolant. The circulation of the secondary coolant is achieved by any common system such as a condenser. The heat exchanger pump is designed to enclose a reactor and radiation shield resulting in a compact self regulating reactor power unit. (auth)

Volume 11, 1957

227 NP-6132

Mine Safety Appliances Co., Callery, Penna.
PROGRESS REPORT NO. 36 FOR AUGUST AND SEPTEMBER, 1956. W. J. Posey, ed. Oct. 10, 1956. 70p. Contract NObs-65426.

Tests are continuing on the 3000 KW steam generator. The unit has been subjected to a life test at cyclic conditions. The test system is shown schematically. The cycle test has been completed on the evaporator for the 3000 KW steam generator. A complete operational history of the evaporator is given. Stress tests are continuing on a tee in the S2G system used to join to liquid metal streams of different temperatures. The work on nitriding of Be, 347 stainless steel, and tool steel is complete; tables of corrosion rates of the three metals in liquid Na are presented. Methods of installing freeze seals and design of the seals are being investigated to prevent Na from being carried in the venting system of the S2G into the upper level reactor compartment. Radioactive leak experiments were continued. Isopropyl biphenyl, a proposed organic moderator coolant, is being tested in the Brookhaven pile. Tests are continuing on the effect of velocity on the corrosion rate in biphenyl at 800°F of 9 metals being considered in reactor design. Experiments have been performed on the corrosion of Zr at 800°F and 300 psig by water and/or dissolved oxygen in biphenyl. (For preceding period see NP-6068.) (W.L.H.)

249

INEXPENSIVE WAY TO CONTROL OXYGEN IN SODIUM HEAT-TRANSFER SYSTEMS. I. L. Gray, R. L. Neal, and B. G. Voorhees (General Electric Co., Schenectady, N. Y.). *Nucleonics* 14, No. 10, 34-7(1956) Oct.

Sodium oxides in molten Na accelerate metal corrosion and plug systems in cold regions. Rugged, reliable devices were developed to measure 3 to 300 ppm O₂ in Na and NaK (200 to 700°F) and to reduce O₂ to less than 10. (auth)

275 NP-6138

Illinois Inst. of Tech., Chicago. Armour Research Foundation.

DEVELOPMENT OF OXIDATION AND LIQUID SODIUM RESISTANT BRAZING ALLOYS. Quarterly Report No. 1 [for] July 15, 1956 to October 15, 1956. Domenic A. Canonico and Harry Schwartzbart. Oct. 22, 1956. 20p. Project No. B 110. Contract AF33(600)-33406.

Progress is reported on developing oxidation and liquid Na resistant brazing alloys and a simple ductility test for brazed joints. Three base metals have been selected: Cr, Fe and Ni. Various temperature depressants, selected on the basis of their binary eutectics formed with one of the above three metals, are being alloyed with one or more of the above elements in the effort to obtain a brazing alloy having a flow temperature within the range of 1750 to 1900°F plus the oxidation and liquid Na resistance neces-

sary. A technique is being studied that may permit the evaluation of ductility of a brazed joint. It is felt that the joint design and method of loading simulate service loading to the extent that significant values of ductility will be obtained, permitting the prediction of service behavior. The specimen is sectioned from a T-specimen and loaded in a tensile machine so that a fillet is subjected to tensile stresses similar to those in service. Preliminary examination of the method indicates some promise. (auth)

313 LM/TAB-1

Mine Safety Appliances Co., Callery, Penna.
LIQUID METALS TECHNOLOGY ABSTRACT BULLETIN FOR THE PERIOD JULY 1 TO AUGUST 31, 1956. Sept. 7, 1956. 15p.

The first of a series of abstracts covering current literature on liquid metals is presented. (J.E.D.)

452 AECU-3172

General Electric Co. General Engineering Lab., Schenectady, N. Y.

SECOND REPORT ON LIQUID METAL LEVEL INSTRUMENT. C. R. Droms. Dec. 21, 1954. Includes Supplement by C. R. Droms and P. W. Marks. Feb. 1, 1955. 93p. (R55GL1). \$15.30(ph OTS); \$5.40(mf OTS).

Results of additional development work on liquid-metal level indicators are given. Tests performed indicate satisfactory operation up to 1000°F. The system accuracy depended on operating conditions and ranged from 2 to 8% in the tests. (T.R.H.)

540

INTERATOMIC POTENTIAL FUNCTIONS OF SODIUM AND POTASSIUM. Rufus C. Ling (Univ. of Missouri, Columbia). *J. Chem. Phys.* 25, 609-13(1956) Oct.

The liquid structure theory is used to interpret x-ray-diffraction measurements on liquid Na and K to find an effective interatomic potential function for pairs of Na and pairs of K atoms. This potential function predicts approximately the correct binding energy for solid Na and K, and when reinserted in the x-ray formulas predicts scattering curves at higher temperatures which are in good agreement with experiments. (auth)

670

HOW STRONG MUST REACTOR HOUSINGS BE TO CONTAIN Na-AIR REACTIONS? Edward Hines, Andrew Gemant, and J. K. Lelley (Detroit Edison Co., Detroit, Mich.). *Nucleonics* 14, No. 10, 38-41(1956) Oct.

Experiments and calculations point to 40 psig as highest pressure to expect for closed-system Na-air reactions, regardless of the amount of Na or size of the reactor housing. Maximum gas-phase temperature would be about 1000°C. (auth)

736

X-RAY SCATTERING BY LIQUID-METAL ALLOYS (A KINETIC APPROACH). Rufus C. Ling (Univ. of Missouri, Columbia). J. Chem. Phys. 25, 614-16(1956) Oct.

The Born-Green theory of liquids is extended to the case of liquid mixtures, and a formula for the x-ray scattering by such liquids is developed. The formula is used to calculate the x-ray scattering by a liquid sodium-potassium alloy, and fair agreement with the experimental scattering is found. (auth)

1061 WIAP-M-30

Westinghouse Electric Corp. Industrial [Atomic Power] Group, Pittsburgh.

A 50 KW DC ELECTROMAGNETIC PUMP FOR LIQUID METAL APPLICATION. A. R. Jones. [1953?]. Changed from OFFICIAL USE ONLY May 17, 1956. 17p. \$3.30 (ph OTS); \$2.40 (mf OTS).

The results of the study and design of a pump to handle three thousand gallons per minute of liquid Na at 600°F pumping against a developed head of 100 ft. While Na and the other liquid metals do not differ radically from water in density or viscosity they do have certain characteristics which indicate changes in the component designs in systems for their handling. (auth)

1127 LM/TAB-2

Mine Safety Appliances Co., Pittsburgh.

LIQUID METALS TECHNOLOGY ABSTRACT BULLETIN FOR THE PERIOD SEPTEMBER 1 TO OCTOBER 31, 1956. Nov. 1, 1956. 28p.

1129 NAA-SR-Memo-758

North American Aviation, Inc., [Downey, Calif.]

PROPOSED PROGRAM TO PROVIDE DESIGN DATA FOR ZIRCONIUM FOR USE IN A ZIRCONIUM-GRAPHITE-SODIUM REACTOR SYSTEM. F. E. Bowman. Aug. 7, 1953. Decl. June 6, 1956. 13p. \$3.30 (ph OTS); \$2.40 (mf OTS).

A brief résumé of the strength and sodium corrosion data that have been found available in the classified literature is given. Tensile properties of Zr and Zr alloys at 500°F, comparison of room temperature and 500°F tensile and creep properties of various Sn-Zr alloys, stress rupture of Zr-Al alloys in Na at 1000°F and a proposed research program are included. (F.S.)

1957 KAPL-M-LFE-10

Knolls Atomic Power Lab., Schenectady, N. Y.

THE SOLUBILITY OF HELIUM GAS IN LIQUID SODIUM. Leo F. Epstein. Oct. 30, 1951. Changed from OFFICIAL USE ONLY Nov. 30, 1956. 12p. Contract W-31-109-Eng-52. \$3.30 (ph OTS); \$2.40 (mf OTS).

Equations are derived for the computation of the solubility of He in liquid Na from 450 to 900°F at one atmosphere pressure. (W.L.H.)

2251 KAPL-557

Knolls Atomic Power Lab., Schenectady, N. Y.

SUMMARY REPORT OF REACTION TESTS OF VARIOUS MATERIALS TESTED WITH SODIUM AND SODIUM-POTASSIUM. C. O. Nelson. June 1, 1951. Changed from OFFICIAL USE ONLY June 26, 1956. 51p. Contract W-31-109-Eng-52. \$7.80 (ph OTS); \$3.30 (mf OTS).

Tabular data show the methods, conditions, and observations of tests carried out in air to determine the reactions of liquid Na and NaK with Al roofing, cloth (including protective clothing), laboratory equipment, fire-extin-

guishing materials, insulating and packing materials, oils, paints, brass and Cu screens, and Li fire-extinguishing materials. (F.S.)

2264 CF-3748

Argonne National Lab., Lemont, Ill.

DETERMINATION OF HYDROGEN IN SODIUM-POTASSIUM ALLOY. O. C. Simpson and E. G. Rauh. Dec. 23, 1946. Decl. Feb. 16, 1956. 13p. Contract W-31-109-eng-38. \$3.30 (ph OTS); \$2.40 (mf OTS).

An analytical procedure for the determination of very low concentrations (~0.1 at %) of H₂ in Na-K alloys is presented. The procedure consists of converting the H₂ present into OH⁻ ions, equilibrating with D₂O of known concentration, and determining, mass spectrometrically, the dilution of D₂ in the D₂O by H₂. (C.W.H.)

2423 KAPL-M-WMK-2

Knolls Atomic Power Lab., Schenectady, N. Y.

PRESSURE RISE IN A CONFINED VOLUME OF MOLTEN SODIUM UPON ADDITION OF HEAT. W. M. Knox. May 20, 1953. 7p. Contract W-31-109-Eng-52. \$1.80 (ph OTS); \$1.80 (mf OTS).

The increase of pressure in a confined volume of molten Na is determined for a few representative cases. Assuming a rigid container which is initially completely filled with a homogeneous mass of Na, the results indicate that an increase in the temperature of the liquid from 300 to approximately 1000°F will be accompanied by a pressure rise of the order of 10⁴ psi. The results obtained are considered to have limited practical significance since it would be difficult to satisfy the assumptions given above. Whenever adequate venting is not provided a more detailed analysis is recommended. (auth)

2422 KAPL-589

Knolls Atomic Power Lab., Schenectady, N. Y.

COMPATIBILITY OF MATERIALS IN LIQUID METAL. Donald B. Vail. Aug. 18, 1951. Changed from OFFICIAL USE ONLY June 26, 1956. 103p. Contract W-31-109-Eng-52. \$16.80 (ph OTS); \$5.70 (mf OTS).

A series of tests were initiated to determine the materials which are best suited for use as Na- or NaK-lubricated bearings under conditions of boundary lubrication. In order to evaluate the compatibility of materials for use in slider, hydraulic piston, or anti-friction bearings a compatibility tester was designed. The specimens constructed of similar or dissimilar materials are of two types. The sleeve specimen is rotated against a fixed specimen to which a known load is applied. A variety of materials have been evaluated under a limited set of conditions. Of the materials tested, exceedingly hard materials and Al alloys gave the best results. (F.S.)

2437 KAPL-M-LBV-5

Knolls Atomic Power Lab., Schenectady, N. Y.

ELECTROMAGNETIC PRESSURE GAGE. L. B. Vandenberg and G. P. Hendricks. July 18, 1952. 10p. Contract W-31-109-Eng-52. \$1.80 (ph OTS); \$1.80 (mf OTS).

Development is described of a pressure gage for use with electromagnetic liquid metal pumps in which the current necessary to maintain equal and opposing force is proportional to the applied pressure to be measured. The pressures are maintained equal and opposite by means of an automatic liquid metal rheostat. A schematic sketch of the apparatus is included. (C.H.)

2438 KAPL-M-LFE-16

Knolls Atomic Power Lab., Schenectady, N. Y.
AN OBJECTIVE STUDY OF BARRIER MATERIALS FOR
SODIUM-WATER SYSTEMS. Leo F. Epstein. Nov. 17,
1955. 49p. Contract W-31-109-Eng-52. \$0.35(OTS).

The question of the choice of barrier materials for stain-
less steel heat exchangers using Na as a heat transfer fluid
is discussed. (F.S.)

2442 KAPL-M-WWK-5

Knolls Atomic Power Lab., Schenectady, N. Y.
REMOVING THE SODIUM RESIDUE FROM THE ALPLAUS
MAIN HEAT TRANSFER SYSTEM WITH ETHYLENE
GLYCOL. W. W. Kendall and M. Nazar. Aug. 5, 1954.
21p. Contract W-31-109-Eng-52. \$4.80(ph OTS); \$2.40
(mf OTS).

The Na residues were cleaned from the Main Alplaus
Heat Transfer System to remove all Na from the system
for base shut down and, to demonstrate the use of ethylene
glycol in cleaning a large scale system. The latter objec-
tive is in support of the program for developing a non-Na
flushing agent for use in the Mark B Coolant System. All
residual Na was cleaned from the system. Slight traces of
C was found on the inside of the pipe by wiping with a white
cloth. The decomposition of the glycol caused operational
difficulties such that ethylene glycol cannot be recom-
mended as the non-Na flush for Mark B. (auth)

2446 KAPL-521

Knolls Atomic Power Lab., Schenectady, N. Y.
LIFE TEST OF LIQUID METAL LUBRICATED THRUST
BEARING. D. B. Vail. May 7, 1951. Changed from
OFFICIAL USE ONLY June 26, 1956. 17p. Contract W-
31-109-Eng-52. \$1.80(ph OTS); \$1.80(mf OTS).

Results are given of a life test of 2700 hours duration
performed on a liquid metal lubricated thrust bearing.
Detailed procedures for life testing are included. (J.H.M.)

2447 KAPL-1021

Knolls Atomic Power Lab., Schenectady, N. Y.
COMPATIBILITY OF MATERIALS IN LIQUID METAL;
SECOND REPORT. D. B. Vail. Jan. 5, 1954. Changed
from OFFICIAL USE ONLY June 26, 1956. 69p. Contract
W-31-109-Eng-52. \$10.80(ph OTS); \$3.90(mf OTS).

Studies previously reported are extended to include a
larger selection of pairs of materials and to determine the
effect of temperatures up to 950°F upon the compatibility of
materials. It was concluded that at a temperature of ap-
proximately 850°F and at a liquid metal ambient certain
combinations of ceramals (ceramic plus metallic binder)
showed negligible wear or surface damage and no apparent
transfer of material. At lower temperatures, some com-
binations of nonmetallic materials, metallic materials, and
ceramals indicated satisfactory compatibility character-
istics during boundary lubrication. (auth)

2448 KAPL-1079

Knolls Atomic Power Lab., Schenectady, N. Y.
THE PERFORMANCE OF TUNGSTEN CARBIDE JOURNAL
BEARINGS OPERATING IN LIQUID METALS. D. B.
Vail. Jan. 25, 1954. Changed from OFFICIAL USE ONLY
June 26, 1956. 49p. Contract W-31-109-Eng-52. \$7.80
(ph OTS); \$3.30(mf OTS).

The results of a series of tests indicated that liquid-
metal-lubricated journal bearing performance may be
predicted adequately by existing theoretical and empirical
concepts. Test performance of the journal bearings was
closely correlated with the theoretical performance

postulated by Cameron and Wood for a full journal bearing.
The calculated minimum film thicknesses were also shown
to be as empirically postulated by Cameron. In the range
of boundary lubrication it was observed that tungsten
carbide ceramal bearings resisted the immediate seizure
characteristics shown by other alloys, but that some
roughening of the bearing surfaces occurred for the
particular ceramals used in this series of tests. (auth)

2451 KAPL-M-KDL-1

Knolls Atomic Power Lab., Schenectady, N. Y.
ANALYSIS OF THE SODIUM AND WATER PERFORM-
ANCE OF THE ATWOOD-MORRILL SWING CHECK
VALVE. K. D. Lantz and D. B. Vail. Mar. 19, 1953.
31p. Contract W-31-109-Eng-52. \$4.80(ph OTS); \$2.70
(mf OTS).

The Atwood and Morrill swing check valve was tested
for Na flow and for water flow under a variety of condi-
tions. An analysis was made to determine the effects of
friction and valve inclination upon the Na flow rate re-
quired to close the valve. Recommendations are made
which may minimize the flow rate required to close this
type of valve design. (C.H.)

2452 KAPL-M-RFK-5

Knolls Atomic Power Lab., Schenectady, N. Y.
EVALUATION OF METHODS OF PREVENTING THE
GALLING OF STAINLESS STEEL THREADS IN SODIUM.
R. F. Koenig. May 15, 1952. 5p. Contract W-31-109-
eng-52. \$1.80(ph OTS); \$1.80(mf OTS).

The effectiveness of a number of lubricants and treat-
ments in reducing the tendency of stainless steel threads
to gall during exposure to Na was determined, using the
torque required to loosen bolted assemblies as the crite-
rion. Of the methods tested, only nitriding and carburizing
were successful. Additional tests will be made of other
methods of preventing galling, which are based on thread
contour and clearances. (auth)

2464 KAPL-M-LT-3

[Knolls Atomic Power Lab., Schenectady, N. Y.]
CALCULATIONS ON A D.C. ELECTROMAGNETIC
PUMP. Lewi Tonks. June 16, 1948. Decl. Feb. 8,
1956. 10p. Contract W-31-109-eng-52. \$1.80(ph OTS);
\$1.80(mf OTS).

An analysis was made of the electromechanics of a cen-
trifugal d-c-actuated liquid metal pump. A uniform axial
magnetic field assures constancy of angular velocity
through the whirling chamber. A hyperbolic profile assures
uniform radial velocity—which simplifies the mathematics
slightly but has no essential advantage over constant height,
except possibly in the power required to maintain the
magnetic field. Such a pump is a very low impedance
device, 10^4 to 10^5 mhos. It has a low efficiency because of
the circular currents arising from the radial component of
flow. A set of freely rotating insulating vanes could elimi-
nate this power drain but would add mechanical complica-
tions. (auth)

2465 TID-5143

Allis-Chalmers Mfg. Co., Milwaukee.
DEVELOPMENT OF HERMETICALLY SEALED CENTRIF-
UGAL PUMP UNITS FOR LIQUID METALS. Final Re-
port. Report No. 43-112. June 30, 1953. Changed from
OFFICIAL USE ONLY Aug. 9, 1956. 307p. [For Knolls
Atomic Power Lab.] Contract W-31-109-Eng-52. Sub-
contract No. 56.

Contains abridged translation by O. A. Schulze: "Outline
of the Theory of Eddy Current Brakes" from the text

"Energie der Wirbelströme." R. Rüdberg. 348p.
\$55.80(ph OTS); \$11.10(mf OTS).

2481 KAPL-M-EGB-4

Knolls Atomic Power Lab., Schenectady, N. Y.
ALPLAUS SURVEILLANCE PROGRAM. Progress Report
No. 2. E. G. Brush. Aug. 29, 1952. Changed from
OFFICIAL USE ONLY June 26, 1956. 9p. Contract W-
31-109-Eng-52. \$1.80(ph OTS); \$1.80(mf OTS).

Type-347 stainless steel and L nickel, considered as
construction materials in the Alplaus heat-transfer system,
were placed in the system to determine their corrosion
resistance to liquid Na and NaK. The specimens were very
resistant to attack by Na at 950°F and NaK at 850°F. There
was no evidence of mass transfer between the stainless
steel and Ni specimens. No transfer of mass from the
hot to the cold zones occurred in one year. (D.E.B.)

2701 KAPL-M-IMC-1

Knolls Atomic Power Lab., Schenectady, N. Y.
TRANSIENT AND STEADY-STATE TEMPERATURES IN A
LIQUID METAL COOLING SYSTEM. Ingard M. Clausen,
Jr. Dec. 17, 1952. 36p. Contract W-31-109-Eng-52.
\$6.30(ph OTS); \$3.00(mf OTS).

A method for the numerical solution of transient and
steady-state temperatures in a liquid metal cooling system
are developed. The cooling system around which the for-
mulation is built is fairly complex; including forced con-
vection and free convection multi-channeled coolant loops,
and internal heat generation. The finite difference equa-
tions derived allow for heat transfer by conduction and
convection, and permit extreme variation in channel flow
rate. (auth)

2892 KAPL-M-GDC-6

Knolls Atomic Power Lab., Schenectady, N. Y.
EXPERIMENTAL WORK ON CLASS C INSULATION FOR
LIQUID METAL PUMPS. G. D. Collins. Aug. 15, 1952.
Decl. June 18, 1956. 7p. Contract W-31-109-Eng-52.
\$1.80(ph OTS); \$1.80(mf OTS).

The development of a program to learn the use of class
C insulating materials in liquid metal pumps is presented.
The specification for the insulation assembly is given.
The fabrication of insulated coil assemblies using tapes,
binders, and enamels and the insulation of conductors
placed in slots using enamels, ceramic spacers, and fill-
ers, and fugitive or permanent binders were investigated.
(J.E.D.)

3328 KAPL-1653

Knolls Atomic Power Lab., Schenectady, N. Y.
SOLUBILITY OF SODIUM MONOXIDE IN LIQUID SODIUM.
O. N. Salmon and T. J. Cashman, Jr. Nov. 30, 1956. 29p.
Contract W-31-109-Eng-52. \$0.25(OTS).

The solubility of Na₂O in liquid Na in the temperature
range 100 to 500°C has been obtained by analysis of the O₂
content of Na samples taken from liquid Na in contact
with excess Na₂O. The method of least squares has been
applied to the data to derive the solubility equation $\log_{10} y =$
 $-1816/T + 1.266$ in which y is the solubility of Na₂O in Na,
expressed as wt. % O₂ in Na, and T is the absolute tem-
perature of the Na in °K. A brief description of corrosion
of Type 347 stainless steel specimens by Na saturated with
Na₂O at 500°C is also presented. (auth)

3383 KAPL-M-WEJ-3

Knolls Atomic Power Lab., Schenectady, N. Y.
TRANSIENT THERMAL STRESSES IN THIN-WALLED

CYLINDERS. SIR MECHANICAL ENGINEERING ANALY-
SIS. W. E. Jahsman. Oct. 12, 1956. 41p. Contract W-
31-109-Eng-52. \$6.30(ph OTS); \$3.00(mf OTS).

Using experimental data showing the time behavior of
temperatures at various depths in the thin wall of a cylin-
drical pipe whose exterior is insulated and whose interior
is repeatedly thermally shocked by a liquid Na stream, it
is possible to predict the surface temperature transient
analytically by representing it by a series of straight lines.
Once the transient temperature distribution across the
wall thickness is known, the time at which the surface tem-
perature deviates most from the mean wall temperature
can be obtained. The temperature distribution at this time
of maximum deviation has importance because it can be
used to determine the maximum surface thermal stress.
Plasticity theory is used for the stress calculations be-
cause results by elastic theory show that maximum ther-
mal stresses exceed the yield strength of the pipe mate-
rial, AISI 347 stainless steel. Transforming the thermal
strains associated with the calculated stresses into equiv-
alent uniaxial strains, it is found that the thermal shock
test results do not contradict any of the existing strain
fatigue data for the material. (auth)

3398 NP-6178

Mine Safety Appliances Co., Callery, Penna.
A STUDY OF NITROGEN AS A COVER GAS IN SODIUM
SYSTEMS. Technical Report No. 53. E. F. Batutis, C. A.
Palladino, R. Gagne, and J. W. Mausteller. Dec. 7, 1956.
25p. Contract NObs-65426.

Nitrogen used as a cover gas in several MSA Na sys-
tems, ranging from 900 to 1100°F and 1 to 7 fps, did not
induce excessive corrosion of Types 304 and 347 stainless
steel and tool steel specimens. Average corrosion rates
found of the stainless steels ranged from +0.01 to +0.23
mg/cm²-mo and tool steel ranged from -0.24 to -0.96
mg/cm²-mo. The corrosion rate of Be in a 1100°F Na sys-
tem (S2G mock-up) for six specimens exposed for 90 days
averaged 1.27 mg/cm²-mo. This rate of Be attack may be
undesirable in some applications and would require definite
consideration in design work. Factors affecting Be attack
to varied degrees were: entrained N, Ca content, tempera-
ture and distance to Na-N interface. The order of magni-
tude of these factors was not definite but the last mentioned
seemed to be least effective. These factors were negligible
in the corrosion of stainless steels and tool steel in the
MSA test systems. (auth)

3414 AECU-3385

Massachusetts Inst. of Tech., Cambridge. Dept. of Metal-
lurgy.
ACTIVITIES IN LIQUID AND SOLID BINARY METAL SYS-
TEMS. Progress Report on Research Program [for]
February 1, 1956 to January 31, 1957. John F. Elliott.
Nov. 13, 1956. 14p. Contract AT(30-1)-1888. \$3.30(ph
OTS); \$2.40(mf OTS).

The progress made in the selection of materials and in
designing of equipment for making e.m.f. measurements of
600 to 1000°C on liquid and solid binary alloy systems under
the subject contract is reported. General status of the
program is reviewed briefly. (auth)

3682 NAA-SR-1771

Atomics International Div., North American Aviation
Inc., Canoga Park, Calif.
THE BEHAVIOR OF TETRALIN IN LIQUID SODIUM.
R. L. McKisson and K. E. Horton. Feb. 1, 1957. 19p.
Contract AT(04-3)-49. \$0.20(OTS).

A simplified, nonequilibrium experiment designed to qualitatively study the behavior of tetralin i.e., rate of reaction or decomposition in the presence of sodium, at temperatures up to 950°F has been performed to establish the probable consequences of a tetralin leak in the Sodium Reactor Experiment. It was found that tetralin decomposes with rapidity in the presence of hot liquid sodium. The ultimate decomposition products are hydrogen, carbon, and low molecular weight aliphatic compounds. The hydrogen is rapidly absorbed by the hot sodium up to approximately 750°F. At higher temperatures, sodium tends to release hydrogen. Zirconium metal submerged in sodium irreversibly absorbs hydrogen, at least up to 950°F, so that most of the hydrogen resulting from tetralin decomposition in the SRE ultimately would be absorbed in the zirconium moderator can sheaths. The carbon would circulate in the sodium, so that very slight carburization of the stainless might be expected with operation at 950°F. The hydrocarbon residues will collect in the gas space over the sodium pool and eventually decompose. (auth)

3791 KAPL-M-WLF-5

Knolls Atomic Power Lab., Schenectady, N. Y.
EXAMINATION OF THE NATURAL CIRCULATION STEAM GENERATOR FROM THE LIQUID METAL HEAT TRANSFER TEST FACILITY AT ALPLAUS, NEW YORK. Report No. 2. E. J. Callahan and W. L. Fleischmann. Sept. 12, 1953. Changed from OFFICIAL USE ONLY Oct. 8, 1956. 35p. Problem No. 70: INVESTIGATION OF THE CAUSES OF CRACKING IN THE NATURAL CIRCULATION. Contract W-31-109-Eng-52. \$6.30(ph OTS); \$3.00(mf OTS).

The first structural failure of a heat exchanger used in the Alplaus liquid metal system is discussed. The metallurgical examination revealed failure of two Type 347 stainless steel tubes (NaK outside, mercury inside) and two tube sheets. The location of the failure was confined to the hot end and the area around these two hottest tubes. Judging by the fracture appearance, the majority of the cracks were caused by thermal cycling. Further studies are under way to establish more definitely the cause of the failure. (auth)

3818

ACTIVITY TRANSPORT IN SODIUM-COOLED SYSTEMS. Fred G. Haag (Knolls Atomic Power Lab., Schenectady, N. Y.). Nucleonics 15, No. 2, 58-61(1957) Feb.

An experiment is described in which the transfer rates of Co^{60} , Mn^{54} , Ta^{182} , Fe^{59} , and Cr^{51} from stainless steel by liquid Na are determined. The effect of temperature, O_2 concentration, and various inhibitors is reported. (T.R.H.)

3845 LM/TAB-3

Mine Safety Appliances Co., Callery, Penna.
LIQUID METALS TECHNOLOGY ABSTRACT BULLETIN FOR THE PERIOD NOVEMBER 1 TO DECEMBER 31, 1956. Jan. 8, 1957. 36p.

3878

SPECIFIC HEATS OF LIQUID METALS AND LIQUID SALTS. T. B. Douglas (National Bureau of Standards, Washington). Trans. Am. Soc. Mech. Eng. 79, 23-8(1957) Jan.

In view of the general use of liquid metals and liquid salts in heat-transfer systems at high temperatures, their specific heats are reviewed. First, the general method of measuring them is described, and the more important sources of error are discussed. Known data are then ex-

amined on a volume basis, and two examples are presented which bear on the relation of the specific heats of mixtures to those of their components. It is finally shown that the specific heats of most liquid metals and liquid salts, when converted to an atomic basis, appear to be sufficiently alike to justify an approximate prediction in many cases for which no data exist. (auth)

3885 AECU-3200

Massachusetts Inst. of Tech., Oak Ridge, Tenn.
Engineering Practice School.

VAPOR TRAPS FOR HANDLING LIQUID SODIUM. A. J. Erickson, C. L. Gregory, and P. M. Lang. Aug. 25, 1951. 11p. For Carbide and Carbon Chemicals Div. [K-25 Plant. Contract W-7405-Eng-26, Subcontract 70]. (KT-109). \$3.30(ph OTS); \$2.40(mf OTS).

Proposals for removing Na aerosol by an electrostatic precipitator, a copper coil condenser, and a bubbler were tested and evaluated. All were at least partially effective, the condenser proving to be the most practical to operate. (F.S.)

4095 NAA-SR-1760

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.
SODIUM GRAPHITE REACTOR QUARTERLY PROGRESS REPORT [FOR] JULY-SEPTEMBER 1956. L. E. Glasgow, ed. Jan. 15, 1957. 61p. Contract AT(04-3)-49. \$0.40(OTS).

Studies were made of various alternate core configurations for the SRE. Determinations were made of SRE power and temperature coefficients of reactivity. Lattice code computations given an over-all temperature coefficient of reactivity of $+9 \times 10^{-5}/^\circ\text{C}$ at 200°C. Schematic diagrams are given of the dynamic cold-trapped Na loop (NaZrI) and of the hot-trapped loop (NaZrII). The weight gain for samples of technical reactor grade Zr exposed to cold-trapped Na was further investigated. The effects of surface oxide, dissolved H_2 , and grain size on the fatigue life of Zr test specimens are shown graphically. Tensile tests of SRE Zr exposed to Na were performed at 500 and 985°F and results are tabulated. The dimensional stability of moderator can Zr under thermal cycling was rechecked. An analog analysis was made of the SRE main airblast heat exchanger. Figures are given to show some of the representative severe transients that were run on the analog computer. Progress on reactor construction is briefly described. Tests to determine the ability of Stellite No. 3 and Stellite No. 6 to withstand reactor operating temperatures were continued. Tests on the safety rod prototype are also summarized. Calculations were made to determine the γ -ray dose rates at SRE instrument tubes. A summary of data for Na centrifugal pumps is given. Pump washing experiments were conducted to ascertain the problems involved in cleaning centrifugal pumps after service in a Na system. (For preceding period see NAA-SR-1690.) (B.J.H.)

4155

INELASTIC SCATTERING OF 0.3, 0.77, AND 1.0 MEV PHOTONEUTRONS. Kh. R. Poze and N. P. Glazkov. Soviet Phys. JETP 3, 745-51(1956) Dec.

Cross sections were measured for inelastic scattering of neutrons of three energies; 0.3, 0.77 and 1.0 Mev by the nuclei of 13 elements: uranium, bismuth, lead, mercury, tungsten, antimony, tin, cadmium, copper, nickel, iron, aluminum, and sodium. For heavy nonmagic nuclei (uranium, mercury and tungsten), the cross section for inelastic scattering of neutrons with energies 0.8 and 1 Mev was found to

be 1 to 2 barns. For light and magic nuclei the cross section for these same neutrons was found to be small, of the order 0.1 to 0.2 barns. In addition, for incident neutrons with $E_0 = 1$ Mev, an estimate was made of the average energy of the inelastically scattered neutrons, and the energy levels excited were determined for some nuclei. (auth)

4448 AGC-AE-34

Aerojet General Corp., Azusa, Calif.
THE REACTION OF MOLTEN METAL WITH WATER.
Progress Report [for] January 1 through January 31, 1957.
Feb. 13, 1957. 7p. Contract AT(04-3)-44. (AGC-L2914-23). \$1.80(ph OTS); \$1.80(mf OTS).

Explosion dynamometer tests were performed on 10g samples of Zr from 3550 to 4670°F, 9g samples of NaK at 120°F, 9g samples of stainless steel at 4120°F, and Al at 2050°C. High-pressure high-temperature corrosion-rate tests were performed on Zircaloy-2 wire in steam at 1000 to 1200°C. (For preceding period see AGC-AE-33.) (W.L.H.)

4460 NP-6202

Illinois Inst. of Tech., Chicago. Armour Research Foundation.

DEVELOPMENT OF OXIDATION AND LIQUID SODIUM RESISTANT BRAZING ALLOYS. Quarterly Report No. 2 [for] October 15, 1956 to January 15, 1957. Domenic A. Canonico and Harry Schwartzbart. Feb. 5, 1957. 21p. ARF Project No. B-110. Contract AF33(600)-33406.

A program is being conducted by ARF to develop oxidation and liquid Na resistant brazing alloys and a simple ductility test for brazed joints. Three metals, Fe, Cr, and Ni, were selected from oxidation and Na resistance considerations, as the base metals from which to develop acceptable brazing alloys. From a study of all the available phase diagrams, fifty-five alloys have been selected for initial evaluation. Thirty-one alloys have been prepared and examined for melting points between 1700 and 1900°F. Six alloys melted within this range; a seventh had a melting point below 1700°F. All seven alloys were used to braze six-in. long T-specimens. Two alloys had sufficient flowability (3 in.) to be acceptable. These alloys are 45.5 Ni-54.4 In and 40% Ni-30% Cr-30% Ge. A test for the ductility of brazed joints, based on the premise that the load necessary to cause cracking in the fillet of a braze is a measure of the ductility of the brazing alloy, has been studied. To date, the test has not yielded sufficient experimental reproducibility. (auth)

4464 TID-7526(Pt. 1)

Ames Lab., Ames, Iowa
METALLURGY INFORMATION MEETING, AMES LABORATORY, IOWA STATE COLLEGE, MAY 2, 3 AND 4, 1956. 284p. \$1.50(OTS).

The topics included are: Nondestructive Testing of EBWR Fuel Plates; Wetting Temperatures of Fuel Element Components with Na and NaK; Strengthening of Be for High-Temperature Use with BeO and Be₂C Dispersions; Mechanical Metallurgy of Zircaloy-3B; Mechanical Properties and Corrosion Behavior of Zircaloy-3B; Constitution of U and the Pt metals; Production of Th-Bi Dispersions; Preparation of B-Containing Alloys; Al-B and Al-U-B Alloys for Improved Reactor Performance; Radio-analysis of Kr and Xe and Its Use in Diffusion Experiments with Ag; Preferred Orientation in Extruded Th Rod; Morphology of Zircaloy-2; Microstructural Appearance and Identification of Hydrides in Zr and Zircaloy-2-H₂ Alloys; Inspection of Small Diameter Tubing by Eddy Current Methods; Application of Immersed Ultrasonic Technique for the Inspection

of Small Diameter Tubes; Corrosion and Mass Transfer by Li at High Temperatures; and Siliconizing of Metals in Liquid NaK. (T.R.H.)

4695

LIQUID METALS AND NUCLEAR POWER. 1. C. D. Boadle (Rolls-Royce Ltd., Derby). *Atomics* 8, 41-5(1957) Feb.

A survey is given of the use of liquid metals as a means of high-temperature heat extraction from nuclear reactors. Data are included on the physical and nuclear properties of the various metals considered, such as Li, Na, K, Hg, Pb, Bi, and their alloys. Typical diagrams are given for liquid-metal cooled reactors. (B.J.H.)

4849 TID-3305

Technical Information Service Extension, AEC.
HEAT TRANSFER: A BIBLIOGRAPHY OF UNCLASSIFIED REPORT LITERATURE. James M. Jacobs and Gifford A. Young, comps. Mar. 1957. 177p. \$1.00(OTS).

This bibliography contains 1031 annotated references to unclassified reports on heat transfer held by the Technical Information Service Extension, Oak Ridge, as of July 18, 1956. Author, subject, and report number availability indexes are included. (auth)

5305

ELECTROMAGNETIC PUMPS FOR LIQUID METALS. D. A. Watt (Atomic Energy Research Establishment, Harwell, Berks). *Engr.* 181, No. 4703, 264-8(1956) April.

The elementary considerations affecting the design and application of compensated d-c and travelling field a-c pumps for liquid metals are given. A brief survey of electromagnetic pumping equipment developed by U. K. A. E. A. is included. (T.R.H.)

5311 NRL-Memo-581

Naval Research Lab., Washington, D. C.
EVALUATION OF CROLOY STEEL FOR SODIUM USE.
B. F. Brown. Mar. 23, 1956. 14p. Project No. NS 200-021.

The resistance of Croloy 2 1/4 to corrosion by Na was studied in thermal convection harps. The results of these tests indicate that there is no mass transfer of Croloy 2 1/4 at 500°C (923°F) maximum temperature with a delta T of 175°C (315°F), no decarburization of Croloy 2 1/4, no carburization of Type 347 stainless steel in the presence of Croloy, and no detectable difference in effect of O concentration in Na at 0.003 wt. % and 0.014 wt. %. (auth)

5357

LIQUID METALS—2 AND NUCLEAR POWER. C. D. Boadle (Rolls-Royce Ltd., Derby). *Atomics* 8, 83-5, 106 (1957) March.

Advantages and disadvantages of liquid metals for high-temperature heat extraction from nuclear reactors are discussed. (W.L.H.)

5758 AERE-ED/D-10(Issue 2)

Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.

SODIUM, (Na). Data Sheet-D.10. Apr. 14, 1955. 15p.

A brief report on the procurement, chemical, nuclear, and physical properties of sodium is presented, together with charts on temperature-corrosion and resistance of materials at 300 and 600°C. (J.E.D.)

5832

PROGRESS IN NUCLEAR ENERGY. SERIES IV. TECHNOLOGY AND ENGINEERING. R. Hurst and S. McLain, eds. New York, McGraw-Hill Book Co., Inc., 1956. 432p.

Methods of producing and purifying such reactor materials as D_2O , graphite, BeO , Na, and NaK alloys are reviewed, and the efficiencies of the various methods are discussed. Many of the problems associated with reactor cooling and heat transfer are considered; specific treatment being given to the cases of boiling and liquid metal heat transfer. Coolant pump requirements and development are noted. Papers are included which treat specific chemical and corrosion problems in both heterogeneous and homogeneous, and water and metal cooled reactors. (D.E.B.)

5860 NBTI-P-243

Naval Boiler and Turbine Lab., Philadelphia.

HIGH TEMPERATURE CORROSION. A RESEARCH AND DEVELOPMENT TEST. Interim Report No. 3 [for] April to October 1954. Hormann Meyer. Jan. 19, 1955. 55p. (AD-76707).

Research was conducted to evaluate the effects of Na in the presence of V, S, Mg, $PhNH_2$, and excess air, individually and collectively, on corrosion of certain alloys under actual combustion conditions at elevated temperatures and to compare them with the effects obtained by the addition of V. The effects of Na, added to a boiler fuel in the form of Na oleate, on the corroding tendencies of 5 stainless steel alloys were determined by exposure to diverse elevated temperatures. Corrosive conditions were produced in a furnace by burning diesel fuel with 3 Na contents, employing 2 V, 2 S, and 2 excess air percentages as well as 1 Mg and 1 $PhNH_2$ concentration. Eighteen 30-hr runs were conducted. A scale was formed in the majority of cases; slag formed only when Mg was present at lower temperatures. Na was a corrodent agent at elevated temperatures. O and Mg retarded, while S and $PhNH_2$ augmented corrosion caused by Na as well as that by combined Na and V. A general diagram for Na and V corrosion is included. (auth)

6209 KAPL-1615

Knolls Atomic Power Lab., Schenectady, N. Y.

RADIOLOGICAL DEVELOPMENT ACTIVITIES IN HEALTH PHYSICS. Semiannual Progress Report [for] January-June 1956. L. J. Cherubin and J. J. Fitzgerald. 45p. Contract W-31-109-Eng-52. \$0.35(OTS).

An evaluation was made of optimum particle size and face velocities for the penetration of $KMnO_4$ particles through millipore filters. An investigation was made of the rate of deposition of debris resulting from a liquid NaK-water reaction. An analysis was made of the dispersion rate and subsequent fall-out of fluorescent particles from the roof of a critical assembly. An automatic fall-out sampler was constructed to provide a means for determining the number of size characteristics of particles falling out from a cloud at finite periods after generation. The radio-operated on-off switch for an air sampler was tested for the radio control of portable air samplers. The energy dependence of the Cutie Pie and Juno radiation survey meters was determined using beta sources evaluated for surface dose rate by means of an extrapolation chamber. The feasibility of using a thyroid scintillation monitor as a quick, relatively sensitive, and accurate external monitor of the internal dose from the inhalation or ingestion of fission products following a nuclear (power reactor) incident was investigated. A method was investigated for the radiochemical determination of Th in urine. A study on the radioactivity of samples of a quatic life in the Mohawk River was continued. Criteria and methods for evaluating

credible reactor hazards to the environs were developed to simplify the assessment of reactor hazards. Data are tabulated. (For preceding period see KAPL-1572.) (C.H.)

6396 AEC-tr-2900

THE POSSIBILITY OF USING SIMILARITY METHOD TO DETERMINE LIQUID-METAL PARAMETERS. I. M.

Kirko and O. A. Lielausis. Translated by M. C. Wheeler from *Fiz. Metal. i Metalloved. Akad. Nauk S.S.S.R., Ural. Filial* 2, 563-4(1956). 2p.

6400

AN APPROXIMATE CALCULATION OF SURFACE TENSION OF METALS. S. N. Zadumkin (Kabarda State Pedagogical Inst.). *Doklady Akad. Nauk S.S.S.R.* 112, 453-6 (1957) Jan. 21. (In Russian)

An approximate calculation of the σ for metals by the thermal evaporation method is presented. A table is given of the experimental values of σ and γ for various melted metals. (R.V.J.)

6521 ANL-5657

Argonne National Lab., Lemont, Ill.

REACTOR ENGINEERING DIVISION QUARTERLY REPORT—SECTION II [FOR] JULY, AUGUST, SEPTEMBER 1956. Dec. 1956. 69p. Contract W-31-109-eng-38. \$0.40(OTS).

Experimental Breeder Reactor II. A study was made of the coolant flow characteristics of the primary system. A schematic diagram of the system is shown, and flow rates and pressure drops in the system are shown graphically. Data are also included on pump rectifier voltages. Illustrations are given of the pumps for the heat transfer systems. A preliminary test was made of the 5000-gpm Na pump using H_2O as the circulating fluid. A pump efficiency of 79% was obtained at the design flow rate. A test facility was constructed to determine the performance of a low-melting alloy, gas tight seal for the rotating plugs. Supporting and Alternate Design Research and Development. Calculations were made to investigate the reactivity effects of inhomogeneities in the ZPR-III facility. Calculation methods and results are described in detail. Heating tests were made on fissium alloy pins and the results are tabulated. Tests were made to evaluate gears and bearings for service in high-temperature Na. The apparatus used is shown and complete test results are tabulated. Experiments were also conducted on the Na-air reaction. (For preceding period see ANL-5601.) (B.J.H.)

6708

MEASUREMENT OF LOCAL HEAT TRANSFER COEFFICIENTS WITH SODIUM-POTASSIUM EUTECTIC IN TURBULENT FLOW. K. D. Kuczen and T. R. Bump (Argonne National Lab., Lemont, Ill.). *Nuclear Sci. and Eng.* 2, 181-98(1957) Apr.

Local heat transfer coefficients were measured in a circular, copper tube of inner diameter 0.25 in., outer diameter 0.55 in., and length 36 in. Direct resistance heating of the tube wall from a direct current power source dictated the size and material of the test section. Since the electrical resistivity of copper varies appreciably with temperature, the radial heat flux was nonuniform along the length. (The temperature drop across the tube wall was small; therefore the heat flux in the radial direction was assumed uniform.) The test section was cooled from the inside with the eutectic alloy of sodium and potassium (22% Na, 78% K) flowing turbulently in a vertical direction. The range of variables covered in the experi-

ment was as follows: fluid temperature from 85° to 1175°F, fluid velocity 4 to 60 ft/sec, Reynolds number 13,000 to 466,000, Peclet number 268 to 3850, average heat flux 28,600 to 3,200,000 Btu/(hr ft²). The maximum local heat flux was 6,000,000 Btu/(hr ft²). For the above test conditions the experimentally measured Nusselt numbers ranged from 1.4 at the low Peclet number to 22.4 at the high Peclet number. Most of the fully-developed Nusselt numbers found are lower than indicated by the Lyon-Martinelli equation, but are in quite good agreement with data of most other experimenters. The values of Nusselt number in the entrance region are about 40% higher than those predicted by Deissler, and approximately 10% higher than the data of Johnson, Hartnett, and Clabaugh. Near a Peclet number of 300, the Nusselt numbers observed were lower, by a factor of more than two, than the theoretical minimum for fully developed laminar flow. The reason for this abnormality has not been established. (auth)

6719 IGR-TN/W-454

Gt. Brit. Windscale Works, Sellafield, Cumb., England. MASS TRANSFER IN LIQUID METAL CIRCUITS. A REVIEW OF PROGRESS IN INITIAL STUDIES. A. Draycott and P. D. Rich. Jan. 1957. 12p. (IGC-FRDC/P-217; IGC-SGDC/P-8).

Significant mass transfer of stainless steel constituents, and to a lesser extent of Zr has been measured in NaK circuits. In the first instance, at least, the oxide content of the liquid metal was a contributory influence. Solubility-temperature dependence was only one of several mechanisms that appeared to be operative, and isothermal mass transfer has been measured with some of the materials. In the circuits examined so far, washing with selected solvents has been a successful method of removing deposited activity. Methods of oxide determination are being surveyed; the Wurtz reaction has been usefully employed and promises wider scope with appropriate precautions. The next stage of the work being undertaken is detailed. (auth)

7186

STATIC AND DYNAMIC CORROSION AND MASS TRANSFER IN LIQUID METAL SYSTEMS. Leo F. Epstein (Knolls Atomic Power Lab., Schenectady, N. Y.). Chem. Eng. Progr. 53, Symposium Ser. No. 20, 67-81(1957).

In many systems involving liquid metals, the principal mechanism of corrosion of a solid exposed to the fluid is simple solution. In a static isothermal assembly the rate of corrosive attack is determined by the classical theory involving the solution rate constant α . The value of this parameter depends on whether the rate-determining step is (1) the diffusion of the solute through the liquid or (2) transfer of the solute through a solid film or some product of chemical reaction at the solid-liquid interface. In dynamic corrosion, such as is encountered in heat transfer loops, where parts of the system are at different temperatures and the fluid flows continually from the hot to the cold zone, different expressions are obtained for the corrosion rate depending on whether mechanism 1 or 2 is more important. These results are examined for a few solid-liquid metal systems, and quantitative relations capable of yielding order-of-magnitude agreement with experiment are obtained. The material dissolved in the hot zone of a heat transfer loop tends to deposit out of solution in the cold zone, resulting in an over-all transport of material. Factors influencing this mass transfer rate are examined. The effects of minor impurities in the solvent in accelerating and inhibiting corrosion are discussed. (auth)

7189

SODIUM CORROSION AND OXIDATION RESISTANCE OF HIGH-TEMPERATURE BRAZING ALLOYS. G. M. Slaught, C. F. Leitten, Jr., P. Patriarca, E. E. Hoffman, and W. D. Manly (Oak Ridge National Lab., Tenn.). Welding J. (N. Y.) 36, 217s-25s(1957) May.

Many of the brazing alloys which were investigated possessed excellent resistance to sodium corrosion and oxidation. Alloy systems of the Ni-Si-B, Ni-Cr-Si-B, and Ni-Cr-Si types were found to be compatible in both media. Precious-metal alloys were, in general, severely attacked by sodium, as were many of the silicon-free, chromium-free, phosphorus-bearing alloys. Alloys containing manganese, tin or copper exhibited poor resistance to oxidation at 1500°F. In most cases, oxidation was more pronounced at 1700°F. (auth)

7196 NP-6292

Illinois Inst. of Tech., Chicago. Armour Research Foundation.

DEVELOPMENT OF OXIDATION AND LIQUID SODIUM RESISTANT BRAZING ALLOYS. Quarterly Report No. 3 [for] January 15, 1957 to April 15, 1957. Domenic A. Canonico and Harry Schwartzbart. Apr. 22, 1957. 9p. ARF Project No. B-110. Contract AF33(600)-33406.

A program is in progress at Armour Research Foundation which has as its objectives: the development of filler metals for brazing stainless steel to Inconel, the brazements to be resistant to oxidation and attack by molten sodium at 1650°F, and the development of a simple test for the ductility of a brazement. Atmospheric difficulties have been encountered during the brazing of T-specimens. A titanium sponge furnace has been added to the purification train in an attempt to eliminate this problem. Approximate melting temperatures have been obtained for 50 out of the 55 alloys originally proposed. Twelve alloys melted below 1900°F. Fifteen additional alloys have been prepared and are under study. These new alloys have as their base four alloys previously studied that had melting points above the maximum permissible temperature. Indium and/or silicon have been added as temperature depressants. (auth)

7205

LOW TEMPERATURE HEAT CAPACITIES AND RELATED PROPERTIES OF POTASSIUM AND Na₂K. C. A. Krier, R. S. Craig, and W. E. Wallace (Univ. of Pittsburgh). J. Phys. Chem. 61, 522-9(1957) May.

Constant pressure heat capacities between 12 and 320°K are presented for K and an alloy of composition Na₂K. The Na₂K-K eutectic point was established to be -12.65 ± 0.01°, and the incongruent melting point or meritectic point for Na₂K was established to be 6.90 ± 0.00°. From the heat capacity data the entropies at 273.16 and 298.16°K, relative to absolute zero, are found to be, 14.77 ± 0.03 and 15.38 ± 0.03 e.u./g. atom for potassium, and 12.48 ± 0.02 and 16.07 ± 0.03 e.u./g. atom for Na₂K, respectively. A residual entropy for Na₂K at absolute zero was estimated, assuming an ideal entropy of mixing, to be -0.05 e.u./g atom; this result suggests that the entropy of formation of Na₂K exceeds the ideal mixing entropy. (auth)

7208

STRUCTURE OF LIQUID METALS. I. V. Radchenko. Uspekhi Fiz. Nauk 61, 249-76(1957) Feb. (In Russian)

Roentgenographic and neutronographic investigations showed that the atomic packing in liquid metals is related to the atomic packing in the solid state, however the character of such bond depends on the type of the metal. The coordination number of all metals either increases or

changes. The indication of reduced coordination numbers for Pb, Tl, and In was not sufficiently substantiated due to the side maximum appearing on the atomic distribution curve. This could be an error incurred in developing the intensity distribution curves. The temperature relations of the intensity curves of K, Tl, Sn and other metals show that liquid metals retain their type of packing at considerably higher temperatures than the melting point. (R.V.J.)

7328 KAPL-1770

Knolls Atomic Power Lab., Schenectady, N. Y.
QUARTERLY REACTOR TECHNOLOGY REPORT NO. 1
[FOR] JANUARY 1-MARCH 31, 1957. 76p. Contract W-31-109-Eng-52. \$0.45(OTS).

Developments in hot extrusion techniques for dispersion-type fuel elements are discussed. Results from radiation effects experiments with U-Zr alloys and UO_2 -stainless steel systems are reported. Experimental castings of Be were made in an effort to produce a fine-grained equiaxed structure. The effects of SiC, ZrH_2 , and Al additives on nucleation and structure are discussed. In-pile loop tests were conducted to determine the characteristics of corrosion product activity buildup in carbon steel cooling systems and to evaluate the efficiency of various resin forms in removing this activity. Activity buildup and removal using intermittent and continuous H^+ , NH_4^+ , and Li^+ -form resin demineralizers are plotted. A series of tests on the sliding friction and wear characteristics of stainless steel in high-temperature water is reported. Satisfactory techniques for extruding Eu_2O_3 -stainless steel dispersion-type control rods are described. Expressions are developed for describing natural-convection heat transfer in liquid metals. Calculations were performed to determine the extent of epithermal neutron absorption by theoretically pure thermal slabs. Flux distribution studies of spiked lattices are reported. Critical mass as a function of radius was plotted for a number of right-cylinder Fe- H_2O matrices. (D.E.B.)

7664 CT-2787

[Chicago. Univ. Metallurgical Lab.]
METALLURGY DIVISION PROGRESS REPORT FOR
MARCH 17 TO MARCH 24, 1945. F. Foote, E. W. Brugmann, and J. H. Chapin. Mar. 24, 1945. Decl. Feb. 16, 1957. 11p. Contract W-7405-eng-37. \$3.30(ph OTS); \$2.40(mf OTS).

Corrosion data on Nb-Zr-U, Nb-U, Be-Th, and Si-Th alloys in boiling distilled water are reported. The corrosive properties of liquid Na and BeF_2 -NaF melts were investigated. Beryllium extrusion and thorium fabrication results are presented. Corrosion data on Be and Nb-U alloy in aqueous NaCl solutions are also reported. (C.W.H.)

7665 CT-2794

[Chicago. Univ. Metallurgical Lab.]
DIVISION OF METALLURGY REPORT FOR MONTH OF
MARCH 1945. Apr. 12, 1945. Decl. Feb. 20, 1957. 110p. Contract W-7401-eng-37. \$18.30(ph OTS); \$6.00(mf OTS).

The casting of U into water-cooled Cu molds was investigated. Tensile tests on U-Nb and Mo-U alloys have shown that strength and ductility are markedly affected by heat treatment. Tantalum and Zr additions improved the corrosion resistance of uranium to boiling distilled H_2O . The hot-wire method is applicable for the production of small quantities of Th. The compressive strength of Th decreased rapidly with increasing temperature until 700°C was reached. Tensile properties, corrosion rates in H_2O , and phase studies of Th alloys are reported. Extruded Be rods showed internal defects.

The corrosive properties of liquid Na were studied. Pre-treatment of the Th surfaces had little effect on coating formation. Corrosion rates of Nb-U, Si-U, Mo-U, Al-U alloys and Be in boiling H_2O are reported. Work was continued on extrusion of Be and casting, rolling, and extrusion of Th. (C.W.H.)

7666 CT-2925

[Chicago. Univ. Metallurgical Lab.]
DIVISION OF METALLURGY REPORT FOR THE MONTH
OF APRIL 1945. May 8, 1945. Decl. Feb. 23, 1957. 29p. Contract W-7401-Eng-37. \$9.30(ph OTS); \$3.60(mf OTS).

Investigations were continued on the corrosive effects of boiling distilled H_2O on Si-U, Mo-U, Nb-U, Th, and U alloys. Thorium has been refined by the hot wire method. A number of Be extrusions were examined for recrystallization. The corrosion of several metals in liquid Na at 500°C was studied. Attempts to plate Th by immersion plating of Zn followed by electroplating with Cu were not successful. Heat treatment of U improved its corrosion resistance to H_2O . Rolling and forging experiments were carried out on Th. (C.W.H.)

7718 ANL-4274

Argonne National Lab., Lemont, Ill.
EXPERIMENTAL BREEDER PROJECT REPORT FOR THE
PERIOD DECEMBER 1, 1948 THRU FEBRUARY 28, 1949.
H. V. Lichtenberger. Apr. 12, 1949. Decl. Jan. 17, 1957. 34p. Contract W-31-109-eng-38. \$6.30(ph OTS); \$3.00(mf OTS).

7727 APDA-102

Atomic Power Development Associates, Detroit.
INFORMATION REPORT BY ATOMIC POWER DEVELOPMENT
ASSOCIATES COVERING WORK FOR THE PERIOD
AUGUST 1, 1954 TO JANUARY 31, 1955. Jan. 31, 1955. Decl. Jan. 7, 1957. 82p. \$0.55(OTS).

Five-group diffusion theory equations were used in calculations performed to assist in selection of a fast breeder reactor engineering design, and results are tabulated. Analyses were conducted to determine whether the rapid expansion of solid fuel elements during a prompt critical accident can stabilize a fast reactor. Data are given on the effect of allotropic transformations on, and grain refinement of Cr-U alloys. Corrosion tests were made on Globeiron, zirconium tubing, and titanium. Dynamic and static corrosion testing was performed on various other materials, and results are given. The effect of Na on the self-welding of two metals is being investigated. The prolonged operation of a piston-type Johnson valve in Na was studied. Progress is reported on fuel element design and development. Analyses of the thermal performance of the elements was made. The fabrication of cast, plate-type, perforated-wafer, and pin-type fuel elements is described, and figures are shown of their assemblies. Testing and economic studies of the elements are being made. Blanket design and specifications are discussed. A cross sectional view of the reactor vessel design is given. Investigations are being made on fuel and blanket element support. Fuel loading and unloading equipment and reactor compartment arrangements have been further studied. The mechanical design of the control rod is discussed and a cross sectional view of the rod is given. The coolant flow characteristics through the reactor core during scram conditions are studied and typical scram histories are shown. A diagram of the liquid and steam-power systems is given. The intermediate heat exchanger is also shown. Diagrams of the once-through-type steam generator and the reactor and steam plant elevation are also shown. A facility for NaK-water reaction tests has

been designed. Diagrams of the boiler test facility, the once-through-type test boiler and thermocouple locations for the proposed steam generator unit are shown. An analysis of relative merits of on- and off-site fuel reprocessing has been made. The design of the full-scale reactor and Na loop test facility is also discussed. (For preceding period see DCDE-101.) (B.J.H.)

7847 NAA-SR-1292

North American Aviation, Inc., Downey, Calif.
SODIUM GRAPHITE REACTOR. QUARTERLY PROGRESS REPORT [FOR] OCTOBER-DECEMBER 1954. SECTION A. A. B. Martin, ed.; SECTION B. Guy M. Inman, ed. May 15, 1955. Decl. Feb. 28, 1957. 133p. Contract AT(04-3)-49. \$0.60(OTS).

Further reactivity calculations have been performed for the steady-state Pu feed-back technique and results are presented. The neutron economy for the Th-U²³³ twin core of a full-scale sodium-graphite power plant is shown. Exponential assemblies with different lattice arrangements proposed for use in sodium-graphite power reactors are shown, and neutron flux distributions given. Experimental neutron attenuation factors for iron, magnetite concrete, and ordinary concrete are presented. Results of thermal cycling of hollow slugs and powder metallurgy U alloys are discussed. Tests on fourteen Th-U diffusion couples are briefly discussed. Results are given for irradiation stability tests to 1-Mev electrons for 3 terphenyl isomers, p-quaterphenyl, and mixtures of these polyphenyls. The latest criticality enrichment values for the SRE are briefly discussed. Design and operational features of the SRE for containment of radioactivity during normal operation, fuel loading, and reactor incidents are described. Theoretical physics calculations for the two-group SRE lattice constants and their application to reactor control are discussed. Latest development results and specifications for SRE fuel elements, moderator and reflector cells, core structure, Na coolant system, control rod system, safety device systems, and instrumentation are presented. A leak detector capable of detecting 10⁻⁶ moles Na/liter N₂ at atmospheric pressure is described. Revised ring and loading face shielding specifications are briefly discussed, and thermal cycling and Na corrosion tests on thermal shielding material (cast iron) were performed. Twelve thermal insulating materials showed various degrees of deterioration after exposure to molten Na at 950°C for two hrs. Tests for determining and maintaining the optimum purification of the inert blanket gas (helium) are described. The fuel handling coffin development studies are summarized. (L.M.T.)

7848 NAA-SR-1457

North American Aviation, Inc., Downey, Calif.
SODIUM GRAPHITE REACTOR QUARTERLY PROGRESS REPORT [FOR] APRIL-JUNE 1955. SECTION A. A. B. Martin, ed. SECTION B. Guy M. Inman, ed. Oct. 1, 1955. Decl. Mar. 8, 1957. 113p. Contract AT(04-3)-49. \$0.65(OTS).

The buildup of U isotopes in recycled Th-U²³⁵ fuel, and the amount of additional U²³⁵ necessary to restore the original reactivity for the full-scale SGR was studied. Determination of the relative activities of indium and dysprosium foils exposed in an SGR lattice allow determinations of buckling and neutron flux within the lattice. Results of these experiments are given in graphical and tabular form. General specifications for SRE experimental fuels are listed. A study was made of the behavior of Zr samples placed in the Na corrosion loop. It was suggested that tetralin might be suitable as an organic reactor coolant.

Gas evolution of tetralin under MTR radiation was studied, and the corrosion of Fe and Al in tetralin while in the radiation field was determined. The status of SGR reactor construction is discussed. A metallographic analysis of the stainless steel tubing for jacketing the fuel rods is summarized. The results of tensile tests on the tubing are also given. A vacuum retort for outgassing U slugs and heat treating fuel rods was constructed. The design of the fuel rod guides and fuel elements is discussed. The design, fabrication and welding, and gas evolution of moderator and reflector cells were studied. Test apparatus is shown for the determination of galling and sliding friction between the stainless steel core bottom and steels considered for the support plate. Assembly of the core cavity liner is shown. Design of toluene coolant lines is discussed. Results of heat transfer tests on control rod rings indicate that the maximum temperature should not be more than 1400 to 1450°F for the 2.487-inch ring. Friction tests were made to determine the life time of control rod screws. Modifications of the top shield design are suggested and discussed. The radiation within and at the surface of the fuel handling coffin are calculated, and the coffin shielding is discussed. Hot cell shielding is discussed in detail. The radiation level vs. shield density is given for the primary gallery shielding. Data on the specific activity of the primary Na coolant are tabulated. Design of, and gas purification in the inert gas system are discussed. Completed fuel handling equipment is shown. Cooling characteristics of irradiated fuel elements are analyzed. (B.J.H.)

7982

CONSIDERATIONS FOR SELECTION OF LIQUID METAL PUMPS. F. G. Hammitt (Univ. of Michigan, Ann Arbor). *Chem. Eng. Progr.* 53, 249-53(1957) May.

The design and development of large-scale, liquid-metal circulating pumps such as would be suited to application in nuclear power plants have been investigated. Fluid dynamic problems—cavitation and erosion damage to the structural components at the high relative velocities obtained in the pump impeller—were the particular concern. (auth)

8290 CF-56-4-31

Oak Ridge National Lab., Tenn.
PROCEDURE FOR THE DETERMINATION OF OXYGEN IN SODIUM AND NaK BY THE DISTILLATION METHOD. J. C. White. Apr. 5, 1956. 11p. Contract [W-7405-eng-26]. \$3.30(ph OTS); \$2.40(mf OTS).

The working procedure for the determination of oxygen in sodium and NaK by the distillation method is given. The apparatus, which is based on that developed by the Argonne National Laboratory, can be connected to either dynamic or static systems and makes possible the direct sampling of alkali at operating temperatures. Sodium and NaK have been sampled with this device at temperatures as high as 1400°F. The alkali metal is transferred, under pressure, to the sampler where a fixed volume of the metal is retained in a removable hemispherical cup. The metal is then distilled from the oxide at a temperature of 800°F and at a pressure of <5 microns of Hg. After the sampler has cooled, the cup is removed from the sampler and the oxide, which remains as a residue in the cup, is dissolved in water. The resulting solution of alkali metal hydroxide is then titrated to a methyl orange indicator end point with a standard solution of hydrochloric acid. The concentration of oxygen in the alkali metal is calculated on the basis of the equivalents of acid consumed in the titration, and the weight of the alkali metal, retained during sampling, in the cup. (auth)

8479 CF-56-4-73

Oak Ridge National Lab., Tenn.
TRANSFER OF CARBON BETWEEN DISSIMILAR METALS IN CONTACT WITH MOLTEN SODIUM. TEST CONDITIONS: 1000°C-400 HOURS. R. Carlander and E. E. Hoffman. Apr. 2, 1956. 8p. Contract [W-7405-eng-26]. \$1.80(ph OTS); \$1.80(mf OTS).

The extent to which AISI-C 1043 steel is decarburized in certain container materials when in contact with molten sodium has been determined at 1000°C for 400 hours. The extent of decarburization of a steel specimen was greater when an Armco iron container was used than when a type 304 elc stainless steel container was used. In addition, sufficient nickel mass transferred to the surface of the AISI-C 1043 steel in the stainless steel test to cause a phase transformation to a depth of 2 to 4 mils. The extent of decarburization of the AISI-C 1043 steel was greater in the 400 hour test than in a previous 100 hour test under similar test conditions. The amount of nickel mass transferred to the surface of the steel specimen was greater in the 400 hour test than in the 100 hour test and furthermore, carburization of the vapor zone of the stainless steel capsule occurred while it did not in the previous 100 hour test. Further tests are to be performed in which the extent of decarburization will be studied when an inert container material (tantalum) and sodium low in oxygen (distilled) will be used. (auth)

8682 LWS-24701

California Research and Development Co., Livermore, Calif.

FAST REACTOR COOLANT COMPARISON. H. A. Brammer. Dec. 15, 1952. Decl. Feb. 27, 1957. 11p. (CRD-R-17). \$3.30(ph OTS); \$2.40(mf OTS).

Calculations are made of the variation in critical mass of a fast reactor caused by several possible coolants. The coolants considered are Na, NaK, S, Pb, Bi, and Hg. Each system is calculated for U, Fe, Pb, and Bi reflectors. The derivation of the critical equation for a spherical core with an infinite reflector is included in an appendix. (B.J.H.)

8686 NAA-SR-878

North American Aviation, Inc., Downey, Calif.
SODIUM GRAPHITE REACTOR QUARTERLY PROGRESS REPORT FOR JUNE-AUGUST 1953. G. M. Inman, ed. Jan. 20, 1954. Decl. Mar. 4, 1957. 118p. Contract AT-11-1-GEN-8. \$0.70(OTS).

Studies were completed on problems related to the nuclear performance of the sodium-graphite reactor such as temperature coefficients of reactivity, poison transients, neutron leakages, possible runaway during start-up, and the variation of conversion ratio with burnup. Some of these studies were specifically for the 30 megawatt SGR pilot plant. In connection with the reactor engineering work, an investigation was carried out in order to optimize the cooling system and power plant conditions in the full-scale plant. Also, the desirability of operating with two different fuel element diameters in a single reactor and of operating with more than one reactor as the heat source for a single power plant was evaluated. Design and experimental work was conducted in regard to problems in the use of stainless steel coolant tubes, an inner steel core tank to protect the graphite from the sodium coolant, and the alternative arrangement of Zr cans containing cell-sized stringers of graphite. Materials work was initiated or continued on the joining of Zr and stainless steel, the carburization of stainless steel, the weldability of stainless steel and Ni, mass transport by Na in stainless steel, and the properties of U

fuel alloys. The fuel rod loading apparatus was successfully used to prepare a seven-rod fuel element of U slugs in stainless steel jackets and bonded by Na. As alternate power reactor design studies the use of S and diphenyl as coolants was investigated. Attention was also given to the possible use of some hydrocarbon liquid as the moderator. On the basis of present information, reactor arrangements making use of such materials do not appear capable of the high performance expected from the sodium-graphite combination. A major integrated effort was placed on the preliminary design and proposed program for the Sodium Reactor Experiment (SRE). This is envisaged as a tank-type reactor with initial operation using graphite moderator canned in Zr and with Na as the coolant. The design stresses maximum experimental flexibility and has no provision for the generation of electricity. Its primary purpose is for development work on the technology of fuels, moderators, coolants, and general reactor components. While the SRE arrangement permits a variety of experiments to be performed relative to high-temperature, low-pressure reactor core concepts, the study of problems pertinent to the Na-cooled, graphite-moderated arrangement will be emphasized. (auth)

8695 NAA-SR-Memo-100

North American Aviation, Inc., Downey, Calif.
NEUTRON ABSORPTION AND RADIOACTIVITY OF COMMERCIAL SODIUM AND LEAD EXPOSED TO A NEUTRON FLUX. C. H. Robbins. Sept. 26, 1951. Decl. Feb. 27, 1957. 12p. \$3.30(ph OTS); \$2.40(mf OTS).

In order to compare Pb and Na as possible reactor coolants, calculations were made of the neutron absorption and radioactivity of these elements when exposed to a neutron flux of 10^{13} neutrons/sec/cm². Calculation methods are described in detail, and resultant data are tabulated. Results indicate that impurities cause little additional neutron absorption. Most of the induced radioactivity in commercial Na is due to Na²⁴, and the induced radioactivity in high purity Pb is due largely to Pb²⁰⁹, Cu⁶⁴, Cu⁶⁶, As⁷⁶, and Sn¹²³. Dose rates around pipes carrying these metals are estimated. (B.J.H.)

8687 NAA-SR-956

North American Aviation, Inc., Downey, Calif.
SODIUM GRAPHITE REACTOR QUARTERLY PROGRESS REPORT [FOR] SEPTEMBER-NOVEMBER, 1953. G. M. Inman, ed. July 1, 1954. Decl. Mar. 2, 1957. 105p. Contract AT-11-1-GEN-8. \$0.65(OTS).

Two sodium-graphite central station power plant designs were investigated. The first design is for an enriched U converter of 150 Mw, and the second is a Th thermal breeder of 300-Mw capacity. Engineering studies related to the general design of sodium-graphite reactors are reported. Metal, moderator, and coolant temperature coefficients of reactivity were evaluated for slow, fast, and very fast runaways in sodium-graphite reactors. The reactor is stable except at room temperature. Calculations for a startup accident in a 30-Mw SGR were carried out, the results of which emphasize the importance of full-power coolant flow rates during the startup process. By using the fact that the U β phase does not exist in a U-Zr alloy containing 20 at. % Zr, it is shown that substantial reduction in power cost per kwh may be achieved by operating the reactor at higher power. Neutron age was calculated for a number of hydrocarbons which show some promise for use as moderators. Tensile tests and welding properties of the projected Zr cans for the graphite moderator sections are reported. Strength tests were completed for flash-welded joints of Zr-347 stainless steel tubing. The joints are

mechanically feasible for reactor use, and favorable corrosion results were obtained from static Na studies. Dynamic corrosion data are required. Weldability studies are reported for Ni, 304 L stainless steel, and a series of typical core tank joints. The design of a forced-convection loop for dynamic Na-Zr corrosion studies is described. A remote welding device was designed for the repair of coolant tubes. The dimensional stability of U and U alloys subjected to thermal cycling and quenching tests was studied in the α and high β regions. The unfavorable characteristics of the β phase transformation were noted, and it is suggested that under the reactor operating conditions, where the surface of the fuel slug is adequately cooled, a sufficient shell of α material might be maintained around an inner β phase to contain the dimensional instability. No significant differences were noted in the thermal and electrical conductivity of polycrystalline α -rolled U specimens which were oriented parallel and perpendicular to the rolling direction. Nondestructive testing of fuel element components at high temperatures is proceeding with an evaluation of techniques using eddy currents, temperature-sensitive paints, and infrared photography. A study of the production of thermal energy in an Fe thermal shield by capture processes has been extended to include the effect of fast-neutron leakage. The results are graphically presented for several shield thicknesses. The physical properties of several hydrocarbons were investigated in order to determine their suitability as biological shield coolants. Kerosene and toluene seem particularly promising. (K.S.)

8845

PARTICLE SIZE DETERMINATION BY RADIOACTIVATION. Bernard M. Abraham, Howard E. Flotow, and Roger D. Carlson (Argonne National Lab., Lemont, Ill.). *Anal. Chem.* 29, 1058-60(1957) July.

A rapid and reliable sedimentation method has been developed for determination of particle size of UO_2 powders in NaK alloy. Powder is first activated by neutron bombardment. Resultant activity that radiates from a thin lamina of suspension is a measure of weight of material in lamina. Method can be used for any radioactive powder in any fluid. (auth)

8919 KAPL-1763

Knolls Atomic Power Lab., Schenectady, N. Y.
THE KINETICS OF MOLTEN METAL-WATER REACTIONS: A REPORT ON Na_2K -WATER VAPOR. H. M. Saltsburg. Apr. 30, 1957. 36p. Contract W-31-109-Eng-52. \$0.30(OTS).

A method has been suggested for the experimental study of the kinetics of the reaction of molten metals with vapors so that the reactive metal surface is relatively free from films of reaction product and the vapor flow is definable, not only in terms of pressure and composition, but also in a hydrodynamic sense. In this manner, the influence of vapor phase processes upon the heterogeneous reaction may be determined. Preliminary experiments are reported for NaK alloy (78% potassium) reacting with water vapor. Certain experimental difficulties are noted which make quantitative interpretation of the data not feasible at this time. Possible solutions are suggested. (auth)

9285 AERE-M/M-148

Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
METALLURGICAL INVESTIGATIONS OF SODIUM HEAT TRANSFER RIG. 18p. A. G. Ward and J. W. Taylor. Feb. 1957.

A study was made of the attack of stainless steel and Ni by Na, both oxygen-free and contaminated, at temperatures in the range 300 to 600°C in static and dynamic tests. A number of miscellaneous metallurgical investigations on components taken from a stainless steel/Ni double annulus heat exchange rig are also reported. Under the conditions of test, stainless steel of the 18 wt. % Cr-8 wt. % Ni type containing free carbide, undergoes considerable attack, both in static and dynamic tests in Na nominally free from and also heavily contaminated with O_2 . From the evidence available it is suggested that the mode of attack consists of a decarburizing action which proceeds intergranularly and modifies the spheroidal carbide in the affected region by diffusion of this phase into the matrix. Under similar test conditions Ni undergoes no detectable corrosion even at the highest temperature. It is recommended that prior inspection be carried out on stainless steel for use in systems containing Na at temperatures above 300°C, to ensure that the steel specification has been fulfilled and, that the material is devoid of free carbide. (auth)

9330 NAA-SR-1867

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.
EFFECT OF SODIUM ON THE MECHANICAL PROPERTIES OF ZIRCONIUM. J. C. Bokros. June 15, 1957. 39p. Contract AT-11-1-GEN-8. \$0.30(OTS).

Zirconium is useful as a structural material in nuclear reactors, and is employed in contact with high temperature liquid Na. It was found that surface oxide which develops on Zr in Na significantly lowers the fatigue life at elevated temperatures. Hydrogen on the other hand has very little effect on the fatigue life at elevated temperatures but lowers the fatigue life at room temperature. It was also found that exaggerated grain growth which occurs above 950°F in Zr severely reduces the fatigue life at elevated as well as low temperatures. The effect of Na, i.e., the pick-up of surface oxide and reasonable amounts of H_2 , does not significantly alter the tensile properties of Zr at high temperature. Data also indicate that Zr is stable to dimensional changes after thermal cycling. (auth)

9725 NAA-SR-258

North American Aviation, Inc., Downey, Calif.
COMPATIBILITY OF SODIUM, GRAPHITE AND STAINLESS STEEL. T. A. Coultas and R. Cygan. July 8, 1953. Decl. Mar. 5, 1957. 30p. Contract AT-11-1-GEN-8. \$0.30(OTS).

Experiments have been performed to determine the compatibility of graphite and molten Na under various conditions. Effects such as corrosion, thermal shock, dimensional changes and penetration of Na into the graphite pores were investigated. Significant corrosive attack on the graphite was noted only in the presence of carburization of the container material. Stainless steel showed no appreciable carburization below 550°C, but carburization was found at temperatures of 600°C and higher. Carburization of Zr was observed only at 750°C and higher. Graphite was found to be wet by liquid Na above 150°C and to absorb the Na into its pores above the level of the bulk liquid by capillary action. Experiments with previously irradiated graphite indicated no significant differences in behavior from that of the unirradiated material. (auth)

Refer also to abstract 9783.

9747 ORNL-1647

Oak Ridge National Lab., Tenn.
STATIC LIQUID-METAL CORROSION. Interim Report

[Covering] the Period July 1949–September 1952. Anton deS Brasunas. W. D. Manly, ed. May 11, 1954. Decl. Mar. 12, 1957. 99p. Contract W-7405-eng-26. \$0.50 (OTS).

Static corrosion tests have been made in molten sodium, lithium, lead, bismuth, and several alloys containing uranium. Temperatures have been varied, but the bulk of the data is concerned with tests made at 1000°C (1832°F). Sodium was found to be the least corrosive in static and dynamic tests, and almost all alloys tested have shown good corrosion resistance. Lithium, on the other hand, attacked many alloys quite severely, especially nickel and nickel-containing alloys. Thermal-gradient dynamic tests have also shown lithium to be much less attractive than sodium because of the susceptibility to mass transfer. Lead and bismuth were quite similar to lithium in many respects, both in static and dynamic corrosion tests, and are compatible with very few metals at 1000°C (1832°F). (auth)

10068

ELECTROMAGNETIC PUMPS FOR REACTORS. W. B. Woollen (Atomic Energy Research Establishment, Harwell). *Nuclear Power* 2, 267-76(1957) July.

10115

EQUATIONS GIVE LIQUID HEAT CAPACITIES. Wallace R. Gambill (Union Carbide Chemicals Co., Charleston, W. Va.). *Chem. Eng.* 64, No. 8, 257-8(1957) Aug.

10510 LM/TAB-4

Mine Safety Appliances Corp., Callery, Penna. LIQUID METALS TECHNOLOGY ABSTRACT BULLETIN FOR THE PERIOD JANUARY 1 TO May 31, 1957. June 18, 1957. 28p.

10562 NRL-4961

Naval Research Lab., Washington, D. C. AN ANALYSIS OF TEMPERATURE COEFFICIENTS OF SOLUBILITY IN DILUTE LIQUID METAL SOLUTIONS. S. W. Strauss, J. L. White, and B. F. Brown. May 27, 1957. 23p. Project NA 585-001.

Temperature coefficients of solubility taken from the literature were compared with (a) electronegativities of solvent and solute, and (b) relative atomic sizes of solvent and solute, in order to identify the fundamental factor or factors which determine the temperature coefficient of solubility of a solid metal in a second liquid metal. The data were for the following binary solvent: solute systems; Bi: Cr, Fe, Pu, U, and Zr; Cd: Ni; Hg: Ba, Fe, Rb, and Sn; In: U; K: Sb; Mg: Fe, Mn, Ti, and U; Na: Ag, Ca, Cd, Fe, Ni, Pb, Sb, Sn, and Ta; Pb: Fe and W; Sb: U; Sn: La and Te; Tl: Th; and Zn: Ni and U. Graphical multiple correlation indicates that the dominant factor in determining the temperature coefficient is the relative sizes of the solvent and the solute atoms, the coefficient increasing with increasing ratio of radius of solvent atom to radius of solute atom. These results suggest that a strain-energy (or "misfit-energy") factor is operative in liquid metal solutions in a manner similar to that in solid solutions. The effects of electronegativity and of solute concentration in the solid phase in equilibrium with the liquid appear to be small. The systems Na: Fe and Na: Ni are strongly exceptional to the general trend, and it is proposed that in such liquid alloys where the solute atom is much smaller than the solvent atom, a state of aggregation resembling interstitial solution may result. (auth)

10603 AEC-tr-2739

ON THE LINE INTENSITY DISTRIBUTION OF SODIUM SUBORDINATE SERIES IN THE POSITIVE COLUMN. V. M. Zakharova and Yu. M. Kagan. Translated from *Vestnik Leningrad. Univ., Ser. Mat. Fiz. Khim.* 10, No. 2, 125-34(1955). 8p.

Sharp and diffuse sodium series as a function of the discharge parameters were studied in an attempt to observe the case of departure from a Maxwellian electron velocity distribution. The sodium vapor pressure was varied from 1.3×10^{-4} to 1.3×10^{-2} mm. Helium at 3 mm was added to the sodium. The discharge current varied from 10 to 100 ma. (R.V.J.)

10884 AGC-AE-22

Aerojet General Corp., Azusa, Calif. THE REACTION OF MOLTEN METAL WITH WATER. Monthly Progress Report [for] July 1 through July 31, 1956. Sept. 14, 1956. Decl. Jan. 15, 1957. 9p. Contract AT(04-3)-44. \$1.80(ph OTS); \$1.80(mf OTS).

A discussion of previous and future work on molten metal drop tests, molten spray tests, high-pressure corrosion-rate tests, burning rates of metals in various atmospheres and transition-state theory of linear oxidation rates is presented. (W.L.H.)

10885 AGC-AE-26

Aerojet General Corp., Azusa, Calif. THE REACTION OF MOLTEN METAL WITH WATER. Progress Report [for] August 1 through September 30, 1956. Oct. 26, 1956. Decl. Jan. 15, 1957. 10p. Contract AT(04-3)-44. \$1.80(ph OTS); \$1.80(mf OTS).

A study was made of the effects of the sudden mixing of molten metals, used in reactor fuel elements, with H₂O. Some data from explosion dynamometer tests are included. (B.J.H.)

10921 ANL-4238

Argonne National Lab., Lemont, Ill. REACTOR ENGINEERING DIVISION REPORT FOR THE PERIOD MARCH 1, 1948 THRU NOVEMBER 30, 1948. Feb. 3, 1949. Decl. Mar. 28, 1957. 67p. Contract W-31-109-eng-38. \$10.80(ph OTS); \$3.90(mf OTS).

Studies reported on equipment for circulating NaK in Experimental Breeder Reactor development include considerable information on wear of bearings in NaK. Blanket blocks of natural U provided with press-fitted finned cooling tubes have been fabricated and jacketed in deep-drawn Ni cans. Which have been welded shut and welded to the cooling tubes to form a gas tight envelope for the blocks. The steps in fabricating the cans and jacketing the blocks are described. A mock-up of a section of the blanket cup formed from the jacketed blocks has been thermal cycled to simulated operating conditions. The blanket cup safety device mock-up and safety rod mechanism are illustrated. One voltage drop method for detecting voids and meniscus in the NaK-filled fuel rods has been developed. Operating characteristics of electromagnetic pumps and a homopolar generator are reported. A NaK level indicator is described briefly. (G.Y.)

10923 ANL-5297

Argonne National Lab., Lemont, Ill. REACTOR ENGINEERING DIVISION QUARTERLY REPORT [FOR] APRIL 1, 1954 THROUGH JUNE 30, 1954. July 15, 1954. Decl. Mar. 28, 1957. 206p. Contract W-31-109-Eng-38. \$33.30(ph OTS); \$9.60(mf OTS).

Boiling Experimental Reactor. Revised core and fuel element designs have been established as a result of mockup tests on the removal of heat by natural air circulation at

shutdown. A flow sheet for the BER is presented. Power Breeder Reactor. Major work on the EBR-II has been devoted to the design of a working model. Several plan views and perspective drawings are shown. Small Power Reactors. Further design factors for a small horizontal boiling power reactor are discussed. The reactor is primarily designed for operation in remote arctic regions at a power level of $5\frac{1}{2}$ Mw. Design Research and Development. A theoretical analysis was made of the effect of Pu^{238} produced in the BER on the reactor temperature coefficient. For the particular BER considered, it appears that the coefficient may become less negative as Pu^{239} builds up. It is also possible that the cross section temperature coefficient may be positive at reactor operating temperatures. Thermal and fast neutron fluxes were calculated for a given 20 Mw BER core, together with the γ flux. The values obtained for the thermal neutron and γ flux were used to determine the radioinduced heating in the Fe pressure vessel. The accuracy of modified diffusion theory (removal theory) for calculating the photon source distribution from neutron captures in the EBR shield was determined by comparison with measured values. Discrepancies noted are attributed to variations in the U^{238} fission rates and the use of point source geometry. New data have been obtained from a Monte Carlo calculation of neutron transmission and reflection by slabs of H_2O . The time dependent response of a reactor due to localized reactivity variations was treated for the case of low time rate of change where the response is measured some distance from the localized change. Amplitude responses and phase shifts were made as a function of driving function frequency for a series of short lifetimes. At very low frequencies, the amplitude response is not equally sensitive to all delay groups. The kinetics of a supercritical reactor with no sources is analyzed, and values of Σ , k_{ex} , and λ were calculated as a function of τ . Heat Transfer. A modified electrical-geometrical analogue has been designed to solve temperature distribution problems within fuel elements of complex geometry. Good accuracy for the device is reported. Factors affecting the precision of a given thermal analysis of EBR-II fuel elements are discussed, including uncertainty factors which are helpful in determining the worst possible effects of a number of thermal parameters. A heat transfer analysis was made for 5 different EBR-II fuel element designs. Three radiator-type and 2 pin-type elements were tested, and their comparative performance is summarized. Natural circulation tests were made to determine the steady-state relationship between maximum plate temperature and power density of shutdown heating. It is concluded that the reactor core will not be adequately cooled during shutdown when there is a loss of water from the core area. A pulse-heating test facility was designed to investigate the fundamentals of water expulsion from a Cu tube to which short pulses of a-c current are applied. Fuel Elements. The feasibility of fabricating the reference type EBR-II fuel element was investigated. This design consists of a hexagonal array of fuel tubes which consist of in-line fuel and blanket sections. An experimental ball tower apparatus was constructed for the fabrication of ball-type fuel elements. The results of 4 shooting runs are given. Data are collected on the water-corrosion of unclad U-Nb, U-Si, and U-Nb-Zr alloys at high temperatures. Other corrosion studies include corrosion-irradiation tests on Zircaloy-2-clad U fuel plates, the corrosion of Zircaloy-2 by superheated steam and moist and dry air, and the corrosion characteristics of plates with deliberate defects introduced in the clad. Structure Materials and Compound Tests. Four reactor pressure vessels, fabricated from Carillon T-1 alloy steel, were tested to destruction by impact testing. Highly satisfactory results were achieved. Further tests are reported on the magnetic jack control rod drive unit described in the previous report. A preliminary in-

vestigation is under way to develop a void detector for boiling water systems. Most promising methods involve the absorption of γ or x rays, the dielectric constant of the steam-water mixture, the detection of boiling noise, and the transmission or scattering of visible light. Two types of liquid level indicators were examined for use in pressurized closed reactor systems. One instrument consists essentially of a resistance bridge circuit, whereas the second depends on the changing capacitance of an insulated probe immersed in the water tank. Coolants. The dynamic Na corrosion loop was operated at 400 and 500°C to determine the oxygen content of the Na as an oxide. For operating times of 8 to 55 hr, the content was found to vary between 0.001 and 0.0061 wt. % oxygen. Specific damage to diphenyl by fast neutron flux irradiation was studied. Design and Evaluation. Design details of the BER pressure vessel and control rod drive mechanisms for the BER and EBR-II are presented. (K.S.)

11060 RDB(C)/TN-33

Gt. Brit. Culcheth Labs., Culcheth, Lancs, England. THE SYSTEM SODIUM-OXYGEN. A Review of Progress to March 1, 1953. D. S. Oliver and J. D. Noden. Apr. 30, 1953. 13p.

The solubility of O_2 in liquid Na is being investigated by a method previously employed by Williams. Samples prepared by filtration are analyzed by a method of amalgamation of the Na and flotation and estimation of the oxide. Insufficient results are as yet available to ascertain the complete shape of the liquidus in the Na- O_2 system. (auth)

11569 KAPL-M-EDL-100

Knolls Atomic Power Lab., Schenectady, N. Y. NaK FLUSHING OF SODIUM-CONTAMINATED TEST EQUIPMENT. P. E. Bissonnette. July 1, 1955. 15p. Contract [W-31-109-Eng-52]. \$3.30(ph OTS); \$2.40(mf OTS).

Sodium-potassium flushing was tested in order to determine its efficacy in removing Na from a test fixture after testing. It was determined that the use of this method facilitates disassembly of the test fixture. (auth)

11669 ORNL-156

Oak Ridge National Lab., Tenn. HEAT TRANSFER IN MANHATTAN DISTRICT AND ATOMIC ENERGY COMMISSION LABORATORIES: A CRITICAL SURVEY. W. B. Harrison. Oct. 1, 1948. Decl. Mar. 6, 1957. 274p. Contract W-7405-eng-26. \$1.10(OTS).

An effort was made to study, correlate, and bring together in one volume the heat transfer data found in reports of the Manhattan Project and in the continuing activities of the Atomic Energy Commission. Information was categorized on the basis of its common nature such as the state of the medium, solid, liquid, gas; and the nature of the heat transfer, conduction, convection, turbulent flow, boiling. The physical properties of the mediums considered and references to source material are also given. (D.E.B.)

11742 ANL-4554

Argonne National Lab., Lemont, Ill. EXPERIMENTAL BREEDER REACTOR PROJECT. REPORT FOR THE PERIOD FEBRUARY 1, 1950, THROUGH MARCH 31, 1951. R. A. Cameron, B. C. Cerutti, L. J. Koch, H. V. Lichtenberger, D. F. McGinnis, M. Novick, E. N. Pettitt, H. E. Stanton, E. F. Stone, G. K. Whitham. Apr. 1, 1951. Decl. Jan. 17, 1957. 60p. Contract W-31-109-Eng-38. \$9.30(ph OTS); \$3.60(mf OTS).

The design of a pressure gauge system to show pressure changes in the fuel rods throughout the Experimental Breeder Reactor (CP-4) is described. Apparatus has been designed and built for filling the annulus in the lower section of the CP-4 fuel rod with NaK alloy. The procedure for adding NaK to fuel rods is described. Photographs are shown of the Reactor Inner Assembly and of its various parts. Safety and control rods and their drive mechanisms have been constructed and are shown. Operation of the safety plug is described. Velocity, acceleration, and time vs. distance curves of the plug fall are included. A detailed drawing is shown of a die for forming the external ribs on the CP-4 fuel rod jackets. The blanket bricks have been fabricated, autoclaved, and assembled on the lower shield section of the CP-4. The design of a totally enclosed liquid metal pump for the cooling circuit of the CP-4 is described in some detail. Results are given of a test of this pump in a NaK alloy coolant loop to determine its hydraulic characteristics. The design and operation of pressure transmitter unit for the reactor coolant system are described. Tests have been carried out to determine the heat transfer characteristics of a full size steam generator tube assembly under full power conditions. Design details and construction specifications of the tube are shown. Characteristics are shown of a gas circulating blower tested operating on air. (B.J.H.)

11743 ANL-5023

Argonne National Lab., Lemont, Ill.

EXPERIMENTAL BREEDER REACTOR PROGRESS REPORT FOR APRIL 1, 1951 THROUGH JANUARY 31, 1953.

H. V. Lichtenberger, M. Novick, B. C. Cerutti, R. A. Cameron, D. F. McGinnis, E. N. Pettitt, G. K. Whitam, R. A. Haroldsen, and L. J. Koch. Feb. 20, 1953. Decl. Jan. 7, 1957. 46p. Contract W-31-109-eng-38. \$0.45 (OTS).

The following EBR studies are reported: criticality studies; calibration of the control system; neutron flux measurements; fission-rate measurements; over-all temperature coefficient measurements; determination of the sign and magnitude of the metal temperature coefficient; measurement of power distribution in the core and in the internal and external blankets; over-all performance of the reactor cooling system; reactivity losses resulting from thermal expansion of slug elements; measurement of γ intensities around the reactor shielding; and disassembly of fuel rods. The shape of the flux for fission neutrons was determined by measuring the radioactivity of fuel rods at various positions along the rod and using rods from various reactor positions. U^{235} , normal U, and steel were evaluated when placed in the enriched fuel assembly of the reactor. (L.M.T.)

11745 ANL-5371

Argonne National Lab., Lemont, Ill.

REACTOR ENGINEERING DIVISION QUARTERLY REPORT [FOR] OCTOBER 1, 1954 THROUGH DECEMBER 31, 1954. Jan. 15, 1955. Decl. Jan. 17, 1957. 284p. Contract W-31-109-eng-38. \$1.60(OTS).

Physics. Two-group UNIVAC calculations were made for the BER in order to investigate the safety and operating characteristics of various core designs. Results indicate that considerable control over critical mass, power distribution, and to a lesser extent void and temperature coefficients, can be achieved by suitable arrangement of enriched- and natural-U fuel elements. Void coefficients can be made more negative by reducing the $H_2O:U$ ratio. In all designs considered, the negative reactivity void coefficient of the cold reactor depends strongly on the increased leakage. Good results are obtained in calculating

the reactivity held in steam for the operating boiling reactor with uniform fuel distribution, by assuming the steam to be uniformly distributed. Some reduction in reactivity held in the steam in a "flattened" reactor may be produced by reducing the steam voids in the outermost fuel elements. Other calculations are also reported for the EBR-II and the PBR on the following parameters: longterm changes, temperature coefficients of reactivity, control effectiveness, blanket power flattening, and power flattening by radial variation of enrichment. An iteration technique for calculating mutual interactions between steam voids and thermal neutron flux was studied for a uniformly loaded U^{235} , H_2O boiling reactor design. A control-rod analysis of various materials was undertaken to determine material thicknesses equivalent to a black Cd rod, and to establish burnup allowances for about 10-yr continuous operation. The materials studied were Cd, Hf, boral, B^{10} , B_4C , CaB_6 , and ferro-boron. Burnup data were obtained for some of the Hf isotopes with appreciable neutron absorption cross sections. An extensive study of AVIDAC reactivity and kinetic calculations are presented. The use of diphenyl as a reactor coolant and moderator was studied at different power levels and moderator ratios, using stainless steel as a structural material. These reactor types were investigated for use with control-rod override of maximum Xe and burnup, and borated fuel elements and temperature override of maximum Xe. Temperature override was effective for maximum Xe in these reactors. Experimental work on bucklings, reflector savings, and $U^{235}:U^{238}$ fission ratios in the Fast Exponential Experiment are being completed, and a final report on this project will appear as ANL-5379. A method for measuring the ratio of fission cross sections of two elements in a given flux was developed which is independent of the absolute sensitivity of the equipment. The following values were obtained in the center of the EBR: $U^{238}/U^{235} = 0.115$, $Th/U^{235} = 0.0305$, and $Pu/U^{235} = 1.42$. Design of a very small fission counter for pile measurements is described. Heat Transfer. The expected steady-state nuclear heating of the BER pressure vessel was calculated, relating pressure vessel thickness, heat generation, temperature distribution, thermal stress, and pressure stress. Stresses in a carbon steel vessel without thermal shielding need not be excessive, but 304 and 347 stainless steel are not as desirable. Multi-channel natural circulation boiling density tests at 600 psia, and single-channel forced circulation tests at 260 psia are reported. The apparent thermal conductivity of steel shot in NaK eutectic was measured in an apparatus described in ANL-5134. The experiment is designed to simulate the conductivity of U in liquid Na. Fuel Elements. An alternate fuel element design for EBR-II consists of a radiator-type element in which the coolant flows through channels in a stack of fuel wafers. An experimental procedure for electroplating U with Ni and Ag is given. Unclad high-U alloy samples (U-Si, U-Nb-Zr, and U-Nb) were corrosion tested in 500 and 550°F water. Additional corrosion testing of Ni-plated 2S Al was continued in 600°F water. Weight change data of thorium-uranium bodies in 600°F water were obtained. A test facility is described for the irradiation of EBR-II pin-type fuel elements. A central thimble of the CP-5 reactor is used, and air cooling of the irradiated element is provided. One EBR-II pin-type fuel element (7 U pieces in a 304 stainless steel tube) was thermal cycled 200 times from 300 to 100°F in NaK. The U showed an average length gain of 2%. Structural Materials and Component Engineering Tests. A full-scale test section of a BER-type core was constructed, and air-cold water tests were made to determine the flow characteristics in the top reflector and downcomer. Water pressure-drop tests were made in a modified EBR-II pin-type subassembly. A

reduction in pressure drop of 16 psi was effected by a new grid structure and fuel element orientation. A 4-in. Na loop with a d-c electromagnetic pump driven by a homopolar generator is described. The loop will be used to test thin-walled stainless or Nichrome tubing with fast-flowing Na up to 500°C. Certain changes in the control-rod layout of the BER are outlined. A test facility has been built to test the reference BER rod drive mechanism, which is also described. A number of alternate control rod drive mechanisms are evaluated. An apparatus is presented for developing Na-vapor rotary seals, and to test mechanical components, gears, bearings, and couplings immersed in Na vapor or liquid Na. Two newly-developed seal systems are discussed. Coolants. A dynamic corrosion loop was constructed to study the effect of circulating liquid Na(30 gpm) on irradiated and non-irradiated normal U. The content of Na₂O was studied as a function of time. Oxide content rose to a maximum, and dropped off. The maximum occurred sooner at higher operating temperatures. Two irradiated normal U pins were corrosion tested. Design and Evaluation. A detailed design study (No. 1) of the EBR-II is presented. The analysis includes reactor arrangement, shielding, fuel and blanket assembly designs, neutron and power distribution, Pu distribution, and a thermal analysis. (For preceding report in series see ANL-5345.) (K.S.)

11746 ANL-5471

Argonne National Lab., Lemont, Ill.
REACTOR ENGINEERING DIVISION QUARTERLY REPORT [FOR] APRIL 1, 1955 THROUGH JUNE 30, 1955. SECTION II. Sept. 1955. Decl. Jan. 17, 1957. 173p. Contract W-31-109-eng-38. \$1.10(OTS).

Development of the thermal power reactor program is summarized. A complete conceptual design study is given for a nuclear power plant for 100-kw electric and 400-kw heat capacity. Calculations were made to evaluate the inherent safety of 20-Mw D₂O-cooled and moderated EBWR-type boiling reactors. The effects of rapid and slow, but large, increases in reactivity are summarized. Methods of calculating reactivity variation as a function of total energy production for enriched fuel, thermal reactors are discussed, and the methods were applied to two reactors. Results of the analysis are given in graphical form. Results of measuring fission cross section ratios in the EBR are also summarized. A brief account is given of neutron flux measurements using Np²³⁷ foils and of the foil preparation technique. Heat transfer tests include studies of the multi-channel natural circulation boiling density at 600 psig, a discussion of the representation of average voids in boiling length with measurable parameters, normalized plots of void distribution along the boiling length, local boiling pressure drop in round and rectangular vertical channels, and burnout heat flux for wires in crossflow at atmospheric pressure. Fabrication and corrosion test history of EBWR fuel plates are tabulated. Zircaloy-2 specimens which had been heliarc spot welded are shown. The EBR-II core subassembly is shown. Designs are given for a Na-bond filling device for EBR-II pin-type fuel elements. Further attempts were made to produce a protective coating for uranium. The corrosion of high-U alloys in 500 and 550°F H₂O and the corrosion-irradiation of unclad high-U alloy pins are summarized. Water solubility tests on urania-thoria bodies were made. Corrosion data for nickel-plated 2S Al in 600°F H₂O are given, as are data on the dynamic H₂O corrosion of Al-Ni alloys. Static corrosion of anodized 2S Al in H₂O is also reported. Results of experiments of the fission product contamination of NaK bond in contact with U during irradiation are reported. The results of examination of the in-reactor tube tip from the

Argonne Water Loop at the MTR are given. Water pressure drop tests of EBR-II core subassemblies were made. Heat capacity characteristics for the EBR-II working model electromagnetic pump are given. The primary EBR-II Na system is shown. Summaries of packing gland tests for liquid metal service are given. A study was made to estimate the rate of water decomposition in the EBWR. Corrosion inhibition studies have been continued. A dynamic cold trap liquid metal purification facility was installed in the EBR-II working model, and the initial results are reported. Schematics are given for the Na transfer system for the EBR-II working model. A manually operated electronic Na level probe is also shown. (For preceding period see ANL-5345.) (B.J.H.)

11747 ANL-5561

Argonne National Lab., Lemont, Ill.
REACTOR ENGINEERING DIVISION QUARTERLY REPORT [FOR] OCTOBER, NOVEMBER, DECEMBER 1955. SECTION I. Apr. 1956. Decl. Jan. 17, 1957. 169p. Contract W-31-109-eng-38. \$1.10(OTS).

Experimental Boiling Water Reactor. It was decided to use several types of fuel elements in order to achieve flexibility in the core loading. The structure of these fuel elements is tabulated. Using phenomenological methods, lattice constants, reactivities, and neutron economy of the reference EBWR were calculated, and results are tabulated. Neutron flux distributions in the core are shown. An analytical prediction was made of the natural circulation performance of EBWR at 600 psig. Calculations were also made to determine whether simple changes in the riser length and/or geometry would favorably affect EBWR performance. Complete results are given in graphical form. Design-economics analyses of EBWR fueling are summarized. The boiling water corrosion of Zircaloy-2 is shown. The EBWR control rod scram-time curve at 600 psig is shown. The thermocouples to be used for measurement of vessel temperatures are shown. The final designs for the pressure vessel shock springs are shown, and a load-deflection diagram is given. The gamma-ray flux and corresponding heat generation in the D₂O-moderated EBWR are listed. The status of EBWR construction is discussed. Data are included on the leakage-rate tests of the EBWR steel shell and on compression tests on specimen concrete shielding. Supporting and Alternate Design Research and Development. Boiling heat transfer studies were made. Riser studies indicate that riser height is not too important a parameter in influencing the ratio of velocities of steam and liquid. Data are given on the pressure drop resulting from 2-phase flow. The transient behavior of the multi-channel natural circulation loop is discussed. Single-channel unrestricted and restricted natural circulation boiling studies are summarized in detail. Data showing the relationship between power density, voids, quality, recirculation flow, pressure, and geometry for boiling systems are given in both tabular and graphical form. Pressure drop measurements are included, and an analytical method of calculating natural circulation performance is outlined. The sources of error in steam void measurements are evaluated. A heating power source, which is to be used to determine experimentally the physical response of reactor components during a power excursion, is described. Corrosion tests on Zircaloy 2-clad U-Zr plates in 550°F degassed H₂O are summarized. Corrosion test data are also given for high-U alloys in 500°F H₂O. The high-temperature water corrosion of Al-Ni alloys is discussed. Corrosion-irradiation tests were also made on Al-Ni alloy plates. Progress is also reported on solution-irradiation and thermal cycling tests of urania-thoria bodies. A model of the rare earth oxide powder-filled control rod was thermal cycled and

exposed to H₂O at 600 psig and 486°F in the EBWR control drive test facility. The mechanical properties of B-contained stainless steel alloys were listed. These alloys are being considered for use as the thermal shield for the EBWR pressure vessel. The corrosion characteristics of boron-stainless steel are also listed. Schematic diagrams are given for a hydraulically operated control rod drive and position indicator. A scram-time curve is given for the hydraulically operated control rod. Diagrams are also given for a magnetic jack control rod drive. Experimental Breeder Reactor—I. Danger coefficient experiments on EBR-I are summarized. Experimental procedures are outlined, and results are tabulated. Experimental Breeder Reactor—II. CP-5 irradiation tests on EBR-II pin type fuel elements are summarized, and photographs of the irradiated fuel elements are shown. An electrically heated model of an EBR-II fuel subassembly was constructed to determine the cooling requirements to remove the decay heat after irradiation. It was determined that a flow of 15 scfm of A gas at room temperature at a pressure of about 3 in. H₂O will maintain a maximum temperature below 1100°F. The activation of Na coolant by a fuel element with a hole in the end closure is discussed. A loop was constructed to test the release of such activity, and it was determined that in the EBR-II, 0.265 curies of activity would be released to the coolant Na every three months. The possible eutectic point formation of U with Fe in the stainless steel fuel tube was studied. Test conditions and results are listed. Diagrams are given of the EBR-II control rod mechanism. Calculated axial and radial γ and neutron fluxes in the EBR-II are shown. EBR-II Working Model. Design status is described. Supporting and Alternate Design Research and Development. Thermal cycling tests of Mo-U and Zr-U alloys are described. The development of electromagnetic pumps for the Na test loop is briefly discussed. (For preceding period see ANL-5511.) (B.J.H.)

11748 ANL-5571

Argonne National Lab., Lemont, Ill.
REACTOR ENGINEERING DIVISION QUARTERLY REPORT [FOR] JANUARY, FEBRUARY, MARCH 1956.
SECTION I. July 1956. Decl. Mar. 28, 1957. 174p.
Contract W-31-109-eng-38. \$1.10(OTS).

Advanced Water Reactor Program. Flux distribution studies associated with the use of various combinations of natural and enriched U fuel plates in EBWR are reported. Fuel plate dimensional changes necessitated the calculation of revised thermal data. These new data are given along with the assumptions made in the calculations. The design of fuel assemblies, control rod channel closures, and the grid plate handling assembly are shown. Of the 9 EBWR control rods, 4 will be fabricated from a B-stainless steel system and 5 from Hf. The nuclear and economic considerations of such a rod arrangement are reviewed. The reactor shield and insulation is described and discussed. Reactor loading and unloading, fuel element storage, and the design and operation of the fuel transfer coffin and carriage are considered. A method of control rod removal without draining the pressure vessel is described. The status of fuel element corrosion tests and reactor component construction and fabrication is summarized. Boiling heat transfer studies associated with the EBWR were continued. Natural circulation boiling in single and multiple channels at 600 psig was investigated. Phase velocities, void effects, and friction factors are plotted. An analysis of the electrical characteristics of the power supplies used in these studies is also presented. A portion of the data gathered from Borax III operation is presented. Fission product activity buildup and decay in H₂O and steam, H₂O decomposition, and reactivity changes due to

fission products and burnup were analyzed. Additional high-temperature H₂O corrosion data on U and Al alloys are reported for various pH values, H₂ concentrations, and flow velocities. Corrosion and irradiation data on ThO₂-UO₂ type fuel elements are also reported. Studies of the corrosion resistance, weldability, and machining properties of B-stainless steel systems were continued. Corrosion study results for other control materials and structural materials are reported. Fast Power Breeder Reactor Program. Two-dimensional calculations are reviewed which indicate minor changes in reactor component composition. The decay heat characteristics of EBR-II were determined, and a natural convection heat removal system was designed. The heat transfer characteristics of the bayonet cooler used in the system were investigated. In connection with the EBR-II shielding program, the fast neutron constants for Na and graphite were calculated. Results of thermal cycling tests on fission alloys are reported. Liquid metal heat transfer, fused fluoride corrosive effects, and liquid metal pump performance were also studied. (For preceding period see ANL-5561.) (D.E.B.)

11807 TID-10097

Dow Chemical-Detroit Edison and Associates. Atomic Power Development Project, Detroit.
INFORMATION REPORT ON THE PROJECT ACTIVITIES FOR THE PERIOD DECEMBER 1, 1953 TO JULY 31, 1954. Sept. 1, 1954. Decl. Jan. 7, 1957. 78p. \$0.55(OTS).

The organization and current budget of the Atomic Power Development Project are briefly summarized. Fuel element design and fabrication studies are reported. General corrosion tests are being conducted on a variety of materials for use in liquid metal systems. Globeiron and Zr show promise as reactor core cladding materials. An evaluation of various mechanical components of liquid metal and steam power systems is being carried out. Studies of reactor control methods have been emphasized. The most promising concept appears to be a control system in which a fast neutron reflector (iron) is exchanged for a fast neutron poison (Li⁶) in the reflector region. Temperature coefficients of reactivity have been calculated for the reference design reactor. A conceptual design of the mechanical handling system for fuel and blanket elements in the reference design is shown. Aqueous and nonaqueous methods of fuel processing are being studied and evaluated. Studies of reactor economics, safety, and alternate reactor designs are reported. (M.P.G.)

12323 KAPL-1495

Knolls Atomic Power Lab., Schenectady, N. Y.
METAL-WATER REACTIONS. H. M. Saltsburg. Apr. 2, 1956. Decl. Apr. 2, 1957. 28p. Contract W-31-109-eng-52. \$0.25(OTS).

The role of the metal-water reaction in the course of a nuclear incident is qualitatively examined in an attempt to create a coherent phenomenological picture upon which one may base an evaluation of the hazards involved. The fundamental concept is that at some point in the course of the reaction, the fundamental nature of the reaction becomes governed by external hydrodynamical (and heat transfer) considerations rather than chemical considerations. It is postulated that this occurs in region beyond the melting point but far below the vaporization point of the metal. Based upon this concept, the loss of coolant accident as described by Lustman is reviewed and the analysis extended to the case of the nuclear runaway. The assumed temperature dependence of the reaction rate is shown to imply a less severe reaction than heretofore assumed, prior to vaporization of the metal. An experimental program is recommended to test the hypothesis advanced

and an analytical program is considered based upon the phenomenological assumptions. (auth)

12495 ORNL-1090

Oak Ridge National Lab., Tenn.

METALLURGY OF THORIUM AND THORIUM ALLOYS. Interim Report [for] July 1, 1949 to July 1, 1951. D. E. Hamby. Dec. 7, 1951. Decl. Mar. 4, 1957. 93p. Contract W-7405-eng-26. \$0.60(OTS).

A comprehensive study has been made of the physical metallurgy of Th and some of its alloys. Mechanical properties such as tensile strength, ductility, modulus of elasticity, Poisson's ratio, shear modulus, and impact strength were determined for Ames Ca-reduced Th. A few tests were made on iodide Th and Westinghouse powder-compacted Th. Density determinations are reported for Ames, iodide, and Westinghouse Th samples. Precision measurements of the lattice parameters of iodide Th made by x-ray diffraction are given. Work-hardening characteristics and recrystallization temperatures were established for both Ames and iodide Th. The fabricating characteristics of Th were studied by rolling, swaging, extrusion, forging, and welding. Cladding of Th with Zr was accomplished by extrusion. Thermal cycling of Th was carried out in NaK at temperatures of 100 to 500°C to investigate dimensional stability. A preliminary investigation is reported on binary Th alloys containing additions of Be, Si, Zr, Ti, Al, Nb, Cr, Mn, and Ce. Melting ranges, fabricating characteristics, hardness, and tensile properties were studied. Ternary alloys containing Zr-Ti and Zr-Si were investigated in like manner. Corrosion tests in water at 95°C were carried out on Ames Th and all the alloys under study. (auth)

12555 KAPL-340(Del.)

Knolls Atomic Power Lab., Schenectady, N. Y.

PROGRESS REPORT NO. 45 FOR APRIL 1950. SECTION III. REACTOR MATERIALS. May 29, 1950. Decl. with deletions Feb. 21, 1957. 31p. Contract W-31-109-Eng-52. \$6.30(ph OTS); \$3.00(mf OTS).

The results are reported of research on the structure of graphite, self-diffusion of Be, the effect of O₂ on the hardness of V, annealing of extruded and arc-melted V, mechanical properties of V, transformation kinetics of Cr-U alloys, and corrosion of 347 stainless steel by Na. (T.R.H.)

12629 LWS-24734

California Research and Development Co., Livermore, Calif.

RADIOACTIVITY OF RECYCLED LIQUID METAL COOLANTS. W. E. Drummond. Jan. 30, 1953. Decl. Mar. 29, 1957. 3p. (CRD-R-23). \$1.80(ph OTS); \$1.80(mf OTS).

In order to determine which liquid metal coolant is the most desirable from the shielding standpoint, sample calculations were made to determine the thickness of concrete needed to shield a semi-infinite pool of the material. These calculations were made for Na, K, Pb, Bi, Sn, and Hg. (B.J.H.)

12669 NP-6429

Mine Safety Appliances Co., Callery, Penna.

CLEANING ALKALI METAL SYSTEMS WITH LIQUID AMMONIA. Memo 59. W. Milich and E. C. King. June 9, 1954. Decl. Aug. 2, 1955. 8p. Contract NObs-65426.

Results of two cleaning operations indicate that liquid NH₃ and NH₃-NH₄Cl washes are an effective method of removing Na and Na sludges from a liquid metal system. (W.L.H.)

13065 BMI-1149(Del.)

Battelle Memorial Inst., Columbus, Ohio.

PROGRESS RELATING TO CIVILIAN APPLICATIONS DURING NOVEMBER 1956. Russell W. Dayton and Clyde R. Tipton, Jr. Dec. 1, 1956. Decl. with deletions Mar. 1957. 66p. Contract W-7405-eng-92. \$9.30(ph OTS); \$3.60(mf OTS).

Research is reported in the development of materials for reactors, development, of Al-clad fuel elements, plant assistance to MCW, reactions between H₂O and Zr alloys, general fuel element development, Zr-U alloys studies, corrosion of Zr, reactor materials development, physical metallurgy, development of PWR, and Na-Ta compatibility at high temperatures. (T.R.H.)

13149 KAPL-341(Del.)

Knolls Atomic Power Lab., Schenectady, N. Y.

PROGRESS REPORT NO. 45 [FOR] APRIL 1950. SECTION IV. REACTOR ENGINEERING. May 23, 1950.

Decl. with deletions Feb. 21, 1957. 60p. Contract W-31-109-Eng-52. \$10.80(ph OTS); \$3.90(mf OTS).

The status of SIR development is briefly reviewed. The status of construction of the special facility for studying liquid metal heat transfer and flow properties is given. Extensive studies were made of liquid Na reaction rates in H₂O-alcohol mixtures, thermal stress distribution in long, thin-walled tubes, electromagnetic pump performance, and bearing behavior in liquid metals. The results of these studies are given. (D.E.B.)

13516

PROBLEMS IN NUCLEAR ENGINEERING. SELECTED PAPERS FROM THE 1ST NUCLEAR ENGINEERING AND SCIENCE CONGRESS HELD AT CLEVELAND, OHIO. VOL. I. D. J. Hughes, Stuart McLain, and Clark Williams, eds. New York, Pergamon Press, 1957. 372p.

Papers are presented on safety, fuel production, and heat transfer problems concerned with the design of economical power plants. (M.H.R.)

13564 KAPL-101

Knolls Atomic Power Lab., Schenectady, N. Y.

PROGRESS REPORT NO. 26 [FOR] SEPTEMBER 1-30, 1948. Decl. Apr. 4, 1957. 97p. Contract W-31-109-Eng-52. \$15.30(ph OTS); \$5.40(mf OTS).

Physics. Reactor theory studies are presented on: Doppler effect; multi-group calculation for the Preliminary Pile Assembly (PPA-3); Pu production distribution in the blanket; adjoint calculation and control effect calculation for PPA-3; leakage through local voids in thick shields; and radiation protection associated with unloading machine parts in Schenectady Reactor. **Nuclear Measurements.** Studies are presented on the Pu alpha experiment and activation experiment. **Chemistry:** Studies on Chemistry of reactor components include the determination of O₂ in sodium by the amalgam and AgCl method. **Separations Chemistry-Redox Process.** The following investigations are given: sulfate complexing of U; effect of Al(NO₃)₃ on sulfate complexing; extraction of Th by thenoyltrifluoroacetone (TTA); sulfate complexing of Th; Pu oxidation kinetics; fission product chemistry of Ru and Ce; conductivity of process solutions; fluorimetric determination of U; fission product analysis of Ru; chelation of Hf with TTA; and Pu valence states. **Research Problems.** Progress is reported on the following: Interaction of metals with Na; solubility of Fe in liquid Na and related thermodynamic and kinetic studies; crystal structure of graphite and β-U; U filled Mo pins; U alloy studies; heat treatment of U and orientation of U; and Ni plating of Be. Metallurgical Engi-

neering. Studies are reported on the following: leak, radiographic, and ultrasonic testing; erosion of Be in Na; static corrosion; inert arc welding; pin sealing; brazing of stainless steel; resistance welding; and creep testing. Data are included on Xe transients in intermediate reactors and thermal stress analysis. (W.L.H.)

13597 ORNL-323(Pt.1)

Oak Ridge National Lab., Tenn.

TECHNICAL DIVISION—REPORT FOR QUARTER ENDING FEBRUARY 28, 1949. PART I. E. C. Miller, ed. Feb. 28, 1949. Decl. Mar. 15, 1957. 116p. Contract [W-7405-eng-26]. \$18.30(ph OTS); \$6.00(mf OTS).

The status of MTR Mockup design, testing, and construction is reviewed. Methods for control and removal of airborne particles are considered. Chemical engineering tests in solvent extraction, liquid metal heat transfer, coolant properties, and radiation effects are reported. The properties of some of the more important shielding materials were determined. (D.E.B.)

13710 CF-54-8-225

Oak Ridge National Lab., Tenn.

SOME OBSERVATIONS MADE ON CAVITATING SODIUM FLOW IN A VENTURI. J. M. Trummel. Aug. 31, 1954. 10p. Contract [W-7405-eng-26]. \$1.80(ph OTS); \$1.80(mf OTS).

Cavitating sodium flow was obtained in the venturi of an isothermal loop at temperatures from 1215 to 1475°F. Cavitation was detected in three ways: by observing the minimum venturi throat pressure, by observing the loop pressure drop, and by listening to the flow noise. Cavitation occurred promptly when venturi throat pressure was reduced to within about 1.5 psia of vapor pressure. Venturi wall damage due to cavitation has not been determined. (auth)

13716 KAPL-M-JJK-1

Knolls Atomic Power Lab., Schenectady, N. Y.

SODIUM VAPOR TRANSPORT IN A CLOSED SYSTEM. J. J. Kauzlarich. June 17, 1953. Decl. Mar. 12, 1957. 11p. Contract W-31-109-Eng-52. \$1.80(ph OTS); \$1.80(mf OTS).

The transport of Na in a closed system is studied, and a Labyrinth-type vapor seal is investigated for possibilities of limiting Na vapor transport. Theory predicts that such a seal will be ineffective because it will collect Na vapor, the large cross section does not limit diffusion or evaporation, and the seal will not offer resistance to pressure surges. (F.S.)

13868 ANL-5260(Del. 2)

Argonne National Lab., Lemont, Ill.

REACTOR ENGINEERING DIVISION QUARTERLY REPORT [FOR] DECEMBER 1, 1953 THROUGH MARCH 30, 1954. Apr. 15, 1954. Decl. with deletions Apr. 8, 1957. 185p. Contract W-31-109-eng-38. \$31.80(ph OTS); \$9.30(mf OTS).

Boiling Experimental Reactor (BER). An H₂O-type reactor has been selected for an initial pilot boiling reactor. Information given here pertains to the D₂O design developed during the course of study. Plate-type and co-extruded tubular fuel element assemblies were considered for this reactor. Several cross section drawings of the proposed design are given. EBR-II. Several tank designs are proposed whereby the primary system, submerged in a Na-filled, double-walled tank, may be connected to the reactor vessel. A fuel element loading and unloading mechanism

has been designed which incorporates a boom carried by a vertical column, and a moving head along the boom. Reactor Physics. Reactor physics calculations are reported on the feasibility of a pilot D₂O boiling reactor of 20 Mw heat output. The basic core design provides for fuel tube clusters, consisting of Zircaloy-clad fuel tubes containing slightly enriched U alloyed with Zr and Nb. Procedures for the determination of lattice constants are discussed, and the critical enrichment was determined for a core without burnup allowance. A similar analysis is made for a supercritical reactor. It was found that an enrichment was necessary for 10,000 Mwd/t exposure. The effects of moderator and fuel region D₂O density, and neutron and metal temperature on the reactivity of a boiling reactor are considered. Criticality changes resulting from small additions of H₂O and D₂O to the reactor were also evaluated. A number of activation cross sections were measured in various locations of the EBR. Tabular data of these cross sections referred to Au are presented for Ni⁶⁴(n,γ), Bi²⁰⁹(n,γ), Fe⁵⁶(n,p), Zr⁹⁶(n,γ), Zr⁹⁴(n,γ), Fe⁵⁸(n,γ), and Pb²⁰⁸(n,γ) reactions. UNIVAC solutions of the multigroup diffusion equations in cylindrical geometry were obtained for a variety of specific problems related to fast reactors. Tables of cross section data and problem parameters are given. Fuel Elements. Several new techniques were tested for the fabrication of ball and wire fuel elements. Samples of stainless steel UO₂ fuel plates were corrosion tested in H₂O saturated with O₂ and H₂. The plates were not corroded during a 16-week exposure at 500, 600, and 680°F. Selected data are given for the water corrosion of Ni, Si, and Zr alloys of U in the unclad condition. Detailed information was obtained on the stages of corrosion penetration for a group of Zircaloy-clad U-Nb fuel plates in 500°F H₂O. Moderator, Reflector, and Structural Materials. Zn(C₂H₃O₂)₂ and ZnO were found to be effective corrosion inhibitors of 347 stainless steel and 2-S Al. An apparatus was constructed for thermal conductivity determinations of reactor materials up to 1000°F. The embrittling effects of irradiation, H₂, and temperature on the impact properties of materials were studied. The specimens tested included a variety of stainless steels, Ni-A, Ni alloys, Co alloys, and Zr. Reactor Coolant, Heat Transfer, and Power Generation. A new series of tests have been initiated on diphenyl as an organic moderator material, in order to determine the amount of carbonization on heat generating surfaces and the degree of decomposition as a function of neutron dosage. Tar deposits and an 11.1% decomposition was found in a closed loop test operated in the EBR for 73.5 hr at a power level of 1200 kw. Several thermal test loops for organic coolants are described. A liquid-metal level indicator has been developed which measures a change in the electrical inductance of a 60-cycle circuit, according to the amount of metal surrounding the test element. With a view of reducing high D₂O inventories for boiling D₂O reactors, an air-water atmospheric test facility was constructed in order to study separator configurations. A complete description of the apparatus is given, together with some representative test results and separator designs. A technique has been developed for the thermal analysis of complex fuel element designs under steady-state and transient conditions. An electrical, geometrical, analogue device is used, consisting of a resistive plotting surface of conducting paper, a d-c source, a resistive network coupling the plotting surface to the source, and a null-type voltage measuring device. Comparison of the analogue data with analytical results shows close agreement. A group of 16 fuel element configurations have been analyzed from the standpoint of maximum permissible temperatures and heat transfer characteristics, to determine the most feasible design for the PBR. The conclusions include other factors besides heat transfer considerations. A study was

also made of the thermal conductivity characteristics of laminated fuel elements, where U particles and stagnant Na are arranged in layers within a containing structure. The condition of parallel heat flow is obtained when the laminations are made thin. Preliminary investigation of power plant cycle and reactor core designs using flashed water to produce steam indicates that a more detailed study is justified. Local heat transfer film coefficients of Na and NaK under conditions of high heat flux and non-circular channels will be measured in a heat transfer loop which is described. The construction of a 600-psi multiple channel boiling density test facility has been completed. A detailed description of the system and test section is presented. The facility will be used for the study of boiling H_2O phenomena at pressures near reactor operating conditions. The flow rate of naturally circulating boiling water was studied as a function of additives such as $HC_2H_3O_2$, Dow-Corning anti-foam, and caustic soda. Slow and rapid heat transients in boiling D_2O reactors were simulated in a water expulsion test apparatus, which was used to obtain considerable data on the characteristics of a 7-tube fuel-element cluster. The removal of core decay heat in the event of a sudden reactor shutdown accompanied by a loss of coolant water will be assumed by the natural circulation of cooling air through the core. In connection with such an event several tests were made to determine the relationship between maximum metal temperature and the heat that can be dissipated to ambient air. Four- and five-ft channels, $\frac{3}{4} \times 4\frac{1}{2}$ in. were tested. Instrumentation and Control. A magnetic jack-type control rod mechanism was developed. The device is designed for operation in a pressure shell located in the reactor coolant. The performance of Na and H_2O seals was tested, together with H_2O -lubricated ball bearings mounted vertically under a thrust load. Irradiation Test Facilities. Thermal neutron flux measurements were made in the Argonne Water Loop at the MTR. (For preceding period see ANL-5208.) (K.S.)

13869 ANL-5461

Argonne National Lab., Lemont, Ill.

REACTOR ENGINEERING DIVISION QUARTERLY REPORT ON THE POWER REACTOR PROGRAM [FOR] JANUARY 1, 1955 THROUGH MARCH 31, 1955. Apr. 15, 1955. Decl. Jan. 17, 1957. 124p. Contract W-31-109-eng-38. \$0.60(OTS).

Construction drawings and specifications have been completed for the building and power plant of the Experimental Boiling Water Reactor (EBWR). The design of the pressure vessel has been evaluated for safety in case of internal explosion. The results of steam pipe rupture studies and tests of impurity carry-over in the boiling process are reported. The design and performance of a fuel assembly grappling tool are described. Design studies of control rods and control rod drive mechanisms are continuing. Tests are being made to observe the corrosion behavior of Zircaloy 2 coupled with types 304 and 347 stainless steels in static and dynamic high-temperature water. The results of stress analyses of EBWR type fuel plates and subassemblies are reported. Data are presented from corrosion and irradiation tests of high-uranium alloys, ThO_2-UO_2 bodies, and Al (Ni-plated or with Ni additions). Theoretical studies have been performed on the effect of the spatial distribution of voids on reactivity, and results are reported. The results of final shielding calculations for the EBWR are presented in graphical form. Calculations have been performed to determine the operating characteristics of D_2O -cooled and moderated, EBWR-type boiling reactors. Construction and pre-installation performance tests of the Experimental Breeder Reactor (EBR-II) Working Model are described. Low-frequency induction heating is being studied for the Na piping sys-

tem. Convection heat transfer data are presented on eutectic NaK. Results of an EBR-II design study are reported, including a skeleton flow chart of the entire plant and a temperature-enthalpy diagram for the steam generator. A thermal analysis has been made of radiator-type fuel elements for the EBR-II, and results are presented. Results of irradiation tests of EBR-II pin-type fuel elements are summarized. Preliminary information from a set of UNIVAC multigroup calculations on the EBR-II is reported. (T.R.H.)

13968 NAA-SR-1347(Del.)

North American Aviation, Inc., Downey, Calif.

SODIUM GRAPHITE REACTOR QUARTERLY PROGRESS REPORT [FOR] JANUARY-MARCH 1955. SECTION A. A. B. Martin, ed. SECTION B. Guy M. Inman, ed. Oct. 1, 1955. Decl. with deletions Feb. 27, 1957. 108p. Contract AT(04-3)-49. \$16.80(ph OTS); \$5.70(mf OTS).

Performance and design data are given on the SRE. Temperature coefficients of the effective resonance integrals of U^{238} and Th^{232} were measured and for $\frac{3}{4}$ -in-diameter cylinders, values of $+0.9 \pm 0.2\%$ per $100^\circ C$ for U^{238} and $2.0 \pm 0.3\%$ per $100^\circ C$ for Th^{232} are given. Exponential experiments were made on lattices of 4- and 7-rod clusters, and resulting average neutron fluxes are given in graphical and tabular form. Characteristic analytical data from finished α -rolled, β -heat-treated SRE fuel slugs are given. Observations were made on the dimensional stability of thermal-cycled U alloys at high temperatures. Porous U slugs were thermal cycled in both the α and the β phases, and resulting dimensional changes are shown. Results of thermal cycling jacketed and cored slugs are tabulated. The behavior of Kroll-process zirconium in Na systems was observed, and data on the hardness profile are tabulated. Decomposition of MTR-irradiated terphenyls is observed, as was the gas evolution of MTR-irradiated xylene. Nuclear constants for the SRE were re-evaluated using the average density and enrichment of the U fuel now on hand, and the thermal utilization, resonance escape probabilities, and infinite multiplications are shown. SRE reactor design has been modified so as to lock core components and moderator cells into place. SRE core and reflector data for three cases of SRE criticality are given. Flux and adjoint flux for one of the cases are also shown. SRE neutron flux decay after scram is also shown. The status of reactor construction is discussed. The SRE fuel rod fabrication flow chart is shown. The fuel loader vacuum system and a mockup fuel element are also shown. The design and procurement of materials for the moderator and reflector cells are discussed. Results of tests on the sodium pump development test are given. Engineering tests of sodium flow under SRE conditions are discussed. Preliminary results on control-rod ring heat tests are given. Design and development of safety device systems are discussed. Radiation shielding for the loading face and ring shields of the SRE are shown. Density and thickness requirements for ring and loading face shield concrete are given. The coolant gallery shield plug seal is shown. Results of preliminary experiments with NaK bubblers show O concentration in He after flowing through the NaK bubblers. The interlock region of the fuel handling coffin is shown. (B.J.H.)

13969 NAA-SR-1513

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

SODIUM GRAPHITE REACTOR QUARTERLY PROGRESS REPORT [FOR] JULY-SEPTEMBER 1955. SECTION A. A. B. Martin, ed. SECTION B. J. C. Cochran, ed. Mar. 15, 1956. Decl. Apr. 8, 1957. 141p. Contract AT(04-3)-49. \$0.80(OTS).

Loading schedules were proposed for both U and Th-U fuels. Calculations of the isotopic composition of the fuels at discharge from the reactor are tabulated. Measurements were made of neutron distributions in exponential assemblies similar to the lattices proposed for sodium graphite power reactors. Material buckling data for graphite lattices are given. Neutron flux distributions are also given for various lattice arrangements. The development of hot cell facilities is summarized. A temperature monitor assembly for SRE fuel elements is shown. Macroetches of SRE α -rolled β -heat treated slugs indicate a columnar type of structure. Final designs are given for a large hollow slug fuel element. Experiments on the gas evolution and distortion of graphite are briefly discussed. The weight gain of Zr in Na systems was studied. The progress of construction on the reactor is shown. Fuel loading equipment is shown, as is a disassembled SRE fuel element model. Sodium-potassium alloys were prepared and used as bonding material with full length experimental fuel rods loaded with natural U slugs. High-temperature tests on the bond are summarized. A special alignment jig used in moderator canning is shown. Engineering tests

on Zr cans are discussed. Data are also given on the tensile stress in Zr. Sodium system designs are discussed. Apparatus is shown for a sodium vapor trap. The pressure distributions in the upper and lower plenum of the SRE were studied. Tests to determine the possibility of galling between the core tank and the core tank sliding pad were continued. A test is described for determining the lubricating properties of MoS_2 . A temperature profile through the SRE radiation shield is given. Control and safety rod systems are discussed. Shielding problems are discussed, and data are given on the dose rate above the gap as a function of the thickness of the head shield. Shielding requirements for the radioactive liquid waste disposal system were re-evaluated. Data are given on the radiation level from the hold-up tank as a function of concrete thickness and on the radiation level from the sump discharge line as a function of earth thickness. A system for the analysis of ppm quantities of H in He was developed, and data are tabulated on samples analyzed by this method. Reactor operations are summarized. Diagrams are given for the SRE cooling system and steam plant systems. (For preceding period see NAA-SR-1457.) (B.J.H.)

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NUSSELT VALUES FOR ESTIMATING TURBULENT LIQUID METAL HEAT TRANSFER IN NONCIRCULAR DUCTS. James P. Hartnett and Thomas F. Irvine, Jr. (Univ. of Minnesota, Minneapolis). *A.I.Ch.E. Journal* 3, 313-17 (1957) Sept.

A simple expression for estimating the turbulent forced-convection heat transfer performance of liquid metals flowing through noncircular ducts is presented. This equation requires the knowledge of the slug Nusselt number evaluated for the specific geometry and for the pertinent boundary conditions. Such Nusselt values are presented for a number of technically important geometries. One check on the heat transfer prediction is in the case of an annular duct with constant heat flow through the outer wall with the inner wall insulated, for which experimental data exist. The prediction agrees within 20% with the experimental data. Several possible boundary conditions that may exist in noncircular cross sections are thoroughly discussed, and it is hoped that as a result this paper may serve to clarify some of the confusion existing in the literature. (auth)

217

HANDLING AND USES OF THE ALKALI METALS. ADVANCES IN CHEMISTRY SERIES 19. Washington, American Chemical Society, 1957. 181p. \$4.75.

The production, recovery, uses, and handling of K, Na, and Li are described and discussed. Papers are included on: alkali metal polymerization catalysts, recleaning Na heat transfer systems, corrosion resistance of metals and alloys to Na and Li, manufacture, uses and handling of NaH, Na₂O₂ production, preparation and use of NaO₂, uses of Na in metallurgy, reactions of Na with organic compounds, determination of NaO in Na, and manufacture of K and Na-K alloys. (T.R.H.)

843

KAPL-M-DRM-1

General Electric Co. General Engineering and Consulting Lab., Schenectady, N. Y.

COMPARISON OF COOLANTS. D. R. Miller. Oct. 3, 1946. Decl. Feb. 14, 1957. 5p. \$1.80(ph OTS); \$1.80(mf OTS).

Liquid metal coolants Na, Na-K, Hg, Bi, Pb, and Pb-Bi are compared in terms of a figure of merit dependent only on cooling properties. (T.R.H.)

844

KAPL-M-LFE-4

Knolls Atomic Power Lab., Schenectady, N. Y.

CORROSION AND OTHER FACTORS IN THE APPLICATION OF SODIUM TO THE KAPL REACTOR. L. F. Epstein and C. E. Weber. Dec. 15, 1948. Decl. Mar. 25, 1957. 38p. Contract [W-31-109-Eng-52]. \$6.30(ph OTS); \$3.00(mf OTS).

Data accumulated on the nature of the engineering and technological problems involved in the use of liquid Na as a heat transfer medium in a nuclear reactor are presented. Some possible solutions are included. (M.H.R.)

847

KAPL-M-SCT-10

Knolls Atomic Power Lab., Schenectady, N. Y.

PROJECT OWL: 8-INCH WATER INJECTION TEST. RUN NUMBER 1. Preliminary Results. C. W. Sorenson. Mar. 28, 1956. 7p. Contract [W-31-109-eng-52]. \$1.80(ph OTS); \$1.80(mf OTS).

Sodium heated to 600°F and flowing initially at 2980 gpm was subjected to water injection at the rate of 0.024 lbs/sec. After about 124 sec the water injection was terminated because of greatly reduced Na flow. After ~10 min., a small leak was found in the loop at the point of water injection and the pressure in the loop was relieved by venting off gases. After the leak sealed itself, H₂ was removed by outgassing and the loop pressure raised to 20 psig by addition of N₂. When the loop was heated to 653°F a few hours later, flow returned to normal. Cold trapping was successfully initially at 500°F and eventually down to 300°F. A summary of flow, temperature, and pressure data are presented. (L.M.T.)

971

ANL-5060(De1.)

Argonne National Lab., Lemont, Ill.

REACTOR ENGINEERING DIVISION QUARTERLY REPORT [FOR] MARCH 1, 1953 THROUGH MAY 31, 1953. June 15, 1953. Decl. with deletions Jan. 17, 1957. 157p. Contract W-31-109-eng-38. \$24.30(ph OTS); \$7.50(mf OTS).

Power Breeder Reactor. Conceptual design studies for the Power Breeder Reactor indicate the feasibility of a contained primary coolant system in a package arrangement. One- and two-group calculations are presented in detail for preliminary PBR estimations. A technique for impregnating UO₂ with NaK has been developed. The resulting putty-type fuel was successfully extruded through a 1/8-in. hole. Data are presented on the fuel element design factors imposed by heat transfer and cooling limitations for fuel plates, pins, and spheres. Fission heat liberated in the PBR blanket was estimated to be 7.7% of the total core power. Design criteria resulting from this estimate are analyzed. Heat exchanger size for the transfer of 500 Mw of heat from Na to NaK has been calculated for the intermediate exchanger and for the NaK-to-H₂O steam generator. A theoretical treatment is presented for the thermal stress analysis of stainless steel-clad U fuel plates. Boiling Reactor Heat Transfer Experiments. Further results have been obtained from natural-circulation boiling-density tests and investigations of natural-circulation flow rates. A special thermocouple design, meeting the rapid-response requirements of high-power plate transients,

is described. Feasibility studies on heavy water boiling reactors are presented for spherical boiler, pressurized tube, and horizontal pressure tank configurations. Reactor Physics. Detailed theoretical methods are developed for determining long-time changes in reactors. Application is made to a one-group calculation of such changes in a spherically symmetric fast converter. Further data are reported from investigations of irradiation effects on the reactivity of U^{238} - U^{235} and Th^{232} - U^{235} systems. New data are available on the efficiency of the upper shield of the EBR, determined by neutron flux traverses taken on axes through the core center and inner blanket. Fuel Element Development. Attention has been directed to the study of U alloys with lower corrosion rates in water. Corrosion characteristics are given for UO_2 , Zr-clad U plates, U, and Mg in diphenyl, and free energies for chemical reactions commonly occurring in reactor studies are tabulated. A study is reported on the pressure-drop characteristics of fuel elements with variations in flow rate, metal-to-water ratio, pitch, and water density. The increased resistance of such fuel wires was found to be less than anticipated. Radiation Studies. A comparison is made between the radiation effects of Dow-Corning high-vacuum silicone stopcock grease and Standard Oil Co. Lg-0147 grease. (C.H.)

974 ANL-5345(Del.2)

Argonne National Lab., Lemont, Ill.

REACTOR ENGINEERING DIVISION QUARTERLY REPORT FOR PERIOD JULY 1, 1954 THROUGH SEPTEMBER 30, 1954. Oct. 15, 1954. Decl. with deletions Mar. 29, 1957. 127p. Contract W-31-109-eng-38. \$19.80(ph OTS); \$6.30 (mf OTS).

Reactor Programs. The design of the Boiling Experimental Reactor is described. The Borax-I reactor was intentionally destroyed by suddenly adding 4% excess reactivity. Design of the Borax-II reactor is described. It will be used for studies of transient behavior and steady-state operation as a steam producer. A preliminary design configuration has been established in EBR-II employing central, inner, and outer blankets. Fuel geometries including a smaller pin-type element are being investigated. Supporting Design, Research, and Development. The accuracy of diffusion theory for fast reactors was investigated. Water corrosion tests have been performed on high-U alloys, Zr- and Ti-base alloys, and Ni-plated Al plates. Thermal cycling tests were performed on fuel rods and pin-type fuel elements. Results are reported on tests on a current conductor connection for a high-temperature d-c electromagnetic pump, on Na valves with conventional packing, and on a rod-gripper test facility for the EBR-II. A vacuum cup sampler for high-temperature Na and NaK systems is described. Lifting and loading mechanisms for the EBR-II working model are described. (T.R.H.)

977 ANL-5511

Argonne National Lab., Lemont, Ill.

REACTOR ENGINEERING DIVISION QUARTERLY REPORT [FOR] JULY, AUGUST, SEPTEMBER 1955. SECTION II. Jan. 1956. Decl. Jan. 17, 1957. 186p. Contract W-31-109-eng-38. \$1.10(OTS).

Experimental Boiling Water Reactor. The boiling water corrosion of Zircaloy-2 clad stainless steel thimbles is shown. Designs of the EBWR control rod and drive mechanism are given. The deceleration curve for the drive shaft at 600-psig operation is given. The prototype test facility for the control mechanisms is also shown. Calculated heat generation and thermal stresses in the pressure vessel wall for each type of thermal shielding are tabulated. The me-

chanical arrangement of the thermal shielding is given.

The pressure vessel containment structure is described in detail, and calculated impact loading stresses are summarized. A redwood, steel, and celotex blast shield for the pressure vessel is also shown. Fast and thermal neutron flux calculations for the heavy water-reflected EBWR in the adjusted shield are summarized. The physical arrangement of this shielding is also described. An emergency boric acid injection system to reduce the reactor core activity below criticality was designed. The reactor water purification system is discussed. A schematic flow diagram of the air drying and fluid recovery system is given. Estimated flows in this system are also given, and the operation of the system is briefly discussed. A schematic plan view is shown of the EBWR power plant and control areas. A simplified line diagram is also given of the EBWR electrical system. The schematic for the emergency air-lock doors for the EBWR is shown. Supporting and Alternate Design Research and Development. The design of a

boiling D_2O reactor is briefly discussed. Data given on boiling heat transfer studies include the ratio of steam-to-liquid velocity as a function of the variable inlet temperature, power, flow, and pressure. The analytical and experimental studies made of the 600 psi, unrestricted, single-channel circulation loop (Armadilla) are described, and preliminary data are plotted. These plots show modified Martinelli-Nelson factors as a function of slip ratio and exit and local void fraction. Data from single channel forced and natural circulation boiling density tests at 150 psig are summarized. Slip ratios are also plotted as a function of inlet water velocity at 150 and 250 psig, indicating that there is no significant pressure effect on the slip ratio pattern in going from 150 to 250 psig. The corrosion of Zircaloy 2-clad, U-Zr fuel plates in 550°F degassed water. The corrosion behavior of Al-clad, natural U plates is compared to that of EBWR reference alloy plates. The corrosion of Al-Ni alloy in 500°F H_2O is also shown. Corrosion data are also reported for austenitic stainless steel, and its weight changes are plotted. Corrosion and irradiation tests were continued on urania-thoria bodies. Several methods were tested for the detection and location of ruptured fuel elements in the core of a reactor. These included comparisons of fission product activities in various sampling devices and of γ activities in H_2O samples. It was, however, concluded that neither of these methods would be useful. A proposed alternate control rod for the EBWR is described and discussed. Progress in the development of boron-stainless steel alloy is discussed. Boron-stainless steel corrosion tests are summarized. Results of experiments on the removal of boric acid using Amberlite IRA-400 resin are summarized. Experimental Breeder Reactor I. The conversion ratio was measured in the second U fuel loading of the EBR-I. U^{238} capture distributions and U^{235} fission distributions in the reactor are shown. The conversion ratio with the cup about $\frac{1}{4}$ in. below its uppermost position was found to be 1.03 ± 0.05 . Activation cross section ratios at various locations in the outer blanket of the EBR were surveyed. Experimental and theoretical values are compared. Experimental Breeder Reactor II. The dissipation of simulated decay heat generated in the EBR-II core sub-assembly is shown. Water pressure drop tests were conducted on the complete EBR-II core subassembly, and the results of the tests are summarized. Calculations of hold-down forces in the core are also given. Irradiation tests were made on EBR-II fuel elements. EBR-II Working Model. A general description is given of the control rod and the cover raising and rotating mechanisms. A diagram of the fuel unloading system is given. Performance characteristics are given for a model tank pump in Na at 370°C. Supporting and Alternate Design Research and

Development. The composition, grain size, and appearance of Mo-U and Zr-U alloys, which were thermal cycled in NaK are shown. Equipment is shown for the induction heating of the Na test loop, and the induction heating time for this loop is shown. **Reactor Safety and Kinetics.** Machine solutions of the kinetics equation are described in some detail. Analytical solutions of kinetics equations are also discussed. These methods were used to investigate the oscillatory behavior of the kinetic system for a reactor with a lifetime of 4×10^{-8} sec, and resultant calculations are plotted. The solution to the general problem of obtaining temperature distributions in two-region cylindrical geometry for an exponentially rising heat source in the central region is also given. The time variation of stored heat in a Na-cooled U rod during transient is also calculated, and the fraction of heat remaining in the fuel rod is shown as a function of the reciprocal period of the heat source. **Fuel and Structural Materials.** The failure in the tube assembly for the MTR loop water-to-water heat exchanger is discussed. **Instrumentation.** The pulse height distribution of fission signals in B^{10} and Al-U-Al neutron-sensitized photomultiplier tubes is shown. (C.H.)

1032 KAPL-238(Del. 2)

Knolls Atomic Power Lab., Schenectady, N. Y.
TECHNICAL FEASIBILITY REPORT FOR THE KAPL WEST MILTON AREA REACTOR. Feb. 14, 1950. Decl. with deletions Mar. 8, 1957. 280p. Contract W-31-109-Eng-52. \$43.20(ph OTS); \$11.10(mf OTS).

This feasibility report is presented under the following topics: objectives of the program; description of reactor system; criticality considerations; nuclear components—design, materials, fabrication, assembly, and testing; reactor structure; reactor controls; liquid metal heat transfer systems; power conversion; loading, transfer and storage facilities; shielding; processing fuel and breeder rods; experimental program and facilities; servicing reactor components; special waste handling facilities; and plan for reactor operation. (L.M.T.)

1087 NAA-SR-1582

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

SODIUM GRAPHITE REACTOR QUARTERLY PROGRESS REPORT [FOR] OCTOBER-DECEMBER 1955. SECTION A. A. B. Martin, ed. SECTION B. J. C. Cochran, ed. Apr. 15, 1956. Decl. Apr. 8, 1957. 100p. Contract AT(04-3)-49. \$0.60(OTS).

An analysis was made of the nuclear parameters for sodium graphite reactor lattices. These parameters include thermal utilization, macroscopic cross sections, thermal diffusion length, and neutron absorption. Results of all calculations are given in graphical form. Test fuel slugs for the SRE were cycled up to 500 times between 100 and 500°C at the rate of 2 cycles/hr. Results are tabulated. The centrifugal casting of U alloy fuel slugs is briefly evaluated. Results of the microscopic examination of the extruded Th-U breeder fuels are shown. The percent elongation of graphite due to the presence of Na is shown for various temperatures. Results of wear tests on graphite are also tabulated. The behavior of Zr in liquid Na was studied, and weight gains in Zr are summarized. Analog computer studies were continued, and data are included on the temperature effects of the response time of coolant channel Na outlet temperature thermocouples, the effects of continuous rod motion and pump speed changes on the outlet Na temperature and power, and the outlet temperature as a function of scram time. The critical evaluation of B-Ni rods is tabulated. The fuel rod assembly apparatus is described.

Fuel rod development is discussed. Cyclograph traces of rods bonded with various Na-K alloys were recorded for rods at room temperature and heated to 450 and 600°F. The traces are indicative of uniform bonding. The moderator can fabrication and testing is also discussed. Tests were completed on Freeze Seal No. 2 for the 6-in. oval port Wedgeplug test valve at 450, 850, and 1250°F. The temperature gradients from the hot flange face to the end of the seal mechanism for various valve temperature conditions are shown. Sodium leak rates through the valve are tabulated. Progress in the development of a liquid Na level gage is briefly reported. The tubular heater experiment was completed, and the times to raise pipe temperatures from ambient to 350°F are tabulated. Designs for a 6-in. Na pump loop are described briefly. A one to 3.5 scale model of a SRE fuel element was constructed to study the effect of side drag on the element during insertion operations at those fuel channels located near the outlet of the upper plenum chamber. The calibration of the SRE fuel element orifices was studied. Control rod lead screw development is discussed. Development of the safety rod system is described. Core tank galling tests are summarized. Experiments to determine the effects of radiation on MoS_2 are described. Dose buildup factors for the concretes to be used in the reactor top shield are tabulated. Constants for the quadratic representation of the dose buildup factor and the capture γ rays from heavy concrete are also tabulated. The sodium pumps and service system are described. The rated cooling capacity of the SRE tetralin evaporative cooler was checked. Results of a study on the effects of NaK temperature on the H content of He are tabulated. (D.E.B.)

1118 CRD-T2C-87

California Research and Development Co. Livermore Research Lab., Livermore, Calif.

CONTAMINATION OF NaK COOLANT IN BARE THORIUM TARGET. L. M. Litz and R. E. Batzel. Mar. 13, 1952. Decl. Apr. 2, 1957. 18p. (LWS-24338). \$3.30(ph OTS); \$2.40(mf OTS).

The nature, magnitude, and sources of activities to be expected in the NaK coolant of the Th primary target for the Materials Testing Accelerator were estimated. The primary target consisted of bare Th plates inserted in a stainless steel tube bank with molten NaK as coolant. The major source of activity will be due to nuclear reactions induced in the NaK by the incident deuteron beam and slow neutron flux; fission-product recoil activities will be a secondary source of activity. (C.W.H.)

1343 NP-6458

General Electric Co. Light Military Electronics Equipment Dept., Schenectady, N. Y.

RESEARCH ON LIQUID METALS AS POWER TRANSMISSION FLUIDS. Quarterly Progress Report No. 4 [for] June to September 1957. R. C. Kumpitsch, J. Huthsteiner, and D. Lombardo. Sept. 1, 1957. 27p. Project 7-(1-7331). Contract AF33(616)-3698.

The General Electric Co. has provided a new facility in which to determine the feasibility of using sodium-potassium alloys, especially NaK 77, as a power transmission fluid for high temperature applications. The facility, complete with an integral disposal and clean-up area, provides a more efficient, clean, confined, and safe location in which to undertake this development. Operation in the new test area is scheduled for 16 September 1957. Initial tests conducted with the single cylinder NaK test pump revealed that modification and improvement of this equipment was necessary to insure consistent 3000 psi 1000°F operation. All design changes being made to the

single piston pump tester are described in detail in the report. An investigation was conducted to determine the most suitable high temperature wear tester commercially available for preliminary screening of materials and for evaluating the lubricity effects of additives in NaK 77. Several of the wear testers being considered have been evaluated. This investigation has not been completed. The results to date are included in this report. Future effort will be directed toward getting the Single Piston NaK Pump tester into operation and the selection and purchase of the most desirable wear tester. (auth)

1410

THE WETTING OF SOLIDS BY LIQUID METALS. B. R. T. Frost (A.E.R.E., Harwell). *Atomics* 8, 387-90(1957) Oct.

The fundamentals of wetting are reviewed, and methods of measuring the wetting of metals by liquid Na, Bi, and Pb are discussed. Reactor problems concerned with wetting properties are summarized. These are concerned with corrosion, slurries or suspensions, and thermal and electrical conductivity. (M.H.R.)

1438 KAPL-M-WMP-1

Knolls Atomic Power Lab., Schenectady, N. Y.
THERMAL CONDUCTIVITIES OF GASES, METALS,
LIQUID METALS. W. M. Przybycien and D. W. Linde.
Aug. 6, 1957. 29p. Contract [W-51-109-Eng-52]. \$4.80
(ph OTS); \$2.70(mf OTS).

Graphs on the thermal conductivities of gases (air, Ar, CO₂, CO, He, H₂, Kr, Ne, NO, N₂, O₂, and Xe), metals (Al, Be, Inconel X, Types 304, 347, and 446 stainless steel, Ti, U-Zr alloy, and Zircaloy-2), and liquid metals (Na and Na-K alloy) are shown. Densities of liquid Na and Na-K are included. (J.E.D.)

1926 R-50GL231

General Electric Co. General Engineering and Consulting
Lab., Schenectady, N. Y.
INVESTIGATION OF LIQUID METAL LUBRICATED BEAR-
INGS. Harry Apkarian. Nov. 27, 1950. Decl. Mar. 19,
1957. 10p. \$6.30(ph OTS); \$3.00(mf OTS).

The liquid metal lubricated bearing program was an investigation to determine (1) the feasibility of using liquid metals as bearing lubricants, (2) characteristics and behavior of bearings with liquid metal lubricants, and (3) design criteria for liquid metal lubricated bearings. The liquid metal lubricant used was a mixture of 50% Na and 50% K by weight. It was determined that liquid metals, such as NaK, when used as lubricants behave in accordance with established hydrodynamic principles in much the same manner as any conventional lubricant. Properly designed bearings lubricated by liquid metal will support practical loads through a wide range of temperature and speed. (auth)

1932 R49GL82

General Electric Co. General Engineering and Consulting
Lab., Schenectady, N. Y.
PREDICTED PART LOAD HEAT TRANSFER PERFORM-
ANCE OF THE "GENIE" SMALL TEST SYSTEM.
T. Trocki, H. A. Johnson, and T. W. Hunt. Sept. 6, 1949.
Decl. Mar. 16, 1957. 179p. \$28.80(ph OTS); \$8.40(mf
OTS).

The part load performance calculation of a system for which all geometrical data are known is described in detail. The method of control maintains constant sodium temperatures in and out of the intermediate heat exchanger and constant steam conditions leaving the steam generator. The geometrical data and evaluation of corresponding over-all heat transfer coefficients U, which are characteristic of the individual system components, are given. (auth)

1933 TID-278(Del.)

Technical Information Service, AEC.
HEAT TRANSFER. Reports from Session XII, General
Information Meeting, October 24, 25, 26, 1949, Oak Ridge,
Tennessee. Decl. with deletions Feb. 28, 1957. 53p.
\$9.30(ph OTS); \$3.60(mf OTS).

Papers are presented on heat transfer with boiling, heat transfer to liquid metals, transient heat transfer effects resulting from supercriticality, heat transfer coefficients for Bi alloys, and heat transfer and pressure drop through graphite ball columns. (L.T.W.)

1967 ANL-4003(Del.)

Argonne National Lab., Lemont, Ill.
METALLURGY DIVISION REPORT FOR APRIL, MAY,
AND JUNE 1947. June 30, 1947. Decl. with deletions
Feb. 12, 1957. 27p. Contract W-31-109-eng-38. \$4.80
(ph OTS); \$2.70(mf OTS).

Progress is reported in the following studies: the casting and fabrication of Co; the rolling of as-cast Th; the physical properties and corrosive effects of liquid NaK on a number of metals; the diffusion of U with several solid metals; the fabrication of a flash boiler for use in a NaK to water heat exchanger; the canning of uranium bricks; the electrodeposition of pure Fe foil; and the metallography of Be. (C.H.)

2226

REACTION RATE OF SOLID SODIUM WITH AIR. William
H. Howland and Leo F. Epstein (Knolls Atomic Power
Lab., Schenectady, N. Y.). *Ind. Eng. Chem.* 49, 1931-2
(1957) Nov.

This study was undertaken to determine the influence of temperature and composition of solid sodium on its rate of reaction with air. A quantitative re-examination was made of the observation that the speed of reaction of alkali metals and air is markedly dependent on purity. The rate of reaction is greater for filtered sodium than for the relatively pure distilled material, particularly at lower temperatures, and the difference between the rates tends to vanish at the melting point of the metal. These experimental results suggest that the reaction is catalyzed by the presence of small amounts of impurity and that the catalysis reaction has a high energy of activation. (auth)

2338 LM/TAB-5

MSA Research Corp., Callery, Penna.
LIQUID METALS TECHNOLOGY ABSTRACT BULLETIN
FOR THE PERIOD JUNE 1 TO OCTOBER 31, 1957. Nov.
11, 1957. 37p.

2736 KAPL-1807

Knolls Atomic Power Lab., Schenectady, N. Y.
SOLUBILITY OF CARBON IN SODIUM AT ELEVATED
TEMPERATURES. J. G. Gratton. June 30, 1957. 13p.
Contract W-31-109-eng-52. \$0.75(OTS).

An investigation was conducted to determine the solubility of carbon in sodium. This information was required to determine the difference in carburization of stainless steels between that caused by soluble carbon and that caused by suspended carbon. The data indicated that all carbon in amounts < 5μ was, in fact, sodium-soluble carbon. The solubility of carbon in sodium under the experimental conditions varied from 32 to 74 ppm in the temperature range 147° to 700°C. The variation in the solubility, (S = ppm) of carbon with temperature may be expressed in S = 4.96 - 6.21 × 10²/T at 0.003% oxide content, and as ln S = 5.61 - 3.76 × 10²/T at 0.026% oxide content. (auth)

2864

HOW TO TAKE SAMPLES FROM LIQUID METAL LOOPS. Marx Weech and Gordon Fluke (Univ. of Michigan, Ann Arbor). *Nucleonics* 15, No. 10, 112(1957) Oct.

A sampler is described which gives leak-free performance and requires a minimum of operator attention. The sampler design will operate in either a high vacuum or an inert gas atmosphere of low or moderate pressure. (L.T.W.)

2866 APEX-327

General Electric Co. Aircraft Nuclear Propulsion Dept., Cincinnati.

DESIGN AND OPERATION OF A SODIUM-TO-LITHIUM-TO-AIR HEAT TRANSFER SYSTEM. Work Period from September 1949 to June 1953. A. R. Crocker, R. L. Potter, R. J. Spera, T. D. McLay, and S. H. Esleeck. Dec. 1954. 195p. \$5.00(OTS).

This report describes the design and operation of a 50-gallon-per-minute liquid-metal circulating system transferring heat from sodium to lithium to air. Included is a detailed listing of the test equipment with its cost and installation expense. (auth)

2901 TID-10021

North American Aviation, Inc., Downey, Calif.

DISSOLUTION AND DISTRIBUTION BY LIQUID SODIUM OF ACTIVATED TYPE 347 STAINLESS STEEL. A. M. Saul. Mar. 15, 1954. Decl. Mar. 19, 1957. 26p. Contract AT-11-1-GEN-8. (NAA-SR-284). \$0.30(OTS).

The distribution by Na of the radioactive elements of Type 347 stainless steel was studied under dynamic conditions using convection-diffusion capsules operating between 300 and 700°C. The nuclides identified as depositing on the initially inactive walls of these capsules are Ta^{182} , Fe^{59} , Co^{60} , Cr^{51} , and Mn^{54} . Deposition of these activities does not seem to be a function of capsule wall temperature alone. It was found that the presence of O_2 greatly accelerates the transfer of activity. (auth)

2908

SYMPOSIUM ON CORROSION FUNDAMENTALS. A SERIES OF LECTURES PRESENTED AT THE UNIVERSITY OF TENNESSEE CORROSION CONFERENCE AT KNOXVILLE ON MARCH 1, 2, 3, 1955. Anton de S. Brasunas and E. E. Stansbury, eds. Knoxville, University of Tennessee Press, 1956. 260p.

The following papers were presented at the symposium on corrosion fundamentals at the University of Tennessee on March 1 to 3, 1955: corrosion and metal structures; nature of corrosion; atmospheric corrosion; coatings for atmospheric corrosion protection; high temperature corrosion; liquid metal corrosion; principles of cathodic protection; corrosion problems in steam power and industrial boiler plants; corrosion failures in chemical plants; inhibition of metallic corrosion in aqueous media; passivation of stainless steel; the influence of mechanical factors on corrosion; geometric factors in electrical measurements relating to corrosion and its prevention; cathodic protection principles and system design; and the use of plastics and plastic liners for corrosion protection. (W.L.H.)

2927 KAPL-M-CTU-10

Knolls Atomic Power Lab., Schenectady, N. Y. RADIOACTIVE ACCESSIBILITY REPORT [FOR] MARCH AND APRIL 1954. W. W. Kendall. Decl. Feb. 25, 1957. 41p. Contract W-31-109-eng-52. \$7.80(ph OTS); \$3.30 (mf OTS).

Sodium irradiation experiments were made to determine the typical amounts of impurities included in Na. Diagrams are shown of the Na in-pile loop. The use of barrier coatings as a means to reduce the transport of long-lived radioactive isotopes from stainless steel reactor components in Na was investigated. The effects of increased sodium oxide concentrations on mass transfer of stainless steel were studied. Tests of Na flow in toroids were continued. Apparatus for isothermal exchange experiments is shown. Data from saturation rate experiments are included. A laboratory-scale Na_2 loop is shown. Thermal harps were used to determine the inhibiting action of Mg, Zn, Be, Ca, and K on stainless steel mass transfer in Na. A loop system for Mg-in-Na studies is shown. (C.H.)

3027

D-C MAGNETIC FLOWMETER FOR LIQUID SODIUM LOOPS. C. G. Pfister and R. J. Dunham (Knolls Atomic Power Lab., Schenectady, N. Y.). *Nucleonics* 15, No. 10, 122-4(1957) Oct.

3364

INELASTIC SCATTERING CROSS SECTIONS OF NUCLEI FOR 2.5 Mev NEUTRONS. V. I. Strizhak (Academy of Sciences, Ukrainian SSR). *Soviet Phys. JETP* 4, 769-70 (1957) June.

The inelastic scattering cross sections for 2.5 Mev neutrons were measured for the following materials: Na, Mg, Al, P, S, Cl, Ca, Cr, Fe, Co, Ni, and Cu. The results make possible the following conclusions: (1) the inelastic cross sections for 2.5 Mev neutrons for most nuclei increase smoothly with mass number; and (2) nuclei having a magic number of nucleons have inelastic scattering cross sections that are significantly smaller than neighboring nuclei. (A.C.)

3453

VALVES FOR CONTROLLING HIGH-TEMPERATURE FLUIDS. F. L. Speed (to U. K. Atomic Energy Authority). British Patent 777,039. *Nuclear Eng.* 2, 494(1957) Nov.

A valve for high-temperature liquid (sodium) with a self-sealing leak-proof gland of (a plurality of) O-ring seals arranged as an insert over the spindle on a sleeve-like extension of the valve body. The extension and the spindle are of such length that combined with fins around the extension, a temperature drop is caused between the valve seat and the gland which results in liquid sodium passing through the valve becoming solid at the gland. (auth)

3459

SEALING MEANS FOR RECEPTACLES CONTAINING METAL IN LIQUID OR FUSED STATE. (to Allmanna Svenska Elektriska A. B. (Sweden)). British Patent 780,151. *Nuclear Eng.* 2, 538(1957) Dec.

The conventional solid sealing means, rings of soft wire laid between flanges of the receptacle, are separated from the liquid metal by a cushion of inert gas introduced into a chamber between the sealing means and the interior of the receptacle. This provides a safe seal (e.g. for pipelines and receptacles containing liquefied sodium as coolant) where covers have to be removable, and are sometimes moved by remote control. (auth)

3544 NYO-4804

Massachusetts Inst. of Tech., Cambridge. Dept. of Metallurgy. KINETICS OF REACTIONS BETWEEN LIQUID METALS AND LIQUID SALTS. Progress Report Covering Period

March 1, 1957 to November 1, 1957. Thomas B. King. 14p. Contract AT(30-1)-1985. \$3.30(ph OTS); \$2.40(mf OTS).

Progress made in the design of experiments, construction of apparatus, and preliminary experimental work is described. The kinetics of reactions involving both transport control and phase boundary reaction control are being studied. Measurements of diffusion coefficients are a part of the program. (auth)

3639 AERE-R/R-1891

Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.

SOME PRELIMINARY TESTS ON BEARING MATERIALS TO OPERATE UNDER LIQUID SODIUM—REVISED INTERIM REPORT—JUNE 1954. D. F. Elliott, E. Holland, and K. A. Tomblin. Apr. 23, 1956. Decl. Sept. 17, 1957. 37p.

The object of these tests is to determine the most suitable materials to be used in the construction of bearings for a 50 H.P. Sodium Pump. The most critical period of operation for these bearings is during start up, when a condition of 'boundary lubrication' will exist, and metal-to-metal contact will occur between the rotating shaft and the bearing until the speed of the pump shaft is sufficient to give true 'hydrodynamic lubrication' by creating a continuous film of sodium within the bearing. The characteristics required for a suitable pair of bearing materials are given. The results of these tests may also be useful in the selection of materials for use as rubbing surfaces in reactor mechanisms which are required to operate submerged in liquid Na or Na-K alloy. (auth)

3540 ANL-5054(Del.)

Argonne National Lab., Lemont, Ill. CHEMISTRY DIVISION, SECTION C-I QUARTERLY REPORT FOR OCTOBER, NOVEMBER, AND DECEMBER 1952. D. W. Osborne, ed. Feb. 1, 1953. Decl. with deletions Feb. 14, 1957. 35p. Contract W-31-109-eng-38. \$6.30(ph OTS); \$3.00(mf OTS).

Progress is reported on the following studies: the half life of Am^{243} ; neutron capture cross sections for Ac^{227} ; U^{233} recovery from sea water by solvent extraction; corrosion of U, Pu, and U-Pu alloys in NaK; heats of formation of UH_3 , UO_3 , and UT_3 ; determination of the low-temperature heat capacity of UF_4 ; the reaction of $\text{Th}(\text{NO}_3)_4 \cdot 4\text{H}_2\text{O}$ with N_2O_5 in anhydrous HNO_3 ; determination of the reflection spectra of some solid Co(II) salts in the visible region; separation of Li isotopes, Ce-Th mixtures, and Ra-Ba mixtures by an electrogravitational method; theoretical studies of the transference cell; the isotope effect in the Br oxidation of ethanol; and the synthesis of trimethyl borate. (C.H.)

3644 KAPL-M-EDL-75

Knolls Atomic Power Lab., Schenectady, N. Y. MARK A CONTROL ACTUATOR SHAFT FREEZE-SEAL. P. W. Bissonnette and R. D. Vallee. Sept. 1, 1954. Decl. Mar. 13, 1957. 26p. Contract W-31-109-Eng-52. \$4.80(ph OTS); \$2.70(mf OTS).

Investigations were conducted to determine the mechanical properties of Na sheared in a narrow annulus at controlled temperature gradients and shear velocities. The test fixture consisted of a 1 in. diameter stainless-steel shaft centered in a 1.099 in. ID Type-304 stainless-steel tube. Sodium shear values were found to be dependent upon the temperature and shear velocity at a given test condition. Sodium shear values obtained were found to be consistent, wherever wetting of components had been assured

by contact with hot Na at temperatures above 500°F for periods of one-half hour or greater. Tests conducted showed Na shear to have occurred internally, rather than at freeze-seal interfaces within the range of shaft velocities tested. The apparent shear strength of Na was found to fall off rapidly with successive shearing cycles to steady-state values corresponding to particular shearing velocities. Tests showed that with the freeze-seal at rest, a healing action occurred as a function of time, resulting in substantially complete regaining of initial shear strength. (auth)

3652 AERE-R/M-144

Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.

DESIGN OF TRAVELLING FIELD INDUCTION PUMPS FOR LIQUID METALS. D. A. Watt. Sept. 1957. 13p.

Theory and examples of design for maximum rate of pressure rise are given. It is shown that while designs for low resistivity, low density liquid metals optimized do not give the maximum possible rate of head rise the condition for this is not greatly different. A technique for rapidly deriving the condition for maximum rate of head rise is illustrated and the basic principles discussed. For high resistivity liquid metals it is explained that an approach limiting flow speed and gap flux density would be needed, although performance is inevitably reduced and the D.C. pump offers a much better power rating and efficiency. (auth)

3724 ORNL-1301(Del.)

Oak Ridge National Lab., Tenn. SOLID STATE DIVISION QUARTERLY PROGRESS REPORT FOR PERIOD ENDING MAY 10, 1952. J. T. Howe, ed. Jan. 9, 1953. Decl. with deletions Feb. 20, 1957. 53p. Contract W-7405-eng-26. \$9.30(ph OTS); \$3.60(mf OTS).

Progress is reported on the following studies: creep of stainless steel and inconel under irradiation, ORNL Graphite Reactor liquid-metals loop, LITR Na stress-corrosion loop, MTR fluoride-fuel loop, nuclear heating of materials, radiation damage to liquid fuels, thermal conductivity of structural materials, tests on irradiated graphite- UO_2 bars, position of bombardment-produced energy levels in Ge, radiation effects on KCl, half-life determination of Ge^{71} by electric measurements, resolution of precipitate nuclei sizes by retrogression phenomena, radiation-induced resistivity changes in Cu-Be alloy, physical properties of irradiated elastomers, and radiation damage to miscellaneous materials. (L.T.W.)

3899 NAA-SR-1109(Rev.)

North American Aviation, Inc., Downey, Calif. SODIUM GRAPHITE REACTOR QUARTERLY PROGRESS REPORT [FOR] JULY-SEPTEMBER, 1954. Sidney Siegel and Guy M. Inman, eds. Dec. 1, 1954. Decl. Mar. 4, 1957. 101p. Contract AT-11-1-GEN-8. \$0.65(OTS).

Reactivity calculations have been performed for the steady-state Pu feedback technique outlined in the previous progress report. A full-scale power plant study was initiated, based on sodium-graphite technology. A twin-core power plant is now considered to be the most promising configuration. Several design drawings are given of such a reactor, using slightly enriched U to produce Pu and electrical power. The thermal neutron flux distribution in a cluster of 6 U rods was measured, and the results are compared with previous measurements for a 7 rod cluster. The average thermal cycling of hollow U slug elements was begun. Results are given for 500 cycles between 100 and 500°C. A series of powder-compacted U alloys were

thermal cycled between 200 and 700°C. Data on the transfer of radioactivity from Zr by Na has been obtained from a capsule of the first series of three miniharps. Fe, Al, and Cu were immersed in toluene and irradiated at 150°F in the MTR-Gamma canal. Toluene is being considered as a shield coolant for the SRE. The effect of 1-Mev electron irradiation on terphenyls was also studied. A venting tube arrangement has been designed for the Zr-canned graphite moderator. A number of thermal insulating brick and fiber materials were subjected to liquid Na to study deterioration effects. The materials tested were Johns-Manville Brick C-16 (Sil-O-Cel mortar), Superex Paste, and Eagle-Pitcher Mineral Wool. Encouraging results were obtained in an effort to evaluate the effectiveness of Na decontamination by liquid ammonia. Pressure drop and flow characteristics of the latest design SRE fuel element have been completed. Design details of the 2-speed control rod drive assembly are given. Other aspects of the reactor control system, including design and component fabrication, are discussed. Gamma dose rates at the surface of the top shield were measured, together with the heat generation in the top thermal and biological shields. Revised plans for a fuel element and moderator-cell handling coffin, fuel storage system, and waste disposal system are outlined. (For preceding period see NAA-SR-1049.) (K.S.)

4231 AERE-Inf/Bib-92(2nd Ed.)
Gt. Brit. Atomic Energy Research Establishment,
Harwell, Berks, England.
HOMOPOLAR GENERATORS AND LIQUID METAL
BRUSHES. A BIBLIOGRAPHY. M. Greenhill and N.
Skeats. Sept. 1957. 10p.

4444 KAPL-M-DGC-14
Knolls Atomic Power Lab., Schenectady, N. Y.
ACCESSIBILITY TO LOWER REACTOR COMPARTMENT.
PART IV. CONTRIBUTION OF SODIUM AND IMPURITIES
IN EVAPORATOR, EXPANSION TANK, SUPERHEATER
AND PIPES. D. G. Chappell. July 10, 1953. Decl. Mar.
9, 1957. 13p. Contract W-31-109-Eng-52. \$3.30(ph
OTS); \$2.40(mf OTS).

The γ dose contribution from commercial Na (plus impurities) in pipes. Evaporator, surge tank, and superheater is calculated as a function of days after shutdown. The Na is assumed to be activated one year at full power; the impurities one year at 1/10 power. The Na impurities became the controlling factor 16 days after shutdown; the dose is 452 mr/hr. Elimination of Sc and Co reduces this level to 71 mr/hr. (auth)

4447 KAPL-M-EDL-99
Knolls Atomic Power Lab., Schenectady, N. Y.
PRESSURE GRADIENTS AROUND UNIVERSAL JOINT
THERMAL BAFFLES-MARK "A". Paul A. Benson and
Robert G. Jacoby. July 1, 1955. Decl. Mar. 19, 1957.
78p. Contract W-31-109-Eng-52. \$12.30(ph OTS); \$4.50
(mf OTS).

An investigation was conducted in order to substantiate a theoretical analysis which indicated that surges of hot Na would tend to enter the annulus around the control element. Flow tests were conducted in the half-scale reactor model with water at a temperature of 100°F. The resultant data are presented as curves of the characteristic gradient of pressure at the circumferential surface of the thermal baffles which surround the universal joints. On the basis of these determinations it was possible to design flow restric-

tions which would eliminate the objectionable surge pattern. (auth)

4448 KAPL-M-FJM-1
Knolls Atomic Power Lab., Schenectady, N. Y.
SUMMARY OF DUPLEX TUBE ANALYSES. F. J.
Mehring. Sept. 28, 1956. Includes Appendices A
through G. 73p. Contract W-31-109-Eng-52. \$12.30
(ph OTS); \$4.50(mf OTS).

The heat transfer characteristics and stress levels in duplex tubes for heat exchangers are interdependent. The various studies of the heat transfer characteristics and stress analyses are summarized. The heat transfer characteristics discussed are those for boiling water, liquid metal, and metal-to-metal contact. Analyses have been made of the fabricating and operating stresses. As a result of these various analyses recommendations were made regarding material properties, tolerances and surface conditions of the tubular components, fabricating procedures, and operating precautions. Where areas of uncertainty still exist tests have been recommended. This information is significant to the SIG Test Steam Generator Program, since this steam generator is to have duplex heat exchanger tubes. (auth)

4900 NP-6561 (Rpt: UNCLASSIFIED)
Canada. Dept. of Mines and Technical Surveys. Mines
Branch.

A VISCOMETER FOR MOLTEN METALS. W. B. Muir.
Oct. 21, 1957. 15p. (TR-146/57).

A simple noncritical viscometer is described which is in the process of development. The instrument is capable of measuring the relative viscosity of a low-melting metal from its melting point to about 500°C. The progress made on this project during the past two years is reviewed. (A.C.)

5013 TID-7548
Argonne National Lab., Lemont, Ill., Los Alamos
Scientific Lab., N. Mex., and Power Reactor Develop-
ment Co., Detroit.

FAST REACTOR PROGRAM INFORMATION MEETING,
CHICAGO, ILLINOIS, NOVEMBER 20-21, 1957. Sum-
maries of Papers. Nov. 20, 1957. 53p. \$1.50(OTS).

Papers are presented on: the ANL, LASL, and PRDC fast reactor programs; the engineering design of the Experimental Breeder Reactor-II- the reactor and power cycle and the fuel process and fabrications cycle; the design of the Enrico Fermi atomic power plant; fast reactor safety in the EBR-I; meltdown and analysis; and analysis of prompt excursions in simple systems, reactor design and analysis of LAMPRE I, EBR-II, and the Enrico Fermi Reactor; nuclear analysis by critical experiments with ZPR-III and static analysis; fuel element design; the EBR-II fuel cycle-fuel cycle plant and process and remote fuel element fabrication and processing; irradiation and thermal stability; Na technology, pumps, and piping system components; heat exchangers and steam generators; high purity Na systems; advanced Pu reactor concepts; fluid fuels; Pu-U alloy metal systems; fuel element concepts; fuel and blanket process development; and a coupled fast-thermal reactor. (M.H.R.)

5205 AECU-3193
Atomic Power Development Associates, Inc., Detroit.
ATOMIC POWER DEVELOPMENT ASSOCIATES, INC.
NaK-WATER REACTION TESTS. R. H. Jones, H. J.
Williams, and J. A. Murphy. Dec. 1956. 12p. \$0.15(OTS).

An investigation is being carried out on the reaction pressures, temperatures, and rates developed by leakage of a $\frac{1}{2}$ -in.-diam. stream of water, at various boiler pressures, into contact with a circulating stream of NaK initially at 50 psig. (W.L.H.)

5375 LM/TAB-6

MSA Research Corp., Callery, Penna.
LIQUID METALS TECHNOLOGY ABSTRACT BULLETIN
FOR THE PERIOD NOVEMBER 1 TO JANUARY 15, 1958.
Feb. 1, 1958. 23p.

5877 AERE-R/M-138

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.

SOME STUDIES OF THE REACTION BETWEEN SODIUM AND BISMUTH. R. I. Hawes. Sept. 1957. 13p.

In a circulating fuel, liquid metal fuelled reactor, a secondary liquid metal coolant circuit is likely to be used. There is interest in a solution of U in Bi as a fuel and Na as a secondary coolant. An exothermic reaction occurs between Na and Bi leading to a high melting point intermetallic compound. This paper discusses the effects which might occur if a leak occurred in the primary heat exchanger and reports some experiments which were carried out to investigate these effects. (auth)

5952 AERE-R/R-2190

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.

EXPERIENCE OBTAINED ON A LIQUID SODIUM HEAT TRANSFER RIG 1954/1956. E. C. Firman, R. I. Hawes, and D. W. G. Sturge. Aug. 1957. 31p. (LMFT/P-19).

Heat transfer data for Na flowing at moderately low Reynolds number in a double annulus heat exchanger are reported. The results qualitatively confirm the findings of coefficients well below the theoretical minimum. Addition of an inert gas to the flowing liquid produced a pronounced lowering of the heat transfer coefficient. After some 1400 hr operation, deposits mainly of Na_2O occurred throughout the apparatus. It is shown that such deposits could be an important factor in depressing the heat transfer coefficient. It is not claimed, however that this is the only or principal factor. Other possibilities are commented upon. General operating experience is also described. The experiment included an investigation of the metallurgical changes occurring in a dynamic Na in stainless steel system and the results are compared with static controls. (auth)

5996

MASS TRANSFER IN LIQUID METAL SYSTEMS. 1. THERMAL GRADIENT TRANSFER. J. W. Taylor (Babcock and Wilcox, Ltd.). Nuclear Power 3, 53-7 (1958) Feb.

Mass transfer in liquid metal systems occurs by thermal gradient transfer or isothermal transfer. In liquid-metal systems having a temperature differential, mass transfer of the container material may result in failure of the hot limb component or stoppage of the flow because of precipitation in the cold limb. Experimentally this transfer may be studied in thermal or forced convection conditions. The basic steps of the transfer process are solution of the container components and precipitation at the cold limb. The kinetics of dissolution and the pa-

rameters influencing it have been studied and the results are reviewed. Less is known about the kinetics of the second process. (J.S.R.)

6192 NDA-084-3

Nuclear Development Corp. of America, White Plains, N. Y.

SDR PROJECT QUARTERLY TECHNICAL PROGRESS REPORT FOR THE PERIOD AUGUST 1, 1957 THROUGH OCTOBER 31, 1957. Dec. 31, 1957. 52p. Contract AT(30-3)-256. \$7.80(ph OTS); \$3.30(mf OTS).

Engineering design and experimental studies have been continued, with the objective of demonstrating the feasibility of separating Na and D_2O in the Sodium Deuterium Reactor (SDR). Fabrication methods for manufacturing SDR fuel-coolant tubes were examined; there is every indication that the design is feasible, and a good possibility that the tube can be formed in one piece, without welds. D_2O calandria design was backed up by visits to Chalk River and Savannah River. A modified barrier arrangement has been studied and will be evaluated further. A Na leak detection system has been outlined. Detailed design is proceeding on both static and fatigue rigs for testing the mechanical integrity of fuel-coolant tube and header joints. Screening tests on barrier materials were essentially completed, using the single-failure test apparatus at the NDA Pawling Laboratory. Results on Al were especially encouraging; two samples of 0.060-in. thick Al were exposed to a jet of 950°F Na for more than 16 hr, and both survived. Design work has been completed, and fabrication is now proceeding, on the multiple-failure test apparatus, in which both H_2O and Na system failures can be simulated at the same time. Detailed design is progressing on the mock-up test, which consists of three fuel-coolant tubes and associated barriers in a tank of water; this test will be used to demonstrate the reliability of integrated Na and H_2O circulating systems under simulated reactor operating conditions. Additional analysis was done on the straight-through configuration, for two types of fuel elements—a U-Mo alloy, and UO_2 . An alternative design concept, based on a slab configuration, was also studied; the slab design has some potential maintenance and safety advantages as compared with the calandria (or lattice) configuration. Shielding studies continued to concentrate on after-shutdown radiation levels in the header rooms. (For preceding period see NDA-84-2.) (auth)

6373

REMOVAL OF HEAT EXCHANGE MEDIUM FROM HEAT EXCHANGE SYSTEMS. A. Bell (to Foster Wheeler Ltd.). British Patent 782, 943. Nuclear Eng. 3, No. 23, 90 (1958) Feb.

The removal of residual metal from systems in which, e.g., sodium or a sodium/potassium alloy is circulated as heat exchange medium is discussed. When the bulk of the metal has been drained off (after a shutdown of the system) small amounts of metal will be left in pockets and crevices. The system is freed from these last traces by passing dry heated steam under low pressure through the circuit while maintaining the temperature above the melting point of the metal and above the condensation temperature of the steam. The steam reacts with the metal to form hydrogen (vented out) and metallic oxide to be dissolved in and washed out by water.

6596

MASS TRANSFER IN LIQUID METAL SYSTEMS. 2. ISOTHERMAL TRANSFER. J. W. Taylor (Babcock & Wilcox,

Ltd.) and A. G. Ward (Atomic Energy Research Establishment, Harwell, Berks, Eng.). *Nuclear Power* 3, 101-5 (1958) Mar.

Isothermal mass transfer is a second type of transfer process in liquid metals, the other being thermal-gradient transfer. In general it involves the transfer of a component from a source via a liquid metal solution to a reaction site usually near a second component, the driving force for the transfer being a free energy change of reaction; the solubility of the transferring in the liquid metal need only be very slight. The form of the reaction product and its location depend upon the phase relationships between the transferring component and the reactant, and between the latter and the liquid metal. The kinetics of the transfer is complex and is influenced by such factors as system geometry, form of reaction product, and source of transferring component. Surface films may seriously influence the transfer in so far as they may affect the source of the transferring component and also the reaction stage. (auth)

6910

ANGULAR DISTRIBUTION OF NEUTRONS SCATTERED BY THE 2.80-keV RESONANCE IN SODIUM. R. C. Block (Oak Ridge National Lab., Tenn.). *Phys. Rev.* 109, 1217-18 (1958) Feb. 15.

The angular distribution of neutrons scattered by the 2.80-keV resonance in sodium has been measured with a pile beam and various combinations of boron and sodium filters. This distribution is found to be isotropic to within 10%. (auth)

6993

METHOD FOR REMOVING SODIUM OXIDE FROM LIQUID SODIUM. W. H. Bruggeman and B. G. Voorhees (to U. S. Atomic Energy Commission). U. S. Patent 2,815,277. Dec. 3, 1957.

A method is described for removing sodium oxide from a fluent stream of liquid sodium by coldtrapping the sodium oxide. Apparatus utilizing this method is disclosed in United States Patent No. 2,745,552. Sodium will remain in a molten state at temperatures below that at which sodium oxide will crystallize out and form solid deposits, therefore, the contaminated stream of sodium is cooled to a temperature at which the solubility of sodium oxide in sodium is substantially decreased. Thereafter the stream of sodium is passed through a bed of stainless steel wool maintained at a temperature below that of the stream. The stream is kept in contact with the wool until the sodium oxide is removed by crystal growth on the wool, then the stream is reheated and returned to the system. This method is useful in purifying reactor coolants where the sodium oxide would otherwise deposit out on the walls and eventually plug the coolant tubes.

7123

IDO-28000

Aerojet General Corp., Azusa, Calif.

THE REACTION OF METALS WITH WATER AND OXIDIZING GASES AT HIGH TEMPERATURES. H. M. Higgins and R. D. Schultz. Apr. 30, 1957. 116p. Contract AT(04-3)-44. \$0.60(OTS).

The molten metals, zirconium, Zircaloy-2, aluminum, uranium, sodium-potassium alloy, and stainless steel, were sprayed into water. The Aerojet Explosion Dynamometer was used in these tests to permit the measurement of explosive power, reaction time, reaction efficiency, and the effects of temperature and droplet size. It was shown that the percentage of reaction depends primarily on the particle size and on the temperature of the metal. It

was found that the reactivity of molten aluminum is nil at temperatures up to 1170°C. At temperatures above 1170°C, the reaction becomes increasingly more complete. At a temperature of 2200°C, aluminum was found to be a more powerful reactant than zirconium. Stainless steel was slightly less powerful than zirconium under these conditions. (auth)

7491

MATERIAL AND CORROSION PROBLEMS IN A REACTOR WITH LIQUID METALS AS COOLANT. Willibald Machu (Universität Cairo). *Atomkern-Energie* 3, 97-100 (1958) Mar. (In German)

The first part of a series on material and corrosion problems in a liquid metal cooled reactor is presented. The behavior of different materials in liquid sodium and calcium is discussed. (S.R.)

7792

HEAT TRANSFER IN LIQUID METALS. P. S. Lykoudis and Y. S. Touloukian (Purdue Univ., Lafayette, Ind.). *Trans. Am. Soc. Mech. Engrs.* 80, 653-66 (1958) Apr.

The problem of heat transfer in liquid metals is studied for the case of a fully developed turbulent flow in cylindrical pipes of constant diameter, the fluid under consideration being heated (or cooled) by a constant and uniform heat input at the wall. In the analysis, the similarity theory between heat and momentum transfer is used. A theory is presented which gives the ratio of eddy diffusivities for heat and momentum transfer as a function of the Prandtl modulus. It is shown that heat transfer in liquid metals can be analyzed universally in terms of a dimensionless parameter called the "generalized Peclet modulus" and defined by the relation $N_{Pr}^* = (N_{Re}^*)(N_{Pr}^*) = [N_{Re}(f/2)](N_{Pr}\sigma)$. Temperature profiles are presented and the limiting cases for $N_{Pr} = 0$ are studied. (auth)

7806

BW-3792

Babcock and Wilcox Co. Research Center, Alliance, Ohio. THE CORROSION TESTING OF VARIOUS MATERIALS IN SODIUM. W. Markert, Jr. Aug. 4, 1954. 31p. \$4.80 (ph OTS); \$2.70(mf OTS).

These tests were conducted to determine the corrosion resistance of various structural materials to liquid sodium at a temperature of 1100°F and to determine if the materials are satisfactory for use in a reactor power plant. Three separate tests were conducted using a modified enclosed rotor pump corrosion apparatus with sodium at 1100°F and with the specimens at an absolute velocity of 55 ft/sec and static. The materials investigated were a group of 300 series stainless steels, Croloys, nickel alloys, Zircaloy 2, carbon steel, Globeiron, and modified Globeiron. The Globeiron materials were essentially extra low carbon iron to which various alloy materials had been added in two cases. (auth)

7807

BW-3988

Babcock and Wilcox Co. Research Center, Alliance, Ohio. INVESTIGATION OF THE CORROSION AND MASS TRANSPORT RESISTANCE OF STRUCTURAL MATERIALS TO LIQUID SODIUM. PART I. R. F. Dudek. PART II. K. Mildred Ferguson. Apr. 23, 1957. 41p. \$7.80(ph OTS); \$3.30(mf OTS).

These tests were conducted to determine the corrosion and mass transport resistance of various structural materials to liquid sodium in a dynamic test loop operating at a temperature differential. (auth)

7808 BW-7020

Babcock and Wilcox Co. Research Center, Alliance, Ohio. THE CORROSION TESTING OF VARIOUS MATERIALS IN SODIUM. PART I. R. F. Dudek. PART II. K. Mildred Ferguson. Apr. 26, 1957. 39p. \$6.30(ph OTS); \$3.00(mf OTS).

These tests were conducted to determine the corrosion resistance of various materials to liquid sodium at a temperature of 1100°F. Four separate tests were conducted using a modified enclosed-rotor pump corrosion apparatus with sodium at 1100°F and with the specimens at an absolute velocity of 55 ft/sec and static. The materials tested were a group of 300 and 400 series stainless alloys, low Croloys, carbon steel, nickel alloys, zirconium, and Lukens-clad stainless steels. Oxygen was controlled by the use of a diffusion-type cold trap for three of the four tests. A flow-through cold trap was used for the fourth test. The measurement of the oxygen content was made both chemically and by the use of a plugging indicator. After test, the specimens were subjected to metallographic investigation. (auth)

7809 BW-7050

Babcock and Wilcox Co. Research Center, Alliance, Ohio. METALLURGICAL INVESTIGATION OF FUEL ELEMENT PINS TESTED IN LIQUID SODIUM. K. Mildred Ferguson. [1957?]. 33p. \$6.30(ph OTS); \$3.00(mf OTS).

Of the pins tested for corrosion resistance in sodium, the most promising ones were those with a swaged end cap. Although the pins swaged to a point appeared good visually, they contained deep folds vulnerable to marked attack. Pins capped by two methods obviously are unsatisfactory; the screw-cap mechanism and the countersunk cap locked by pressure both permit free circulation of sodium to the core alloy. The countersunk and welded method would be improved by a closer fit between cap and pin. Corrosion resistance of the pins capped by the resistance-welded method is determined by the pressure or absence of mechanical defects produced by welding. All zirconium surfaces in contact with freely circulating sodium developed the hard and brittle surface layer attributed to the absorption of oxygen into solid solution. All exposed core alloys oxidized during test. It has been proven that the formation of the hard and brittle surface layer on zirconium exposed to sodium is not related to the frequently observed mechanically deformed surface layer. Its formation is independent of prior surface condition. (auth)

7833 BMI-1035(Del.)

Battelle Memorial Inst., Columbus, Ohio. PROGRESS REPORT FOR AUGUST 1955. Russell W. Dayton and Clyde R. Tipton, Jr. Sept. 1, 1955. Decl. with deletions June 18, 1957. 114p. Contract W-7405-eng-92. \$18.30(ph OTS); \$6.00(mf OTS).

Progress is reported on the following investigations: fuel-element end closures; effects of milling time on preparation of active UO_2 from UO_3 ; ignition reaction pressures of H_2 - O_2 mixtures; corrosion loop studies with F^- and NaOH ; corrosion of Mo in liquid NaK; cladding of Nb with Inconel; tensile and creep properties of Zr and Zircaloy; corrosion resistance of stainless alloys; hydration of UO_3 ; electrical and magnetic properties of UO_2 ; development of refractory fuel elements from BeO , MoSi_2 , or graphite; casting, rolling, and forging of Al-Cr-Fe alloys; hardness testing of Nb alloys; powder-metallurgy studies of Nb; fabrication of UO_2 -containing BeO tubes; preparation and properties of low-melting U alloys; mechanism of U corrosion; corrosion of Zr and U-Zr and

Sn-Zr alloys; mechanical properties of heat-treated Zr alloys; development of porcelain-enamel coatings for Zr; heat treatment of U-Zr alloys; and hydridization of Zr and Zr alloys. (C.W.H.)

8049 AECU-3656

Knolls Atomic Power Lab., Schenectady, N. Y. THE EFFECT OF NITROGEN-COVERED-SODIUM ON S2G STRUCTURAL MATERIALS. G. C. Wheeler. Mar. 21, 1957. 23p. Contract [W-31-109-Eng-52]. \$4.80(ph OTS); \$2.70(mf OTS).

Tests were made to determine the effects on structural materials of using nitrogen as a cover gas for the liquid sodium in the S2G system. Various materials including beryllium, 18-4-1 tool steel, and 347 stainless steel were exposed to N_2 -covered Na, both flowing and static, at temperatures of 600 to 1100°F. The effects of several variables, including temperature, irradiation and sodium flow rate, were investigated. The effects on the specimens were monitored by weight and dimensional changes, metallographic and x-ray examinations, and mechanical tests. Many of the materials, including beryllium, tool steel and stainless steel were found to nitride. The nitrides of stainless steel and tool steel form an adherent "case" on the metal surface, but are more readily corroded than their parent metals. Thus, in flowing Na no case is formed except on protected portions of the metal surface, while in static Na a case is formed which increases in thickness with increasing time. In flowing Na the mutually competing reactions of case formation and corrosion, plus solubility of N_2 in the metals, make the weight changes unreliable as indices of metal loss, even for beryllium, whose nitride is in adherent. Consequently, directly-measured metal losses must be used to follow the reaction rates in flowing sodium. The effects of sodium-produced nitride cases on mechanical properties of stainless steel specimens were studied by tensile, stress-rupture, internal-pressure stress-rupture, and strain-fatigue tests at various temperatures. At temperatures up to at least 850°F, the strength, ductility, and strain fatigue resistance of nitrated specimens are markedly lower than those of unnitrated specimens. The observed changes in ductility and fatigue strength result from the brittleness of the case, and the consequent production of surface cracks in the specimens at relatively low strains. (auth)

8155

NEUTRON RESONANCES IN THE kev REGION: DIFFERENTIAL SCATTERING CROSS SECTIONS. Robert C. Block, Willy Haeberli, and Henry W. Newson (Duke Univ., Durham, N. C.). Phys. Rev. 109, 1620-31(1958) Mar. 1.

The ratio of the differential elastic neutron scattering cross sections for scattering by 180° and 90°, $R = \sigma_{\text{nn}}(180^\circ)/\sigma_{\text{nn}}(90^\circ)$, has been measured as a function of neutron energy between approximately 30 and 110 kev for F, Na, Mg, Al, K, V, Cr, Cu, Zn, As, Se, Sr, Zr, Nb, Mo, Ag, and Cd. When plotted against atomic weight, the average ratios $\bar{R}$ (averaged over the energy range of each element) exhibit peaks at $A \approx 90$ and $A \approx 25$, in qualitative agreement with the predictions of the complex square well potential model of the nucleus. However, the experimental ratios are in general larger than those predicted by the theory. Scattering from the lighter elements was also analyzed by single-level resonance theory and resulted in the following assignments: resonance in Al at 88 kev, $J = 3^+$; Mg (85 kev), $3/2^-$; Na (53 kev), 3^- ; F (99 kev), 1^- ; F (49 kev), 1^- ; F (27 kev), 1^- or 2^- . These assignments are in good agreement with those obtained from the latest transmission measurements. (auth)

8421 NAA-SR-74(Del.)

North American Aviation, Inc., Downey, Calif.
CYCLOTRON IRRADIATION OF TYPE 347 STAINLESS
STEEL WELDS IN NaK AT ELEVATED TEMPERATURES.
A. A. Epp, Jr., R. D. Moeller, and H. Pearlman. Jan. 7,
1953. Decl. with deletions 4/11/57. 42p. Contract AT-
11-1-GEN-8. \$7.80(ph OTS); \$3.30(mf OTS).

Capsules of type 347 stainless steel, containing samples of arc welded 347 immersed in NaK of 78 weight-per cent K, were irradiated with deuterons on the 60 inch cyclotron at Berkeley while maintained near 450°C. Power densities ranging from 2500 to 5000 watts/cm³ were achieved in the weld samples near the NaK interface. The irradiations were between 10 and 20 hours in length, at average beam currents from 1.5 to 3 micro-amperes. Control runs in which the capsules were heated, but not irradiated, and in which a weld sample was irradiated in an evacuated capsule, were also made. No conclusive evidence was obtained that weld corrosion was accelerated in the irradiated runs, compared with unirradiated controls. In addition to weighing the samples, examining them metallographically for evidence of corrosion and analyzing the NaK chemically after the runs, observations were also made of surface hardness, grain size and x-ray-diffraction patterns of the weld samples. No significant differences were found between the irradiated and control samples. (auth)

8560 IGR-R/CA-255

United Kingdom Atomic Energy Authority. Industrial
Group. Capenhurst Works, Capenhurst, Ches., England.
MEASUREMENT OF LIQUID-METAL LEVELS BY THE
EFFECT OF EDDY CURRENTS ON AN INDUCTANCE.
D. F. Davidson. Dec. 1957. 10p.

Remote-reading liquid-metal level indicators were developed for the proposed sodium-cooled test loop in the Dounreay materials testing reactor. The principle used is the effect of eddy currents on the inductance of a coil. The coil is made in the form of a probe which is inserted in a vertical stainless steel pocket in the tank. Tests were made in a test rig, using liquid metals, to prove the instruments and to provide calibration curves. An approximately linear scale is obtained for an instrument in a tank 6 in. deep, but the instrument for a 3-in. tank needs a calibration. A standardizing facility allows for changes in the electronic circuits and enables a simple correction to be applied for temperature changes. A search probe was constructed to assist in the tests. It may prove to be a valuable instrument in some applications, since it is self-calibrating and independent of temperature. (auth)

9038

THE DETERMINATION OF THE OXYGEN CONTENT OF
SODIUM METAL BY THE BUTYL BROMIDE METHOD.
L. E. Smythe and H. J. de Bruin (Australian Atomic Energy
Commission, Sutherland, N. S. W.). 242-4(1958) Apr.

An accurate acidimetric end point detection, required for micro determination of oxygen in sodium metal by the butyl bromide method, is described. (J.R.D.)

9134 AEC-tr-3200

ELECTROMAGNETIC PUMPS WITHOUT MOVING PARTS
FOR THE CONDUCTION OF LIQUID METALS. (Über
Elektromagnetische Pumpen ohne bewegte Teile zur
Förderung flüssiger Metalle). Julius Steiner and Hans
Hohn. Translated from *Chem.-Ing.-Tech.* 28, 405-10(1956).
26p.

Structure and method of operation of electromagnetic direct current pumps are briefly described, and the theo-

retical relationships and problems of economy are discussed. Results are given for several direct-current pumps with permanent magnets and pump bodies of synthetics for the conduction of mercury. (auth)

9135

THE ELECTROMAGNETIC PUMPING OF LIQUID
METALS. 2. J. A. S. Hilditch (British Thomson-Houston
Co., Ltd., Rugby, Eng.). *Atomics and Nuclear Energy* 9,
125-7(1958) Apr.

In the second part of a series on electromagnetic pumping of liquid metals, the design and characteristics of the a-c conduction pump and the induction pump are discussed. Possible future developments in the pumping of liquid metals are described. (J.S.R.)

9147 NDA-084-4

Nuclear Development Corp. of America, White Plains,
N. Y.

RESISTANCE OF BARRIER MATERIALS TO SODIUM JET
IMPINGEMENT. Feb. 26, 1958. 48p. Contract AT(30-
3)-256. \$7.80(ph OTS); \$3.30(mf OTS).

Preliminary screening tests were made with several materials to provide an index of their suitability as barrier materials for use in the SDR. The tests were made by directing a jet of sodium through a 3/32-in. diameter nozzle at uncooled 2 in. by 2 in. plate specimens; the sodium jet conditions included temperatures from 950 to 1140°F, velocities up to 50 fps, and impingement times ranging from 15 min to 18 hr. A summary of tests made and their results is presented. It was found that aluminum performed well in these tests. No failure of samples having practical thicknesses occurred at 950°F in tests which ranged up to 18 hr. Failure was finally effected at 950°F with a 5-mil aluminum sample. It was found that 0.060 in. aluminum plate also performed well at 1050°F; the maximum test time at this temperature was 3 1/2 hr. One sample was tested at 1140°F and lasted for the length of the test (15 min), but one sample tested at 1100°F failed after 3 hr. (The maximum sodium temperature expected in the SDR is 1025°F.) Zirconium and steel performed well, as was expected. While graphites in general performed poorly, AGOT-type (reactor grade) performed well enough to indicate that it may be developed into a suitable high-temperature barrier. (auth)

9444 TID-7546(p.565-87)

Atomics International [Div., North American Aviation,
Inc.], Canoga Park, Calif.
CORROSION OF URANIUM, THORIUM, AND URANIUM
ALLOYS IN SODIUM AND ORGANICS. Harry Pearlman.
p.565-87 [of] FUEL ELEMENTS CONFERENCE, PARIS,
NOVEMBER 18-23, 1957. 23p. (NAA-SR-Memo-2169).

Sodium and sodium-potassium alloys and the polyphenyl class of organic compounds possess certain advantages over water for use as reactor coolants. There are no reactions between uranium and the pure liquid metals; but thermodynamic data predict that formation of uranium carbide and uranium hydride is possible in reactions with organics and with their pyrolytic and radiolytic products. Available experimental data are reviewed for uranium and uranium alloys exposed both to sodium and sodium-potassium alloys in static and dynamic systems. Effects of irradiation on corrosion rate do not appear to be significant. The observed corrosion rate of uranium and uranium alloys depends very strongly on the impurity, especially oxygen, content of the liquid metal. In capsule type static corrosion experiments, made with liquid metal with oxygen content near 0.01 wt. % (100 ppm), corrosion rates are of

the order of 10 mg/cm²-month at temperatures up to 750°C. UO₂ and UO have been identified as corrosion products. In dynamic systems, corrosion rates of more than 600 mg/cm²-month have been observed at 500°C, with oxygen content ranging near 0.005 wt. % (50 ppm). Corrosion rates of uranium and uranium alloys in purified biphenyl are of the order of 1 mg/cm²-month at temperatures up to 400°C in static systems. Under dynamic conditions in loop experiments, rates are perhaps five times greater. Formation of UC, through UH₃ as an inferred intermediary, has been observed in monoisopropyl biphenyl under hydrogen gas pressures of the order of 100 psi. Impurities dissolved in the organic, such as air, oxygen, or water, greatly accelerate the corrosion rate. It is concluded that the corrosion rate of uranium and its alloys in liquid sodium and NaK is low enough to permit the use of a static liquid metal bond between the fuel and a cladding of some other metal. Exposure of relatively large surfaces of fuel to circulating liquid metal coolant appears not feasible, because of the difficulty of adequate control of oxygen in a large volume liquid metal system. There would be no advantage in reactor performance in direct exposure of unclad fuel to an organic coolant; but, in case of accidental exposure by way of a cladding failure, the corrosive attack would be relatively very slow. (auth)

10076 NDA-2084-5

Nuclear Development Corp. of America, White Plains, N. Y.

SDR PROJECT QUARTERLY TECHNICAL PROGRESS REPORT FOR THE PERIOD NOVEMBER 1, 1957 THROUGH JANUARY 31, 1958. Mar. 31, 1958. 60p. Contract AT(30-3)-256. \$9.30(ph OTS); \$3.60(mf OTS).

Engineering studies have continued on the through-tube reactor design. Full-scale drawings showing the units in a complete lattice position were prepared. A bellows assembly has been added to each calandria tube to accommodate possible thermal stresses. Design of the barrier system now includes a second barrier tube between the stainless steel barrier and the calandria tube. The heat loss from the sodium in the fuel tubes to the D₂O in the calandria is calculated to be less than 0.3 Mw. Studies completed during the quarter indicate that sodium-water reactions do not inherently limit the feasibility of the SDR. A careful review of the literature has shown that sodium-water systems can be designed for safety against a reaction between the two fluids. Adherence to basic safety design rules prevents shock wave formation and high temperature peaks. Adequate surge volume, low system pressures, inert gas blanketing, and oxygen exclusion are the most important of these rules. Fabrication and assembly of the apparatus for the fuel-coolant tube and header test program is nearing completion. Single-failure barrier tests were performed, using higher sodium temperatures, on six specimens of type 1100 aluminum (2S). The feasibility of using aluminum as a barrier material against hot sodium has been demonstrated. Apparatus for the multiple-failure barrier tests was installed, and a test program has been established. Detail design of the mockup test apparatus was completed. Fabrication and assembly of the apparatus at the test site is nearing completion. A test program was established which is directed at demonstrating the ability to handle sodium and water under simulated reactor temperature conditions. General studies included an investigation of reactor maintenance techniques, fuel element studies, and reactor control and core physics calculations. It was tentatively concluded that a U-10 wt. % Mo alloy is satisfactory for a slightly enriched SDR and that UO₂ is

satisfactory for both a natural uranium and a slightly enriched SDR. Results of a series of two-group reactor criticality calculations indicate that a 6/1 fuel channel to control rod arrangement is satisfactory for the present design (~120 fuel tubes). A brief study was made of the advantages and disadvantages of incorporating some of the desirable features of the slab design into the present calandria design. Shielding studies were concentrated on the design requirements for the thermal shield and the bulk shield between the reactor and header rooms. Preliminary design flow sheets for the D₂O cover gas, sodium cover gas, and barrier gas systems were prepared. (For preceding period see NDA 084-3.) (auth)

10343

SODIUM-POTASSIUM ALLOY. AN EXPERIMENTAL STUDY OF ITS HAZARDS. Asher J. Finkel and Willard B. Lyons (Argonne National Lab., Lemont, Ill.). *Arch. Ind. Health* 17, 624-33(1958) June.

The thermal, chemical, and radiation hazards of liquid sodium-potassium alloy (NaK) have been reviewed and the nature of the therapeutic problems has been evaluated. Experiments with an artificial indicator system were performed in a study of the penetration of test films by NaK. In the light of these investigations it is suggested that 1.0 to 2.5% stearic acid in light mineral oil may be effective in retarding the reactivity of the NaK with water on and in the skin. Skin and hair covered with NaK or sodium metal should be flooded with the oil preparation and the alkali metal brushed or gently scraped off with a metal spatula. Disposal of the alkali metal should be accomplished by allowing it to react with butyl alcohol. The use of water should be avoided until the alkali metal is removed from the surface of the body. Appropriate surface active agents added to the mineral oil may enhance its control over NaK reactivity. (auth)

10388 IGO-AM/CA-110

United Kingdom Atomic Energy Authority. Industrial Group. Capenhurst Works, Capenhurst, Ches., England.

THE ANALYSIS OF SODIUM METAL AND SODIUM-POTASSIUM ALLOY (COLLECTED CAPENHURST METHODS). Mar. 1958. 59p.

Various methods for the sampling of sodium or sodium-potassium alloys from storage drums or similar containers are outlined. A sample is withdrawn from the bulk storage container by means of a suction pump. The whole operation is carried out under an atmosphere of nitrogen. Associated apparatus and experimental procedures are included. (L.T.W.)

10593

CORROSION SCREENING OF COMPONENT MATERIALS FOR NaK HEAT EXCHANGE SYSTEMS. Presented at Nuclear Engineering and Science Conference, held at Chicago, March 17 to 21, 1958. Preprint 24, Session 23. Samuel J. Basham, John H. Stang, and Eugene M. Simons (Battelle Memorial Inst., Columbus, Ohio). New York, American Institute of Chemical Engineers, 1958. 26p.

Sixty-one materials which might be useful for special components, such as valve-seat inserts, valve plugs, shaft-seal facings, and bearings, in high-temperature NaK flow systems were screened in tilting-furnace corrosion experiments. These include high-temperature alloys, pure metals, cermets, and ceramics. The

standard test consisted of confining a specimen to the hot end of a sealed Inconel X capsule partially filled with NaK and exposing the capsule for 110 hr (5000 cycles) in a tilting furnace. The hot end of the capsule was controlled at 1600 F, while the cold end was 1200 F. Post-test corrosion evaluations were based on metallographic examinations of the specimen weight-change measurements, capsule-wall examinations, and specimen surface-roughness changes. The materials were divided into three classes according to corrosion resistance: Class I (most promising)—attacked to a depth of 1 mil or less; Class II (marginal)—attacked to a depth of 1 to 4 mils; Class III (unsuitable)—attacked to a depth greater than 4 mils. (auth)

10637

THERMODYNAMICAL SIMILARITY AND THE VISCOSITY OF FUSED METALS. A. N. Solov'yev. *Atomnaya Energiya* 3, 550-2(1957).

An attempt was made to find a relationship between the thermodynamic and physical properties of a number of elements. The viscosity of fused Na, K, Li, Ru, Cs, Sn, Hg, Sb, Bi, and Ga was plotted against temperature. The curves fell into two groups, one for the alkali metals and the other for the rest of the metals. The hypothesis is made that the physical properties of similar metals could be deduced if the physical properties of one were accurately known. (J.S.R.)

11414

HIGH TEMPERATURE MECHANICAL "CANNED MOTOR" LIQUID METAL PUMPS. Presented at Nuclear Engineering and Science Conference, held at Chicago, March 17 to 21, 1958. Preprint 76, Session 2. Oliver P. Steele, III (Westinghouse Electric Corp., Cheswick, Penna.). New York, American Institute of Chemical Engineers, 1958. 18p.

Studies of certain type nuclear power plants to employ superheated steam has placed emphasis on sodium and sodium-potassium alloys as high-temperature heat transfer mediums. After careful consideration of all various pumping problems for handling these materials, a mechanical "canned motor" pump was considered to have the greatest success potential. The design problems and their solutions are outlined. Pumps of this type have already been produced in sizes to 700 horsepower and for stream temperatures to 1500°F. (auth)

12178 TID-7551(p.133-9)

Harvard [Univ.], Boston. School of Public Health. **PROGRESS REPORT ON FILTRATION OF A FRESHLY GENERATED NaK FUME.** Edward Kristal, Richard Dennis, and Leslie Silverman. p.133-9 [of] FIFTH ATOMIC ENERGY COMMISSION AIR CLEANING CONFERENCE HELD AT HARVARD AIR CLEANING LABORATORY, JUNE 24-27, 1957. 7p.

Absolute filters, high-efficiency roughing filter, combination of the two, slag wool filter, curled glass fiber filter, curled Saran fiber filter, bulk Dynel fiber filter, were tested for filtration of a mixed sodium and potassium oxide fume. The last mentioned material approached the requirements, presenting the following characteristics: air flow, 700 cfm (180 fpm); initial resistance 13.0 in. water; final resistance 15 in. water; efficiency, 90%; fume holding capacity, 0.5 lb. for a 24 x 24 x 24-in. filter. (T.R.H.)

12435

MOLECULAR STRUCTURE AND VISCOSITY OF LIQUID METALS AND ALLOYS. A. Z. Golik. *Nauk Zapiski Kiev. Inst.* 14, No. 8, 159-69(1956). (Translated from: *Referat. Zhur. Fiz.* No. 3, 1957, Abstract No. 6396.)

12532

HIGH TEMPERATURE PRESSURE MEASUREMENT. Presented at Nuclear Engineering and Science Conference, held at Chicago, March 17 to 21, 1958. Preprint 157, Session 15. Robert J. Ingham and R. Clark DuBois (Manning, Maxwell, and Moore, Inc., Stratford, Conn.). New York, American Institute of Chemical Engineers, 1958. 27p.

A NaK filled diaphragm seal assembly has been developed which can be used up to 1500°F to measure pressure in liquid metal systems. The pressure can be shown on an indicating gauge connected by a suitable length of capillary to the seal. Both pneumatic and electric transmitters can be provided. Units have been made of several materials and with ranges of 0 to 100 to 0 to 400 psi. Minimum material thickness used in contact with the process fluid is 0.025 in., one ply. The change in calibration for temperatures between 70 and 1400°F is approximately 1% of full scale. Extensive testing has indicated good results. (auth)

13081 MSAR-TR-321-12

MSA Research Corp., Callery, Penna. **TEST RESULTS OF LIQUID METAL CLOSED CYCLE COOLANT SYSTEM.** Supplementary Report No. 1. R. C. Andrews and J. R. Betz. Nov. 15, 1957. 23p. (D-143-941-035). For Bell Aircraft Corp.

The test loop consisted of two systems: a NaK loop in which NaK was heated in a gas-fired furnace and pumped through a coil-in-shell evaporator in which the NaK (tube side) transferred its heat to a boiling pool of sodium (shell side). The resultant sodium vapors passed through a sonic flow nozzle, through a radiant condenser, and into a measuring tank. Both systems were complete loops in which electromagnetic pumps supplied the necessary pumping force. Following completion of the test program the NaK system was washed and dismantled and inspected for evidence of corrosion or erosion. (W.L.H.)

13095

HEAT TRANSFER TO LIQUID METALS. S. S. Kutateladze, V. M. Borishanskii, and I. I. Novikov. *Atomnaya Energ.* 4, 422-36(1958) May. (In Russian)

A review is presented of basic research on heat exchange between solid surfaces and flowing liquid metals. Results are given from experiments with long or short tubes having flat apertures; on the longitudinal flow of molten metal over rod bundles or plates; on the transverse flow over cylinders; and on free convection and vapor condensation of liquid metals. Also, problems connected with liquid metal boiling and the effects of quenching on hydraulic resistance and heat exchange are discussed. Formulas for calculations of heat exchange are included. (tr-auth)

13098

HEAT TRANSFER BY MOLTEN METALS. M. A. Mikheyev, V. A. Baum, K. D. Voskresenskiy, and O. S. Fedynskiy. pp. 139-51 in "Reaktorostroyeniye i teoriya reaktorov." Moscow, Izd-vo Akad. Nauk S.S.S.R., 1955.

(Translated from Referat. Zhur. Mekh. No. 11, 1957, p. 72)

Heat transfer by mercury, tin, lead, bismuth, sodium, and bismuth-lead and potassium-sodium alloys was investigated. The flow velocities varied from 0.1 to 20 m/sec, the Reynolds number from 1×10^4 to 6.5×10^5 , the Prandtl number from 4×10^{-3} to 3.2×10^{-2} , and the specific heat flux from 2×10^4 to 1×10^6 kg-cal/m² hr. Criteria for pure and oxidized surfaces based on 600 test points are given. A comparison is made between the test data and existing theories. From an evaluation of a variety of test data a new criterion is proposed in the form of a formula which applies to molten metals as well as to "common" liquids in which the Prandtl number exceeds 0.7. Investigations were also performed on the heat transfer in conditions of natural convection on heated plates and tubes for heavy and alkaline molten metals and their alloys. As a result of the evaluation of the test material, and also from available data on liquids exhibiting low heat conductivity, a single formula for the heat transfer in large volumes, applicable over a wide range of Grashof and Prandtl numbers is offered. The data relative to the hydrodynamic resistance in the flow of liquid metals show that the general formulas of hydrodynamics are applicable. (TCO)

13112 BW-3794

Babcock and Wilcox Co. Research Center, Alliance, Ohio.

THE INVESTIGATION OF CORROSION AND MASS TRANSPORT WITH SODIUM IN A FIGURE-OF-EIGHT CIRCUIT. W. Markert, Jr. Aug. 9, 1954. 20p. \$4.80(ph OTS); \$2.70(mf OTS).

An apparatus for studying corrosion and mass transport under simulated sodium-cooled reactor conditions is described. The operation of the figure-eight loop with sodium on Globeiron specimens is reported. The device met the operation requirements. The Globeiron showed a very slight weight loss, probably from decarburization, and there was no evidence of mass transfer. (T.R.H.)

13481 TID-7553(p.57-71)

[Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.]

SGR COMPONENT DEVELOPMENT TECHNOLOGY. R. W. Dickinson. p.57-71 [of] PROCEEDINGS OF THE SRE-OMRE FORUM HELD AT LOS ANGELES, CALIFORNIA, FEBRUARY 12 AND 13, 1958. 15p. (NAA-SR-2600(p.57-71)).

Specific examples of developments in pumps, valve configurations, and cold traps are noted. Experience with SRE leading to the development of these designs is discussed. Studies of alternate materials of construction for SGR systems are covered, with a brief summary of current results at this and other laboratories; prospects for the use of low-alloy steels are particularly noted. The status of sodium-heated steam generators is reviewed, and preliminary results from the operation of the "once through" steam generator as they affect the heat transfer system are noted. Developments in the method of cleaning sodium-filled cavities are discussed, noting an unusual procedure which has proved satisfactory in preliminary tests. Experiments in progress to determine the necessity for extensive cleaning procedures in sodium system construction are covered. A brief review of experiments under construction or planned for the immediate future is made. (auth)

13643 NP-6829(Sect. 1)

Australia. Atomic Energy Commission.

MATERIALS. Sect. 1 [of] SYMPOSIUM ON THE PEACEFUL USES OF ATOMIC ENERGY IN AUSTRALIA, 1958, HELD IN SYDNEY IN JUNE 1958. 107p., 2 illus.

The environments of the known uranium occurrences in South Australia are described, and the relation of uranium mineralization with sodic granitic rocks is emphasized. The problems in designing equipment for radiometric prospecting are reviewed. The fabrication and properties of BeO, UO₂, ThO₂, and mixed oxides are discussed. The use of pulsing in a uranium extraction pilot plant ion exchange column is described. The wetting of metals by liquid metals is reviewed with emphasis on liquid sodium. The geological nature, extent, and future prospects of minerals with atomic energy applications, occurring in New South Wales are outlined. The development of a process for uranium recovery from Mary Kathleen ores is described. Techniques and processes involved in locating, mining, and concentrating davidite-type ores at Radium Hill, South Australia are described. The uranium deposits of the Northern Territory, Australia, are classified and described. The flotation behavior of the simple oxide minerals, uraninite and the colloform variety is discussed. The Port Pirie Treatment Plant for uranium recovery from refractory Radium Hill concentrates is described. The plant utilizes the sulfuric acid-ion exchange process. The uranium deposits of Queensland are described. The details of the production of uranium ore concentrates at Rum Jungle near Darwin, Australia, are given. A brief account of the use of neutron diffraction analysis in crystallography is given, and the neutron spectrometers installed on the High Flux Australian Research Reactor are described. (T.R.H.)

13889 TID-3305(Suppl. 1)

Technical Information Service Extension, AEC.

HEAT TRANSFER AND FLUID FLOW: A BIBLIOGRAPHY OF SELECTED REPORT LITERATURE.

James M. Jacobs, comp. June 1958. 435p. \$6.00 (OTS).

A total of 2519 annotated references to the unclassified report literature is presented. Subjects covered under heat transfer and fluid flow include radioinduced heating, boiling, boilers, evaporators, pumps, heat exchangers, hydrodynamics, coolants and their properties, thermal and flow instrumentation, high-temperature materials, thermal properties of materials, and thermal insulation. Subjects covered less completely include thermodynamics, aerodynamics, high-temperature corrosion, corrosion specific to heat transfer systems, erosion, mass transfer, corrosion film formation and effects, coolant processing and radioactivity, radiation effects of heat transfer materials, and pertinent data of thermonuclear processes. Subject, report number, and author indexes are given. (auth)

13908 CF-54-8-234

Oak Ridge School of Reactor Technology, Tenn.

SUMMARY OF HIGH TEMPERATURE LIQUID METAL, FUSED SALT PUMP DEVELOPMENT WORK IN THE ORNL-ANP PROJECT FOR THE PERIOD JULY 1950-JANUARY 1954. Edsel S. Farris, comp. Aug. 1954. Decl. Nov. 15, 1957. 98p. \$15.30(ph OTS); \$5.40(mf OTS).

All of the information available on high-temperature pumps originally reported in the ANP quarterly reports

is summarized. The development program was more of a seal development than a specific pump program. Frozen seals of various kinds were tried and for many commercial applications would be perfectly satisfactory. For application in a system such as the ARE, operation of the frozen seal pump is questionable. A gas-sealed pump was developed and is expected to be entirely adequate for a system like the ARE. (W.L.H.)

14004

MAGNETIC SUSCEPTIBILITY OF ALKALI ELEMENTS. PART II. LIQUID ALLOYS OF SODIUM AND POTASSIUM. K. Venkateswarlu and S. Sriraman (Annamalai Univ., Annamalaiagar, South India). *Z. Naturforsch.* 13a, 455-8(1958) June.

Alloys of sodium and potassium were prepared in vacuum in a specially blown pyrex glass apparatus. Several bulbs containing these alloys of different compositions have been studied at temperatures ranging from 30 to 250°C. The compositions of these alloys have been determined by gravimetric method. The results show that for the alloys of all compositions the additivity law is obeyed both at room temperature and at higher temperatures. No evidence for the formation of the compound Na₂K could be detected from the magnetic study. (auth)

15501 NDA-84-9

Nuclear Development Corp. of America, White Plains, N. Y.

EFFECTS OF SODIUM AND WATER LEAKS ON EXPERIMENTAL SDR BARRIERS. C. Bolta and J. O'Neill. Aug. 15, 1958. 45p. Contract AT(30-3)-256. \$7.80 (ph OTS); \$3.30(mf OTS).

Tests are described which are part of the experimental program on means of maintaining separation of sodium coolant and heavy water moderator in the SDR. A test section was built to simulate a portion of a fuel coolant tube with its encasing barrier tube assembly and calandria tube. Leaks of sodium and moderator from their containment were simulated by means of sodium and water jets directed against the barrier tube assembly. Double and single-walled barrier assemblies were tested. (auth)

15603

HEAT TRANSFER IN THE CONDENSATION OF METAL VAPORS: MERCURY AND SODIUM UP TO ATMOSPHERIC PRESSURE. Balabhadra Misra and Charles F. Bonilla (Columbia Univ., New York). *Chem. Eng. Progr. Symposium Ser.* 52, No. 18, 7-21(1956).

The condensing heat transfer coefficients of metal vapors were studied. The coefficients for mercury were determined by condensing mercury on cooled vertical copper plated steel, carbon steel, nickel, stainless, and nickel-stainless-carbon steel composite condensers. The coefficients for sodium were determined using a bimetallic nickel-stainless steel condenser. Various calculational methods give results that place Δt across a liquid metal condensate film much higher than indicated by theory, pointing to an unexpected thermal resistance at the solid-liquid interface. (J.R.D.)

15788 IDO-16436

Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.

QUARTERLY PROGRESS REPORT FOR MTR-ETR TECHNICAL BRANCHES. Fourth Quarter-1957.

G. H. Hanson, ed. Mar. 31, 1958. 63p. Contract AT(10-1)-205. \$1.75(OTS).

MTR-ETR Technical Assistance. Since the plutonium material available for a full loading of MTR fuel elements contains an appreciable fraction of Pu²⁴⁰, the resulting decrease in initial reactivity was calculated for nine possible combinations of plutonium contents and Pu²⁴⁰ concentrations. Calculations show that a uniform U²³³ loading employing 155-gram fuel assemblies in the 3 x 9 MTR lattice gives the same charge life as a uniform U²³⁵ loading employing 180-gram fuel assemblies. A complete map of relative thermal neutron flux is reported for an ETR Critical Facility core consisting of 59 fuel assemblies and six withdrawn control rods; the measured excess reactivity with all 16 control rods withdrawn is 9.7%. Two alternate control rod withdrawal programs are possible for ETR operation, and the ETR safety rod shutdown response with both programs was studied. Reactor period measurements show that the worth of the upper portions of the safety rods is significantly greater for the single rod withdrawal program than for the ganged withdrawal. A map of the maximum thermal neutron flux at current ETR operating power of 80 Mw is reported and presents flux information for fuel elements, lattice facilities and the beryllium reflector. **MTR-ETR Developments.** The new cylindrical MTR shim rod magnet was standardized. Four cylindrical magnets are currently in use and are outstanding in their performance; the remaining three rectangular magnets will be replaced as soon as shutdown and maintenance schedules permit. The reactor transfer function of the MTR 20%-enriched-U loading was measured experimentally; the experimental behavior of the loading is essentially the same as the calculated behavior of the 93%-enriched loading. Detailed experimental statistical weight information for both fuel and poison was developed for the ETR core and its experimental facilities; the variation in statistical weight even within the same reactor region is very marked. The stability of the ETR and its associated heat dissipation system is being studied employing a transfer-function analysis; the reactor core transfer function and the feedback transfer function based on thermal effects and transport delays have been developed. RMF measurements with 33 samples from different heats of ETR fuel core material reveals that the boron content varied from 0.05 to 0.58 weight % and U content varied from 14.8 to 16.3 weight %. **Reactor Physics and Engineering.** A generalized IBM 650 program was developed for computing the transport approximations (P_1 and P_3) of the local flux distributions in slab geometry; the routine is written to accommodate three-region problems. An application of this program to a fuel assembly problem reveals that the local flux variation predicted by the P_3 approximation is significantly greater than that predicted by the P_1 approximation. Thorium irradiation calculations show that the ultimate U²³³ content is negligibly affected by cycling for periods of the order of an MTR cycle; therefore, thorium is attractive as a monitoring material because the measured change in reactivity is dependent primarily on the accumulated dosage. A concept and engineering design for a Co⁶⁰ Production Reactor were developed. The primary design objective is set by the requirement that the reactor operating at a nominal power of 60 Mw produces at least 100,000 c annually of Co⁶⁰ having a minimum specific activity of 50 c per g. A square reactor core arrangement having a central hole was selected, and Co⁵⁹ control rods are used. The design employs blankets of relatively low cobalt content for the production of high specific activity material and an outer blanket of high cobalt content to minimize loss of

neutrons from the reactor. The estimated annual Co^{60} production is 3,200,000 c of which 330,000 c have a specific activity between 90 and 125 c per g. A literature search on metal-water reactions and the related subjects of reaction kinetics, explosives, and high-temperature chemistry was continued. *Nuclear Physics*. A large single crystal of magnetite was scanned to determine how it should be cut to make a monochromator suitable for the production of polarized neutrons. In addition to completing the wiring of the 1024-channel analyzer and other improvements into a unified fast chopper system, a 240-counter high efficiency fast chopper detector was added. The automatic sample changer for radioactive samples is in the detailed design stage. Total cross section data for sodium, potassium, strontium, and yttrium were measured. Some preliminary slow neutron measurements with beryllium-filtered neutrons were made with a promising new technique. The sample is attached to a motor-driven rotating arm, and this provides bursts of scattered neutrons with no background of neutrons scattered from the sample between bursts. Time-of-flight measurements were made with an oscilloscope. In the nuclear chemistry program, it was found that the saturated activity $\text{Mo}^{99}/\text{Ag}^{111}$ ratio (peak-to-trough ratio) was larger by $15 \pm 3\%$ for 1.8 ev fission than for thermal fission in U^{235} . The gamma energies and half-lives of Ba^{141} , Ba^{142} , La^{141} , and La^{142} were measured. No Tl^{206} was observed in a mercury sample which had been irradiated with an nvt of 1.1×10^{20} neutrons/cm². A value for α_K of 0.16 ± 0.03 was obtained for the K-shell internal conversion coefficient of 15-min Xe^{135m} (isomer). The beta decay of 4.5-hr Sb^{129} was found to be very complex; ten major gamma-rays with energies between 0.18 and 1.73 Mev were identified. (For preceding period see IDO-16430.) (auth)

15806 NDA-10-110

Nuclear Development Associates, Inc., White Plains, N. Y.

A GRAPHICAL COMPILATION OF SOME NEUTRON CROSS SECTIONS. Norman R. Adolph, comp. Jan. 12, 1954. 14p. \$4.80(ph OTS); \$2.70(mf OTS).

The neutron cross section data used by ORNL in multi-group calculations on the UNIVAC are collected in a convenient graphical form. Absorption, transport, and total cross sections are presented as a function of lethargy for Be, B, D, F, Inconel, Li, Ni, Na, 302 stainless steel, and Zr. (L.T.W.)

16355 BMI-1284

Battelle Memorial Inst., Columbus, Ohio.

CORROSION AND CREEP BEHAVIOR OF TANTALUM IN FLOWING SODIUM. Gilbert E. Raines, C. Vernon Weaver, and John H. Stang. Aug. 21, 1958. 29p. Contract W-7405-eng-92. \$1.00(OTS).

The corrosion behavior of commercial tantalum in high-purity flowing sodium from 700 to 1200°F and the effect of sodium exposure on the creep strength of tantalum at 1200°F were investigated. The tests were conducted in forced-convection flow loops constructed of Type 316 stainless steel. With continuously gettered sodium systems (probably containing less than 10 ppm oxygen) operating for periods up to 50 days, weight losses sustained by 1200°F specimens corresponded to only about 0.1 mil of metal removed per year. Maximum weight losses, encountered with a continuously cold-trapped (about 40 ppm oxygen) sodium system, were equivalent to about 3 mils per year for 1200°F specimens. For the most part, metallographic examinations

revealed no deleterious corrosion effects; however, one particular group of arc-cast tubing specimens suffered severe intergranular attack in sodium with about 80 ppm oxygen. In addition to the corrosion findings, the corrosion tests yielded information about the partition of interstitials, particularly oxygen, in the sodium-tantalum system. Oxygen, for example, showed a tendency for migration from tantalum to high-purity sodium considerably stronger than would be predicted from limited thermodynamic data available. In the creep experiments, the oxygen content of the sodium was maintained at the <10 ppm level by continuous gettering. In general, the results demonstrated that sodium exposure at 1200°F had very little, if any, effect on tantalum creep strength. Baseline data necessary to establish this were obtained in supplementary helium-atmosphere creep tests. (auth)

16401 NRL-Trans-659

ENERGY OF ACTIVATION OF THE VISCOSITY OF MOLTEN ALLOYS. (Aktivací Energie Viskozity Rostavených Slitin.) Antonín Hrbek. Translated for Naval Research Lab., Washington, D. C. from *Hutnické Listy* 11, 715-21(1956). 12p.

The activation energy of alloys and its dependence on the composition of the alloys are discussed. Methods of viscosity calculation for molten alloys at any temperature are presented, and equilibrium diagrams are used to judge the effects of molten admixtures on molten alloys by their influence on the melting point and on the isochoric heat capacity. Calculated viscosity energies for various alloys are tabulated. (J.R.D.)

16492

THE HEATS OF FORMATION AT 25° OF THE CRYSTALLINE HYDRIDES AND DEUTERIDES AND AQUEOUS HYDROXIDES OF LITHIUM, SODIUM AND POTASSIUM. Stuart R. Gunn and LeRoy G. Green (Univ. of California, Livermore). *J. Am. Chem. Soc.* 80, 4782-6(1958) Sept. 20.

The heats of reaction with water have been measured at 25° for lithium, sodium and potassium and for their hydrides and deuterides. The values determined, in kcal./mole, are: $\text{M}(c) + 1001 \text{H}_2\text{O}(l) = \text{MOH} \cdot 1000\text{H}_2\text{O} + \frac{1}{2}\text{H}_2(g)$, $\Delta H^\circ_{\text{Li}} = -53.142 \pm 0.019$, $\Delta H^\circ_{\text{Na}} = -44.069 \pm 0.006$, $\Delta H^\circ_{\text{K}} = -46.900 \pm 0.010$; $\text{MH}(c) + 1001\text{H}_2\text{O}(l) = \text{MOH} \cdot 1000\text{H}_2\text{O} + \text{H}_2(g)$, $\Delta H^\circ_{\text{Li}} = -31.476 \pm 0.018$, $\Delta H^\circ_{\text{Na}} = -30.582 \pm 0.019$, $\Delta H^\circ_{\text{K}} = -33.081 \pm 0.005$; $\text{MD}(c) + 1001\text{H}_2\text{O}(l) = \text{MOH} \cdot 1000\text{H}_2\text{O} + \text{HD}(g)$, $\Delta H^\circ_{\text{Li}} = -31.321 \pm 0.007$, $\Delta H^\circ_{\text{Na}} = 30.693 \pm 0.004$, $\Delta H^\circ_{\text{K}} = -33.625 \pm 0.004$. The thermochemical crystal energies are calculated and compared with electrostatic crystal energies. (auth.)

17294 TID-2501(DeL.)(p.291-316)

Knolls Atomic Power Lab., Schenectady, N. Y.

PROBLEMS IN THE USE OF MOLTEN SODIUM AS A HEAT TRANSFER FLUID. Clifford E. Weber and Leo F. Epstein. p.291-316 [of] NUCLEAR SCIENCE AND TECHNOLOGY. (EXTRACTS FROM JOURNAL OF METALLURGY AND CERAMICS. ISSUE NOS. 1 TO 6, JULY 1948-JANUARY 1951). 26p. (KAPL-139).

The basis for the current interest in liquid metals as coolants for nuclear reactors is discussed, and the favorable characteristics of liquid sodium as a heat transfer medium are pointed out. This is followed by a critical analysis of the available data on the physical properties of Na of importance in this application, i.e., density, heat capacity, viscosity, surface tension, thermal conductivity, electrical resistivity, heat transfer coefficients, and nuclear characteristics. The chemical properties of sodium are discussed, including

its reactions with oxygen, water, hydrogen, nitrogen, carbon, metallic oxides, and other metals. (auth)

17306 TID-2501(Del.)(p.455-521)

Knolls Atomic Power Lab., Schenectady, N. Y.
PROBLEMS IN THE USE OF MOLTEN SODIUM AS A HEAT TRANSFER FLUID. PART II. Leo F. Epstein and Clifford E. Weber. p.455-521 [of] NUCLEAR SCIENCE AND TECHNOLOGY. (EXTRACTS FROM JOURNAL OF METALLURGY AND CERAMICS. ISSUE NOS. 1 TO 6, JULY 1948-JANUARY 1951). 67p. (KAPL-362).

A procedure for the fabrication of uranium wire was developed. The method consisted in swaging 0.500-in.-diameter silver-plated uranium rod to 0.042-in.-diameter. The swaged rod was annealed in vacuum at 400°C after each 75 per cent reduction in area. Reduction from 0.042-in.-diameter was accomplished by wire-drawing, using Aquadag as a lubricant. The wire was annealed in vacuum at 400°C after each 75 per cent reduction in area. Wire was produced to 0.0033-in. diameter in tuballoy and to 0.010-in. diameter in enriched uranium (U^{235}). There was no apparent difference in workability between natural uranium and U^{235} . (auth)

17328 TID-2502(Del.)(p.229-31)

Knolls Atomic Power Lab., Schenectady, N. Y.
HOMOPOLAR GENERATOR PUMP. L. B. Vandenberg. p.229-31 [of] NUCLEAR SCIENCE AND TECHNOLOGY. (EXTRACTS FROM REACTOR SCIENCE AND TECHNOLOGY. VOL. 1, ISSUES 1 TO 3, APRIL-DECEMBER 1951). 3p. (TID-5004(Del.)).

This report presents the results of combining a homopolar generator and a simple d-c electromagnetic liquid metal pump in one unit. An experimental pump proved the feasibility of such a combination, and it also proved that compact pumps of high efficiency can be built. The problems usually presented by bearings, seals, heavy bus-bar connections, lead losses, and bulky power-conversion equipment, which are associated with the pumping of liquid metal, are largely eliminated. (auth)

17329 TID-2502(Del.)(p.233-4)

California. Univ., Berkeley. Radiation Lab.
ON THE REMOVAL OF Na_2O FROM Na BY DISTILLATION. Leo Brewer and John L. Margrave. p.233-4 [of] NUCLEAR SCIENCE AND TECHNOLOGY. (EXTRACTS FROM REACTOR SCIENCE AND TECHNOLOGY. VOL. 1, ISSUES 1 TO 3, APRIL-DECEMBER 1951.) 2p. (UCRL-1241(Rev.)).

Results of earlier investigations of the distillation of a Na- Na_2O solution are discussed. An explanation is offered which could account for the removal of O from the still-pot residue which is observed to be leaner in O than the initial feed. 5 references. (W.L.H.)

17408 TID-2505(Del.)(p.167-76)

Knolls Atomic Power Lab., Schenectady, N. Y.
COMPACT REACTOR POWER PLANT WITH COMBINATION HEAT EXCHANGER-THERMOELECTRIC PUMP. Emmeth A. Luebke and Leonard B. Vandenberg. p.167-76 [of] NUCLEAR SCIENCE AND TECHNOLOGY. (EXTRACTS FROM REACTOR SCIENCE AND TECHNOLOGY. VOL. 4, ISSUES 1 TO 4, MARCH-DECEMBER 1954). 10p.

A compact reactor power plant is described in which the reactor proper is located within a cylindrical heat exchanger. The pumping action in this liquid-metal-cooled reactor system is obtained in combination with the heat-exchanger function. By interposing thermoelements a large thermoelectric current is generated in the cylindrical heat exchanger by means of the temperature gradient normally existing between hot and cold tubes. With suitable pole pieces this current produces a perpendicular magnetic field and develops sufficient force on the liquid metal for the desired pumping action. (auth)

17793

SODIUM COOLING OF NUCLEAR REACTORS. Werner Mialki (Univ. of Berlin). Atomkern-Energie 3, 321-8 (1958) Aug.-Sept. (In German)

In spite of difficulties in its handling, liquid sodium could play an important role in the future as a reactor coolant. At the present state of technological development, sodium can be considered only for fast reactors, since it does not slow down neutrons. Sodium is also of interest for thermal reactors since it allows a high temperature to be reached without pressure. The technology of sodium and its corrosive effects are described. Heat transfer by sodium and the possibility of calculating heat transfer with Nusselt's potential formulas are discussed. The radioactivity induced in the sodium by neutron beams is important in its utilization, and the radioactivity equilibrium can be calculated. The construction of heat exchangers, pumps, and instruments for pressure, level, and flow measurements are described. Some data on the operation of the Sodium Reactor Experiment are given. (auth)

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776

ACTIVATION ENERGY VALUES FOR SPONTANEOUS DIFFUSION IN LIQUID METALS. K. A. Osipov (Baikov Inst. of Metallurgy, Academy of Sciences, USSR). *Doklady Akad. Nauk S.S.S.R.* 121, 1019-20(1958) Aug. 21. (In Russian)

An equation was formulated for expressing the activation energy values for spontaneous diffusion and viscosity of liquid Al, Fe, Mg, Na, Pb, and Sn. (R.V.J.)

1099 CF-57-4-115

Oak Ridge National Lab., Tenn.

OPERATION OF THE DISTILLATION METHOD FOR THE DETERMINATION OF SODIUM OXIDE IN NaK DURING THE CALIBRATION OF A PLUG INDICATOR. R. D. Peak. Apr. 30, 1957. 50p. Contract [W-7405-eng-26]. \$9.30(ph OTS); \$3.60(mf OTS).

The distillation method (Argonne Sampler) for the analysis of sodium oxide in NaK was used to calibrate a plug indicator. The description of the equipment, procedure, and experiences with the Argonne Samplers are presented in great detail to aid future users of this method. Although this method is not very precise, it has been thoroughly checked out and is recommended as a standard means for sampling and analysis for oxide in liquid metal systems. (auth)

1278 AECU-3853

Knolls Atomic Power Lab., Schenectady, N. Y.

OPERATIONAL PERFORMANCE OF MAGNETIC FLOWMETERS ON A SODIUM COOLED REACTOR. E. R. Gasser. [1957]. 17p. Contract [W-31-109-Eng-52]. (M-6221). \$3.30(ph OTS); \$2.40(mf OTS).

The design and operation of a magnetic flowmeter for use in estimating sodium flow in cooling channels are described. The flowmeter requires minimum maintenance and is reliable. It is pointed out that the magnets must be carefully calibrated, and the meter should be installed in a clean, easily accessible location. (J.R.D.)

1636 CEA-703

France. Commissariat à l'Énergie Atomique, Paris. INSTALLATION D'ÉTUDE DE TRANSMISSION DE CHALEUR A DENSITÉ DE FLUX ÉLEVÉE. (Installation for the Study of Heat Transfer with High Flux Density.) M. Robin and B. Schwab. 1957. 23p.

A description is given of an installation used for the study of heat transfer with high flux density, which uses liquid metals and alloys as the heat exchanger. The loop was tested with a Na-K alloy containing 56 wt. % K and a flux density of more than 200 w/cm² with the alloy at a temperature of 550°C. (J.S.R.)

1647

HEAT TRANSFER COEFFICIENTS OBSERVED IN SMALL SODIUM EXCHANGERS. Seymour C. Hyman (Nuclear Development Corp. of America, White Plains, N. Y.). *Chem. Eng. Progr.* 54, No. 10, 81-2(1958) Oct.

Results of heat transfer coefficients which lend support to an empirical procedure that may be useful to designers with problems that cannot wait for full understanding of the problem are presented. Equations based on observation for calculation of over-all heat transfer coefficients for tube and annular exchangers are also presented. (J.R.D.)

1815 NAA-SR-2986

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

DESIGN OF AN EDDY-CURRENT BRAKE FOR A SODIUM-COOLED NUCLEAR POWER REACTOR. R. S. Baker. Sept. 15, 1958. 17p. Contract AT-11-1-GEN-8. \$0.75(OTS).

A device known as an eddy-current brake is used to throttle molten sodium flow to prevent excessive thermal stress in the sodium piping of the Sodium Reactor Experiment after the reactor is shut down due to a scram signal. Braking action is provided by a direct-current electromagnet acting across a modified section of 6-inch diameter piping. With power of 2400 watts supplied to the magnet, flow after scram is reduced from 1200 to 12 gpm against the thermal convection driving head of 3 psi. (auth)

2342

SOME EXAMPLES OF TURBULENT DIFFUSION IN LIQUID METALS. A. Paoletti and M. Vicentini (Univ. of Rome). *Phys. Fluids* 1, 453-4(1958) Sept.-Oct.

2748 AEC-tr-3397

BINDING OF ALKALI METALS BY CARBON. V. K. Fredenhagen and H. Suck. Translated by K. S. Bevis (Savannah River Lab.) from *Z. anorg. u. allgem. Chem.* 178, 353-65(1929). 13p.

The type of potassium and sodium binding by carbon was investigated under the same pressure and temperature conditions; carbon black and graphite adsorbed the same amounts of potassium. Sodium reacted with carbon black but not with graphite, and diamond reacted with neither. Potassium was adsorbed by graphite in two distinct stages. Potassium carbide was not formed. (J.R.D.)

2971 CF-58-10-86

Oak Ridge National Lab., Tenn.

DEPLETION OF MINOR CONSTITUENTS FROM COAST

METALS NO. 52 (89 Ni-5 Si-4 B-2 Fe) AND NO. 53 (81 Ni-8 Cr-4 B-4 Si-3 Fe) BRAZING ALLOYS DURING VARIOUS EXPOSURES. D. H. Jansen. Oct. 23, 1958. 15p. \$3.30(ph OTS); \$2.40(mf OTS).

Corrosion tests were made on nickel-base brazing alloys containing boron and silicon in fused fluoride fuels, liquid metals, and oxidizing atmospheres. Impoverished regions, after the tests, contained approximately one third the original amount of boron and silicon that was present before the tests. (A.C.)

2993 ORNL-2544

Oak Ridge National Lab., Tenn.

CORRELATION OF CAVITATION INCEPTION DATA FOR A CENTRIFUGAL PUMP OPERATING IN WATER AND IN SODIUM POTASSIUM ALLOY (NaK). A. G. Grindell. Dec. 11, 1958. 41p. Contract W-7405-eng-26. \$1.50(OTS).

For the centrifugal pump under investigation, the static head at pump suction, in feet absolute, at cavitation inception was correlated for water and for 1500°F NaK on the basis of the differences of the vapor pressures of the two liquids. The difference between the vapor pressure of water and NaK, for the same conditions of pump speed and liquid flow, was added to the water-test cavitation inception value, and this estimate proved to be a good approximation to the experimental value found for cavitation inception with NaK. (auth)

3333

INELASTIC SCATTERING CROSS SECTIONS OF 3.6 Mev NEUTRONS BY ATOMIC NUCLEI. V. A. Batalin and N. S. Kopytin (Inst. of Physics, Academy of Sciences, Ukrainian SSR.). *Ukrain. Fiz. Zhur.* 3, 185-9 (1958) Mar.-Apr. (In Ukrainian)

Measurements of the inelastic scattering of 3.6-Mev neutrons on C, Na, Al, Fe, Zn, Se, Zr, Cd, Sn, Sb, Te, I, Pb, Bi, and NaCl are presented. The inelastic cross sections were determined by the sphere transmission method. The threshold detector was a scintillation detector with ZnS(Ag) phosphor. The threshold sensitivity of the detector was determined by the excitation function of the $S^{32}(n,p)P^{32}$ reaction. The neutron source was the $D(d,n)He^3$ reaction. The deuterons were accelerated by an electrostatic generator. Measurements were corrected for energy loss due to elastic scattering and for two inelastic collisions. The results are given in a table. The investigations showed that the cross sections of inelastic scattering increase steadily with the atomic weight. Deviation from the increase was found at the Zr, Pb, and Bi nuclei. (tr-auth)

3821 NAA-SR-2973

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

CORROSION AND DECARBURIZATION OF THE FERRITIC CHROMIUM-MOLYBDENUM STEELS IN SODIUM COOLANT SYSTEMS. W. C. Hayes and O. C. Shepard. Dec. 1, 1958. 33p. Contract AT-11-1-GEN-8. \$1.00 (OTS).

The commercially available ferritic chromium-molybdenum steels have several advantages over the austenitic stainless steels for sodium coolant systems. The purpose of this work was to investigate both corrosion and carbon transfer phenomena in sodium systems containing both ferritic and austenitic steels. Specimens were exposed at 1025°F in a high-velocity 304 stainless-steel isothermal pump loop and at 1050°F in a low-velocity 304 stainless-steel anisothermal pump loop

(500°F temperature gradient) to obtain corrosion and decarburization data. All of the steels showed negligible corrosion rates (aside from carburization-decarburization reactions). Decarburization was encountered in the low-chromium steels. The rate-controlling step in the decarburization reaction appears to have been the diffusion of carbon in the ferritic steels when the austenitic-to-ferritic area ratio was high. The steel containing 5% chromium with titanium, and the 7 and 9% chromium steels were approximately neutral in carbon activity, with respect to 304 stainless steel in a 304 stainless-steel loop containing sodium which was not contaminated with carbon. In a 304 stainless-steel loop containing sodium which was carbon contaminated, steels with 1¼% and 2¼% chromium were decarburized, while steels containing 5% chromium or more were carburized. Capsule tests showed that carbon-saturated sodium decarburized AISI 1010 steel to 0.07% carbon, carburized 1¼% chromium steel to 0.52% carbon, and carburized 2¼% chromium steel to 0.92% carbon. Results of each of these tests indicate that the magnitude of the carbon activity in one steel, in relation to another and/or in relation to the carbon activity of the sodium, determines whether an alloy is decarburized, neutral, or carburized in a sodium system. (auth)

3851 AEC-tr-3519

ON THE SELF-DIFFUSION ACTIVATION ENERGY IN LIQUID METALS. K. A. Osipov. Translated by S. J. Rothman (Argonne National Lab.) from *Doklady Akad. S.S.S.R.* 121, 1019-20(1958). 3p.

Experimental thermodynamic data are plotted for Na, Sn, Al, Mg, Pb, and Fe to show that the activation energy of self diffusion in metals near the melting point is equal to activation energy referred to one atom minus latent heat of melting. (T.R.H.)

3963 BNL-489(p.156-8)

Argonne National Lab., Lemont, Ill.

CHEMICAL REACTIONS OF GRAPHITE. M. Dzurus, G. R. Hennig, and G. Montet. p.156-8 [of] PROCEEDINGS OF THE FRENCH-AMERICAN CONFERENCE ON GRAPHITE REACTORS, [HELD AT BROOKHAVEN NATIONAL LABORATORY], NOVEMBER 12 TO 15, 1957. 3p.

A brief survey is presented of typical chemical reactions of graphite. Reactions of graphite with hydrogen, reactions of graphite with sodium, and changes in general reactivity of graphite caused by irradiation are discussed in more detail. Graphite does not appear to form any stable lamellar compounds with hydrogen at least below 1000°C as indicated by electrical measurements. If graphite is bombarded with accelerated protons, these are retained by the lattice, apparently as either hydrogen molecules or ions but not as hydrogen atoms. The hydrogen diffuses at elevated temperatures with an activation energy of about 12 kcal. Very pure sodium does not appear to react with polycrystalline graphite at temperatures up to 450°C. (At higher temperatures carbide is formed.) Small amounts of impurity will, however, cause reaction. In Pyrex apparatus, enough potassium is apparently leached out of the glass to cause some reaction. Sodium hydroxide, sodium oxide, barium oxide, and other impurities cause rapid visible interactions of sodium with graphite. The reactions decrease the electrical resistivity. We believe this change to indicate that the oxide occupies what we have called "spacer" positions in the lattice and thus facilitates the intercalation of sodium. Irradiation of graphite decreases the rate at which it reacts with certain sub-

stances like bromine or sulfuric acid. The reasons for this are discussed. It will be shown that a similar effect may well increase the reactivity to sodium although this speculation has not yet been tested. (auth)

3964 BNL-489(p.159-67)

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

INTERACTIONS OF GRAPHITE WITH LIQUID SODIUM. Stephen C. Carniglia. p.159-67 [of] PROCEEDINGS OF THE FRENCH-AMERICAN CONFERENCE ON GRAPHITE REACTORS, [HELD AT BROOKHAVEN NATIONAL LABORATORY], NOVEMBER 12 TO 15, 1957. 9p.

Observations and measurements of the chemical interactions of graphite and sodium are reviewed, covering the temperature range 100 to 900°C. Interpretations of the observed effects are given in terms of the unique structure and properties of graphite. Phenomena discussed include wetting and capillarity, graphite expansion, corrosion and material transfer, and formation of sodium-graphite interstitial compounds. (auth)

3965 BNL-489(p.168-73)

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

RECENT INFORMATION ON MODERATOR SHEATH CORROSION IN LIQUID SODIUM. Robert L. Eichelberger. p.168-73 [of] PROCEEDINGS OF THE FRENCH-AMERICAN CONFERENCE ON GRAPHITE REACTORS, [HELD AT BROOKHAVEN NATIONAL LABORATORY], NOVEMBER 12 TO 15, 1957. 6p.

Results are reported of recent experimental work concerned with the interaction of liquid sodium and dissolved impurities with zirconium and its alloys, niobium, molybdenum, and stainless steel. For zirconium, grain growth and mechanical property changes are discussed. Corrosion behavior as a function of temperature and impurity level in the sodium is described. (auth)

3972 BNL-489(p.239-74)

Nuclear Development Corp. of America, White Plains, N. Y.

A GRAPHITE MODERATED CRITICAL ASSEMBLY—CA-4. E. L. Zimmerman. p.239-74 [of] PROCEEDINGS OF THE FRENCH-AMERICAN CONFERENCE ON GRAPHITE REACTORS, [HELD AT BROOKHAVEN NATIONAL LABORATORY], NOVEMBER 12 TO 15, 1957. 36p.

Material in this paper was presented in Y-881, dated Dec. 7, 1952. Decl. Sept. 17, 1957. Work performed at the Oak Ridge National Lab., Y-12 Area, 1951.

A graphite moderated enriched uranium critical assembly was constructed to provide an experimental check for certain reactor calculation methods and to evaluate a number of experimental procedures used in the Oak Ridge National Laboratory critical facility. In order to minimize uncertainties in subsequent measurements and calculations, the assembly was kept as simple as possible. The assembly approximated a uniformly loaded, unpoisoned, bare cube, containing relatively well-known reactor materials. This simple critical assembly proved to be an excellent tool for basic reactor physics studies. The size of the assembly was $51.0 \times 51.0 \times 44.11$ in., and the critical loading was 52.48 kg U^{235} . With the critical assembly as a model and assuming an extrapolation distance of 2 cm, a bare reactor, 32 group calculations gave a value 0.9912 for the effective multiplications. Several measurements

were made by one or more experimental techniques and compared to calculated results where possible. The observed quantities included: control and safety rod evaluations by rod drop and pile period methods; the effect of neutron streaming in a void; importance functions for fuel and moderator; reactivity coefficients for various materials; fission power distribution by the catcher technique; flux distribution; cadmium fractions; and the effect of transverse gaps on reactivity. In general, the agreement with calculated results was satisfactory. In the case of the reactivity effect of small gaps, the disagreements with earlier theoretical treatment of the problem prompted an effort to improve the existing calculation method for evaluating this effect. Danger coefficients for sodium, iron, nickel, and molybdenum were calculated from the multigroup neutron spectrum and the known cross section data. These values are in substantial agreement with the corresponding observed values. The effect of a sodium filled channel in the reactor was investigated. A 3×2 -in. hole extending from the center of the assembly to the outside along a major axis was filled stepwise with sodium. Plugging the hole near the outside edge of the assembly with sodium caused a slight increase in multiplication, while completely filling the hole gave a small net loss. (auth)

4274 PRDC-TR-14

Power Reactor Development Co., Detroit.

MONTHLY TECHNICAL REPORT [FOR] AUGUST 1958. 13p. Contract AT(11-1)-476. \$3.30(ph OTS); \$2.40(mf OTS).

Results from fuel pin irradiations and nondestructive testing are given. Fuel cycle costs were prepared for various burnups and interest rates on fuel. Conclusions are drawn from fuel pin corrosion tests. Work on computer programs and pressure vessel engineering is reported. A sodium-water reaction test is described. Preliminary tests were run on the sodium vapor trap. Ultrasonic cleaning of dummy nozzles is described. (For preceding period see PRDC-TR-13.) (W.D.M.)

4275 PRDC-TR-15

Power Reactor Development Co., Detroit.

MONTHLY TECHNICAL REPORT [FOR] SEPTEMBER 1958. 24p. Contract AT(11-1)-476. \$4.80(ph OTS); \$2.70(mf OTS).

Sample collection and analysis were started for the preoperational environmental survey. Reports on environmental radioactivity at various locations are attached. Samples of a fissium-type alloy were heated to 2000°F to determine the melting range. A chart showing the status of the design and fabrication of the major components being procured by APDA for the reactor components test is included. Radiation and temperature effects on fuel pins were investigated. Dry lubricants for bearing surfaces were tested. Test operations on reactor components are described. (For preceding period see PRDC-TR-14.) (W.D.M.)

4375 KAPL-M-EDL-66

Knolls Atomic Power Lab., Schenectady, N. Y.

MARK A LIQUID METAL SCRAPER SEAL MATERIALS COMPATIBILITY TEST. P. E. Bissonnette and E. C. Reynolds. Feb. 25, 1954. Changed from OFFICIAL USE ONLY Nov. 21, 1957. 31p. Contract [W-31-109-Eng-52]. \$6.30(ph OTS); \$3.00(mf OTS).

An axially reciprocating shaft was operated in liquid Na against split metallic seals using various combinations of materials as the shaft and seals. The purpose

of the tests was to determine which materials in combination would be suitable for use in liquid Na at temperatures up to 850°F. Three materials were found to be compatible: No. 18-4-1 high-speed tool steel vs. nitrided type 347 stainless steel; nitrided type 347 stainless steel vs. nitrided type 347 stainless steel; and nitrided type 347 stainless steel vs. 440°C hardened stainless steel. (W.L.H.)

4468

DETERMINATION OF HYDROGEN IN ALKALI METALS BY ISOTOPE DILUTION METHOD. Ben D. Holt (Argonne National Lab., Lemont, Ill.). *Anal. Chem.* 31, 51-4(1959) Jan.

The rapid exchange of hydrogen and deuterium in sodium or NaK affords a convenient method for hydrogen determination in these metals. Spikes equivalent to 5 to 250 ppm of hydrogen were recovered on 2-gram samples with a standard deviation, from the quantity added, equivalent to ± 2 ppm. An 8-in. borosilicate sampling tube serves as the reaction vessel and as the gas bulb for mass spectrometric analysis. With many such tubes on hand, samples can be taken at sites of industrial operations and transported to the laboratory for analysis. In the analysis of NaK it is necessary to apply a correction factor to compensate for the effect of different rates of formation of the hydrides and deuterides in the cooler zones of the tube during equilibration. For sodium this effect is negligible and no correction is necessary. The time required for analysis after the sample is taken is about $\frac{3}{4}$ hour. (auth)

5001

CF-58-12-9

Oak Ridge National Lab., Tenn.

TABLE OF GAMMA-ENERGY ABSORPTION CROSS SECTIONS. Lloyd G. Alexander. Dec. 1, 1958. 20p. Contract W-7405-eng-26. \$3.30(ph OTS); \$2.40(mf OTS).

The gamma-energy absorption cross sections for 24 elements were computed and are presented in tabular form. In this computation, the low-energy cut-off was set at 0.1 Mev. (W.D.M.)

5003

WASH-1006

Nuclear Cross Sections Advisory Group, AEC.

REPORTS TO THE AEC NUCLEAR CROSS SECTIONS ADVISORY GROUP, UNIVERSITY OF CALIFORNIA RADIATION LABORATORY, LIVERMORE, CALIFORNIA, JUNE 18-19, 1958. V. L. Sailor. 40p. \$1.25 (OTS).

The cross section research programs at ANL, BNL, Columbia Univ., Duke Univ., KAPL, HAPO, LASL, ORNL, Phillips Petroleum Co., Rice Inst., and UCRL are reviewed. Data are reported from the following studies: (p,n) reaction cross sections; α spectra from t + t interaction; d(t, α), He⁴(t,t), and t(t,t) scattering cross sections; (n, γ) activations and cross sections; (n,2n) and (n,3n) reactions in fissionable nuclei; neutron scattering from Be; neutron resonances in Pm¹⁴⁷ and Pm¹²⁹; U²³³ fission yields; neutron total and (n,2n) cross sections for elements; and neutron spectra from d(p,np) reactions. (For preceding period see WASH-745.) (D.E.B.)

5308

THE UTILIZATION OF A COLD TRAP TO STABILIZE SUSPENSIONS OF UO₂ IN NaK. P. R. Huebotter and W. R. Seitz (General Motors Research Staff, Detroit). *Nuclear Sci. and Eng.* 5, 11-14(1959) Jan.

Loop studies were made on UO₂-NaK slurries at temperatures up to 1050°F. The maximum UO₂ concentration was 4.15 volume per cent or 35 weight per cent at room temperature. A flow rate of 5.4 ft/sec was required to suspend all of the UO₂ in this slurry at 1050°F. Lesser flow rates were required at lower temperatures. It was discovered that by installing a static cold trap, which was joined vertically upward from the lower horizontal leg of the loop, the slurry became more stable at the higher temperatures. The function of the cold trap is thought to be that of removing, from the circulating slurry, oxygen contamination which may have rendered previous attempts to maintain a stable suspension above 932°F unsuccessful. In the present study, the UO₂ could be easily resuspended after prolonged settling. (auth)

5557

APEX-454

General Electric Co. Research Lab., Schenectady, N. Y.

FRICTION AND WEAR OF REFRACTORY COMPOUNDS. Progress Report. K. P. Zeman and L. F. Coffin, Jr. Apr. 1958. 54p. For General Electric Co. Aircraft Nuclear Propulsion Dept. Contracts AF33(600)-38062 and AT(11-1)-171. \$1.50(OTS).

Refractory compounds were selected for investigation as bearings with the possibility of employing liquid metals as lubricants for these materials. An apparatus designed and built for testing ceramic materials at 2000°F in an air atmosphere or liquid metal bath is described. The borides, carbides, nitrides, and silicides of the transition metals and the common oxides which meet the requirements of high-temperature strength, hardness, and oxidation resistance were selected for study. Tests to date show that refractory compounds with solid solubility will have poor friction and wear characteristics when tested as couples. Couples of MgO-SiO₂, MgO-Al₂O₃, AlO₂-TiC, and SiC-TiC show promise of sliding successfully at temperatures as high as 2000°F in air. (W.D.M.)

5575

NYO-4805

Massachusetts Inst. of Tech., Cambridge. Dept. of Metallurgy.

KINETICS OF REACTIONS BETWEEN LIQUID METALS AND LIQUID SALTS. Progress Report Covering Period March 1, 1958 to December 15, 1958. Thomas B. King. 24p. Contract AT(30-1)-1985. \$4.80(ph OTS); \$2.70(mf OTS).

The kinetics of reactions involving both transport control and phase boundary reaction control are being studied by direct rate measurements and by electrochemical polarization techniques. Measurements of diffusion coefficients are proceeding as part of the program to aid in the interpretation of the kinetic results. Transport control is confirmed for some systems, but side reactions have complicated the study of phase-boundary control. (auth)

6354 A/CONF.15/P/1147

CORROSION DE L'OXYDE DE BERYLLIUM. (Corrosion of Beryllium Oxide). J. Elston and R. Caillat (Commissariat à l'Énergie Atomique, Paris). 56p.

Data are presented on the volatilization of beryllium oxide in moist air. The corrosion rate of powder samples or sintered shapes of various densities is dependent on the temperature and water vapor concentration. Data on the corrosion of sintered beryllium oxide in pressurized water are also presented. At 250°C, under

a pressure of 40 kg/cm², water is very slightly corrosive. Some data on corrosion in liquid sodium are given. (J.S.R.)

6764 A/CONF.15/P/25

COMPATIBILITY OF REACTOR MATERIALS IN FLOWING SODIUM. M. Davis (United Kingdom Atomic Energy Authority, Culcheth, Lancs, Eng.), and A. Draycott (Atomic Energy Commission, Australia). 36p.

The validity of various types of compatibility tests is briefly discussed, particularly the severe limitations of static experiments. Differences expected between sodium and NaK are noted. A typical corrosion test rig is described and its application to radioactive mass-transfer measurements discussed. The types of specimens used, the measurements made before and after tests, the assessment of the results, and their correlation with reactor circuits are detailed. The variables studied include the temperature of the specimen, the velocity of the liquid metal over the specimen, the oxide level in the liquid metal and the initial state of the specimen. The materials investigated include stainless steel, various ferritic steels, zirconium, niobium, vanadium, uranium and fission products, thorium, and beryllium. Niobium and vanadium were studied in greatest detail. (auth)

6787 A/CONF.15/P/1091

THE COMPATIBILITY OF BERYLLIUM WITH LIQUID SODIUM AND NaK IN DYNAMIC SYSTEMS. F. L. Bett and A. Draycott (Australia). 16p.

The mechanism of corrosion of beryllium in oxygen-bearing sodium and NaK is briefly discussed. Experiments are described which measure the rate of corrosion of beryllium in cold-trapped NaK. These corrosion rates are found to be excessive. As oxygen in the liquid metal is considered to be the cause of the corrosion, cold trapping is supplemented by hot trapping as a means of deoxidation of NaK in a second series of experiments. These experiments show that with a thorium hot-trap reduced corrosion of beryllium occurs compared with cold-trap conditions, but is still excessive. Calcium, however, when used in the hot-trap reduces beryllium corrosion to an acceptable level. At the levels required for successful hot-trapping calcium removes negligible quantities of nickel from stainless steel which can therefore be used as a container material. (auth)

6832 A/CONF.15/P/2194

ON THE CORROSION RESISTANCE OF SOME MATERIALS IN SODIUM AND LITHIUM. V. S. Lyashenko, V. V. Zotov, et al. (U.S.S.R.). 28p.

The results of investigation of corrosion of steels in the flow of sodium contaminated with oxygen are presented. It was found that strength of many steels increases almost in the same degree while their relative elongation decreases differently. The erosion resistance of cylindrical samples of various steels and nickel when heated in sodium was also studied. In addition the results of investigation of corrosion resistance of certain steels and pure metals in lithium under static conditions are presented. It was found that carbon steels with 0.06 to 0.7% carbon content are unstable due to the carbon transfer from steel to lithium. The ductility of carbon steels after their holding for a certain time in lithium has been found to decrease sharply. Preferential corrosion of the steels high in carbon is observed. It was proved that steels containing chromium, tungsten, niobium, and molybdenum resist corrosive interaction with lithium more effectively. (auth)

6946 A/CONF.15/P/2475

SKOROSTNOI METOD IZMERENIYA KOEFFITSIENTA TEPLOOTDACHI V TRUBE. (A Fast Method for Measuring the Heat Exchange in a Pipe.) M. N. Ivanovskii, V. I. Subbotin, and P. A. Ushakov (U.S.S.R.). 21p.

A fast method for measuring the heat exchange in a pipe was developed, based on the temperature changes in the liquid with considerations for the specific properties of the analyzed liquid metals. (R.V.J.)

6969 A/CONF.15/P/1088

SECCIONES TOTALES EMPLEANDO NEUTRONES RAPIDOS. (Cross-Sections for Fast Neutrons of Some Elements.) M. Mazari and F. Alba (Univ. Nacional Autonoma de Mexico). 6p.

The total cross sections for fast neutrons were determined for sodium, iron, strontium, zirconium, and thallium. The experimental results were compared with the theoretical results. (J.S.R.)

7817

LIQUID METALS. J. W. Evans (United Kingdom Atomic Energy Authority, Culcheth, Lancs, Eng.). *Nuclear Eng.* 4, 59-63(1959) Feb.

The properties and individual characteristics of the liquid metals (Hg, Bi, Na, and Na-K) suitable for reactor coolants are presented. (W.L.H.)

8287 NDA-84-13

Nuclear Development Corp. of America, White Plains, N. Y.

SDR PROJECT QUARTERLY TECHNICAL PROGRESS REPORT NO. 6 FOR THE PERIOD AUGUST 1, 1958 THROUGH OCTOBER 31, 1958. Dec. 31, 1958. 61p. Contract AT(30-3)-256. \$9.30(ph OTS), \$3.60(mf OTS).

A family of 200-Mw(e) SDR's was designed which could be operable in 1965. They give total energy costs in the range 10 to 12 mills/kwh. The most promising of these reactors has the following characteristics: single-region design, moderate steam conditions, natural uranium fuel, Zircaloy cladding, and stainless steel fuel tubes. A study of the applicability of SDR's to a broad range of power outputs (10 to 500 Mw(e)) was made. Although it appears reasonable to design a natural-uranium SDR with a power output down to 10 Mw(e), present studies indicate significant and wide economic interest at 40 Mw(e) and higher. Difficulties were encountered in interpreting the results of natural uranium-D₂O lattice experiments in the Process Development Pile, and studies were initiated to determine the sources of difficulty and corrective measures. A code, called PALINDROME, which solves the Boltzmann transport equation in the P₃ approximation, was written. Work during the quarter on the Chugach 10-Mw(e) reactor was mainly concerned with completing the layout design of the more important reactor components and systems. A listing of the current design data is given, and a cross section of the reactor is shown. Two major changes were made during the quarter: (1) the substitution of steel ball-filled organic-cooled neutron shield disks for the original concrete-filled, water-cooled designs and (2) the reduction in size of the shutdown gas cooling systems. The preliminary safety analysis is briefly outlined. The development of maintenance techniques is discussed. Approximately 280 additional hours of operation of the SDR mockup facility were logged during the quarter. Modifications were made of the barrier test apparatus, and three successful experiments were performed on 6061 Al alloy. A liquid sodium leak detector was constructed, and also a rig for testing fuel-coolant tube closures. Sodium-liquid water

and sodium-water vapor reactions were studied. (For preceding period see NDA-84-12.) (L.T.W.)

8439

PUMPS FOR LIQUID CURRENT-CONDUCTING MATERIAL. D. A. Watt (to U. S. Atomic Energy Commission). U. S. Patent 2,865,291. Dec. 23, 1958.

An induction-type liquid conductor pump is described wherein the induced current flow is substantially transverse to the flow of the liquid in the duct, thus eliminating parallel current flow that tends to cause unwanted pressures resulting in turbulence, eddy-flow, heating losses, and reduced pumping efficiency. This improvement is achieved by offering the parallel current a path of lower impedance along the duct than that offered by the liquid so that the induced currents remaining in the liquid flow in a substantially transverse direction. Thick copper bars are brazed to the liquid duct parallel to the flow, and additional induced currents are created in the copper bars of appropriate magnitude to balance the ohmic drop in the current paths outside of the liquid metal.

8863

EVALUATING HIGH-TEMPERATURE LIQUID PUMPS. A. F. Erwin. *Allis-Chalmers Elec. Rev.* 23, 3rd Qtr., 7-11(1958).

The liquid metal pump requirements for four major nuclear power reactor installations and two high-temperature liquid reactor plants are discussed. Details are given of: the two types of pumps for extensive testing as prototype primary and secondary coolant circulating units for the 75 Mw sodium-graphite reactor; the hermetically sealed and electromagnetic pumps selected for EBR-II; the mechanically sealed pumps selected for the 100 Mw Enrico Fermi breeder reactor plant; and the pumps considered for the LMFRE project; the 10 Mw SDR project for Alaska, and the 240 Mw molten-salt homogeneous-type reactor. (auth)

9065

LIQUID METALS AND SOLIDIFICATION. A Seminar on Liquid Metals and Solidification Held During the Thirty-Ninth National Metal Congress and Exposition, Chicago, November 2 to 8, 1957, Sponsored by The American Society for Metals. Cleveland, American Society for Metals, 1958. 350p.

The papers presented at this seminar include: The Theory and Structure of Liquids; Transport Properties in Pure Liquid Metals; Thermodynamics and Properties of Liquid Solutions; Nucleation in the Solidification of Metals; Solid Metal-Liquid Metal Reactions in Bi and Na; Discussion of Weeks and Gurinsky paper on Solid Metal-Liquid Metal Reactions in Bi and Na; Some Aspects of the Mechanism of Metal Deposition and Dissolution; Mechanism of Growth; Thermal Considerations of Freezing; Redistribution of Solute During Freezing; Imperfections Resulting from Solidification; Polyphase Solidification; and Structure of Ingots and Castings. (W.L.H.)

9253 RDB(W)/TN-198

United Kingdom Atomic Energy Authority. Industrial Group. Windscale Works, Sellafield, Cumb., England.

HEAT TRANSFER EXPERIMENTS WITH SODIUM POTASSIUM ALLOY. A. E. Jenkins and G. McKee. Mar. 1955. 25p.

A description is given of experiments in which the heat transfer coefficients between two annuli each carrying a flow of sodium-potassium alloy were measured. For Peclet numbers above 60 the results are in good agreement with the theoretical values. For Peclet numbers below 60 the results do not agree with theory but are of doubtful accuracy. Circumferential temperature variations caused by eccentric positioning of one of the tubes of the exchanger have been measured for varying degrees of eccentricity. The maximum values obtained are only a fraction of those predicted by the simple theory. (auth)

9255

CEA-tr-R-565

ECHANGE THERMIQUE PAR METAUX LIQUIDES. (Thermal Exchange by Liquid Metals.) S. S. Kutateladze (Koutateladze), V. M. Borishanskii (Borichansky), and I. I. Novikov. Translated into French by B. Vinogradoff from *Atomnaya Energ.* 4, 422-36(1958). 43p. (Includes original, 17p.)

A review is presented on the studies of heat transmission between a solid surface and liquid metals. The results of investigations on the thermal exchange during discharge through long and short pipes and through slits, during flowing around bundles of rods or groups of plates, during transverse flow around cylinders by free convection, and by condensation of liquid vapor were discussed. The effects of addition substances on the intensity of the heat exchange were studied. Problems connected with boiling of the liquid metals as well as the effect of wetting on the hydraulic resistance and the intensity of thermal exchange were also considered. Some formulas which permit the calculation of the thermal exchange are presented. 30 references. (tr-auth)

9358

BAW-1030

Babcock and Wilcox Co. Atomic Energy Div., Lynchburg, Va.

LIQUID METAL FUEL REACTOR EXPERIMENT; PRELIMINARY HAZARDS EVALUATION FOR THE USE OF SODIUM IN THE BNL FOUR-INCH LOOP. Oct. 1957. 10p. Contract AT(30-1)-1940. \$3.30(ph), \$2.40(mf) OTS.

The design changes considered necessary for the use of sodium in place of bismuth in the secondary system of the four-inch loop are discussed. An evaluation of the possible hazards involved and methods of coping with them are included. (A.C.)

9372

NP-7320

Detroit Edison Co., Detroit.

DETERMINATION OF THE MAXIMUM PRESSURES ATTAINED DURING THE REACTION OF SODIUM WITH AIR IN CLOSED SYSTEMS. Engineering Laboratory and Research Department Report 55C80. Edward Hines and J. K. Kelley. Feb. 15, 1956. 29p.

Tests were conducted to gather data on the maximum pressure to be expected in the reaction of molten sodium at 850°F with air above the operating floor of a nuclear power plant in an equipment failure incident. Preliminary studies were made using a 1 liter reaction vessel. In subsequent tests 92 and 532 liter vessels were used. The results of the tests made with the 532 liter container are of interest. The procedure is outlined, and an analysis of results is given. It was concluded that under conditions similar to those in the test, a pressure not exceeding 38 psig would develop in the reactor house. Decreasing the oxygen content to 14 vol. % has little effect on reaction pressures. (J.R.D.)

9684 AERE-M/R-1729

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.

SOLID METAL-LIQUID METAL INTERACTION STUDIES. PART II. CONTACT ANGLE RELATIONSHIPS FOR SODIUM ON SOLIDS. J. W. Taylor and S. D. Ford. Nov. 19, 1955. 26p.

Using a sessile drop technique, a study has been made of the contact angle behavior of liquid sodium on a variety of solid metals and ceramics in the temperature range 100 to 550°C. Sodium forms a contact angle of less than 90° on all the metals studied at temperatures in the range 300 to 400°C; the corresponding temperatures for the ceramics are a little higher. No dewetting of the materials occurs on cooling and this, in conjunction with the observed influence of absorbed gas on the solid surface, suggests that in the early stages the contact angle temperature relationship is not one of equilibrium. While sodium readily wets most solid materials, the solid-liquid interfacial tension is high as shown by an experimental value of 580 dynes/cm. for the sodium-copper interface; the failure of sodium to attack metals intergranularly would support the view of a high interfacial tension. The low surface tension of sodium accounts for its ease of wetting. In structures, either metallic or ceramic, in which the bond strength is weak and or, stressed, complete disruption or failure of the solid can occur when the contact angle falls below 90°. (auth)

9759

DETERMINATION OF THE SOLUBILITY OF OXYGEN BEARING IMPURITIES IN SODIUM, POTASSIUM AND THEIR ALLOYS. D. D. Williams, J. A. Grand, and R. R. Miller (U. S. Naval Research Lab., Washington). *J. Phys. Chem.* 63, 68-71(1959) Jan.

Current interest in liquid metals, particularly sodium, as heat transfer media has emphasized the need for basic information on impurity solubility. Such data are important in the interpretation of corrosion and physical property experiments. The compounds resulting from partial oxidation of potassium and sodium metal have been isolated and identified as the respective monoxides. The equilibrium oxide in a sodium-potassium (NaK)-oxygen system is sodium monoxide. The various solubilities have been determined: sodium monoxide in sodium, potassium, and NaK alloys; potassium monoxide in potassium; sodium hydroxide in sodium; mixed sodium hydroxide-sodium monoxide in sodium; and sodium carbonate in sodium. Positive errors in oxide content may result from failure to account for each species of impurity if separation and analysis of a sample depends solely upon total alkalinity calculation. (auth)

9946 RDB(W)/TN-221

United Kingdom Atomic Energy Authority. Industrial Group. Windscale Works, Sellafield, Cumb., England. **THE CALIBRATION AND USE OF ELECTROMAGNETIC FLOWMETERS IN 1 INCH S. S. PIPE CIRCUITS PASSING LIQUID METAL. (22% NaK).** T. I. M. Crofts. Aug. 1955. 17p.

Electromagnetic flowmeters were calibrated. Methods employed and such factors as the effects of changes in pipe size, liquid temperature, and flow restrictions on flow measurements were given a limited study. The error due to angular displacement of the magnets between 0 to 32° was also studied. (auth)

10377 RDB(W)/TN-160

Gt. Brit. Windscale Works, Sellafield Cumb., England. **CAVITATION IN A VENTURI TUBE PASSING NaK. (78% K.) ALLOY AT 200-300 C.** T. I. M. Crofts. Aug. 1954. 18p. (FRDC/P-72).

Tests with NaK (78% K) eutectic alloy at 200 to 300°C in a venturi tube show that cavitation takes place at pressures approaching absolute zero. The effects of gas entrainment and also of a magnetic field were studied. (auth)

10860 WADC-TR-57-294(Pt. II)

General Electric Co. Light Military Electronics Dept., Schenectady, N. Y.

RESEARCH ON LIQUID METALS AS POWER TRANSMISSION FLUIDS. Robert C. Kumpitsch. Feb. 1, 1959. 178p. Project title: SECONDARY POWER COMPONENTS AND MATERIALS. Task title: HYDRAULIC FLUIDS. Contract AF33(616)-3698.

The behavior of liquid metal NaK-77 (a eutectic alloy of sodium 23% by weight and potassium 77% by weight) as a hydraulic fluid was observed over a temperature range of 80°F to 1000°F and at cyclic pressures of 15 psia to 3000 psia. An evaluation was made of several bearing and construction materials and several types of static seals to determine their effectiveness in NaK-77 under such conditions of operation. Capillary and orifice flow characteristics were obtained with this fluid and a correlation was made of these test results with the calculated results. A single piston test pump operating in an inert atmosphere "glove box" has pumped NaK-77 to pressures of 3000 psi at 1000°F and delivered a cyclic flow rate of 0.02 GPM. A total of 368 hours of NaK pumping have been accrued, two and one-half hours of which were at temperature and pressure. Various material combinations, clearances, orifice characteristics and static seals were successfully evaluated. Materials compatibility tests were conducted with friction and wear test equipment in NaK-77 at 1000°F. A total of 19 tests were conducted, nine for the calibration of the test equipment, and ten tests to evaluate the five most promising material combinations. Test results essentially confirmed previous work conducted by others in which carbide materials appear to be the most compatible combinations in NaK-77 at 1000°F ambients. A high pressure (3000 psi) and temperature (1000°F) test loop was also designed to circulate NaK-77 at a flow rate of 1 GPM for purposes of evaluating the feasibility of using liquid metals as a hydraulic fluid for power transmission and control systems applications. The design of this test loop also included the design of a 1000°F, 3000 psi, 1 GPM continuous flow, staged gear pump as a prime mover. (auth)

11222

PRODUCING A EUTECTIC POTASSIUM-SODIUM ALLOY. F. S. Maron and Z. P. Uspenskaya. *Trudy Ural. Nauch. Issledovatel. Khim. Inst.* No. 5, 91-8 (1957). (Translated from *Referat. Zhur. Met.* No. 8, 1958, p. 74.)

An investigation was made of a method of producing a eutectic K-Na alloy without organic additions. The process is conducted in airtight equipment consisting of a retort 180 mm high, 75 mm in diameter, and 2 mm in wall thickness. Before the experiment, pieces of Na and K were freed of kerosene and oil by filter-paper pressure. The surface film of oxide was then cut away, and samples calculated to contain 22 weight % Na and 78 weight % K were then prepared in a dry, closed box.

The K was placed on the bottom of the retorts, and the Na atop the piece of K. The metal was heated to 70 to 80°C, stirred, and poured into the receiver after cooling to room temperature. To separate the films from the alloy, the metal was filtered through an Fe screen with ~1-mm mesh, the screen being pulled over a tripod installed in the retort. The K and Na were placed on the screen. With heating the metal melted and flowed onto the bottom. The resultant alloy cast to a mirror-smooth surface. Airtight containers were developed and tested for the production, storage, and transportation of the K-Na alloy.

11380 NDA-57-27

Nuclear Development Corp. of America, White Plains, N. Y.

POINT VALUE CROSS SECTIONS FOR THE MATERIALS H, Li⁶, Be, B, C, F, Na, K, Cr, Fe, Ni, Zr, Gd, W, and Pb. C. W. Monroe, D. Pomeroy, and J. Ray. Sept. 1956. 72p. For Pratt and Whitney Aircraft Div. \$15.30(ph), \$5.40(mf) OTS.

Neutron cross sections for the reactor materials H, Li⁶, Be⁹, B, C, F, Na, K, Cr, Fe, Ni, Zr, Gd, W, and Pb are presented, accompanied by reference information and calculation methods. For each material the source of the total, absorption, and scattering cross sections are given. If cross sections were calculated (e.g., in the case of resonances), a calculation date, the method of calculation, constants used, and pertinent comments are listed. In most cases the scattering cross section was calculated by subtracting the absorption cross section from the total cross section, the equation being $\sigma_s = \sigma_t - \sigma_a$. Other equations used in the calculations are presented in the discussions of the individual elements. A table of "Energy and Lethargy" is presented at the end of the report. (auth)

11500 NAA-SR-Memo-1178

North American Aviation, Inc., [Downey, Calif.]. INITIAL TEST OF SODIUM PUMP AND INSTRUMENT LOOP. R. Cygan. Dec. 1, 1954. Decl. Nov. 6, 1958. 35p. \$3.30(ph), \$2.40(mf) OTS.

An isothermal loop for testing a full-scale sodium pump for SRE and associated instruments has been operated for ~600 hrs. A summary of data obtained, together with recommendations, is given. (auth)

11610 NP-7401

Mine Safety Appliances Co., Callery, Penna. SODIUM REACTIVITY TESTS—FIBERFRAX INSULATION. Memo Report 79. W. Milich and E. C. King. Mar. 2, 1955. 3p. Contract NObs-65426.

Samples of "Fiberfrax" insulation were immersed in sodium under an inert atmosphere at 500°F for 10 minutes and 1 hour periods. There was no apparent reaction with the sodium other than a slight charring at the outer surface of the insulation. (auth)

11611 NP-7415

Mine Safety Appliances Co., Callery, Penna. REMOVAL OF MERCURY FROM SODIUM. Memo Report 97. S. J. Rodgers. Nov. 22, 1955. 5p. Contract NObs-65426.

Three methods of removal of mercury from sodium were studied: fractional crystallization, amalgamation with copper, and cold trapping. Fractional crystallization and amalgamation with copper showed promise in small systems but proved impractical in larger systems; cold trapping was ineffective. Copper corrosion in 800°F

sodium was increased by a factor of ~24 over corrosion in 600°F sodium. (auth)

11612 NP-7422

Mine Safety Appliances Co., Callery, Penna. REACTION TEST; HOT NaK-BIPHENYL. Memo Report III. W. Milich and E. C. King. May 14, 1956. 5p. Contract NObs-65426.

A small quantity of NaK (56 wt. % K, ~6 grams) and biphenyl (~6 grams) were mixed and heated gradually to a temperature of 800°F under a cover of nitrogen to see if any chemical reaction would take place. The biphenyl first vaporized, as was evident by the vapors being expelled at 500 to 540°F. With further heating biphenyl vapors were no longer evident when the mixture reached 740°F and visual inspection of the remaining NaK after cooling indicated that all the biphenyl had been vaporized. It was therefore concluded that no chemical reaction was evident when heating small quantities of NaK and biphenyl under nitrogen at atmospheric pressure to 800°F. (auth)

11653

THE DETERMINATION OF LOW OXYGEN CONCENTRATIONS IN SODIUM. W. Jahns and G. Weidmann (Siemens-Schuckertwerke AG., Erlangen, Ger.). Nukleonik 1, 189-90(1959) Apr. (In German)

The possibility of determining low concentrations of oxygen in sodium was discussed. A simple amalgam method was described, and the solubility curve from it was given. (tr-auth)

11820 ASAE-26

American-Standard. Atomic Energy Div., Redwood City, Calif. MATERIALS FOR LIQUID METAL SYSTEMS. William Holman. Oct. 28, 1957. 32p. \$6.30(ph), \$3.00(mf) OTS. Lecture presented at the Atomic Industrial Forum's Third Course on Reactor Materials, Stanford University, Stanford, California, July 9-19, 1957.

A review of progress in the use of liquid metals is presented. A number of liquid metals are compared, and the general problems of selecting container materials are considered. In addition, a discussion of corrosion mechanisms and corrosion testing methods commonly employed are examined as well as problems encountered with the liquid metals of greatest interest. (J.R.D.)

11838 NAA-SR-Memo-1171

North American Aviation, Inc., [Downey, Calif.]. EFFECT OF MOLTEN SODIUM ON THERMAL INSULATION SPECIMENS. M. Tarpinian. Nov. 19, 1954. 8p. \$1.80(ph), \$1.80(mf) OTS.

Every type of thermal insulating material tested showed attack in varying degrees. Many specimens which had been cured at 1000°F, with no color change, did show drastic changes at 950°F due to the action of sodium. The materials showing the least disintegration and greatest preservation of mechanical properties were Superex paste and Eagle-Picher mineral wool. The uncured Superex Block did not hold up as well as Superex paste, presumably due to the presence of water of crystallization; after curing, the results were similar to that of the paste. The refractory clays showed the greatest degree of destruction. The time element is of vital importance, since a long period of contact with liquid sodium would presumably result in complete destruction of every specimen tested. (auth)

11846 NP-7403

Mine Safety Appliances Co., Callery, Penna.
TYPE SS GA-3 ELECTRIC CABLE TEST WITH
SODIUM. Memo Report 83. V. K. Heckel and E. C.
King. May 9, 1955. 3p. Contract NObs-65426.

The effects of Na on SS GA-3 electric cable were examined. The cable is considered as replacement for the M. I. cable specified for the SSN 575. The cable is described, along with test procedures and results. It was concluded that further tests are required before a recommendation can be made. (J.R.D.)

11847 NP-7404

Mine Safety Appliances Co., Callery, Penna.
TEST OF THIRD FLUID VALVE FOR USE WITH NaK.
Memo Report 84. W. Milich and E. C. King. June 14,
1955. 7p. Contract NObs-65426.

A $\frac{1}{4}$ in. bellows "Hoke" valve designed for use with mercury in the third fluid system of Mark B was tested and proved satisfactory for use with NaK-78. The valve was found to be leak tight on the valve body and across the seat by mass spectrometer tests given after each series of the major tests listed: valve open, 600 psig nitrogen pressure over NaK at 70, 125, 250, 375, and 500°F for 1 hr each on valve body; and, 100 cyclic tests of opening and closing with NaK at room temperature at 40 psig, followed by 600 psig across the seat for 1 hr. (auth)

11860 NP-7431

Mine Safety Appliances Co., Callery, Penna.
MINIATURE BOILER TEST—NaK INJECTION (NO. 2).
Memo Report 125. W. Milich, G. E. Kennedy, E. A.
Schultz, and E. C. King. Feb. 8, 1957. 10p. Contract
NObs-65426.

A test was run to determine the effect of a slow NaK leak to the water side nozzle where temperature measurements indicated the presence of superheated steam. Approximately 110 grams (0.242 lbs) was injected over a period of $6\frac{1}{2}$ hours with no indication of a temperature rise due to the water-NaK reaction. The boiler was operated 18 hours after the NaK injection was started before a steam leak was noticed. The system was immediately secured, allowed to cool and the boiler removed from the system. Several cracks were visible in the shell at this time. The unit was then returned to B & W for metallurgical examination. Preliminary examination revealed cracks in both the shell and outer tube. (auth)

11966 NP-7409

Mine Safety Appliances Co., Callery, Penna.
ELECTRICAL RESISTANCE OF A SODIUM SHORT
ACROSS A TWO-CONDUCTOR CONSTANTAN LEAK
DETECTION CABLE. W. Milich and E. C. King.
Sept. 14, 1955. 5p. Contract NObs-65426.

An attempt was made to measure the electrical resistance of a 300, 500, and 800°F sodium short over a length of 3 in. from an approximate 10 ft length of the present two-conductor constantan, ceramic beaded leak detection cable. The resistances measured in a bridge-type circuit were very small, the highest being 0.32 ohms. For comparison, the resistance due to synthetic sea water shorting across the leads was found to be 300 ohms. (auth)

12088 MSAR-59-29

MSA Research Corp., Callery, Penna.
FINAL REPORT. (A review of the work from

December 1953 to December 1958 with abstracts of reports issued.) W. J. Posey, ed. Mar. 20, 1959. 73p. Contract NObs-65426.

This report completes the task orders for research and development work on liquid metals, organics, and water technology under Contract NObs-65426. A brief general review of the work accomplished during the 5 year life of the contract is followed by a list of all reports issued, along with an abstract of each. (auth)

12091

SOME ASPECTS OF RADIATION PYROMETRY OF
LIQUID METAL. D. Ya. Svet. *Fiz. Khim. Osnovy
Proizvodstva Stali, Akad. Nauk S.S.S.R., Inst. Met. im.
A.A. Baikova*, Trudy 3-ei Konf. 399-409(1957). (Translation from *Referat. Zhur. Met.* No. 5, 1958, p.305.)

A method and apparatus are proposed for determining the radiating power of the surface of a liquid metal. The method consists of measuring the magnitude of the coefficient of reflection without interference from the flow of reflected radiation. The device consists of a system of mirrors, a shutter, a temperature lamp, a turret with light filters, a photocell, an amplifier, and a recording device. (W.D.M.)

12438 NP-7397

Mine Safety Appliances Co., Callery, Penna.
NaK AS A THIRD FLUID IN A SODIUM-WATER SYS-
TEM. Memo Report 75. R. C. Werner. Jan. 19,
1955. 10p. Contract NObs-65426.

The hazards involved if a leak should develop between NaK as a third fluid and water or sodium in a steam generator or superheater are discussed. If NaK were to leak into the water, the water would dissolve the hydroxides formed. The steam would act as a blanket to reduce any pressure waves and would sweep the hydrogen formed to the condenser. If water were to leak into the NaK third fluid system, the reduction in pressure initially and being closer to the heating sodium stream, the water would become steam thus greatly reducing any pressure wave formations. If NaK were to leak into the sodium system there would be a change in the nuclear operation of the unit and possibility of sludge formation by changing the primary stream from sodium to NaK thus lowering the solubility ability of the fluid. (auth)

12439 NP-7418

Mine Safety Appliances Co., Callery, Penna.
REMOVAL OF MERCURY IN RESIDUAL SODIUM
FROM A DRAINED SYSTEM USING A SODIUM FLUSH.
Memo Report 103. E. F. Batutis, C. A. Palladino, and
K. F. Barker. Jan. 17, 1956. 9p. Contract NObs-
65426.

The use of a fresh sodium charge to dilute mercury in the residual sodium of a drained system is a practical method for eventually removing the mercury. This was confirmed by using a hold-up pocket filled with a sodium amalgam and circulating fresh sodium past the $\frac{1}{2}$ in. pocket opening. The sodium amalgam in the bottom of the pocket was more effectively diluted by raising the system temperature to 600°F. The major portion of the mercury, in the pocket, mixed with the flush sodium circulating at 2.5 fps, at any temperature from 350 to 600°F in 15 to 30 minutes. (auth)

12444 RDB(R)/TN-1

Gt. Brit. Div. of Atomic Energy (Production),
Risley, Lancs, England.
THE CALCULATION OF THE VISCOSITY OF LIQUID

METALS (WITH SPECIAL REFERENCE TO LITHIUM).
E. S. Smith. Jan. 1952. 11p.

Results indicate that the relationship between the viscosity and temperature for liquid metals is of a type similar to that suggested for liquids in general. The viscosity of lithium at its melting point was calculated to be 0.006 poises, and the variation of viscosity of molten lithium with temperature was estimated. An equation for the summation of fluidities was found to give good results when applied to the calculations of the viscosity of K-Na alloys from the known viscosities of the compounds. There is apparently a connection between the viscosity of the liquid metal and its position in the Periodic Table. (auth)

12488

DETERMINATION OF MICROGRAM AMOUNTS OF COBALT IN SODIUM METAL. 2-NITROSO-1-NAPHTHOL SPECTROPHOTOMETRIC METHOD.
Louis Silverman and Rachel L. Seitz (Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.). *Anal. Chim. Acta.* 20, 340-3 (1959) Apr.

A colorimetric method, with 2-nitroso-1-naphthol, is outlined for determining Co in Na metal, which is used as a coolant in nuclear reactors. The Na metal is reacted with water, neutralized with HCl and the Co content determined; the cobalt nitrosonaphtholate is extracted with CCl_4 and the absorbance is measured at 535 m μ . Chloride ion is requisite for the extraction of the Co complex in dilute solutions. Li and K as well as Na have no effect. Ammonium ions have an adverse effect. As little as 0.1 ppm Co can be determined in Na metal. In order to determine Co in the fractional ppm range, 10 g of sample are used. The molar extinction coefficient is 11,780. (auth)

12646 AECU-4071

American-Standard. Atomic Energy Div., Mountain View, Calif.

MASS TRANSFER BY HIGH TEMPERATURE LIQUID SODIUM. Interim Progress Report No. 1. W. R. Holman. Feb. 3, 1958. 22p. Project D-14. \$4.80(ph), \$2.70(mf) OTS.

The design and development of equipment for obtaining mass transfer data in liquid sodium systems are reported. Preliminary data are given. (L.T.W.)

12647 AECU-4072

American-Standard. Atomic Energy Div., Mountain View, Calif.

MASS TRANSFER BY HIGH TEMPERATURE LIQUID SODIUM. Interim Progress Report No. 2. W. R. Holman. Oct. 15, 1958. 37p. Project D-14. \$6.30(ph), \$3.00(mf) OTS.

Experiments were carried out in thermal convection loops in which sodium was induced by thermal convection to flow past a number of accurately weighed corrosion specimens located at close intervals throughout the entire temperature range existing within the loop. The specimens were accurately weighed prior to and following the test, and the weight changes were used as a measure of local mass transfer. Operating conditions, dimensions, materials, and temperature distributions are tabulated. (For preceding period see AECU-4071.) (J.E.D.)

12676 NP-7389

Mine Safety Appliances Co., Callery, Penna.
REPORT 1 ON FREEZE SEAL PERFORMANCE.

Memorandum Report 55. T. A. Ciarlariello and R. A. Tidball. May 4, 1954. 6p. Contract NObs-65426.

An apparatus was designed and operated to determine the parameters affecting natural circulation heat transfer rates in horizontal and inclined pipes. The experiments on 1 in. piping are reported. The results of the tests are shown as temperature variation along the test section. The ambient temperature in the duct and the melting point of sodium are also indicated. (J.E.D.)

12678 NP-7391

Mine Safety Appliances Co., Callery, Penna.
PERFORMANCE OF A FROZEN SODIUM SEAL ON A 120 GPM DURIRON CENTRIFUGAL PUMP. V. K. Heckel and E. C. Klug. June 28, 1954. 15p. Contract NObs-65426.

Experimental data indicated that the flow and pressure of the centrifugal pump met the design capacity. The motor was found to be inadequate in that seal friction accounted for 40% of the input. The second test indicated that seal leakage during operation was not excessive and the pump could not be started and stopped without raising the seal temperature. (auth)

12679 NP-7392

Mine Safety Appliances Co., Callery, Penna.
STAINLESS STEEL SHOT IN SODIUM. Memo Report 62. M. M. Shrut and J. K. Richter. July 1, 1954. 4p.

A stainless steel shot was tested for cementing effect in molten sodium. There was no discernable increased resistance to penetration by a rod, as evidenced by daily probing, over a six week soaking period. (auth)

12725

LIQUID METAL PURIFIER. (to Babcock & Wilcox Co.)
British Patent 809,584. Feb. 25, 1959.

A cold-trap device for removing oxides from liquid-metal systems is described. It consists of a heat exchanger at the top and a cold chamber at the bottom. The heat exchanger is so arranged that incoming hot metal warms up outgoing cooled metal. As hot metal flows through the cool region where oxides are precipitated out, heat from it passes through a barrier which is cooled by double-tube helical coils. The inner tube is for coolant and the outer tube contains N_2 for heat conductivity and to prevent contact of liquid metal and coolant. The particular arrangement of the invention and its other features are such that severe temperature gradients are avoided, and thermal stresses in the structure are reduced. (T.R.H.)

12763 AERE-CE/R-757

Gt. Brit. Atomic Energy Research Establishment,
Harwell, Berks, England.

DIRECT CURRENT PUMPING OF LIQUID METALS.
D. A. Watt. Sept. 28, 1951. Decl. Apr. 30, 1959. 58p.

The general theory of d-c electromagnetic pump design is given together with a detailed design study for a pump to circulate sodium-potassium alloy at 250°C with a pressure rise of $3\frac{1}{2}$ atm. and a flow rate 13 $\frac{1}{2}$ liters/sec. All types of ohmic loss are detailed including that due to end current flow with baffles. Several possible designs with efficiencies of approximately 50% are indicated in the summaries of selected instances, covering a range of pump flow speeds from 10 to 30 ft./sec. These designs require a d-c supply of 7,000 to 13,000 amps at 1.1 to 0.6 volts. Hydrodynamic friction losses with zero magnetic field are tabulated. The ex-

tent to which "armature reaction" influences output and ohmic loss in an ideal pump with no compensating return current paths is also detailed. A note on the use of permanent magnet materials is appended. (auth)

12925 RDB(W)-8054

Gt. Brit. Windscale Works, Sellafield, Cumb., England.

HEAT TRANSFER EXPERIMENTS WITH SODIUM.

W. B. Hall and A. E. Jenkins. June 1953. 19p.

The theoretical approach to the problem of heat transfer in liquid metals is briefly reviewed. The difference between this approach and that used in the case of fluids with a high Prandtl number is due to the fact that the thermal conductivity of a liquid metal may be so high as to swamp the "eddy conductivity" in a turbulent stream. A description is given of experiments in which the heat transfer coefficients between two annuli each carrying a flow of sodium were measured. Since a direct comparison with results obtained with a circular tube is not possible, the results are in quite good agreement with the theoretical values given. In the course of the work it was found that there were significant variations in temperature around the annuli carrying the liquid metal in the heat exchanger. It is thought that these variations were due to a slight eccentricity of the exchanger tubes. An approximate theoretical treatment indicates that such variations are likely to be greater (when expressed as a fraction of the over-all temperature difference) in the case of liquid metals than in the case of fluids with a high Prandtl number. In these experiments, where the heat flux was about 50 watts per cm^2 , the temperature variations were quite small, but if full advantage is taken of the liquid metal to obtain high heat fluxes, they might be so large as to produce serious thermal stresses and distortion of the heat exchanger. (auth)

13225 NDA-84-19

Nuclear Development Corp. of America, White Plains, N. Y.

SODIUM-WATER REACTION RATE STUDIES.

L. Corrsin, H. Steinmetz, and B. Marano. May 15, 1959. 32p. Contract AT(30-3)-256. \$6.30 (ph), \$3.00 (mf) OTS.

Experimental techniques have been developed and kinetic experiments have been performed in a sodium-water reaction study undertaken to provide experimental data on the chemical reaction considerations associated with the SDR. Experimental techniques developed for the study of the reaction rate of liquid sodium droplets with liquid water and with steam are described. Results of kinetic experiments on the reaction of sodium with H_2O and D_2O are presented. (auth)

13227 NP-7524

Detroit Edison Co., Detroit.

DETERMINATION OF THE MAXIMUM PRESSURES ATTAINED DURING THE REACTION OF SODIUM WITH AIR IN CLOSED SYSTEMS. Engineering Laboratory and Research Department Report P-55C80-a. Edward Hines and J. K. Kelley. Jan. 17, 1956. 10p.

Preliminary investigation showed that the pressure developed by the molten sodium-air reaction reached a maximum of 15 psi above atmospheric pressure. The period in which the maximum pressure occurred varied from 0.14 to 1.54 seconds after the start of the test. The maximum temperatures of this reaction were calculated from the pressure measurements and appear to be 469 to 486°C. (auth)

13541 ORNL-2630

Oak Ridge National Lab., Tenn.

LIQUID METAL LOOPS IRRADIATED IN THE ORNL GRAPHITE REACTOR AND THE LITR. W. W. Parkinson and O. Sisman. June 1, 1959. 35p. Contract W-7405-eng-26. \$1.25 (OTS).

Liquid alkali metals were circulated in a series of structural alloy loops under reactor radiation at high temperature. The first of these loops was a lithium-stainless steel (type 316) system, and the remainder were sodium-Inconel. The lithium-stainless steel loop operated at 1000°F with a flow of 2 fps for 160 hr, receiving a fast neutron dose of 3×10^{16} neutrons/ cm^2 . Three of the sodium loops operated at 1500°F in the in-pile section and 1100° at the pump cell, with flows of 1 to 1.5 fps; the duration of operation ranged from 101 to 235 hr to give fast neutron exposures of 1.8 to 4×10^{16} neutrons/ cm^2 . The fourth sodium loop incorporated a stress-corrosion specimen stressed at 1500 psi. This loop operated between 1070 and 1270°F for 159 hr at a flow of 1 fps through the specimen. The dose ranged up to 5×10^{18} thermal neutrons/ cm^2 and 2×10^{18} fast neutrons/ cm^2 at the in-pile end of the specimen. In all loops, corrosion, if any, was less than 0.0005 in. No effect of radiation other than radioactivation was found. Mass transfer and metallurgical processes attributable to the operating temperatures were observed. (auth)

13868

HEAT TRANSFER IN TUBES TO MERCURY AND TO A SODIUM-POTASSIUM ALLOY. P. L. Kirillov, V. I. Subbotin, M. Ya. Suvorov, and M. F. Troyanov.

Atomnaya Energ. 6, 382-90 (1959) Apr. (In Russian)

Experimental and theoretical data on liquid metal heat transfer are analyzed. The design is given of the experimental installation, the experimental area, and the thermopair used for measuring the distribution of temperature in the liquid metal flow. It was found that oxygen contamination of sodium-potassium reduces the heat transfer coefficient. The results carried out in the absence of thermal resistance contact at the wall-liquid metal boundary agree with published data. (R.V.J.)

14232 NP-7394

Mine Safety Appliances Co., Callery, Penna.

MIXING OF RESIDUAL SODIUM WITH A SODIUM FLUSH. Report 2. Memo Report 68. E. F. Batutis, J. K. Powledge, and J. W. Mausteller. Nov. 4, 1954. 8p. Contract NObs-65426.

Residual sodium left on draining a 1 in. pipe loop was partially removed by a sodium flush at 650°F. The maximum practical decontamination was done in 4 hr at a flowrate corresponding to $\text{Re} = 38,000$. In this time mixing was 88% of that obtained in a total of 33 hr. (auth)

14247 TID-7568 (Pt. 2) (p.24-32)

MSA Research Corp., Callery, Penna.

OPERATING EXPERIENCES WITH OXIDE MONITORS FOR SODIUM SYSTEMS. E. F. Batutis. p.24-32 [of] ANALYTICAL CHEMISTRY IN NUCLEAR REACTOR TECHNOLOGY. PART 2. INSTRUMENTATION, REMOTE CONTROL TECHNIQUES, AND NUCLEONICS. Second Conference, Gatlinburg, Tennessee, September 29-October 1, 1958. 9p.

The control of oxides in alkali-metal heat-transfer systems is necessary from an operational and corrosion

standpoint since the inception of these metals as heat transfer media. "Wet" chemical methods for determining the degree of control are satisfactory for concentrations as low as 0.002 weight per cent of O_2 . Remote-control monitors have been developed with similar detection limits. In these devices, oxide concentrations are determined by observing the temperature at which oxide precipitates in a cooled by-pass stream, as indicated by an increase in resistance to flow. These so-called plugging indicators have given consistent and reliable results. The development of and the recent operational experience with these indicators in both large and small systems are also discussed. (auth)

14508 EES-090014A

Naval Engineering Experiment Station, Annapolis. BASIC INFORMATION ON THE BEARING PROPERTIES OF VARIOUS MATERIALS IN LIQUID METALS. W. J. Greenert and M. R. Gross. Feb. 19, 1954. 28p. (AD-146169).

Evaluation of materials for use in antifriction bearings exposed to liquid sodium-potassium alloy is presented. In order to establish certain basic information, however, many of the tests described were performed in lubricating oil. Data are presented on the load carrying capacity of SAE 52100 and 18-4-1 high speed tool steel in oil at 500°F. Superiority for the high speed tool steel was found. Also, the plastic behavior of rollers subjected to high stresses is discussed, and dispersion in the results of the contact roller test is statistically analyzed. The effect of liquid metal on laminated phenolic and glass laminated melamine plastics is presented. It is concluded that the maximum operating temperatures for these materials is 275°F. Results are also presented on the effect of liquid metal on the fatigue strength of SAE 52100 steel. The conclusion is that liquid sodium-potassium is not detrimental to the fatigue properties of this steel. (auth)

14895 IDO-16520(p.255-64)

Brookhaven National Lab., Upton, N. Y. LIQUID METAL IRRADIATIONS AND TESTS IN THE BROOKHAVEN REACTOR. R. A. Meyer. p.255-64 [of] TEST REACTORS MEETING FOR INDUSTRY, IDAHO FALLS, IDAHO, MAY 13-15, 1959. PART II. UTILIZATION OF TEST REACTORS. 10p.

Recent fuel element changes in the Brookhaven reactor increased the thermal flux to 2×10^{13} n/cm²/sec. Irradiations were conducted in this reactor to study chemical and property changes of liquid metals and container materials. Details of these tests and reactor conditions are presented. (auth)

14924 AECU-4161

Atomic Power Development Associates, Inc., Detroit. SODIUM-AIR ACCIDENT STUDY FOR A SODIUM COOLED REACTOR. Technical Memorandum No. 20. Edward Garelis. Apr. 6, 1959. 22p. \$4.80(ph), \$2.70 (mf) OTS.

The design requirements of a containment building for a sodium-cooled reactor have been investigated from the point of view of a hypothetical sodium-air reaction. In particular, this study was directed toward the containment building of the Enrico Fermi Atomic Power Plant. The hypothetical accident assumes a major leak in the sodium system with a concurrent or earlier failure of the ventilation and cooling system, which allows air to enter the areas around the sodium system which

are normally maintained in an atmosphere inert insofar as sodium burning is concerned. The resulting sodium pool, equivalent in burning surface to the fraction of the cross sectional area of the containment building, which is flooded, burns at a rate depending upon oxygen concentration and gas temperature in the containment building. A series of experiments were carried out to determine this burning rate and its mechanism. The resulting gas temperature and pressure due to the sodium-air incident were determined by solving a system of equations based on time dependent heat balances on the containment building and its contents. The assumed incident gives a maximum gas pressure of about 26 psig and a corresponding gas temperature of 1115°F. This pressure is well below the design pressure of 32 psig for the containment vessel. In addition to the study of the sodium-air reaction in the assumed incident, the theoretical maximum pressure and temperature for the constant volume adiabatic sodium-air reaction is also discussed. (auth)

15416

THE DESIGN OF ELECTROMAGNETIC PUMPS FOR LIQUID METALS. D. A. Watt (Atomic Energy Research Establishment, Harwell, Berks, Eng.). *Proc. Inst. Elec. Engrs. (London) Pt. A* 106, 94-103(1959) Apr.

The practical design of electromagnetic pumps is discussed with particular reference to construction of the duct/electrode element. Common features of electrical design are explained in terms of a simple theory of tube efficiency. The scope of d-c pumps in meeting different duties and practical conditions is indicated. Some results of an experimental investigation of d-c pump performance in a 4 in.-diameter pipe loop are given. The significance of end current loss is indicated, and also the equivalent reduction effected by the presence of a graded fringing field in the end regions. A technique of electrode "wetting" suitable for mercury and stainless steel is described, together with gas entrainment experiments. A homopolar generator with mercury collector rings is described. This type of machine would provide an efficient source of current for the d-c pump. The newer types of rectifier are briefly compared with the generator for this application. Reference is made to polyphase travelling-field pumps, and their appropriate application is discussed. Simple theory of design is given, with relationships for optimum design at standard supply frequency. Other possible designs of large electromagnetic pump are briefly examined and compared with the basic forms of conduction and induction pump. The various classes of pump suitable for laboratory use are mentioned and general principles of selection are offered. (auth)

15599

TURBULENT LIQUID-METAL HEAT TRANSFER IN CHANNELS. H. F. Poppendiek (Convair, San Diego, Calif.). *Nuclear Sci. and Eng.* 5, 390-404(1959) June.

An analytical heat transfer solution is derived and evaluated for the general case of a turbulently flowing liquid metal which suddenly encounters a step-function boundary temperature in a channel system. Local Nusselt moduli, dimensionless mixed-mean fluid temperatures, and arithmetic-mean Nusselt moduli are given as functions of Reynolds and Prandtl moduli and a dimensionless axial-distance modulus. These solutions are compared with known solutions of more specific systems as well as with a set of experimental liquid-

metal heat transfer data for a thermal entrance region. The results of this study can be used to define the temperature structure and heat transfer in solid-fuel element reactor cores and accelerator targets that are being cooled by liquid metals. (auth)

15718

UTILIZATION OF LIQUID METALS IN NUCLEAR REACTORS. André Ertaud. p.85-96 of "Journées d'Information sur l'Energie Nucléaire, 14-15-16 Janvier 1957." Documents, Suppl. to No. 114. France, Commissariat Général à la Productivité. 1957. 203p. (In French)

The characteristic properties of liquid metals are briefly reviewed, and the problems posed by their utilization in reactors are considered. The types of reactors using liquid metals and their characteristics and structure are examined, with emphasis on the Sodium Graphite Reactor. Thermal reactors with liquid sodium coolant and beryllium moderator, fast breeder reactors, and liquid metal fuel reactors are also discussed. (J.S.R.)

16314 PR-P-41

Atomic Energy of Canada Ltd. Chalk River, Ont. PHYSICS DIVISION PROGRESS REPORT [FOR] JANUARY 1, TO MARCH 31, 1959. 83p. (AECL-830). \$2.00(AECL).

The installation of the Tandem Accelerator was completed, and it has operated well. Proton beams of about 1 ma were obtained at energies from 2 to 10 Mev. A series of neutron threshold measurements were made as calibration points. Studies were made of gamma yields from proton capture in Al^{27} and B^{11} at 3 to 8 Mev. Inelastic neutron scattering at 14 Mev was studied using targets of Na, Mg, Al, Si, P, S, K, and Ca. A study was made of the frequency-wavelength relationship for elastic waves traveling in single crystals of lead and sodium iodide. Calculations were made to determine unsafe configurations for the "bird cage" storage vessel. Calculations on the oscillator model of the nucleus were continued with the introduction of spin-orbit coupling. The general Wigner-Eisenbud resonance theory was used to develop a method of analysis for the measured neutron cross sections of fissionable nuclei. (For preceding period see PR-P-40.) (D.E.B.)

16597

COMPONENTS: PUMPS. R. A. Jaross (Argonne National Lab., Lemont, Ill.). p.199-204 of PROCEEDINGS OF THE 1957 FAST REACTOR INFORMATION MEETING HELD AT CHICAGO, ILL., NOVEMBER 20-21, 1957.

Several notable advancements in the field of sodium pump technology have been made in the past year. The successful testing of two 5,000 gpm, 40 psi head pumps at ANL has afforded much valuable information and added greatly to the store of experience needed in sodium coolant system design. Extensive tests on these two pumps, one a centrifugal sump type and the other an AC linear induction pump, were made to assist in the selection of pumps for EBR-II. The pumps are described and tests are reviewed. (W.D.M.)

16598

COMPONENTS: PIPING SYSTEM COMPONENTS. F. A. Smith (Argonne National Lab., Lemont, Ill.). p.205-14

of PROCEEDINGS OF THE 1957 FAST REACTOR INFORMATION MEETING HELD AT CHICAGO, ILL., NOVEMBER 20-21, 1957.

The EBR-I indicates that reliability in a liquid metals system has been achieved. The components of a sodium piping system are comparable to conventional components. Nearly all the sodium system component items are commercially available and are competitively priced. The present state of development of the piping components other than nuclear cores or steam generators does indicate that there is no serious technical or economical limitation for the reliable operation of sodium piping components at temperatures up to 1,000°F. (W.D.M.)

16599

HEAT EXCHANGERS AND STEAM GENERATORS. R. H. Anderson (Atomic Power Development Associates, Inc., Detroit). p.215-28 of PROCEEDINGS OF THE 1957 FAST REACTOR INFORMATION MEETING HELD AT CHICAGO, ILL., NOVEMBER 20-21, 1957.

The philosophy for the use of, and the safety considerations for, the two coolant systems are presented. For the intermediate heat exchangers the basic over-all design considerations for the Fermi Reactor, EBR-II, and LAMPRE-II are discussed. The general design considerations, operating conditions, design features, and descriptions of the liquid metal steam generators are given. Test units operated by APDA and LASL are described. (W.D.M.)

16600

COMPONENTS—HIGH PURITY SODIUM SYSTEMS. Joseph E. Kemme (Los Alamos Scientific Lab., N. Mex.). p.229-33 of PROCEEDINGS OF THE 1957 FAST REACTOR INFORMATION MEETING HELD AT CHICAGO, ILL., NOVEMBER 20-21, 1957.

A series of small, pumped, sodium loops was used to study the problems peculiar to a LAMPRE-type reactor. The ultimate purpose of these experiments is to discover a means of purifying sodium which also will protect the plutonium fuel. A description and results of the tests are given. (W.D.M.)

16602

FLUID FUELS. B. M. Abraham (Argonne National Lab., Lemont, Ill.). p.248-53 of PROCEEDINGS OF THE 1957 FAST REACTOR INFORMATION MEETING HELD AT CHICAGO, ILL., NOVEMBER 20-21, 1957.

Slurries in general are discussed, and their apparent advantages for fast reactor application are reviewed. Experiments on UO_2 -NaK slurries are described. A slurry of NaK-5 vol. % UO_2 has been circulated successfully for long periods of time at 500°C. Erosion and corrosion do not appear to be a problem. The UO_2 is readily resuspendable after it has been permitted to settle either hot or cold. One preliminary experiment with a 15 vol. % slurry, which begins to approach the concentration of interest for a fast reactor, showed that the suspension was still fluid and it appeared uniform as it was circulated around the loop. (W.D.M.)

16738 AAEC/E-23

Australia. Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales. ESTIMATION OF TRACES OF NICKEL IN SODIUM METAL. T. M. Florence. Feb. 1958. 6p.

A simple and sensitive method is described for the

determination of traces of nickel in sodium metal. The nickel is complexed with potassium cyanide and the absorption measured spectrophotometrically at 268 m μ . Interference of iron and chromium is removed by precipitation of the hydroxides from homogeneous solution. This method should be applicable to a wide range of materials. (auth)

16752 CEA-834

France. Commissariat à l'Énergie Atomique, Paris. RÉALISATION D'UN ÉCHANTILLONNEUR A SODIUM LIQUIDE. (Liquid Sodium Sampler.) H. Chevallier. Feb. 1959. 5p.

A liquid metal sampler which permits the extraction of a given quantity of metal and its introduction into a movable container or analyzer without pollution by atmospheric oxygen is described. The apparatus is constructed of stainless steel. During sampling the pressure does not exceed 5×10^{-5} mm of mercury, and it is possible to remove only a drop of the metal. (J.S.R.)

16936 CF-58-10-13

Oak Ridge National Lab., Tenn. THERMOCOUPLE LIQUID LEVEL INDICATOR USED ON COLD TRAP STANDS. P. D. Peak. Oct. 3, 1958. 6p. Contract [W-7405-eng-26]. \$1.80(ph), \$1.80(mf) OTS.

Thermocouple liquid level indicators for use in detecting and controlling NaK levels in surge tanks were built and tested. While the indicators were not tested against another type of level measuring device, they performed satisfactorily and demonstrated the feasibility of pressure differential manual control. (J.R.D.)

17327

THE DEVELOPMENT AND OPERATION OF CENTRIFUGAL PUMPS FOR LIQUID METALS AND FUSED SALTS AT 1100-1500°F. W. F. Boudreau, A. G. Grindell, and H. W. Savage (Oak Ridge National Lab., Tenn.). *Nuclear Sci. and Eng.* 2, No. 1, Suppl., 17-18 (1959) June.

Four centrifugal pumps developed at ORNL for circulating Na, NaK, and molten salts at temperatures up to 1500°F are described. The pumps were built with capacities of 5-6, 60-150, 500-700, and 1200-1500 gpm. The design heads range from 40 to 375 ft. All are sump type pumps, and they utilize centrifugal impellers and volutes of conventional geometric design. A vertical pump shaft with the impeller overhung at the lower end is supported in a nearly conventional bearing housing. Drive motors are located above or at one side and external to the bearing housing. (W.D.M.)

17336

MASS TRANSFER IN HIGH-TEMPERATURE SODIUM LOOPS. W. R. Holman (American Standard, Redwood City, Calif.). *Nuclear Sci. and Eng.* 2, No. 1, Suppl., 27-8(1959) June.

Mass transport of type 316 stainless steel in sodium was studied by measuring local mass transfer rates in five thermal-convection loops. The results indicated that the mass transfer coefficient for dissolution and that for deposition were approximately equal and suggested that the over-all rate of materials transport was controlled simultaneously by both a slow step in the dissolution process and an equally slow step in the deposition process. Mass transfer coefficients varied from 10^{-3} to 2×10^{-3} cm/month in the temperature range 1000 to 1600°F. (W.D.M.)

17613

MAGNETIC COUPLINGS FOR TOTALLY SEALED SYSTEMS. A. Oltmann (Brookhaven National Lab., Upton, N. Y.). p.229-31 in "Proceedings of the Seventh Hot Laboratories and Equipment Conference."

A means of transmitting rotary motion into a totally sealed system without the use of stuffing boxes, freeze seals, or rotary mechanical seals is described. (auth)

17781 CEA-835

France. Commissariat à l'Énergie Atomique, Paris. DOSAGE DE L'OXYDE DE SODIUM DANS LE SODIUM, THE LA MÉTHODE AU MERCURE: SON UTILISATION DANS LE CAS DE TRES FAIBLES TENEURS. (Determination of Sodium Oxide in Sodium. The Mercury Method: Its Utilization in the Case of Very Low Concentrations.) L. Champeix, R. Derras, and J. Duflo. 1958. 10p.

The precision of the mercury method for the determination of sodium oxide is evaluated for microanalytical applications. The apparatus used for the analysis, the procedure, and the calibration are described in detail. Flame spectroscopy was used for the determination of the sodium hydroxide formed. The errors introduced by the presence of sodium and calcium chlorides are discussed. The results obtained are examined with respect to their reproducibility. The method can be used for the determination of oxygen in sodium at values less than 10 ppm with satisfactory precision if care is taken in the procedure. (tr-auth)

17874

IMPROVEMENT OF SEVERAL ANALYTICAL METHODS USED IN THE NUCLEAR METAL INDUSTRY. Jacques Robin (Centre de recherches d'Ugine, Lyon). *Énergie nucléaire* 1, 72-6(1959) May-June. (In French)

Several examples of analytical control related to the nuclear energy industry are given. Corrosion of steel by molten Na at high temperatures can be evaluated either by direct study of the steel (weight variation or metallography) or by analysis of the Na before, during, and after the test. The apparatus used for sampling the Na and its operation are described. For purity control of Zr and its alloys—determination of low and very low concentrations of impurities—the spectrographic method is preferable to chemical analysis. Determinations run on UF₄ are also discussed. (tr-auth)

17902

THE SOLUBILITY OF TANTALUM AND COBALT IN SODIUM BY ACTIVATION ANALYSIS. J. A. Grand, R. A. Baus, A. D. Bogard, D. D. Williams, L. B. Lockhart, Jr., and R. R. Miller (Naval Research Lab., Washington, D. C.). *J. Phys. Chem.* 63, 1192-4(1959) July.

The solubilities of tantalum and cobalt were determined by equilibrating sodium in tantalum and cobalt vessels at three temperatures. The sodium was irradiated in the Materials Testing Reactor. The solubility values were determined from a separation and counting of active isotopes in the sodium metal. Tantalum solubility ranged from 0.032 to 2.9 parts per million from 325 to 525°C. The range on cobalt was from 0.28 to 0.1 part per million from 365 to 525°C. (auth)

18031 AERE-Bib-120

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.

PUMPS AND ELECTROMAGNETIC FLOWMETERS FOR LIQUID METALS: BIBLIOGRAPHY. May 1959. 28p. \$0.63(BIS).

Supersedes AERE-Inf/Bib-93(4th Ed.).

This bibliography of unclassified literature supersedes AERE-Inf/Bib-93(4th edition), which was compiled in 1956. The scope has been widened to include references on mechanical pumps for liquid metals, as well as on the electromagnetic types. Recently declassified reports have been included. Patent literature and Progress Reports other than Final Reports on projects have been omitted. In the section on electromagnetic flowmeters, a number of general papers, which do not refer specifically to liquid metals, but which are, nevertheless, of considerable interest, have been included. Author and report number indexes have been added at the end of the bibliography. (auth)

18104 NAA-SR-3481

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

HIGH-STRENGTH ZIRCONIUM ALLOYS. R. K. Wagner and H. E. Kline. July 15, 1959. 40p. Contract AT-11-1-GEN-8. \$1.25(OTS).

The properties of zirconium alloyed with aluminum, tin, and molybdenum were investigated. Using reactor-grade zirconium sponge, 11 zirconium-base alloys were double arc-melted and cast into 6-in.-diam. ingots weighing 35 lb each. By such standard hot working procedures as extruding and rolling, the ingots were converted to $\frac{1}{8}$ -in.-thick strips. The extruded and rolled products were used for a variety of evaluation studies which included corrosion, thermal conductivity, tensile, and creep tests. The alloys demonstrated short-time elevated temperature strength properties equal to or greater than type-304 stainless steel. Their corrosion resistance in sodium, at 1000°F, compares favorably with that of unalloyed zirconium. The creep resistance and the thermal conductivity were found to be less than those for type-304 stainless steel, but adequate for nuclear reactor application. (auth)

18118 WADC-TR-57-294(Pt. I)

General Electric Co. Light Military Electronic Equipment Dept., Schenectady, N. Y.

RESEARCH ON LIQUID METALS AS POWER TRANSMISSION FLUIDS. [Period covered]: May 1956 to May 1957. Richard H. Blackmer. Feb. 17, 1958. 100p. Project and task title: HYDRAULIC FLUIDS. Contract AF33(616)-3698. (AD-151001).

The eutectic alloy of sodium (23 weight-percent) and potassium (77 weight-percent), known as NaK 77, has been determined from a technical survey of liquid metals and salts as the most feasible liquid known for 10 to 1000°F hydraulic system applications. A single cylinder test pump in an inert atmosphere glove-box has pumped NaK-77 up to 3600 psi at 100°F and up to 2000 psi at 1000°F. A total of about 100,000 cycles at 1 cycle per second and an average pressure of 1500 psi have been accumulated. Results of literature survey, consultation, and laboratory tests are included in this report. (auth)

18254 AEC-tr-3602

APPLIED MAGNETO-HYDRODYNAMICS. (Prikladnaya Magnitogidrodinamika.) Translated by Benjamin Skolnikoff from Trudy Inst. Fiz., Akad. Nauk Latv. S.S.R., 8, 1956. 127p. \$2.75(OTS).

Nine papers from the Transactions of the Institute of Physics of the Academy of Sciences, Latvian SSR, are

presented. Topics covered include modeling of magnetohydrodynamic phenomena in liquid metals, theory of induction pumps, velocity distribution and magneto-hydraulic pressure losses in a rectangular duct, electromagnetic phenomena in induction pumps, edge effects in linear induction pumps, design of induction pumps for liquid metal, single-phase pumps, and the problem of a conducting sphere in a traveling magnetic field. (W.D.M.)

18855 AAEC/E-22

Australia. Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales. DETERMINATION OF TRACES OF OXYGEN IN

SODIUM METAL BY INFRARED SPECTROPHOTOMETRY. PART 1. H. J. de Bruin and L. E. Smythe. June 1958. 4p.

The principal methods for the determination of traces of oxygen in sodium are based on the titration of sodium monoxide after the metal has been amalgamated and the oxide filtered off, distilled in vacuum, or reacted with an alkyl halide. (J.E.D.)

19354

WETTING BY LIQUID METALS. J. W. Taylor (Atomic Energy Research Establishment, Harwell, Berks, Eng.). p.398-416 in "Progress in Nuclear Energy. Series V. Metallurgy and Fuels. Volume 2."

The wetting of solid metals and ceramics by liquid metals and alloys is of importance in a number of fields of reactor technology. Under ideal conditions, this wetting is controlled by the three interfacial tensions; (1) liquid-vapor, (2) liquid-solid, and (3) solid-vapor, and the dependence of these on temperature and composition is outlined. Some specific cases of wetting are considered to illustrate the general rôle played by each of the three interfacial tensions and the influence of variables affecting wetting behavior is discussed. The rôle of wetting in the application of liquid metals as coolants, to slurry systems, in cermets, and brazing is outlined. (auth)

20133

ELECTROMAGNETIC PUMPS. P. Fortescue (to UK Atomic Energy Authority). British Patent 804,621. Nuclear Eng. 4, 324(1959) July-Aug.-Sept.

A liquid metal duct is arranged axially within the poles of a three-pole circular iron yoke structure. A magnetic field is created transversely across parts of the duct section in turn by field coils on the yoke (with secondary windings and electrodes around the duct) excited by three-phase current and thus a longitudinal pumping action is effected on the liquid metal in the duct.

20182 R58APS116

General Electric Co. Light Military Electronics Dept., Schenectady, N. Y.

RESEARCH ON LIQUID METALS AS POWER TRANSMISSION FLUIDS. Progress Report No. 1 [for] September 1, 1958 to December 15, 1958. R. C. Kumpitsch. Dec. 1958. Project No. 8-(1-7331). Contract AF33(616)-5917.

Research on liquid metals for use as power transmission fluids concerned with the construction, assembly, and operation of a complete 1 gpm, 3000 psi, 1000°F liquid metals test loop is reported. The feasibility of using the liquid metal NaK-77 as a high-temperature

hydraulic fluid is to be investigated by operation of this loop. Construction of the test loop has been initiated. Delivery of all system components and completion of the test loop less the high-pressure NaK pump is scheduled for 15 January 1959. The design of the high-pressure NaK staged gear pump was completed with exception to the selection of materials. The materials compatibility and wear test program was extended for the purpose of determining acceptable bearing, gear, wear plate, and shafts material combinations. Three material combinations were evaluated in NaK-77 at 1000°F for a period of six hours. Test results revealed that Kenametals K-84 running on Kentanium 138A to be the most acceptable combination of the materials evaluated. (auth)

20183 RDB(C)/TN-31

Gt. Brit. Culcheth Labs., Culcheth, Lancs, England. SOME FACTORS INFLUENCING THE COMPATIBILITY OF METALS WITH SODIUM, POTASSIUM AND URANIUM. A. B. McIntosh, J. S. Broadley, and K. Q. Bagley. Apr. 29, 1953. 48p. (FRDC/P-27).

The various factors which may influence the compatibilities of metals with sodium, potassium, and uranium are considered. Where possible these have been assessed using data which can be calculated or are already available in the literature. By studying the relation between the position of metals in the periodic classification and their compatibilities, it is shown that the most likely constructional metals for a fast reactor fuel element container are to be found in Groups IV, V, and VI. (auth)

20208

THE TRUE SPECIFIC HEATS OF URANIUM, THORIUM, AND OF OTHER METALS. E. A. Mit'kina. *Atomnaya Energ.* 7, 163-5(1959) Aug. (In Russian)

The true specific heats of uranium, thorium, beryllium, sodium, and lead-bismuth alloy (43.5% Pb and 56.5% Bi) were determined by a cooling-heating method and by the absolute method using an electron-radiative calorimeter. The design of the calorimeter is presented, and the obtained results and previously published data are tabulated. (R.V.J.)

20275

SODIUM CORROSION AS A FUNCTION OF TIME.

Presented at Nuclear Engineering and Science Conference, April 6-9, 1959, Public Auditorium, Cleveland, Ohio. Preprint V-114. John M. McKee (Nuclear Development Corp. of America, White Plains, N. Y.). New York, Engineers Joint Council, 1959. 20p. \$0.50.

Periodic weight loss measurements were made on tabs suspended in duplicate stainless steel thermal convection loops circulating sodium between 1575 and 1100°F for 5000 hours. Considerable decay in corrosion rate was observed due to the formation of a protective ferritic layer on the tab surfaces. (auth)

20305 AAEC/E-18

Australia. Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales. DISCHARGE COEFFICIENTS FOR THE NO. 1 SODIUM LOOP VENTURI METER. R. C. Cairns. Oct. 1957. 9p.

Discharge coefficients for the Venturi meter are reported for throat Reynolds numbers up to 298,000 using sodium. (auth)

20496 ORNL-1716

Oak Ridge National Lab., Tenn.

TURBULENT HEAT TRANSFER FROM A MOLTEN FLUORIDE SALT MIXTURE TO SODIUM-POTASSIUM ALLOY IN A DOUBLE-TUBE HEAT EXCHANGER. D. F. Salmon. Nov. 3, 1954. Decl. July 16, 1959. 31p. Contract W-7405-eng-26. \$4.80(ph), \$2.70(mf) OTS.

Mixtures of fluoride salts were found to show promise for the circulating-fuel application. An experiment to measure the heat transfer characteristics of the fluoride salt mixture NaF-ZrF₄-UF₄ was performed. A correlation of film heat transfer coefficients and the effect on heat transfer of deposits resulting from corrosion or mass transfer of container materials are reported. (J.E.D.)

20869 AAEC/E-17

Australia. Atomic Energy Commission Research

Establishment, Lucas Heights, New South Wales. STUDIES OF SMALL PARTICLE SUSPENSIONS FOR L.M.F.R. PART III. CORRELATION OF HORIZONTAL SETTLING VELOCITIES. R. C. Cairns. Feb. 1958. 13p.

The available experimental data for the horizontal settling velocities of suspensions with particles of small size were collected. These were compared with the velocities calculated from the several equations existing in the literature for predicting horizontal settling velocities. No consistent agreement between the experimental and calculated velocities was found. Using the effective density ratio, defined as the ratio of the difference in density between solid and liquid to the density of the liquid, the experimental values were correlated satisfactorily. Further data are needed before a generalized correlation for suspensions can be established. (auth)

21084 NAA-SR-Memo-4144

Atomics International Div., North American Aviation Inc., Canoga Park, Calif.

MRI DRIVER AND DETECTOR CIRCUIT FOR PRECISION SODIUM LEVEL PROBE. J. Campbell. July 21, 1959. 8p. \$1.80(ph), \$1.80(mf) OTS.

A circuit was designed which provides a satisfactory display on a 2" center zero meter as the dipstick probe traverses a thimble in a sodium vessel. The unit is self contained and all components are mounted in a 10 x 8 x 6" cabinet. Front panel adjustments are held to a minimum. Gain and sensitivity adjustments are accessible to the operator through the rear of the cabinet. These controls compensate for differences in electromagnetic characteristics between probes.

21431 NAA-SR-3882

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

ELECTRICAL HEATING METHODS FOR LIQUID-METAL SYSTEMS. R. S. Baker and H. W. Lohman. Sept. 15, 1959. 16p. Contract AT-11-1-GEN-8. \$0.50 (OTS).

The application of electric heating to liquid-metal piping systems is discussed. Three electrical methods—resistance, induction, and transformer heating—are identified and described. Temperature variation along an induction heated pipe is explained as a magnetic phenomenon. A comparison of the three heating methods is offered. (auth)

21726 NAA-SR-1190

North American Aviation, Inc., Downey, Calif.
 REACTOR SAFETY QUARTERLY PROGRESS REPORT
 [FOR] AUGUST-OCTOBER 1954. Norman E. Huston,
 ed. Apr. 15, 1955. Decl. July 20, 1959. 43p. Con-
 tract AT-11-1-GEN-8. \$7.80(ph), \$3.30(mf) OTS.

Work was continued on developing fabrication and as-
 sembly techniques for the Hanford safety element. The
 stainless steel Mark II design should provide a reac-
 tivity ratio (triggered loss to stored loss) of 3.7. The
 poison coating studies were terminated. The latest re-
 sults show the coating efficiency to be strongly tem-
 perature-dependent with only a small useful range of
 about 10°C. Studies of the exothermic reaction of BF₃
 with liquid sodium show the reaction to be rapid but not
 violent.

21776 NAA-SR-4102

Atomics International Div., North American Aviation,
 Inc., Canoga Park, Calif.

COMMENTS ON THE APPLICATION OF ASME AND
 ASA BOILER AND PIPING CODES TO SODIUM SYS-
 TEMS. W. C. Hayes. Sept. 15, 1959. 23p. Contract
 AT-11-1-GEN-8. \$0.75(OTS).

The American Society of Mechanical Engineers
 (ASME) Power Boiler Code, Unfired Pressure Vessel
 Code, and the American Standard Code for Pressure
 Piping (ASA B31.1-1955) are reviewed as bases for
 the design of sodium systems and to point out areas
 which may require consideration beyond the scope of
 these codes. It is concluded that the code rules are
 generally adequate in their intention to provide mini-
 mum safety requirements for new construction. How-
 ever, the designer must have additional data in order
 to make realistic allowances for any unusual conditions
 which may be associated with sodium systems. It is
 also concluded that design criteria may, in some in-
 stances, be more appropriately based on the elevated
 temperature notched and unnotched properties of parent
 material, weld material, and the heat-affected zone,
 rather than just the unnotched parent material as pro-
 vided for in the codes. (auth)

22387 CF-54-12-26

Oak Ridge National Lab., Tenn.

RESULTS OF STATIC CORROSION TESTS ON VARIOUS
 NICKEL-BASE BRAZING ALLOYS USED TO FABRI-
 CATE 304 STAINLESS STEEL T-JOINTS. JOINTS
 TESTED IN SODIUM AND FLUORIDE #44 (NaF-ZrF₄-
 UF₆) FOR 100 HOURS AT 1500°F. E. E. Hoffman.
 Dec. 3, 1954. Decl. June 8, 1959. 3p. Contract W-
 7405-eng-26. \$1.80(ph), \$1.80(mf) OTS.

The results of corrosion tests on nickel-base brazing
 alloys indicated that all the alloys tested had good re-
 sistance to attack by fused chloride. The chromium-
 nickel-phosphorus system showed good resistance to
 attack by both fused fluoride and sodium. (J.E.D.)

22922

ANGULAR DISTRIBUTIONS OF NEUTRONS INELASTI-
 CALLY SCATTERED FROM SODIUM. E. N. Shipley,
 G. E. Owen, and L. Madansky (Johns Hopkins Univ.,
 Baltimore). *Phys. Rev.* **115**, 122-6(1959) July 1.

The angular distribution and total cross section for
 neutron inelastic scattering proceeding to the first ex-
 cited state in sodium were measured by observing the
 neutron-gamma coincidences. The measured total
 cross sections for the various neutron energies used

are $\sigma_T(3.49 \text{ Mev}) = 370 \pm 120 \text{ mb}$, $\sigma_T(3.75 \text{ Mev}) = 270 \pm$
 90 mb , and $\sigma_T(4.00 \text{ Mev}) = 280 \pm 90 \text{ mb}$. The differential
 cross sections were found to be higher in the backward
 than in the forward directions. (auth)

23110 NAA-SR-Memo-4119

Atomics International Div., North American Aviation,
 Inc., Canoga Park, Calif.

PERFORMANCE TEST OF A TWO-COOLANT-REGION
 SODIUM PUMP SHAFT FREEZE-SEAL. F. O. Streck.
 July 15, 1959. 15p. \$3.30(ph), \$2.40(mf) OTS.

The operation of the freeze-seal type sodium pump
 requires a shaft freeze-seal capable of retaining so-
 dium. A prototype two-coolant-region freeze seal for
 application on HNPf sodium pumps was designed and
 constructed. It was tested under environmental condi-
 tions to determine its operating characteristics and
 sodium retaining capabilities. (auth)

23115 ORNL-2799

Oak Ridge National Lab., Tenn.

MOLTEN-SALT REACTOR PROGRAM QUARTERLY
 PROGRESS REPORT FOR PERIOD ENDING JULY 31,
 1959. Oct. 8, 1959. 105p. Contract W-7405-eng-26.
 \$2.50(OTS).

The nuclear performance of a two-region graphite
 moderated molten-salt breeder reactor was studied.
 Reactor power was 125 Mw(th). Salt-lubricated hydro-
 dynamic journal bearings with two axial grooves 180°
 apart were tested to failure. Three further tests were
 conducted with bearings containing three equally spaced
 helical grooves. Fabrication of a pump incorporating a
 three-axial-groove hydrodynamic bearing was com-
 pleted. Construction of the Remote Maintenance Demon-
 stration Facility was completed on schedule. One long-
 term corrosion test loop was terminated after a year's
 operation. The enthalpy and viscosity of a high-thorium-
 content blanket salt mixture were experimentally de-
 termined. A redetermination of the viscosities of two
 low-UF₆-content mixtures with the modified viscometer
 resulted in lower values and altered temperature de-
 pendence for both salts. Eleven INOR-8 thermal-
 convection loops and twelve Inconel loops were ex-
 amined. A 6000-hr test and a 5000-hr test of INOR-8
 exposed at 1300°F to a system containing graphite and
 fuel 130 (LiF-BeF₂-UF₆) were completed. Inconel and
 INOR-8 specimens exposed to graphite-sodium systems
 for 4000 hr at 1400°F were carburized to a depth of 30
 to 40 mils and showed a loss in ductility both at room
 temperature and at 1250°F. Fuel 30 (NaF-ZrF₄-UF₆)
 and fuel 130 penetrated to 58% or more of the accessible
 void volume in AGOT graphite specimens when 150 psig
 pressure was applied in a 100-hr exposure at 1300°F.
 Initial gettering and flushing tests to remove oxide con-
 taminants from graphite specimens with fuel 130 in a
 20-hr exposure at 1300°F appeared to reduce the amount
 in uranium oxide precipitation normally observed in
 tests with nongettered graphite. The program for evalu-
 ating the mechanical properties of INOR-8 was re-
 viewed. Initial studies to determine the cladability of
 prefabricated porous nickel for use as a leak-detecting
 component in a triplex heat-exchanger tube have indi-
 cated that the material can be bonded to Inconel with
 retention of core porosity. An INOR-8 weld-metal com-
 position containing 2% Nb exhibited good ductility at
 1500°F. Groundwork for a phase study of PuF₃ fuels is
 provided by cooling curves on a series of compositions
 from the NaF-PuF₃ binary system. Fission product be-
 havior, particularly as related to fuel reprocessing and

recovery, was studied in experiments on the solubility and precipitation of rare-earth fluorides. Solubility measurements were made on NiF_2 . In a study of the compatibility of graphite with fuel, no deleterious or unfavorable effects were encountered with samples of an

impervious graphite which were exposed to circulating fuel for one year in a corrosion-test loop. Two modifications of the HF dissolution process for purifying the LiF-BeF_2 carrier salt are being investigated. (For preceding period see ORNL-2723.) (W.D.M.)

Volume 14, 1960

171 NAA-SR-4005

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

SPECTROPHOTOMETRIC DETERMINATION OF COBALT IN SODIUM METAL. Louis Silverman and Rachel L. Seitz. Oct. 15, 1959. 14p. Contract AT-11-1-GEN-8. OTS.

A colorimetric method, using 2-nitroso-1-naphthol, is outlined for determining cobalt in sodium metal, which is used as a coolant in nuclear reactors. The sodium metal is reacted with water, neutralized with hydrochloric acid, and the cobalt content determined; the cobalt nitrosonaphtholate is extracted with carbon tetrachloride and the absorbance is measured at 535 $m\mu$. Chloride ion is requisite for the extraction of the cobalt complex in dilute solutions. Lithium and potassium, as well as sodium, have no effect. Ammonium ions have an adverse effect. As little as 0.1 ppm cobalt can be determined in sodium metal. In order to determine cobalt in the fractional ppm range, 10 gm of sample are used. The molar extinction coefficient is 11,780. (auth)

287

LIQUID-METAL HEAT TRANSFER MEDIA. S. S. Kutateladze, V. M. Borishanskii, I. I. Novikov, and O. S. Fedynskii. Translation of *Atomnaya Energ.*, Suppl. No. 2, 1958. New York, Consultants Bureau, Inc., 1959. 152p. \$22.50.

The thirteen chapters in this volume cover the following subjects: basic properties of liquid metals, application of liquid-metal heat-transfer media, hydraulic resistance in the flow of liquid metals, turbulent heat transfer in liquid metals, heat transfer during flow in tubes, heat transfer during longitudinal flow around a plate, heat transfer during transverse flow around cylinders, heat exchange during free convection, heat transfer during vapor condensation, heat exchange during boiling, heat-exchanging equipment, stability of heat-resistant materials in liquid metals, and instrumentation. (W.L.H.)

297

A METHOD FOR THE DETERMINATION OF THE INTENSITY OF HEAT EXCHANGE IN MOLTEN METALS BY FREE CONVECTION. A. I. Veynik. *Trudy Inst. Energet. Akad. Nauk Beloruss. S.S.R.* No. 3, 62-7(1957). (Translated from *Referat. Zhur. Met.*, No. 10, 1958, p.187).

To determine the intensity of heat exchange in molten metal by free convection the use of the method of an immersion method is proposed in which a specimen (S) of suitable shape and possessing a specified thermal resistance on the surface is immersed in the melt. During the interaction of S with the molten metal the heat flow passing into the S at first is considerable,

which causes the formation of a hardened crust of a certain thickness on the surface of S. Then, with progressive heating of the S, the heat flow decreases and the hardened crust gradually melts. This is explained by the fact that the amount of heat entering the S through the crust becomes smaller than the amount of heat transferred to the crust from the molten metal. The resulting excess of heat is expended on the melting of the crust. If the S is removed from the molten metal bath before the crust is completely melted, then it is possible to judge the magnitude of the heat flow and the value for the coefficient of heat transfer from the thickness (or weight) of the remaining solid metal. To put the proposed method into practice formulas are developed for the relationship between the thickness of the hardened crust and the value of the heat-transfer coefficient. To simplify the problem it is assumed that the thickness of the hardened crust is small compared to the dimensions of the S, and, therefore, in the thermal sense, the crust is regarded as a plane partition. Moreover, the temperature drop occurring within the crust as a result of the cooling of its inner surface (in contact with S) below the temperature of crystallization is disregarded.

379

ELECTRO-MAGNETIC PUMPS FOR LIQUID METALS. L. R. Blake (United Kingdom Atomic Energy Authority, Caithness, Scotland). *Reactor Technol.* 1, 65-76(1959) Aug.

As a guide to pump selection, about a dozen of the more important types of electro-magnetic pumps are described, including their principle of operation, field of application, and operating characteristics. Manufacturing problems are not discussed. (auth)

587

MASS-TRANSPORT AND CORROSION OF IRON-BASED ALLOYS IN LIQUID METALS. G. W. Horsley (Atomic Energy Research Establishment, Harwell, Berks, Eng.). *Reactor Technol.* 1, 84-91(1959) Aug.

The application of mass-transport equations to the corrosion of metals by liquid metals is discussed. Calculated corrosion rates are compared with experimentally determined rates. It is concluded that diffusion controlled solution attack, although significant, may not under conditions of interest to reactor engineers be as serious as either inter-granular attack or chemically assisted mass-transport. The mechanism of inter-granular attack, the thermodynamics of an example of chemically assisted mass-transport, the role of oxygen in sodium-stainless steel circuits, and methods of reducing mass-transport of iron are discussed. (auth)

1106 NAA-SR-4050

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

A SIPHON BREAK AS A BLOCKING VALVE.

J. McDonald and W. Marten. Oct. 15, 1959. 29p.
Contract AT-11-1-GEN-8. OTS.

An experiment was conducted to determine the feasibility of using the breaking of a siphon as a quick-acting means for stopping sodium flow following a loss of pump power. A 2-in. pipe system with a high-speed free-surface centrifugal pump was used in this investigation. Runs were made with sodium at 500 and 940°F, cover gas at various pressures up to 10 psig, and Reynolds numbers up to approximately 360,000. The siphon-break was established as an effective method for rapid flow stoppage; however, a brief reversal of flow follows the initial flow stoppage. An expression for the flow transient following the breaking of the siphon was derived which agreed reasonably well with experimental results. (auth)

1254

MEASUREMENT OF CONCENTRATION OF TUNGSTEN SUSPENSIONS AND DENSITY OF LIQUID SODIUM BY GAMMA RAY ABSORPTION. J. S. Watt and K. R. Lawther (Australian Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales). p.610-14 of "Australian Atomic Energy Symposium, 1958."

Gamma-ray absorption techniques were applied to measure the density of various media. The theory of selecting the appropriate energy gamma ray to give optimum sensitivity of density determination for a homogeneous system is outlined. A gauge to determine the concentration of tungsten powder suspended in water in a concentration range of 0 to 8 gm tungsten/cc suspension, was developed. In this apparatus the mean tungsten concentration, 0.08 gm/cc can be measured to an accuracy of approximately ± 0.0015 gm/cc. In the case of liquid sodium contained in a stainless steel vessel, preliminary experiments indicate that the density may be measured to an accuracy of ± 0.01 gm/cc, and that 0.01 gm/cc transient changes in density occurring in a few seconds can be resolved. (auth)

1608 ORNL-1330

Oak Ridge National Lab., Tenn.

HEAT EXCHANGER DESIGN CHARTS. A. P. Fraas and M. E. LaVerne. Dec. 7, 1952. Decl. Oct. 9, 1959. 82p.
Contract W-7405-eng-26. OTS.

Several design charts of the ORNL-ANP liquid-to-liquid heat exchanger are given along with brief explanations and sample calculations. Pictures of the models that have been built are given as an introduction to the type of heat-exchanger construction. Fluid flow and pressure losses are discussed, and the heat-transfer coefficients are calculated from physical-property data of the fluids. Finally, a series of charts was prepared to show the performance characteristics of some typical counterflow heat exchangers as an aid in the rapid determination of effects of changes in design conditions. (J.E.D.)

1611

HEAT TRANSFER OF MOLTEN SODIUM FLOWING TRANSVERSELY ACROSS A SINGLE CYLINDER. A. A. Andre-evskii. *Atomnaya Energ.* 7, 254-6(1959) Sept. (In Russian)

The local heat transfer dependence on the flow rate, the distribution of heat transfer along a cylinder, and variations of the relative heat transfer coefficient across the cylinder are analyzed. The mean heat transfer in transverse flow across cylinders and tube systems is plotted. (R.V.J.)

1762 ORNL-2349

Oak Ridge National Lab., Tenn.

AIRCRAFT REACTOR EXPERIMENT—METALLURGICAL ASPECTS. W. D. Manly, G. M. Adamson, Jr., J. H. Coobs,

J. H. DeVan, D. A. Douglas, E. E. Hoffman, and P. Patriarca. Jan. 9, 1958. Decl. Oct. 9, 1959. 57p. Contract W-7405-eng-26. OTS.

The selection of the proper structural material to be used in the construction of an Aircraft Reactor is influenced by a number of important requirements. The material must have an acceptable cross section; be resistant to elevated-temperature corrosion by liquid metals, air, and the molten salts, and be free of temperature-gradient mass transfer. It must possess good creep properties in these environments and be free of structural changes during service. Finally, it must be easy to form and weld into relatively complicated shapes and be commercially available. Inconel was selected as the structural material for the Aircraft Reactor because it met these requirements. The experimental work performed in the fields of corrosion, creep, and welding is described. Although a small amount of corrosion in the salt and some mass transfer in both sodium and salt were observed, the material performed quite satisfactorily during the lifetime of the reactor. The creep properties of Inconel were adversely affected by the various environments; however, by designing to limit the stress, successful operation of the reactor was achieved. Both the successful operation of the reactor and the relative ease with which a multitude of welded joints in the plumbing circuit was produced attested to the weldability of this alloy. (auth)

1763 ORNL-2422(Del)

Oak Ridge National Lab., Tenn.

METALLURGY DIVISION ANNUAL PROGRESS REPORT FOR PERIOD ENDING OCTOBER 10, 1957. Dec. 13, 1957. Decl. with deletions Oct. 29, 1959. 247p. Contract W-7405-eng-26. OTS.

High-Temperature Metallurgy. A series of Inconel loops were operated to study the variation with time of depth of corrosion, effect of flow rate on corrosion, and effect of temperature drop on corrosion using fused salts. The corrosive effects of fused salts on Hastelloy B and Ni-Mo alloys are discussed. A series of Inconel-Na and Inconel-NaK forced circulation loops was operated to study the mass transfer in the systems. The mass transfer between Na and forced circulation loop of stainless steel, Incoloy, and Hastelloys B and W is discussed. Thermal convection loop corrosion resistance studies of Ni-Mo alloy, Inconel castings, and Nb in various systems are presented. Non-destructive testing methods and equipment are discussed. Methods and equipment used in the inspection of materials for reactor service are presented. A distillation apparatus is described for the purification of Na. To determine the effect of concentration on the diffusion coefficients, study on the rate of diffusion of Ni in liquid Pb was initiated. A study is reported to determine why the protective oxide layer of Ni, Ta, and Zr becomes disrupted. A brief survey was made of the microtopography of sulfide films formed on Nb, Ta, and Zr. A research program was undertaken to determine the effect of reactor radiation on the gaseous oxidation of metals. Measurements of the density and absorption spectra of fused salts are presented. **HRP Metallurgy.** Microstructures of aged quench-and-reheat specimens of Zr-Nb alloys are presented. The effect of H₂ on the embrittlement of Ti is given. Tensile and impact specimens of Zircaloy-2 were irradiated in corrosion loops to determine if any harmful mechanical property changes occurred through neutron irradiation or as a result of environment. **Applied Metallurgy.** Substitution of type 347 stainless steel for type 304 in APPR fuel elements because of heat-treatment specifications is discussed. An investigation was initiated to develop a dispersion of Eu₂O₃ in an iron-base material, clad with stainless steel as a replacement for boron-bearing absorber sections. The fabrication

and composition of various reactor fuel materials are described. Treatment of various fuel materials by carburization is presented. Results of experiments on the intergranular diffusion of Zr by Mg are presented. Metallographic examinations of HRP reactor components are presented. Progress and status of development of polishing techniques for metallographic specimens employing vibratory polishing machines are presented. The microstructure of Inconel was investigated. Preparation and identification of some rare earth silicides are discussed. The diffusion of Ca in TiO_2 was studied. A preliminary investigation was made of the ThO_2 - SiO_2 system. The electric arc calcination of ThO_2 is described. Fundamental Metallurgy. The allotropic modifications in metallic Ce are described. Preferred orientation in extruded Al rod is described. Low-temperature measurements of the specific heats of Zr and Zr-In alloys are presented. Phase studies of the Cd-Zr alloys are presented. Structures and phase transformations in Perovskite-type compounds are presented. (See also ORNL-2217.) (W.L.H.)

1786

STUDIES OF LIQUID METALS. *Bull. inform. sci. et tech. (Paris)* No. 31, 63-77(1959) July-Aug. (In French)

Studies of the Societe des Metaux liquides related to the use of liquid metals in reactors are described. The studies include electromagnetic and mechanical pumps, heat exchange measurements, liquid level measurement, and installation of a sodium cooling system for a reactor and production of superheated vapor. (T.R.H.)

1804

ORNL-1934

Oak Ridge National Lab., Tenn.

AN EVALUATION OF THE CORROSION AND OXIDATION RESISTANCE OF HIGH-TEMPERATURE BRAZING ALLOYS. Period covered: July 1954-September 1955. E. E. Hoffman, P. Patriarca, C. F. Leitten, Jr., and G. M. Slaughter. Nov. 7, 1956. Decl. Oct. 9, 1959. 40p. Contract W-7405-eng-26. OTS.

Many of the brazing alloys which were investigated were highly promising for sodium-to-air radiator service. Alloy systems of Ni-Si-B, Ni-Cr-Si-B, and Ni-Cr-Si were especially favorable. Precious-metal alloys were, in general, severely attacked by sodium, as were many of the silicon-free, chromium-free, phosphorus-bearing alloys. Alloys containing manganese, tin, or copper exhibited poor resistance to oxidation at 1500°F. In most cases, oxidation was more pronounced at 1700°F. For fused-fluoride-to-sodium heat exchanger service, the alloy systems Ni-Cr-P, Ni-Cr-Si-B, Ni-Si-B, and Ni-Ge-Cr-Si show promising corrosion resistance. Although the Ni-Cr-Si alloy was compatible with sodium, it was severely attacked by the fluoride bath. The binary alloy 88 Ni-12 P (alloy A-10) was incompatible with sodium but possessed good resistance to fluoride attack. Tests seem to indicate that complex alloy systems containing varying percentages of silicon and phosphorus as minor constituents may be compatible with both sodium and the fused salts, whereas the binary alloys exhibited compatibility with only one of these testing media. The only brazing alloys found to be compatible with fused sodium hydroxide were precious-metal alloys such as 82 Au-18 Ni. In evaluating the corrosion and the oxidation resistances of a brazing alloy for a specific application, emphasis was placed on the seesaw-corrosion and cyclic-oxidation studies, since these tests more nearly simulate the expected operating conditions than do the static tests. It must be remembered, however, that before a brazing alloy is selected for a given operation it should be tested further under the conditions which would closely simulate service conditions. (auth)

2218 ORNL-1215

Oak Ridge National Lab., Tenn.

HEAT TRANSFER AND PRESSURE LOSS IN TUBE BUNDLES FOR HIGH PERFORMANCE HEAT EXCHANGERS AND FUEL ELEMENTS. G. H. Cohen, A. P. Fraas, and M. E. LaVerne. Aug. 12, 1952. Decl. Oct. 9, 1959. 75p. Contract W-7405-eng-26. OTS.

A promising type of construction for both heat exchangers and fuel elements involves parallel flow through bundles of closely-spaced tubes. This report discusses problems encountered in spacing long slender tubes and in handling the cross-flow regions at the ends. A series of model tests, planned to give the more important pressure-drop and heat-transfer information required for ANP design work, are reported. Two heat-exchanger models and three ARE-type fuel-element bundles were flow-tested with water and air, and the heat-transfer characteristics of one heat-exchanger model were determined with NaK. Appendixes include the following: cooling effectiveness and overall heat-transfer coefficient; friction factor and Reynolds' number for air-flow and water-flow tests; correlation of flow through individual tubes with tube length and diameter; and metallographic examination of heat exchanger after 3000 hr operation in NaK. (L.T.W.)

2537

CF-56-5-148

Oak Ridge National Lab., Tenn.

METALLOGRAPHIC EXAMINATION OF HIGH VELOCITY HEAT EXCHANGER (SHE NO. 1). R. J. Gray. May 24, 1956. Decl. Oct. 9, 1959. 14p. OTS.

Judging from the condition of the tube walls, this heat exchanger was close to failure. The depth of intergranular attack on the inner NaK surface (0.003 in.) and the depth of subsurface voids on the fuel side (0.007 in.) were more than half the wall thickness and these measurements were only from a few scattered specimens and on one plane per specimen. The grain size was much larger in the hot end than in the cold end of the heat exchanger. This increased grain size in the hot end could be attributed to the absence of precipitate and greater triaxial stresses due to thermal expansion and a thermal differential across the tube wall. Also, the strain anneal effect due to the thermal cycling during operation at a specific temperature would accelerate grain growth. These stress conditions and the resulting change in microstructures are directly related to the operating temperature at the hot end. The greater depth of corrosion at the hot end could also be due to a greater stressed condition or a corrosion fatigue. Mass transfer was present where the NaK entered the heat exchanger, but this deposition was influenced greatly by flow against the tube walls. The maximum deposit was 0.003 in. (auth)

2538

CF-56-7-135

Oak Ridge National Lab., Tenn.

EXAMINATION OF ORNL 1 AND 2 INTERMEDIATE HEAT EXCHANGERS, TYPE IHE-3. J. H. DeVan and R. S. Crouse. July 20, 1956. Decl. Oct. 9, 1959. 17p. OTS.

Failure, which resulted in the stoppage of fluoride flow in ORNL No. 1, occurred as a NaK to fuel leak in the vicinity of the NaK inlet heater. The reaction of NaK with fuel at this point caused the deposition of nearly pure UF_3 around the tubes and, finally, a sufficient increase in the melting point of the fuel to produce solidification. Fluorides throughout the heat exchangers were found to be depleted in uranium and to contain some potassium. Thus it would appear that stoppage of flow occurred after considerable NaK pick-up had taken place. Fluoride attack observed in these heat exchangers, with the exception of the area of failure, agreed substantially with what would be predicted from other dynamic systems. However, in those tubes near the point of failure, attack on the "tension" side

of the tubes occurred to depths approximately twice those observed in "unstressed" tubes at comparable temperatures. Mass transferred particles were present in the NaK circuit of ORNL No. 1 to a maximum thickness of 15 mils. Deposit thicknesses varied markedly from header to header. (auth)

2671 ORNL-1033

Oak Ridge National Lab., Tenn.

QUARTERLY PROGRESS REPORT FOR PERIOD ENDING APRIL 30, 1951. E. C. Miller and W. H. Bridges, eds. Oct. 23, 1951. Decl. Oct. 9, 1959. 82p. Contract W-7405-eng-26. OTS.

Experience in extruding rods and tubing of thorium indicates that fabrication by extrusion is completely feasible. The extrusion die design and materials present the greatest problems because of the peculiar flow of thorium during extrusion and the high erosion rate. Thorium tubing clad inside with zirconium was extruded satisfactorily. Work is continuing in order to obtain better surfaces and uniformity of cladding. The thermal cycling of thorium and uranium in Na-K has shown no real deformation of the thorium, but oxide scale formation with significant penetration did occur. An investigation on thorium welding was started, and successful butt, edge, and lap welds were made, using Hellarc techniques. The static corrosion testing of construction materials in a liquid-metal environment has continued. Work has started on the corrosion testing of various materials exposed to fused salts. Dynamic corrosion testing using thermal convection loops containing sodium, lead, and lithium is being carried on jointly with the Experimental Engineering Section of the ANP Division. Stainless steel types 347, 321, and 310; Inconel; and Haynes Alloy 25 displayed very little attack by sodium in 1000 hr at 1500°C. The welds are still the vulnerable areas, and various welding techniques need investigation to determine the best way to eliminate this source of failure. Work on the fabrication of solid type fuel elements for high-temperature reactors is progressing. New types of perforated or mechanically deformed metal plates which can be loaded with UO_2 and clad are being considered. The pressed and clad type in which the UO_2 and a metal powder are pressed and then clad by hot rolling shows good continuous metallic network even up to 50% UO_2 , and good bonding to the cladding material can be obtained. The spray coating of a metal surface onto massive beryllium oxide is being attempted; however, evaluation of the bond is difficult. The differences in thermal expansion between the BeO and the metal have led to the consideration of coating with some of the more refractory metals. The Welding Laboratory is engaged in a program to develop suitable techniques for welding Inconel tubing of small diameter to headers. Thus far manual inert-arc welding has been used, but equipment is being assembled to operate a semiautomatic cone-arc apparatus. Recovery in copper at room temperature is being investigated by x-ray methods. An analysis of the (331) line in the copper pattern indicates that in copper filings recovery is complete in about one month. (auth)

2672 ORNL-1108

Oak Ridge National Lab., Tenn.

METALLURGY DIVISION QUARTERLY PROGRESS REPORT FOR PERIOD ENDING JULY 31, 1951. E. C. Miller and W. H. Bridges, eds. Feb. 6, 1952. Decl. Oct. 9, 1959. 92p. Contract W-7405-eng-26. OTS.

The effect of strain rate on the tensile properties of thorium is being investigated. It was found that the yield strength increases slightly with increasing strain rate, and that tensile strength increases but to a lesser extent. The shear modulus was determined to be 4.26×10^6 psi. A pre-

cision measurement of the lattice parameter of iodide-process thorium was made, giving a value of 5.0871 ± 0.0002 Å. Studies on the fabrication of thorium by extrusion and drawing were continued, as were studies on the extrusion cladding of thorium and uranium with zirconium. In order to determine whether or not the type of preferred orientation developed in α -extruded uranium rod was dependent on the actual extrusion temperature, x-ray-diffraction studies were made of completely recrystallized and unrecrystallized extruded uranium. The results show that the texture developed upon deformation is not always retained upon recrystallization. The corrosion testing of various metals and alloys in liquid sodium, lead, and lithium and in molten fluorides and hydroxides was continued. The interaction of sodium with 316 stainless steel appears negligible during static testing. The testing of the molten media in thermal convection loops continues to be plagued by failures other than corrosion. The investigation of means of fabrication of solid fuel elements by powder metallurgy techniques has progressed. Only minor segregation of UO_2 in an iron matrix was noted after hot rolling. Stainless steel matrices, on the other hand, displayed considerable segregation. Rubberstatic pressing was added as a technique for the fabrication of fuel elements and control rods. The Creep Laboratory is essentially complete. The study of thermocouple stability in vacuum has shown that chromel-alumel couples give consistent checks with control and reference temperatures, whereas iron-constantan and platinum-10% rhodium couples gave erratic results. Some preliminary results were obtained on uranium, thorium, 316 stainless steel, Inconel, and columbium. The evaluation of welded tube-to-header joints of Inconel received considerable attention. Tests in tension show that the joint is of the same order of magnitude as the original material, the failures occurring in the zone adjacent to the weld. A rotating tubular beam fatigue test apparatus was developed, and preliminary tests show that joints with complete penetration have better fatigue life than joints with 70% penetration. The establishment of a ceramics laboratory proceeded satisfactorily. Basic research, engineering development, and service work will be done. In research on the fundamentals of liquid metal—solid metal interaction, the immersion of copper in liquid bismuth resulted in the deposition of copper crystals removed from the specimen. This might be the result of one or more mechanisms: thermal gradients, thermal cycling, or free energy changes. A program to investigate the alloys of the transition elements in order to reconcile the theories of Mott and Jones, and Pauling concerning these elements was initiated. At present the program will concern itself with Group IV-A elements: titanium, zirconium, and hafnium. Zirconium alloyed with nickel and with tungsten is being studied. Thus far the nickel alloy up to 4.08% by weight of nickel quenched in various ways has been studied. (auth)

2690 CF-54-9-98

Oak Ridge National Lab., Tenn.

EXAMINATION OF SODIUM, BERYLLIUM, INCONEL PUMP LOOPS, NUMBERS 1 AND 2. G. M. Adamson and E. Long. Sept. 13, 1954. Decl. Oct. 9, 1959. 12p. Contract W-7405-eng-26. OTS.

From data obtained from two loops, the use of beryllium in Inconel systems containing molten sodium appears feasible if the temperature is held below 1200°F. (J.E.D.)

2691 CF-57-2-146

Oak Ridge National Lab., Tenn.

A BRIEF REVIEW OF THERMAL GRADIENT MASS TRANSFER IN SODIUM AND NaK SYSTEMS. J. H. DeVan and J. B. West. Feb. 11, 1957. 19p. Contract [W-7405-eng-26]. OTS.

The fact that material transport does occur under conditions of finite temperature difference in a flowing molten metal system was established. The rate mass transfer was thought to be either diffusion limited or solution rate limited. It is believed that the mass transfer of structural materials in Na or NaK systems is solution rate limited. The limiting process has not been qualitatively or quantitatively confirmed for the Inconel-Na or Inconel-NaK system. Increasing the maximum system wall temperature increases the amount of mass transfer, at least above 1300°F. The effect of the total temperature difference across the system on the amount of mass transfer was determined. (W.L.H.)

2692 CF-57-3-126

Oak Ridge National Lab., Tenn.
COMPATIBILITY TESTS OF VARIOUS MATERIALS IN MOLTEN SODIUM. R. Carlander and E. E. Hoffman. Mar. 25, 1957. Decl. Oct. 9, 1959. 10p. OTS.

Compatibility tests of materials in contact in sodium under 500 psi pressure were conducted for 716 hr at 1500°F. Of the diffusion couples studied, the Inconel-beryllium system showed the largest amount of alloying. The reaction between molybdenum and beryllium resulted in the formation of two compounds, both of which were severely cracked in several areas. The molybdenum-Inor-8 and the Inor-8-type 316 stainless steel interfaces showed little alloying. A compatibility test system was prepared by placing $\frac{1}{4} \times \frac{1}{2} \times 1$ in. specimens of Inconel, beryllium, molybdenum, Inor-8, and type 316 stainless steel together in sodium. (J.E.D.)

2695 MSAR-59-99

MSA Research Corp., Callery, Penna.
EFFECT OF 1200 F SODIUM ON AUSTENITIC AND FERRITIC STEELS. Bi-monthly Progress Report No. 1 for July and August 1959 [on] THERMAL SHOCK, NITRIDING, STRESSED CORROSION, UNSTRESSED CORROSION. J. W. Mausteller and R. C. Werner. Sept. 16, 1959. 22p. Contract AT(11-1)-765. OTS.

Completion of preliminary designs for a thermal shock loop, a corrosion loop, and a nitriding loop is reported. Stressed and unstressed corrosion studies are scheduled to be carried out in the same system. A literature search was started, and various sites were contacted to avoid duplication of effort. It was found that some work has been done at 1200°F sodium temperature with various oxygen concentrations, however part of the data is contradictory. Test plans include corrosion testing of Croloy and stainless steel samples as well as similar and dissimilar welds of these materials in 1200°F sodium. (J.R.D.)

2750

THE ESTIMATION OF THE ACTIVITIES IN BINARY LIQUID METALLIC ALLOYS. Étienne Bonnier and Pierre Desré (École Nationale Supérieure d'Électrochimie et d'Électrometallurgie, Grenoble, France). *Compt. rend.* 249, 1664-6(1959) Oct. 28. (In French)

The methods for the estimation of the activity using the phase diagrams can be made more accurate by the knowledge of the enthalpies of the mixture. The Lumsden theory permits the derivation of a formula using these data. The formula is applied to the liquid systems Na-K, Al-Si, Ag-Bi, and Al-Sn. (tr-auth)

2957 CRD-R-31(and Add.)

California Research and Development Co., Livermore, Calif.

UNCLASSIFIED CROSS SECTIONS FOR FAST REACTOR CALCULATIONS. F. E. Bjorklund. Jan. 20, 1953. Includes Addendum. 18p. OTS.

A compilation of estimated capture and total cross sections is given for 47 elements. Transport and inelastic cross sections are tabulated for various elements and curves of these cross sections vs. pertinent nuclear properties are given. (C.J.G.)

3175

SODIUM—REACTOR COOLANT. B. L. Harbourne (United Kingdom Atomic Energy Authority Risley, Lancs, Eng.). *Chem. & Proc. Eng.* 40, 347-51(1959) Oct.

The advantages of using liquid sodium for a reactor coolant are discussed. The various practical considerations involved in designing sodium-cooled reactor systems such as sodium handling, materials selection for the circuit, and the destructive properties of sodium on the circuit are discussed. (C.J.G.)

3846 CF-59-11-67

Oak Ridge National Lab., Tenn.
THERMODYNAMIC DIAGRAMS FOR LITHIUM, SODIUM, AND POTASSIUM. L. G. Epel and J. R. Simmons. Nov. 12, 1959. 9p. OTS.

Charts for the thermodynamic properties of lithium, sodium, and potassium in the wet and superheated vapor regions were prepared and are presented to facilitate thermodynamic cycle calculations. (auth)

4291

DETERMINATION OF SODIUM VAPOR PRESSURE AT TEMPERATURES FROM 880 TO 1300°C. P. L. Kirillov and N. S. Grachev. *Inzhener.-Fiz. Zhur., Akad. Nauk Belorus. S.S.R.* 2, No. 5, 3-7(1959) May. (In Russian)

A method for determining the saturated vapor pressure of sodium at 880 to 1300°C is described. The results are compared with the work of other authors. An equation is proposed for calculating saturated vapor pressure at various temperatures. (C.J.G.)

4421

HEAT EXCHANGE OF A PLATE IN A TURBULENT BOUNDARY LAYER OF INCOMPRESSIBLE LIQUID AT $Pr \ll 1$. E. D. Fedorovich (Polzunov Leningrad Central Turbine Construction Inst.). *Inzhener.-Fiz. Zhur., Akad. Nauk Belorus. S.S.R.* 2, No. 9, 3-11(1959) Sept. (In Russian)

Results are presented of a theoretical and experimental investigation of heat exchange of a plate in liquid flow where the Prandtl number is much less than 1 (liquid metal). An approximate solution of the problem on the basis of the semiempirical theory of turbulence gives a formula of the type $\bar{Nu} = A Pe_L^{0.65}$, where $A = 0.38$ to 0.46 , depending on the assumed heat transfer scheme in the turbulent boundary layer. Measurements of the coefficient of heat transfer of a plate in a molten sodium flow was in satisfactory agreement with this calculation. In experiments with eutectic lead-bismuth, coefficients of heat exchange were found to be from 20 to 30% below that calculated. (auth)

4434 NAA-SR-4195

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

A COIL TYPE LEVEL GAUGE FOR HIGH TEMPERATURE LIQUID METALS. G. E. Turner. Nov. 15, 1959. 25p. Contract AT-11-1-GEN-8. OTS.

An electromagnetic liquid metal level device with an accuracy of ± 1 in., which requires no prior calibration and which will operate continuously at 1000°F, is described. The level gage can be replaced without opening the liquid metal system and is adaptable to automatic operation and recording. (auth)

4437 RDB(W)-TN-92

Gt. Brit. Windscale Works, Sellafield, Cumb., England. OPERATING EXPERIENCE WITH NO. 1 400 G.P.M. FLAT LINEAR INDUCTION PUMP. T. I. M. Crofts. Sept. 1953. 14p.

Operation of a three phase electro-magnetic pump for 360 hours is reported. Experience gained in this operation with NaK was used when modifications to a second pump rig was made. The effectiveness of these modifications is shown by completion of 1,000 hours operation on the second rig. (J.R.D.)

4500 BMI-1400

Battelle Memorial Inst., Columbus, Ohio. METALLURGICAL STUDIES OF NIOBIUM-URANIUM ALLOYS. John A. DeMastry, Frederic R. Shober, and Ronald F. Dickerson. Dec. 7, 1959. 44p. Contract W-7405-eng-92. OTS.

In a continuing program, fabrication characteristics, physical and mechanical properties, and corrosion behavior in air, CO₂, NaK, water, and steam were studied for binary niobium fuel alloys containing 10, 20, 30, 40, 50, and 60 wt.% uranium. To evaluate the effects of two major impurities of niobium, oxygen, and zirconium, three niobium base stocks, differing according to the level of these impurities, were used for each alloy. The impurity combinations employed were 600 ppm oxygen and 0.74 wt.% zirconium, 700 ppm oxygen, and 0.17 wt.% zirconium, and 300 ppm oxygen and 0.02 wt.% zirconium. Representative specimens of these alloys retained their hardness up to 900°C. The 10 and 20 wt.% uranium alloys were successfully forged at 2500°F and rolled at 1800°F to sheet. Fabrication characteristics of the remaining alloys are under investigation. The 0.2% offset yield strength of the 10 wt.% uranium alloy was 57,200 psi at room temperature and 36,900 psi at 1600°F. For the 20 wt.% uranium alloy it was 93,200 psi at room temperature and 71,000 psi at 1600°F. The corrosion life of all of the alloys in air at 572°F and in CO₂ at 600°F was superior to that of unalloyed niobium. In 1000-hr exposures to 600°F water most of the alloys exhibited corrosion rates only two or three times greater than that of Zircaloy-2. All of the alloys appear compatible with NaK at 1600°F. The impurity combinations employed in the base niobium appeared to have no effect on the corrosion behavior and mechanical properties of the alloys. (auth)

5071 NAA-SR-3638

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

CONTROL OF OXYGEN CONCENTRATION IN A LARGE SODIUM SYSTEM. R. B. Hinz. Dec. 1, 1959. 45p. Contract AT-11-1-GEN-8. OTS.

Data on the performances of two types of cold traps in the 50,000-lb radioactive sodium system at the SRE are tabulated. The rates were determined when trap inlet oxygen concentrations were at 8 to 10 parts per million. Oxygen concentration was readily controlled to 8 ppm using a cold trap. Extraction of oxygen from sodium by zirconium at 1200°F (hot trapping) reduces the concentration below the limit of detection, i.e., oxide solubility saturation temperature below 225°F. The theoretical limit for the equilibrium oxygen concentration was calculated to be less than 7×10^{-6} ppm. The observed extraction rate of 0.009 lb oxygen/hr was one-half of the rate predicted from material behavior studies. (auth)

5334 NAA-SR-Memo-4127

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

TRANSIENT TESTS OF HNPF PROTOTYPE SODIUM PUMP DRIVES. R. W. Atz. Oct. 19, 1959. 7p. OTS.

The objectives of this study were to demonstrate that the pump speed control system will respond as defined in the equipment specifications and to determine optimum values of controlling variables that will minimize the oscillations that occur in the Na flow rate when transient signals are imposed on the pump speed control system. (W.L.H.)

5591 NP-tr-330

HYDRODYNAMICS OF MOLTEN METALS. (Proceedings of the First Conference on the Theory of Casting Processes). (Gidrodinamika Rasplav Lennyykh Metallor). (Trudy Pervogo Soveshchaniya po Teorii Litenykh Protessov). L. I. Fantalov and B. B. Gulyaev (Gulyayev), eds. Translated from a publication of the Publishing House of the Academy of Sciences, Moscow. 1958. 384p. OTS.

Results of theoretical and experimental research on the dynamics of molten metals are presented. The viscosity properties of molten metals are examined along with the relationship of the liquid phase and the metallic aggregate formed from it. Metal flow in conduits, the causes of defects in castings, the effects of aluminum on steel, the relationship between the structural diagram of molten metal and its mechanical properties, and theoretical problems are also considered. (J.R.D.)

6042 ORNL-2012(Pts. I, II, III)(Del.)

Oak Ridge National Lab., Tenn.

AIRCRAFT NUCLEAR PROPULSION PROJECT QUARTERLY PROGRESS REPORT FOR PERIOD ENDING DECEMBER 10, 1955. A. W. Savolainen, ed. Mar. 12, 1956. Decl. with deletions Oct. 22, 1959. 206p. Contract W-7405-eng-26. OTS.

Reactor Theory, Component Development, and Construction. Construction work is under way on the Aircraft Reactor Test facility. System flowsheets and instrumentation lists were prepared in an initial attempt to define the entire ART. The fuel-to-NaK heat exchanger design was modified to overcome interfaces at the headers and to provide additional space in the region of the headers for the Be support struts. The problem of cooling the fuel fill-and-drain tank was studied. The basic mechanical design work on the ART lead-and-water shield and supports was completed. Core flow studies were made on both the full-scale Al and plastic core models. An equipment layout was prepared for the Engineering Test Unit (ETU). Operation of the high-temperature critical experiments revealed that the ZrF₄ vapor traps were inadequate. An in-pile loop was inserted and successfully operated in the HB-3 beam hole of the MTR. Five electrically heated and three gas-heated fused-salt-Inconel forced-circulation loops were in operation. Seals of various designs are being tested for possible use in the lower position in the ART fuel pump. Full-size models of the impeller and the volute for the ART Na pump are being tested with water. Tests of an ART fuel pump are under way with high-temperature (1400°F) NaK as the pumped fluid. Operation of intermediate heat exchanger test A was continued, and test stand B was placed in operation. A small heat exchanger test stand is operating with a 20-tube fuel-to-NaK heat exchanger, a 500-kw NaK-to-self-decomposition of fused NaOH into water and Na₂O. A third 500-kw NaK-to-air high-conductivity-fin radiator, two 20-tube fuel-to-NaK heat exchangers, and two 100-tube bundles for intermediate heat exchangers No. 3 were fabricated. The two NaK-to-air radiators that failed in service were examined. Alloys of the Ni-Mo system are being investigated. Preliminary work on the fabrication of seamless duplex tubing was completed. Attempts are being made to produce suitable B₄C-base tiles for the ART neu-

iron shield and to evaluate the properties of such tiles. The problems associated with the fabrication of Inconel-clad Nb are being studied. A forced-convection fused-salt heat-transfer system that includes a mechanical pump has been fabricated. Additional hydrodynamic studies were made of annuli of the type being considered for the fuel channel of the ART reactor core. The enthalpies and heat capacities of two rubidium fluoride mixtures were determined. Tube-burst creep-test specimens irradiated for two weeks in the LITR are being examined. Studies were undertaken to determine whether positive errors in the determination of oxygen in Na result from the presence of alkaline-earth metals in the alkali-metal samples. The Aluminon method for the spectrophotometric determination of Al was applied to samples of fluoride salt mixtures. A method was developed for the determination of water relative to HF in the effluent gases from a hydrofluorination reactor. A method for the determination of Ta in fused mixtures of fluoride salts with the use of pyrogallol was developed. Construction of the pilot plant designed for using the fused-salt fluoride-volatility process in the recovery of fused-fluoride-salt reactor is described. Shielding Research. The air-scattered gamma-ray dose rate predicted by theory for a Co^{60} source at a source-detector distance of 15 meters was compared with experimental air radiator, and a circulating cold trap. The test data obtained with the intermediate and small heat exchanger test stands have been correlated. A test assembly for use in the development and testing of cold traps and plugging indicators is being fabricated. A full-scale Al model of the top portion of the ART is being fabricated. Several room-temperature experiments on the reflector-moderated-reactor critical assembly were completed. Experiments with the reflector-moderated critical assembly operated with liquid fuel ($\text{NaF-ZrF}_4\text{-UF}_4$) at 1200°F were also completed. Materials Research. Phase equilibrium studies of various fluoride systems were continued. Work continued on determining the phase relationships in the $\text{NaF-LiF-BeF}_2\text{-UF}_4$ system. Studies of the stability of V and Nb in NaF-LiF-KF-UF_4 at 600 and 800°C indicated that V was quite stable and that Nb was not. Examinations were completed of several Inconel forced-circulation loops in which fluoride fuel mixtures were circulated. Several Inconel forced-circulation loops were operated in a study of the effect of the oxide content of the Na being circulated. A series of six thermal-convection loops was operated with $\text{NaF-ZrF}_4\text{-UF}_4$ to which various amounts of ZrH_2 had been added to reduce the UF_4 present to UF_3 . A special thermal convection loop was fabricated for testing brazed Inconel segments in the hot-leg section. Thermocouple assemblies were exposed to Na and to $\text{NaF-ZrF}_4\text{-UF}_4$ in seesaw apparatus so that the effect of various amounts of Chromel-Alumel in the weld nugget could be studied. Titanium carbide cermets with Co- and Ni-base alloys as binding material were exposed to $\text{NaF-ZrF}_4\text{-UF}_4$ for 200 hr in seesaw apparatus. Inconel valve disks and seats were flame-plated with a mixture of tungsten carbide and cobalt for testing to determine the suitability of the coating as a hard-facing material. Measurements were made of the measurements in a similar geometry. A set of integral equations was derived to determine the flux density near a thin foil. The static source tests and corresponding analyses of the recent series of experiments on mockups of a circulating fuel reflector-moderated reactor shield were completed. (W.L.H.)

6416

HEAT TRANSFER DURING TRANSITION FLOW OF LIQUID METALS IN PIPES. V. M. Deryugin and O. S. Fedynskii (Kozhezhnikovskii Inst. of Power Engineering,

Moscow). Inzhener.-Fiz. Zhur., Akad. Nauk Belorus. S.S.R. 2, No. 12, 3-10(1959) Dec. (In Russian)

The "visual wetting" effect on heat transfer to liquid metals in a transition pipe flow is proved experimentally. The abrupt change in the heat transfer rate takes place at the hydrodynamic crisis ($\text{Re} \approx 2300$) when the surface of the heat exchanger is wet, but does not take place when wetting is absent. Empirical equations for non-wetting conditions and for wetting conditions are recommended for calculation of the average heat transfer coefficients in direct pipes ($l/d \geq 70$). The local heat transfer coefficients at all points outside the inlet region of the test section are equal to the average coefficients when $l/d \geq 70$, and the inlet conditions are shown. For an estimation of the local heat transfer in the inlet region, special monograms may be used. When $\text{Re} < 50$, the values of the average heat transfer coefficients cannot be calculated on the basis of the equation $\text{Nu} = 0.7 \text{Re}^{1/2}$, which has been recommended, as it leads to serious exaggeration of the heat transfer rate. (auth)

6417

HEAT TRANSFER TO A TURBULENT FLOW OF LIQUID METAL WHERE HEAT LOAD IS DISTRIBUTED SINUSOIDALLY ALONG THE LENGTH OF THE PIPE. V. I. Petrovichev and L. S. Kokorev (Inst. of Engineering Physics, Inst. of Thermophysics, Siberian Branch, Academy of Sciences, Moscow). Inzhener.-Fiz. Zhur., Akad. Nauk Belorus. S.S.R. 2, No. 12, 20-24(1959) Dec. (In Russian)

The distribution of a thermal load along the length of a pipe wall has a considerable effect on the distribution of local coefficients of heat exchange if the heat transfer medium has a Prandtl number $\ll 1$. This conclusion also follows qualitatively from general considerations, since for liquid metal, because of its high "molecular" heat conductivity, boundary conditions will have a noticeable effect on the temperature field and will, consequently, be reflected in the values of local coefficients of heat exchange. A distribution of local Nu numbers along the length of the pipe is found for a sinusoidal distribution of heat load on the wall of a round pipe, with turbulent flow of liquid metal and Pr number 0.025, for Re numbers 10×10^3 , 50×10^3 , and 100×10^3 , and length/diameter ratios of 44.6, 67, and 100. The dimensionless coefficient of heat exchange Nu falls over the whole length of the pipe, but the greatest change in Nu is at the two ends of the pipe. When the temperature of the wall reaches a maximum in a section of the pipe, the coefficient of heat transfer is somewhat less than the value obtained from the formula $q_{CT} = \text{const}$. This difference is greater for small Re numbers and length/diameter ratios, and decreases with an increase in Re numbers and length/diameter ratio. The position of the temperature maximum on the wall shifts somewhat along the flow of the transfer medium by comparison with results from the formula $q_{CT} = \text{const}$. This shift is greater for large Re numbers and for smaller length/diameter ratios. (auth)

6611 NAA-SR-4204

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.
TESTS OF A MECHANICAL PIPE JOINT FOR SODIUM SERVICE. C. Sutherland, Jan. 15, 1960. 26p. Contract AT-11-1-GEN-8. OTS.

A test program was conducted to determine the suitability of a mechanical pipe joint for use in liquid sodium systems. Tests were performed on a total of five units representing three pipe sizes—2-, 6-, and 12-in. The joints were subjected to flexural, axial, tensile, and compressive

mechanical loads while containing sodium at a maximum temperature and pressure of 1000°F and 150 psig. Of the three sizes tested, only the 2-in. size performed satisfactorily. The other units leaked sodium during the mechanical load tests after having sealed 1000°F sodium under no-load conditions. It is concluded that the 2-in. units have a good probability of performing satisfactorily in elevated temperature sodium service with nominal adjacent pipe wall stresses up to a maximum of 14,000 psi. It is further concluded that the larger sizes tested will probably provide good high-temperature sodium seals, but their use must be restricted to service at very low stress levels. Tolerance limits were not established for flange warpage due to welding. It was found that the mechanical pipe joints tested will not seal under the test conditions if they become out-of-round as much as 10 mils. (auth)

6689 AEC-tr-3961

EXPERIMENTAL DETERMINATION OF TRUE SPECIFIC HEATS OF URANIUM, THORIUM, AND OTHER METALS. E. A. Mit'kina. Translated for Los Alamos Scientific Lab. from *Atomnaya Energ.* 7, 163-5(1959). 5p. JCL or LC.

This paper was previously abstracted from the original language and appears in *NSA*, Vol. 13, as abstract No. 20208.

6722

ELECTROKINETIC EFFECTS IN LIQUID METALS.

G. E. Pikus and V. B. Fiks (Semiconductor Inst., Academy of Sciences, Leningrad). *Soviet Phys.-Solid State* 1, 972-80(1960) Jan.

The theory of electrokinetic effects in liquid metals is developed. These effects are caused by inelastic scattering of current carriers at the metal boundaries and lead to the creation of a transfer flow when an electric current is passed through liquid metal contained in a thin capillary, and to the creation of a transfer current when the liquid flows through the capillary. Using Onsager's relationships, formulas were obtained for the transfer current and transfer potential. (auth)

6755 NAA-SR-Memo-4578

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

HEAT AND MASS TRANSFER ANALYSIS OF PROPOSED EXPERIMENTAL COLD TRAP SYSTEM. J. S. McDonald and F. Perez. Oct. 29, 1959. 28p. OTS.

Studies were made to investigate the possibility of removing oxide impurities from Na-cooled reactor systems by cold trapping in conjunction with fill-drain tanks. (W.L.H.)

7485 NAA-SR-4388

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

A LINEAR INDUCTION PUMP FOR LIQUID METALS. R. S. Baker. Jan. 15, 1960. 25p. Contract AT-11-1-GEN-8. OTS.

A linear induction pump of a special design was used to circulate molten sodium through a mockup of an experimental "overflow" type of sodium-cooled reactor. The distinctive features of this pump are that no seals or moving parts are required; no piping is required to carry sodium to the pump or away from it because the pump is mounted directly on the reactor vessel, with the windings outside of the vessel and the magnetic flux return path inside the vessel. The pump develops 342 gpm at 6.2 psi when pumping sodium at 600°F with an efficiency of 4.7%. (auth)

7493

DEVELOPMENT OF CENTRIFUGAL PUMPS FOR OPERATION WITH LIQUID METALS AND MOLTEN SALTS AT 1100-1500°F. A. G. Grindell, W. F. Boudreau, and H. W. Savage (Oak Ridge National Lab., Tenn.). *Nuclear Sci. and Eng.* 7, 83-91(1960) Jan.

Sump-type centrifugal pumps ranging in capacity from 2 to 1500 gpm were developed for circulating liquid metals and molten salts at temperatures up to 1500°F in metallurgical, heat transfer, and reactor experiments. Each of these pumps uses a nearly conventional bearing assembly to support a vertical shaft and an impeller suspended in a tank containing the high-temperature liquid and an inert blanketing gas. Drive motors and lubrication equipment are external to the pump proper. Seven different models of the sump-type pumps were manufactured and about 400,000 hr of operation were accumulated in the temperature range 1100 to 1500°F. Problems resolved in the development of these pumps are discussed. Limitations on the use of this type of pump for reactor and nonreactor applications are noted. (auth)

8275 APDA-135

Atomic Power Development Associates, Inc., Detroit. PRELIMINARY REPORT ON SODIUM TEMPERATURE COEFFICIENTS IN LARGE FAST REACTORS. J. B. Nims and P. F. Zweifel. Nov. 1959. 24p. OTS.

Present practice in fast reactor design is to eliminate any known positive temperature coefficients of reactivity. This approach has been feasible for the fast power reactors now being constructed. In recent considerations of advanced fast reactor designs at APDA, some cases were encountered in which the sodium temperature coefficient of reactivity was positive. Because of the serious implications of this result, a study of the sodium temperature coefficient of a design in which the problem appears to be most severe was made. The principle objective of the study was to obtain a better understanding of the problem. Simply stated, reducing the sodium density causes spectral reactivity effects which can, in some situations, be positive and larger in magnitude than the negative leakage effect, thereby causing a positive temperature coefficient of reactivity. In addition, some attention was also given to possible methods of influencing the sign of the sodium coefficient. Although the results indicate that these methods could be successfully applied, there are penalties involved with their use. The results given are believed to be qualitatively correct, but the uncertainties in the cross section data on which they are based cast some doubt on the quantitative accuracy. (auth)

8452

DETERMINATION OF TRACES OF OXYGEN IN SODIUM METAL BY INFRARED SPECTROPHOTOMETRY. H. J. deBruin (Australian Atomic Energy Commission, Lucas Heights, New South Wales). *Anal. Chem.* 32, 360-2(1960) Mar.

A method for the determination of traces of oxygen in sodium metal by infrared spectrophotometry is presented. Procedures to a lower limit of 20 ppm with an accuracy to $\pm 20\%$ are detailed. A Wurtz reaction, employing n-amyl chloride, is followed by the application of the infrared pressed disk technique to the solid reaction products, which contain the oxygen impurity. The carbonate absorbance band at 11.38 μ , due to the conversion of the original sodium monoxide to carbonate by atmospheric carbon dioxide, follows the Lambert-Beer law between 0 and 300 ppm. A method is suggested for handling of samples, contained in glass ampoules. (auth)

8671 NYO-4806

Massachusetts Inst. of Tech., Cambridge. Dept. of Metallurgy.

KINETICS OF REACTIONS BETWEEN LIQUID METALS AND LIQUID SALTS. Progress Report Covering Period March 1, 1959 to December 15, 1959. Thomas B. King. 23p. Contract AT(30-1)-1985. OTS.

The reaction kinetics at high temperatures between two liquid phases, one consisting of a metallic alloy and the other of a molten salt, either halide or oxide, were investigated. The investigation was designed to obtain information of general rather than specific, applicability. The experimental program is divided into five parts: study of convection conditions in a model system; direct rate measurements for transport controlled reactions under constant convection conditions; direct rate measurements for reactions controlled by the phase boundary reaction; electrolytic polarization measurements; and measurements of diffusion coefficients in liquid alloys and salts. (W.L.H.)

8679 TID-3544

Technical Information Service Extension, AEC.

LIQUID METAL TECHNOLOGY. A Literature Search. James M. Jacobs, comp. Jan. 1960. 27p. OTS.

Two hundred seventeen references to unclassified reports and published literature on liquid metal technology are presented. (W.L.H.)

8761 NP-tr-343

THERMOPHYSICAL PROPERTIES OF SUBSTANCES. (Teplofizicheskie Svoistva Veshchestv). I. I. Ayzenshtat, ed. Translated from a publication of the Printing House of State Publishing House for Power Engineering, Moscow. 479p. OTS.

The physical properties of various gases at standard pressure and various temperatures and the thermophysical properties of gases at various pressures and temperatures are tabulated. The thermal properties of steam and water at 0 to 700°C and under pressure from 1 to 400 kg/cm² are given. The physical properties of steam in the supercritical region and water near the critical point are included. Physical properties of various liquids including water, heavy water, high-boiling organic and inorganic liquids, low-boiling liquids, molten salts, and liquid metals are tabulated. The physical properties of organic and inorganic compounds, pure metals, and steels are given. Thermal conductivities of dry and moist insulating materials, refractories, and various inorganic compounds and metal oxides are given. Standards for thermocouples and resistance thermometers including various grades of platinum are tabulated. The characteristics of thermocouples at temperatures above 1500°C under laboratory and industrial conditions are reported. (C.J.G.)

8767

THE EMBRITTLEMENT OF ALUMINIUM-MAGNESIUM ALLOYS BY SODIUM. C. E. Ransley and D. E. J. Talbot (British Aluminium Co., Ltd., Gerrards Cross, Bucks, Eng.). J. Inst. Metals 88, 150-58(1959) Dec.

The constitutional factors involved in the embrittlement of Al-Mg alloys by sodium were investigated, and it is shown that these particular alloys are susceptible to embrittlement because the sodium present in them is in the elementary state. As the magnesium content increases there is a phase change involving a ternary Al-Si-Na compound and dissolved magnesium, the net result of which may be represented by the equation: $[NaAlSi] + 2Mg \rightleftharpoons Mg_2Si + Na$ "free." Solubility determinations on the compounds involved and hydrogen-adsorption measurements under various conditions show that the sodium

is released when the magnesium content exceeds ~2%.

The high-temperature properties in both tensile and impact tests are consistent with this result. The mechanism of the embrittlement is discussed in relation to other alloy systems in which trace elements lead to brittle behavior. The embrittlement is ascribed to the adsorption of sodium on internal surfaces generated in plastic flow and consequent modification of the growth of grain-boundary cavities. (auth)

9230

POWER REACTOR TECHNOLOGY. Technical Progress Reviews, Vol. 3, No. 1. Walter H. Zinn, [ed.] Dunedin, Fla., General Nuclear Engineering Corp., 1959. 68p. \$0.55(GPO) domestic; \$0.70 foreign.

General Research and Development. Section one of this volume is devoted to reactor applications and discusses the uses of process heat, process heat generation and consumption, and reactors for producing process steam. The second section discusses thermionic energy conversion and in particular the basis of operation, efficiency equation, estimates of attainable efficiencies, high-vacuum thermionic converter performance, experiments on a cesium-vapor-filled thermionic converter, and Los Alamos plasma thermocouple. In the third section the reactor physics of H₂O-moderated critical assemblies is discussed. The fourth section discusses heat transfer and fluid flow. Recent investigations are reported on the collapse of parallel-plate fuel assemblies, nucleate boiling, liquid-metal heat transfer, liquid metals with internal heat generation, and water flowing parallel to tube bundles. Section five is devoted to reactor kinetics and dynamics. Current investigations are reported on delayed neutrons in reactor kinetics, reduced delayed-neutron group representations, approximations for reactor accident calculations, oscillation experiments on large heavy-water reactors, and transfer functions of distributed parameter systems. In the sixth section reactor safety and containment are discussed. A review of shielding is present in the seventh section. In section eight the radiation effects on semiconductors and magnetic materials along with the corrosion of stainless steel in a nitrogen atmosphere are reported. Progress on Specific Reactor Types. The four sections comprising this part of the volume are devoted to light-water reactors, boiling-water reactors, fluid-fuel reactors, and fluidized-bed reactors. (W.L.H.)

9480 SCS-R-329

United Kingdom Atomic Energy Authority. Industrial Group. Springfields Works, Springfields, Lancs, England.

THE DETERMINATION OF TRACE ELEMENTS IN METALLIC SODIUM AND SODIUM-POTASSIUM ALLOY BY THE POROUS CUP TECHNIQUE. G. I. Goodfellow, A. L. Wilson, T. H. Boyd, L. Lloyd, and P. A. Serin. 1959. Date of MS. Aug. 31, 1954. 18p. (ARDC/P-34).

A method for the determination of trace amounts of 15 elements in metallic sodium and sodium-potassium alloy (22.7% Na-77.3% K) was developed. The porous cup method of excitation is used, with palladium as internal standard. The spectra are recorded by means of a spectrograph. Microphotometry and a plate calibration technique are used for the evaluation of the spectrograms so obtained. Detection limits range from 2 to 15 ppm in the alkali metal or alloy. (auth)

9714 BMI-1405

Battelle Memorial Inst., Columbus, Ohio.

BEHAVIOR OF RUBBING MOLYBDENUM SURFACES IN SODIUM ENVIRONMENTS. John W. Kissel, Carl W.

Melton, and William A. Glaeser. Jan. 4, 1960. 25p. Contract W-7405-eng-92. OTS.

A study has been made of the wear and friction phenomena associated with sliding molybdenum surfaces lubricated by liquid sodium. Operating conditions included sodium temperatures from 250 to 1300° F, sliding speeds of from 0.22 to 2.5 mm per sec, and contact stresses of 80,000 psi. Sliding specimens consisted of a ball and a flat rectangle. Sodium was found to influence the sliding behavior of molybdenum by modifying reacted films which provided boundary lubrication. These effects were also found to be temperature dependent. Addition of clean sodium between dry rubbing molybdenum surfaces in an argon atmosphere of high purity produced a marked drop in friction coefficient, and the character of the wear scar changed from galling to superficial scratching. Furthermore, these effects persisted after removal of sodium by evaporation. Studies of the films formed on molybdenum surfaces during sliding in liquid sodium and under controlled atmospheres were carried out using electron and x-ray diffraction, electron microscope, and differential thermal-analysis techniques. It was established that a sodium molybdate film on the molybdenum surfaces can be associated with low friction and diminished surface damage. Studies in vacuums up to 10^{-6} mm of mercury showed that native oxides on molybdenum also influence its sliding behavior. (auth)

9737 NAA-SR-4386

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

THE LARGE COMPONENT TEST LOOP. H. Strahl. Mar. 1, 1960. 19p. Contract AT-11-1-GEN-8. OTS.

A large-scale loop complex for proof testing reactor components in sodium under simulated reactor operating conditions has been constructed. The system is capable of circulating sodium at variable flow rates to 1200 gpm with temperatures up to 1000° F. Thermal-shock tests may be conducted to simulate reactor scram conditions with temperature differences up to 500° F. (auth)

9739 NDA-15K-3

Nuclear Development Corp. of America, White Plains, N. Y.

AEC SAFETY MONOGRAPH. CHAPTER 11. METAL-WATER REACTIONS. W. L. Brooks and H. Soodak, eds. [1956]. Decl. Dec. 29, 1959. 21p. OTS.

Reactions of reactor materials or coolants with water are considered. Aspects such as the reaction heat quantity, rate of reaction, self-sustaining characteristics of the reaction, and the quantity of hydrogen produced are evaluated. The most dangerous reactions are discussed, and results of in-pile tests of various metals are included. (J.R.D.)

10382 FRDC/P-105

United Kingdom Atomic Energy Authority. Industrial Group. Culcheth Labs., Culcheth, Lancs, England. THE OXIDATION OF SODIUM. A REVIEW OF PROGRESS FROM APRIL 1, 1954 TO DECEMBER 31, 1954. H. C. Cowen and H. Vickers. Apr. 15, 1955. Changed from OFFICIAL USE ONLY June 15, 1959. 9p. (RDB(C)/TN-121).

The tendency of liquid Na to ignite on being forced through a small hole was investigated. The holes ranged from 0.008 to 0.020" in diameter, and the atmospheres into which the Na was ejected included air and N₂, both moist and dry. With atmospheres of air, ignition was observed at all temperatures down to 120°C (the lowest used), irrespective of the moisture content of the air. No ignition was observed with atmospheres of N₂. (auth)

10412

PURIFICATION OF SODIUM FROM OXIDES AND METHODS OF OXIDE CONTENT CONTROL. P. L. Kirillov, F. A. Kozlov, V. I. Subbotin, and N. M. Turchin. *Atomnaya Energ.* 8, 30-6(1960) Jan. (In Russian)

Oxides in sodium coolants induce corrosion in the system and cause plugging. Data are given from tests made with cold traps for catching oxides. The data are useful in designing experimental and industrial installations using sodium and sodium-potassium coolants. (tr-auth)

10545 APDA-134

Atomic Power Development Associates, Inc., Detroit. SODIUM COMPONENTS TEST FACILITY. Nov. 1959. 208p. Contract AT(11-1)-772. OTS.

The design and construction of a test facility that will be capable of subjecting sodium components to both steady state and transient conditions expected in full size nuclear power electric generating stations are presented. This study encompasses design criteria, an estimate of time required to construct, and a survey of existing facilities to be selected by mutual agreement of the commission and APDA which would be suitable to accommodate the desired tests. (W.L.H.)

10602 ORNL-2793

Oak Ridge National Lab., Tenn.

CALIBRATION AND TESTING OF 2- AND 3½-IN. MAGNETIC FLOWMETERS FOR HIGH-TEMPERATURE NaK SERVICE. R. G. Affel, G. H. Burger, and C. L. Pearce. Mar. 4, 1960. 76p. Contract W-7405-eng-26. OTS.

High-temperature calibration tests were made on 12 magnetic flowmeters of 2-in. sched-40 pipe size and 12 magnetic flowmeters of 3½-in. sched-40 pipe size with NaK as the flow medium. Ten of each type of unit were calibrated against a venturi water-calibrated to an accuracy of 0.25%, over periods of operation to 3000 hr. The two remaining units of each type were not operated, but the magnet air gap flux density was monitored to detect changes for comparison with the operated units. The results of the calibration are tabulated and discussed. Background material on magnetic flowmeter application, design, and theoretical principles from the literature is included. (auth)

10729 BMI-1398

Battelle Memorial Inst., Columbus, Ohio.

PROGRESS RELATING TO CIVILIAN APPLICATIONS DURING NOVEMBER 1959. Russell W. Dayton and Clyde R. Tipton, Jr. Dec. 1, 1959. Decl. Feb. 10, 1960. 108p. Contract W-7405-eng-92. OTS.

A comparison of the creep properties of 15% cold-worked Zircaloy-2 and of annealed Zircaloy-2 is being made. In studies to develop a fuel element leak detector which removes fission products from reactor-coolant streams, experimental work included the determination of the exchangeability of Br⁸² and AgBr, determination of gross fission-product retention by AgBr columns, and studies to determine possible methods of reducing gross fission-product contamination of AgBr columns. A thermal-neutron-flux monitoring system is being developed for the Hanford reactors. In the development of corrosion-resistant welding alloys for use with Hastelloy F, twelve experimental Ni-base alloys have been prepared. Aluminum-35 wt.% U alloys containing small additions of Sn or Zr are being evaluated on the basis of casting and fabricating characteristics, mechanical properties, and corrosion resistance in 200°C water. Data are reported on the effect of fast neutron reactions on the activation analysis of cement and cement raw materials. The investigation of radiation-induced free radicals and grafting of polyethac-

rylates was continued. The studies concerned with stabilizing UO_2 by additions of La_2O_3 or Y_2O_3 plus CaO were continued. An investigation is being conducted to determine the effects of high pressure and high temperature on the $\text{U}-\text{O}_2$ system and on reaction of uranium oxide with various mixed oxides. A surveillance program concerned with the effects of irradiation on mechanical properties of A1SI Type 347 stainless steel is in progress. Because of difficulties encountered in cold rolling Nb-base binary alloys of 1.83 wt. % Cr and 4.33 wt. % Zr and several Nb-base ternary alloys, an attempt was made to warm roll the forged billets at 800°F. The evaluation of selected Nb-base alloys for service in pressurized-water reactors was continued. An investigation of the creep properties of Zircaloy-2 during irradiation at elevated temperatures was undertaken. Investigations are being made to establish the feasibility of continuously monitoring the oxygen content of large Na systems at concentrations below 10 ppm. Results of analysis for hydrogen content of Nb-U alloys after 140 days in 680°F water are presented. Corrosion data are presented for Nb-U alloys exposed in 600°F water and in NaK at 1600°F. Various studies are being directed toward understanding the causes of gas release in UO_2 . Fabrication techniques are being developed for the preparation of cermet fuel materials containing 60 to 90 vol. % of UO_2 dispersed in Cr, Mo, Nb, and stainless steel matrices. The gas-pressure-bonding technique is being investigated as a possible method for fabricating Mo- and Nb-clad ceramic and cermet-type fuels. Fabrication methods are described for UC. The rate of self-diffusion of U in UC is being studied by using a tracer technique. The migration of hydrogen in Zr under the influence of a thermal gradient is being examined. Experiments were begun in producing UO_2 crystals from the vapor phase. In support of the Pebble-Bed Reactor program Battelle is studying the properties and fission-gas retention of fueled-graphite spheres. Data are reported on preirradiation and postirradiation measurements of UC specimens in capsules BMI-23-3 and BMI-23-5. Studies were begun on the preparation of large fuel plates containing UO_2 platelets. Studies are being conducted on the development of fuel, absorber, and suppressor materials for the SM-2. (For preceding period see BMI-1391.) (W.L.H.)

11277

REMOVAL OF MOLTEN SODIUM FROM REACTOR COOLANT SYSTEMS. Louis Silverman and Robert A. Sallach (Atomics International Div., North American Aviation Inc. Canoga Park, Calif.). *Ind. Eng. Chem.* 52, 231-42(1960) Mar.

A method for the removal of molten sodium from oxygen-free inaccessible locations in reactor coolant systems by flotation with HB-40 (a liquid hydrogenated terphenyl) is described. Butyl alcohol, under nitrogen pressure, is used to remove small amounts of sodium adhering to the stainless steel surface. (C.J.G.)

11312 ORNL-2890

Oak Ridge National Lab., Tenn.

MOLTEN-SALT REACTOR PROGRAM QUARTERLY PROGRESS REPORT FOR PERIOD ENDING OCTOBER 31, 1959. Mar. 8, 1960. 79p. Contract W-7405-eng-26. OTS.

Engineering and Component Development. Development work on molten-salt-lubricated bearings was continued. Two pumps equipped with hydrodynamic bearings were bench tested and then tested in molten salt. No evidence of self-welding was found between INOR-8 surfaces immersed in molten salt at 1200°F. Construction of the Remote Maintenance Demonstration Facility, including the viewing equipment, was completed. Eleven long-term corrosion

loops completed one year of operating time in this quarter. Tests on two INOR-8 loops and one Inconel loop were terminated for metallurgical examination; the results are not yet available. The PKP centrifugal pump with Fulton Sylphon bellows-mounted seal has logged 17,878 hr of operation in NaK at 1200°F. The MF-type centrifugal pump is operating in a region of cavitation in salt 30, and service time of more than 20,000 hr has been recorded to date. Trouble-free operation of the small frozen-lead pump seal continued. An apparatus for testing graphite-metal seals is under construction. Sectioning of the first two in-pile loops was completed, and metallographic and analytical examinations are in progress. The viscosity of the fuel mixture BULT-14 ($\text{LiF}-\text{BeF}_2-\text{UF}_4-\text{ThF}_4$) was determined in the temperature range from 550 to 800°C. Enthalpy measurements with the BeLT-15 mixture ($\text{LiF}-\text{BeF}_2-\text{ThF}_4$) yielded a heat capacity varying from $0.343 \text{ Btu} \cdot \text{lb}^{-1} \cdot (^\circ\text{F})^{-1}$ at 1000°F to $0.304 \text{ Btu} \cdot \text{lb}^{-1} \cdot (^\circ\text{F})^{-1}$ at 1500°F. The apparatus for measuring the thermal expansion coefficient, β , of molten salt mixtures was tested by using HTS ($\text{NaNO}_2-\text{NaNO}_3-\text{KNO}_3$). Preliminary results were obtained for heat transfer with BULT-14 flowing in heated Inconel and INOR-8 tubes. **Materials Studies.** In an effort to join graphite to graphite and graphite to metal for molten-salt reactor service, an alloy (48% Ti-48% Zr-4% Be) was developed and had satisfactory wetting and flowing characteristics. However, because of its poor corrosion resistance to molten fluorides, other alloy systems are being investigated. Promising alloys in the Au-Ni-Ta system are under study, and alloys in the Ni-Nb, Ni-Mo, Ni-Nb-Mo, Ni-Nb-Ta, Pd-Ni-Ta, and Pd-Ni-Mo systems are being prepared for testing. Preliminary work in electric-resistance brazing of graphite to graphite, using molybdenum as the brazing alloy, has also been undertaken. The second of three INOR-8 corrosion inserts was removed after 10,000 hr from an INOR-8 forced-convection loop. Fifteen grades of graphite were classified according to their resistance to permeation by molten fluorides at 150 psig at 1300°F in 100-hr tests. Tests are being conducted to determine to what extent the bismuth-permeated graphite will pick up salts during standard permeation tests. When held in direct contact with graphite for 20 hr at 1300°F, $\text{LiF}-\text{BeF}_2-\text{UF}_4$ apparently gettered completely the oxide contaminants in the graphite. No precipitation was detected radiographically in the $\text{LiF}-\text{BeF}_2-\text{ThF}_4-\text{UF}_4$ after it had been in contact with graphite for 500 hr at 1300°F in a vacuum. INOR-8 specimens showed no metallographic indications that carburization had occurred after being in contact with TSF graphite at 1000 psi for 700 hr in salt environment at 1300°F. Four braze materials showed good resistance to fuel 130 ($\text{LiF}-\text{BeF}_2-\text{UF}_4$) during a 5000-hr corrosion test in a thermal-convection loop with a 1300°F hot-leg temperature. Corrosion tests of 100-hr duration indicated that the usefulness of titanium-, zirconium-, or beryllium-containing brazing alloys in fuel 130 would be limited in pure nickel or INOR-8 containers at 1300°F. Heavy attack due to the transfer of the refractory material to the nickel or INOR-8 container walls was observed. Detailed description of the ten subsidiary binary and ternary systems incorporated in the $\text{LiF}-\text{BeF}_2-\text{UF}_4-\text{ThF}_4$ quaternary system is nearly completed. The identification of the isomorphous compounds $\text{NaF} \cdot \text{BeF}_2 \cdot 3\text{UF}_4$ and $\text{NaF} \cdot \text{BeF}_2 \cdot 3\text{ThF}_4$ is of especial academic interest since $\text{NaF} \cdot \text{BeF}_2 \cdot 3\text{UF}_4$ has been erroneously reported in the literature as $\text{NaF} \cdot 4\text{UF}_4$. Exchange reactions in molten fluorides are being explored. The diffusion of chromium, which is the rate-limiting process for long-term corrosion in molten fluoride breeders, is strongly dependent on grain size, and hence on annealing history. Under equivalent conditions there is no significant difference between the diffusion co-

efficients of chromium in INOR-8 and in Inconel; thus the steady-state corrosion rate is predicted to be higher by a factor of 15/7 in Inconel, since this is the ratio of chromium concentration in the two alloys. Exploratory studies on the hygroscopicity of fuels and on the possibility of drying at low temperatures without extensive hydrolysis have given additional qualitative evidence of the extreme sensitivity of the fuels to moist air. Evidence of formation of a graphite intercalation compound with MoF_5 was found, but this compound is not expected to be encountered in reactor operation. Several grades of extruded graphite, but none of the molded types, show less than 1 vol.% permeation by breeder fuels at 60 to 75 psig and 1300°F. About 740 kg of purified fuel mixtures were processed during the quarter. Modification of the hydrofluorination-volatilization process is being investigated for application to thorium-bearing fuel salts, a principal objective being the retention of the processed material in the fluoride form. The solubility of ThF_4 in hot aqueous ammonium fluoride solutions is as high as 4 to 5%, and this system is therefore being investigated further. The use of ClF_3 -HF mixtures does not appear feasible because of the suppression of LiF solubility and the correspondingly low UF_4 and ThF_4 solubilities. The NO_2 -HF system is also unattractive because of the low solubility of ThF_4 , although that of UF_4 is higher. (For preceding period see ORNL-2799.) (auth)

11703 NP-8457

General Electric Co. Light Military Electronics Dept., Schenectady, N. Y.

RESEARCH ON LIQUID METALS AS POWER TRANSMISSION FLUIDS. Progress Report No. 3 [for] March 1, 1959 to June 1, 1959. R. C. Kumpitsch. June 1959. 26p. Project No. 8-(1-7331). Contract AF33(616)-5917.

The research effort, during this report period, on liquid metals as power transmission fluids was concerned with establishing a 1-gpm, 3000-psi, 1000°F, NaK-77 test flow loop. The low-pressure portion (console) of the test loop has been completely assembled. A control panel for operation of the loop was fabricated. The "console" was installed in the liquid metals test area and completely instrumented, with exception to the loop's low-pressure sensing and recording equipment. The design of the high-pressure NaK pump mounting and speed drive fixture for the inert atmosphere "glove box" was completed. This fixture is currently being constructed. Continuing progress is being made on the manufacture of the high pressure-temperature NaK staged gear pump. No improvement in the delivery schedule for this pump has been obtained. Difficulty is being experienced in the procurement of correctly fabricated carbide material for this NaK pump. Negotiations are currently underway with both the pump and material vendors to resolve the problem. The revised liquid metals program schedule is included. (auth)

11704 NP-8458

General Electric Co. Light Military Electronics Dept., Schenectady, N. Y.

RESEARCH ON LIQUID METALS AS POWER TRANSMISSION FLUIDS. Progress Report No. 4 [for] June 1, 1959 to February 1, 1960. R. C. Kumpitsch. Feb. 1960. 27p. Project No. 8-(1-7331). Contract AF33(616)-5917.

Continued effort was applied in establishing a 1 GPM, 3000 psi, 1000°F, NaK-77 (liquid metal) flow test loop. This test loop, when completed, will be used in the research of determining the feasibility of using liquid metals as high temperature, hydraulic power transmission fluids. Progress is reported toward completion of the test equipment including completion of the low pressure portion (con-

sole) of the test loop, and installation of the high pressure NaK pump mounting and speed drive fixture in the inert atmosphere glove box. The high pressure NaK pump is currently 60 percent complete. Delivery of the unit is scheduled for April 15, 1960. Three components were added to the liquid metals test loop. These components consist of two over-pressure relief valves and a high temperature liquid metals servo. (For preceding period see NP-8457.) (auth)

11724 IGIS-53(RD/W)

APPROXIMATE CALCULATIONS OF LIQUID-METAL HEAT TRANSFER. K. D. Voskresenskii and E. S. Turilina. Translated by G. R. Taylor (U.K.A.E.A., Windscale) from p.87-92 of "Teploperedacha i Teoriya Tepla," Academy of Sciences, U.S.S.R., Moscow, 1959. 8p.

Approximate calculations are given of heat transfer during turbulent flow of liquid metals in smooth tubes. (W.L.H.)

11922 ANL-5090

Argonne National Lab., Lemont, Ill.

CORROSION OF PLUTONIUM ALLOYS IN NaK. H. H. Hyman and J. J. Katz. July 1953. Decl. Mar. 15, 1960. 10p. Contract W-31-109-eng-38. OTS.

A Pu-Al alloy containing 4 at. % Al showed no attack after exposure to purified NaK for one month at 400°C in the absence of any oxide. The same specimen and other Pu alloys, including pure Pu, showed marked deterioration in shorter exposures in the presence of oxide films from a welded stainless steel container. Pure U was found to be resistant in the presence of such oxides. (auth)

12292 NP-tr-355

APPLIED MAGNETIC HYDRODYNAMICS. Translated from Transactions of the Inst. of Physics, Academy of Sciences, Latvian S.S.R., Riga, 1956. 142p. OTS.

The papers included in this volume are: magnetic hydrodynamic phenomena in liquid metals; electromagnetic pumps for liquid metals; theory of induction pumps; velocity distribution and magnetic hydraulic pressure losses in a rectangular channel; electromagnetic processes in induction pumps for liquid metal; edge effects in linear induction pumps; calculation of induction pumps for liquid metals; single phase alternating current pumps; and conducting sphere in a moving magnetic field. (W.L.H.)

12384 NAA-SR-Memo-1843

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

REACTOR COOLANT PUMPS: SODIUM FREEZE SEAL COOLING LOADS. R. W. Atz. Jan. 24, 1957. 12p. OTS.

A summary of the cooling load data for the SRE sodium coolant pump freeze seals is presented. (J.R.D.)

12703 ORNL-2792

Oak Ridge National Lab., Tenn.

LEVEL TRANSDUCERS FOR LIQUID METALS. R. G. Affel, G. H. Burger, and R. E. Pidgeon. Apr. 28, 1960. 45p. Contract W-7405-eng-26. OTS.

Twenty-two resistance-type, continuously sensing level transducers for use in NaK (56% sodium, 44% potassium) pumps were constructed which gave high reliability. Potentiometer (d-c) strip chart recorders were slightly modified for use with the transducers, and the performance of recorders having 4.5- and 12-sec balance speeds was very good. In a testing apparatus the results were: total range, 8.25 in.; linear range, 7.25 in.; and linearity, 33%. A 2% zero-level shift and ~0.4% maximum-level shift over a NaK temperature range of 300 to 1400°F was observed with

a temperature error less than 1.5% over the range 800 to 1400°F using the 1200°F calibration curve. A system resolution of better than 0.030 in. and reproducibility of better than 1% in the test rig was determined. Wetting errors were negligible for NaK temperatures above 600°F and variable when first exposed to NaK below 400°F. On-off level probes were made but not life-tested. It is concluded that they should be reliable if the center conductor does not rupture. Circuit readjustment was not necessary over the range 100 to 1400°F. Of 40 probes, three failed, one because of improper circuit adjustment and two because of defective welds; 16 have operated more than 3000 hr up to 1500°F without failure, and the remainder have operated at all temperatures of interest for various periods without failure. (auth)

12840 ORNL-2217(DeI.)

Oak Ridge National Lab., Tenn.

METALLURGY DIVISION SEMI-ANNUAL PROGRESS REPORT FOR PERIOD ENDING OCTOBER 10, 1956. Decl. with deletions Nov. 4, 1959. 231p. Contract W-7405-eng-26. OTS.

Progress is reported in corrosion studies of stainless steels, Nb, Zr, Al-Fe-Mo, Mo, Ni alloys, and Al-Ni by various materials including Na, Na-K, Li, Rb, and fused salts. Corrosion studies in pump loops of various materials by fused salts and liquid metals are reported. Fuel elements and shielding materials for ART and APPR are being developed. General studies in welding and brazing, nondestructive testing, fabrication, and inspection are described. Developments in high-temperature metals and ceramics, metallographic techniques, ceramic materials, and Zr alloys are reported. (T.R.H.)

12853 HW-56588

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

RESULTS OF NaK CAPSULE FAILURES IN HOT WATER FLOW TUBE. J. W. Weber. Sept. 12, 1958. 3p. Contract AT(45-1)-1350. OTS.

Results of deliberately caused failure in NaK filled aluminum body capsules containing small diameter uranium rods are presented. Autoclave and flow tube tests results are included. It is noted that the most significant result of these tests is that there is no distortion or capsule swelling from the NaK-water reaction which might cause blockage or injury to reactor process tubes. (J.R.D.)

12859

CORROSION OF IRON AND STEELS IN LIQUID METALS. I. STATIC CORROSION TEST. Y. Imai and T. Ishizaki (Tohoku Univ., Sendai). J. Atomic Energy Soc. Japan 2, 96-101(1960) Feb. (In Japanese)

The modes of attack by liquid metal are direct alloying, dissolution, intergranular penetration, corrosion by contaminants, and others. Microscopic examination of metallographically polished surface was adopted to investigate the attack of liquid metals on iron and steels. The reliability of the experimental method, the effect of oxygen and the effect of stabilizer of oxygen were examined. (auth)

13383 AFOSR-TN-57-57

TORSIONAL MAGNETO-HYDRODYNAMIC WAVES IN THE PRESENCE OF FINITE VISCOSITY. Technical Note No. 1 (Type 2). Edwin Blue. Jan. 1, 1957. 101p. Project No. R-357-50-7. Contract AF18(600)-1041. (AD-115096)

An idealized boundary value problem corresponding to an experiment involving the generation of a system of torsional magnetohydrodynamic waves in liquid sodium in the presence of finite viscosity is considered. The

analysis of the solution of the problem led to the formulation and design of "ideal" experiments which would provide suitable tests of the linearized theory. (W.D.M.)

13830

TRIAL MANUFACTURE OF AN EXPERIMENTAL NaK SYSTEM. Y. Imai, K. Fukushima, and T. Ishizaki (Tohoku Univ., Sendai). J. Atomic Energy Soc. Japan 2, 127-35(1960) Mar. (In Japanese)

From the results of static corrosion experiments, it was found that the stainless steels of types 304, 316, 347, and LCN155 can be used successfully as container materials for NaK. The present investigation was carried out to confirm the safe use of such materials under conditions of dynamic corrosion as well as to get information on the technical difficulty in manufacturing an experimental NaK system. A system was designed to operate up to approximately 600°C with type 347 stainless steel as piping. Heat was supplied by electric heater and removed by air cooler. A regenerative heat exchanger was provided to reduce the required power input; the pump used was of the a-c Faraday type. In this system, NaK was circulated at the rate of about 100g/sec, measured by d-c electromagnetic flow meter. An expansion tank and a sump tank were also provided. "Resistance-type" and "impedance-type" level indicators were used successfully. Wetting of the pipe surface was found to affect both the heat transfer of heat exchanger and the output voltage of the flowmeter. Wetting can be attributed to the reduction of oxides and precipitation of materials (oxide or others) on the pipe surface. (auth)

14569 NAA-SR-Memo-4914

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

RADIAL TEMPERATURE PROFILE OF SODIUM POOL BOILING HEATER ASSEMBLY. H. H. Cappel. Feb. 22, 1960. 8p. OTS.

The radial temperature around a sodium reactor heater assembly submerged in water is calculated using a model of the heater cross section found by conformal mapping. Thermocouple readings were also analyzed. When the heat flux is 5×10^5 Btu/hr-ft², a radial temperature drop of about 680°C across the center of the thermocouple well is calculated and found to be within 6% of the experimental value. Since most of this drop is across the 0.001-in. helium gap between the heater and its sleeve, it is concluded that the thermocouple will have to be bonded to the sleeve for dependable reading of true sleeve temperature. Drawings of the heater assembly and thermocouple are given. (D.L.C.)

14570 NDA-2114-2

Nuclear Development Corp. of America, White Plains, N. Y.

FURTHER EXAMINATION OF SEAWOLF (S2G) COMPONENTS. Jan. 31, 1960. 40p. Contract AT(11-1)-732. OTS.

The components examined were the electromagnetic pump, two-inch shut-off valve, and eight-inch check valve. In the electromagnetic pump, examination was made of the 8-in. bellows, transition section, and pump cell for evidence of erosion, corrosion, leaks, cracks, or unusual deposits. In the shut-off valve, examination was made of the plug and seat for hardness. Analysis was made for composition and structure if any unusual effects were indicated in hardness tests. In the check valve, examination was made of the journal to determine the origin of the pitting and black deposit observed on its surface. (W.D.M.)

14573 ORNL-2157(Pts. 1-5)(Del.)

Oak Ridge National Lab., Tenn.

AIRCRAFT NUCLEAR PROPULSION PROJECT QUARTERLY PROGRESS REPORT FOR PERIOD ENDING SEPTEMBER 10, 1956. Dec. 13, 1956. Decl. with deletions Oct. 28, 1959. 265p. Contract W-7405-eng-26. OTS.

Aircraft Reactor Engineering. Most of the detail drawings of the reactor-core, heat exchanger, pump, and pressure-shell assembly for the ART have been completed, and design work on the reactor shield and the interior of the reactor cell is proceeding. Tests of a fuel pump in a high-temperature test rig have indicated that the cavitation limit is somewhat lower than anticipated. The preliminary design of the fuel-recovery tank was completed. Studies of the reactor support structure were completed. A series of low-frequency thermal-cycling tests of the core shells is under way. Additional core flow studies were made on the full-scale model of the ART core. The results of experiments performed to determine the rate of gamma heating in various target materials near the BSF reactor were compared with results calculated by methods used for determining similar ART gamma heating rates. The ART simulator was used for a study of temperature control of the reflector-moderator and the temperature responses of the reflector-moderator cooling system. Tests were continued on a helium-bubbler type of level indicator for the fuel expansion tank. Evaluation tests of several types of high-temperature pressure-transmitters were continued. Evaluation studies of lubricating and cooling fluids for pumps were continued. Development test work on the fuel pump impeller continued. Liquid-metal-vapor condensers are being developed for use in helium purge systems in the ART sodium and NaK circuits and the NaK dump tanks. **Chemistry.** Phase equilibrium studies of fuel system components were continued. Studies of the $\text{RbF}-\text{UF}_4$ system progressed sufficiently for a tentative equilibrium diagram to be prepared. In studies of the $\text{RbF}-\text{CaF}_2$ system it has not been possible to get reproducible data for compositions containing more than 15 mole % CaF_2 . A study of the $\text{CsF}-\text{BeF}_2$ system was started in order to complete the study of the alkali fluoride-beryllium fluoride systems. Investigation of the equilibrium reduction of NiF_2 by H_2 in $\text{NaF}-\text{ZrF}_4$ was continued. The study of the activity of Cr in Cr-Ni alloys was completed, and the values obtained at 750 and 965°C are presented. Studies of the reduction of UF_4 by structural metals were extended to include the reaction media $\text{RbF}-\text{ZrF}_4$ and $\text{LiF}-\text{BeF}_2$. The solubilities of the structural metal fluorides NiF_2 , FeF_2 , and CrF_2 in molten $\text{NaF}-\text{ZrF}_4$ that were determined by using concentration cells and an emf method are presented. A systematic investigation of the solubilities of rare-earth fluorides in ART-type fuels was initiated. Density determinations were made on $\text{NaF}-\text{ZrF}_4$ at 600, 700, and 800°C. The diffusion of uranium fluoride-containing mixtures into graphite was studied. A device was constructed which will permit visual observation of compatibility tests of molten fluoride salts and alkali metals with pump lubricants. **Metallurgy.** Two Inconel forced-circulation loops were operated with the fuel mixture $\text{NaF}-\text{ZrF}_4-\text{UF}_4$ at maximum fuel temperatures of about 1500 and 1650°F in order to compare the corrosion properties. Examination of a Hastelloy B forced-circulation loop that operated with $\text{NaF}-\text{KF}-\text{LiF}-\text{UF}_4$ verified the excellent corrosion resistance of Hastelloy B to fluoride mixtures as observed previously in thermal-convection loops. Data obtained in cyclic strain tests of Inconel in a He atmosphere are presented. Corrosion tests on resistance-welded Inconel and on brazing alloys are presented. The intermetallic compounds NiAl , $\text{NiAl} + 5\% \text{Ni}$, $\text{NiAl} + 4\% \text{Zr}$, and MoAl were corrosion tested in static Na

and in $\text{NaF}-\text{ZrF}_4-\text{UF}_4$ for 100 hr at 1500°F. Work on the development of Ni-Mo base alloys was continued. The preparation of tubing of the ternary alloys based on Ni-17% Mo alloys with additions of Ti, Al, W, Nb, Cr, Fe, V, or C was continued. Encouraging results were obtained in the fabrication of tubular control rods by co-extrusion. A study of the fabrication and physical properties of europium oxide was initiated. **Heat Transfer and Physical Properties, Radiation Damage, Fuel Recovery and Reprocessing, Critical Experiments.** The fluid friction characteristics of 60-deg staggered spacers and 60-deg inclined spacers placed alternately in a model of the ART fuel-to-NaK heat exchanger were determined. Heat transfer experiments were conducted on the ART core model with a vaned entrance system under uniform volume heat source conditions. The enthalpies and heat capacities of a zirconium-base fuel with additives to simulate fission products were determined. A series of charcoal traps of different geometries but with the same amount of charcoal are being tested in radiokrypton holdup experiments. The fused salt-fluoride volatility pilot plant is essentially complete and shakedown tests have started. The decomposition of the complex $\text{UF}_4 \cdot 3\text{NaF}$ to a nonvolatile product was studied over the temperature range 245 to 355°C. **Reactor Shielding.** The results of calculations of gamma-ray energy flux, dose rate, and buildup factors in a lead-water shield of finite thickness are presented. The gamma-ray energy spectrum and time decay characteristics of the fission products of U^{235} related to circulating-fuel reactors are being investigated. Experiments are under way in an investigation of the effect on the dose rate outside the ART lead shield of gamma-ray streaming through the NaK filled pipes. Nuclear calculations were made in order to provide information for detailed design of the reactor core-reflector-island region of the Shield Mockup Core (SMC). (W.L.H.)

14574 ORNL-2440(Del.)

Oak Ridge National Lab., Tenn.

AIRCRAFT NUCLEAR PROPULSION PROJECT QUARTERLY PROGRESS REPORT FOR THE PERIOD ENDING DECEMBER 31, 1957. Apr. 24, 1958. Decl. with deletions Nov. 4, 1959. 222p. Contract W-7405-eng-26. OTS.

Aircraft Reactor Engineering. A summary of the status of the ART-ETU program at the time it was cancelled is presented. Operation of the fuel pump endurance test was resumed. Operation of the primary NaK pump loop No. 1 at elevated temperatures was resumed in order to observe the effects of the lower seal area of operating without a purge flow down the shaft annulus. The Inconel thermal barrier that was designed to protect the bearing-housing region of the ART sodium pumps from thermal and radiation damage was subjected to tests. The test of the ART control rod drive system was terminated after successful operation. Performance of the fuel-expansion-tank continuous level indicator is presented. A resistance-type fuel level indicator was designed. Operation of a 1-inch turbine flowmeter installed in a forced-circulation gas-fired Inconel loop containing a fused salt fuel is described. Additional tests were made of strain-gage pressure transmitters designed for use at high temperatures. Results of tests on sheathed and well thermocouples are given. A summary of the quantities and types of materials and components inspected is given. Results of high-frequency thermal-cycling tests of Inconel pipes are presented. Forced convection heat transfer studies with $\text{KCl}-\text{LiCl}$ flowing in a heated tube were continued. Results are given of an investigation of burnout heat fluxes for water in nucleate boiling. A comparison of heat transfer data is given for vortex flow and straight-through linear flow. Final results were obtained for the enthalpies and heat capacities

of the eutectic mixtures $\text{LiCl}-\text{SrCl}_2$ and $\text{LiCl}-\text{BaCl}_2$.

Chemistry. A comparison of Russian and ORNL investigations of the $\text{NaF}-\text{ThF}_4$ system is given. An apparatus for high-temperature thermal-gradient quenching experiments is described. The preparation of UF_3 and its stability in molten fluoride mixture is described. Activity coefficients of FeF_2 and NiF_2 in molten $\text{NaF}-\text{ZrF}_4$ are given. The reduction of Fe, Mo, Nb, Ta, V, and W in molten fluorides is described. Data are given on the solubilities of noble gases in molten fluoride mixtures. The solubility of Hf and fission products in $\text{NaF}-\text{ZrF}_4$ mixtures is given. Determination of Cr diffusion coefficients in Inconel-molten salt system is presented. Data are given on steady-state Cr migration in thermal-convection loops. Results of the dissolution of Type 347 stainless steel in $\text{NaF}-\text{KF}-\text{LiF}$ eutectic by hydrofluorination are given. **Metallurgy.** Development work on Ni-Mo base alloys for use as reactor structural materials in contact with fused salt fuels was terminated. Mechanical properties and corrosion resistance of Ni-Mo alloys are given. Creep and stress-rupture data were obtained for Inconel in Ar, Na, and fused salts. Fabrication of thermocouples for high-temperature service is described. An investigation of optimum welding methods for fabricating the fill-and-drain tank tube-to-tube sheet joints was completed.

Radiation Damage. Examination of the four forced-circulation loops that were operated in the MTR with fused fluoride fuels as the circulated fluids was completed. Examinations were continued of the moderator materials that were irradiated in the second exposure in the MTR. The out-of-pile tests that correspond to the MTR tube-burst tests were completed. In an investigation of irradiation effects in photoconductive detectors, both neutrons and gamma irradiation were found to decrease the photoresponse of PbS cells, and the decrease is proportional to the total integrated flux. A state-of-the-art survey of irradiation effects in semi-conductor barriers is presented to unify the material presented in previous progress reports and to establish a reference of current concepts. (W.L.H.)

14960 NYO-4811

Harvard Univ., Boston. Air Cleaning Lab.
FIBROUS FILTERS FOR NaK FUME REMOVAL. Richard Dennis, Edward Kristal, and Leslie Silverman. May 1, 1960. 40p. Contract AT(30-1)-841. OTS.

Accidental release of Na or NaK coolant from liquid loops may lead to rapid burning of the metal and dense fume production. Corrosive properties of the fume require that it be removed from operating areas by ventilation and washing of equipment. Restrictions on the quantity discharged to atmosphere require about 90% retention by fume collection devices to prevent damage to metal surfaces and vegetation. Studies with several bulk fiber collectors (glass, Saran, Dynel) indicate that relatively deep beds of fibers (2 to 6 inches) in the 10 to 50 micron diameter range are the most practical choice to meet specific cleaning requirements of 90% collection efficiency, resistance not to exceed 15 in. of water, holding capacity of 0.5 lb NaK hydroxides per 1000 cu ft per min filtration capacity, fire retardant, and corrosion resistant. Experimental filters composed of bonded Dynel fibers met the above specifications in both laboratory and field tests except for that of filtration capacity (700 rather than the desired 1000 cu ft per min for a filter unit 2 ft $\times$ 2 ft in face area). Tests indicated that finer fibers or graded fiber beds might offer improved performance. Comparative cost and performance data are shown for Dynel filters and other commercial collectors, wet scrubbers, and electrostatic precipitators. (C.H.)

15005 BMI-1403

Battelle Memorial Inst., Columbus, Ohio
PROGRESS RELATING TO CIVILIAN APPLICATIONS DURING DECEMBER 1959. Russell W. Dayton and Clyde R. Tipton, Jr. Jan. 1, 1960. 99p. Contract W-7405-eng-92. OTS.

The creep and stress-rupture properties of annealed and of 15% cold-worked Zircaloy-2 are being determined at 290, 345, and 400°C. Work continued on the development of a AgBr fuel-element leak detector for use in water-cooled reactors. The development of a thermal-neutron-flux monitoring system was directed toward extending the sensing-probe life, increasing the effective instrument range, and improving the instrument reliability. Resistivity of $\text{Al}_2\text{O}_3-\text{MoSi}_2-\text{UO}_2$ ceramic tubes was determined to investigate the effects of MoSi_2 proportion and of extrusion pressure. In the development of corrosion-resistant welding alloys for use with Hastelloy F, a number of alloys are being exposed in boiling Sulfex and Niflex solutions to determine corrosion resistance of these liquids. Corrosion tests in 200°C water for 30 days have shown that the Al-35 wt. % U alloys containing Sn or Zr additives are equivalent to the binary Al-35 wt. % U and superior to 2S Al in their resistance to the corrosion attack of 200°C water. Work was continued on the development of a radiometric-titration method of determining Al and Fe in portland cement. The investigation of the formation and decay of radiation-induced free radicals was continued. The effect of radiation on the nitration of cyclohexane was studied over the range of 15 to 70 wt. % HNO_3 with a 10-to-1 ratio of organic to acid. An investigation is being conducted on the effects of combined high pressure and temperature on the uranium oxides and on the reactions of uranium oxides with other oxide systems. An irradiation surveillance program on AISI Type 347 stainless steel is continuing. The alloys which are being investigated as alternate cladding materials for the EBR include Nb, Nb-1.84 wt. % Cr, Nb-3.21 wt. % Cr, Nb-4.33 wt. % Zr, Nb-9.95 wt. % Ta-3.31 wt. % Cr, Nb-39.8 wt. % Ti-10.6 wt. % Al, Nb-20.5 wt. % Ti-4.28 wt. % Cr, and V-11.7 wt. % Ti-3.07 wt. % Nb. Experimental work concerned with the development of water-corrosion-resistant Nb-base alloy was completed. Feasibility studies are in progress to evaluate new methods for the detection of oxygen in sodium. Niobium-base binary alloys containing from 10 to 60 wt. % U are being studied to determine the applicability of these alloys as high-temperature reactor fuels. Thorium-uranium and Th-U-base alloys are being investigated with the aim of improving their irradiation stability and corrosion resistance. To aid in understanding fission-gas release from UO_2 bodies during irradiation and post-irradiation heat treatments, the surface structures of various preparations are being examined before and after irradiation. Measurements of fission-gas diffusion from single-crystal UO_2 during post-irradiation heating were initiated. Methods of producing cermet of 90% of theoretical density or better containing 60 to 90 vol. % of ceramic fuel are being investigated. The gas-pressure-bonding process is being investigated as a method of cladding ceramic and cermet-type fuels with Mo and Nb. Various methods of producing dense UC by powder-metallurgy techniques are being investigated. Melting and casting, metallurgical and engineering properties, diffusion studies, and radiation effects of UC are being studied. A fundamental study of the reactions of N_2 with Nb is being made. Experiments were continued in producing UO_2 crystals from the vapor phase. The properties, irradiation damage, and fission-gas retention of fueled-graphite spheres are being investigated in support of the Pebble-Bed Reactor Program. Research on core materials

in support of the MGCR program is in progress. The major effort is on the development and evaluation of UO_2 dispersions in BeO or Al_2O_3 and dispersions of UC and UC_2 in graphite. Studies are being conducted to develop fuel, absorber, and suppressor materials for the SM-2. (For preceding period see BMI-1398.) (W.L.H.)

15078

ON THE VALUE OF THE SURFACE ENERGY OF METALS AT THE CRYSTAL-MELT INTERFACE. S. N. Zadumkin (Kabardino-Balkarsk State Univ.). *Doklady Akad. Nauk. S.S.S.R.* 130, 810-11(1960) Feb. 1. (In Russian)

A simple method is suggested for evaluating the surface energy at a polycrystal-melt interface. Results of σ_{12} calculations for body-centered cubic metals and experimental data on surface tension of liquid metals at their melting points are tabulated. The table indicates the interphase tension of metals at a polycrystal-melt interface as 8 to 15% of the surface tension at the melting point. (R.V.J.)

15083

SIGNIFICANT STRUCTURES IN LIQUIDS. V. THERMODYNAMIC AND TRANSPORT PROPERTIES OF MOLTEN METALS. Charles M. Carlson, Henry Eyring, and Taikyue Ree (Univ. of Utah, Salt Lake City). *Proc. Natl. Acad. Sci. U.S.A.* 46, 649-59(1960) May.

Thermodynamic properties calculated for molten metals by the method of significant structures of Eyring, Ree, and Hirai are presented. The application is discussed of the method of significant structures in predicting the viscosities and self-diffusion coefficients of molten metals at various temperatures and pressures. Data are tabulated on sodium, mercury, copper, and lead. (C.H.)

15488 ORNL-1170(Del.)

Oak Ridge National Lab., Tenn.
AIRCRAFT NUCLEAR PROPULSION PROJECT QUARTERLY PROGRESS REPORT FOR PERIOD ENDING DECEMBER 10, 1951. W. B. Cottrell, ed. Mar. 6, 1952. Decl. with deletions Oct. 27, 1959. 141p. Contract W-7405-eng-26. OTS.

The technical progress on the ORNL ANP Project is summarized. Topics covered include Circulating Fuel Aircraft Reactor, Liquid Metal Cooled Aircraft Reactor Experiment, reactor physics, critical experiments, nuclear measurements, experimental reactor engineering, chemistry of high temperature liquids, corrosion research, heat transfer research and physical properties, metallurgy and ceramics, radiation damage, supercritical water reactor, and analytical chemistry. (For preceding period see ORNL-1154.) (W.D.M.)

15725 NAA-SR-Memo-4413(Rev.1)

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.
DESIGN OF 3400 gpm 40 psi LINEAR INDUCTION PUMP FOR THE 250 MWE OVERFLOW REACTOR. R. S. Baker. July 16, 1959. 14p. OTS.

Design of a linear induction pump for the 250 Mwe advanced sodium graphite reactor is described. The pump develops 3400 gpm at 40 psi using sodium at 625°F. (J.R.D.)

15726 PWAC-292

Pratt and Whitney Aircraft Div., United Aircraft Corp., Middletown, Conn.
EXPERIMENTAL CONTROL FOR TP-1 LIQUID METAL TURBOPUMP. P. V. Naples and S. F. Gladczuk. Apr. 29, 1960. 23p. Contract NOas-58-662-c.

The initial tests of an experimental liquid metal turbo-pump control to determine the compliance of this system with its requirements were undertaken. Current results established the validity of the theory, thus justifying further development of system components. Recommendations for modifications and further testing are included. (J.R.D.)

15742

HEAT TRANSFER TO SODIUM AT SMALL VALUES OF REYNOLDS NUMBER. M. S. Priogov. *Atomnaya Energ.* 8, 367-8(1960) Apr. (In Russian)

Heat transfer to sodium from round copper tubes (ID = 28 mm; $\delta = 4$ mm) was measured in the Reynolds number range 17 to 416. The data, developed with the criterion $\text{Nu} = f(\text{Re})$, are plotted and correlated with published data. Agreement with the Martinelli-Lyon formula was obtained. The results do not confirm the postulations on sharp drops in heat transfer at small Re numbers. (R.V.J.)

15891 LM/TAB-14

MSA Research Corp., Callery, Penna.
LIQUID METALS TECHNOLOGY ABSTRACT BULLETIN FOR THE PERIOD, JANUARY, FEBRUARY AND MARCH 1960. 13p.

A bulletin containing abstracts from current literature on liquid metals is presented. 35 listings. (J.R.D.)

15940 GEAP-3333

General Electric Co. Atomic Power Equipment Dept., [San Jose, Calif.].
CORROSION OF BERYLLIUM IN FLOWING SODIUM. W. W. Kendall. Jan. 15, 1960. 30p. Contract AT(04-3)-189. OTS.

Samples of seven types of fabricated beryllium were exposed to sodium flowing at 20 ft/sec at 900°F for 47 hours followed by 520 hours at 1000°F. The oxide content of the sodium was first reduced by cold-trapping and then gettering with about 1% calcium. On completion of the test, all samples were found to be nitrided and some were joined together at points where the beryllium had been in contact with beryllium. Variation in behavior between the different samples was not apparent. The Be_3N_2 film was the thickest (~50 microns) on the face exposed to high velocity sodium. The Be_3N_2 film was black, hard, and adherent. The beryllium below the surface film did not appear to be affected by exposure to sodium. (auth)

16493 KAPL-1491

Knolls Atomic Power Lab., Schenectady, N. Y.
REPORT OF THE CHEMISTRY AND CHEMICAL ENGINEERING SECTION FOR NOVEMBER, DECEMBER 1955, JANUARY 1956. Decl. May 18, 1960. 103p. Contract W-31-109-Eng-52. OTS.

Investigations were continued on dissolution and decontamination of irradiated UO_2 - PuO_2 fuel, radiation effects on TBP, separation and nuclear properties of Cf^{251} , Cm^{245} , Cm^{246} , and Cm^{247} from irradiated Pu, vapor pressure of PuF_6 , properties of UO_2 slurries in Na, NaK, and H_2O , corrosion of aluminum alloys, electrorefining of irradiated U, deposition of Zr on graphite, and coating U with Mo. (For preceding period see KAPL-1438.) (M.C.G.)

16577 GEAP-3208

General Electric Co. Vallecitos Atomic Lab., Pleasanton, Calif.
METAL-WATER REACTIONS. V. THE KINETICS OF METAL-WATER REACTIONS--LOW PRESSURE STUDIES. Sydney C. Furman. July 31, 1959. 72p. Contract AT(04-3)-189. OTS.

A technique was developed for the purpose of studying the kinetics of metal reactions with water vapor at low

partial pressures of $H_2O(g)$. The details of the method were worked out in the study of the reaction of sodium and water vapor and adapted to work involving zirconium and aluminum alloys. Sodium investigations were made at 200 to 350°C and water vapor concentrations up to 400 ppm in a moving stream of helium carrier gas at a total pressure of one atmosphere. Studies involving zirconium and Zircaloy-2 were conducted at temperatures up to 1700°C and water vapor concentrations up to 30,000 ppm in one atmosphere He. The results of these experiments can be explained on the premise that the rate of reaction is controlled by the transport of water vapor through the helium. Good agreement was obtained between experimental results and calculations employing mass transfer considerations. A short study of aluminum was made at 900 to 1400°C with water vapor concentrations up to 6400 ppm. It was concluded from the essentially quantitative reduction of water vapor and the appearance of powdered oxide in the system that a vapor phase reaction between aluminum and water vapor occurred. (auth)

16968

THE LIQUID METAL CORROSION PROBLEMS. Alois Dvořák (Akimov State Univ., Prague). *Jaderná energie* 6, 155-62(1960). (In Czech.)

Recent research on the specific character of corrosion of construction materials by liquid metals as well as factors influencing the development of these corrosion processes are reported. The characteristic effects of corrosion by liquid metals, the principles of corrosion test methods, and the main methods of increasing the corrosion resistance of construction materials are given. (auth)

17166

IONIZATION OF HIGH VELOCITY ALKALI ATOMS BY COLLISIONS WITH ATOMS OF THE INERT GASES. V. M. Dukleskii (Dukelsky), J. F. Bydin, and A. M. Bukteev (Physico-Technical Inst., Academy of Sciences, Leningrad). p.65-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The cross sections for the loss of an electron by high velocity Na, K, Rb, and Cs atoms of energy ranging from 300 to 2,000 eV in single collisions with He, Ne, Ar, Kr, and Xe atoms were measured, and found to have values of the order of 10^{-20} to 10^{-18} cm². In certain cases the experimental results are consistent with the general theoretical predictions concerning slow inelastic collisions between atomic systems. (auth)

17948 NAA-SR-Memo-4442

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.

FINAL PERFORMANCE TESTS OF TWO-COOLANT-REGION SODIUM PUMP SHAFT FREEZE-SEALS. F. O. Streck. Feb. 10, 1960. 44p. OTS.

A prototype of the two-coolant-region pump shaft freeze-seals intended for application to the Hallam Power Reactor sodium pumps was fabricated. Tests under simulated reactor service conditions revealed satisfactory operation only when the lower of the two regions received heat from the circulating fluid (tetralin in the tests). With the inlet temperature of tetralin to the upper region of the seal maintained at 95°F and that to the lower region held in the range 240 to 285°F the seal functioned satisfactorily for 1100 hr. When 95°F coolant was circulated through both sections of the seal excessive cooling occurred, resulting

in either improper formation of the seal or in seizure of the shaft when rotative speed was low. In this case, the cooling load on the seal varied directly with both shaft speed and bulk sodium temperature. A maximum cooling load of 2.56 kw occurred at a shaft speed of 840 rpm and with a bulk sodium temperature of 1000°F. (C.J.G.)

17950 NAA-SR-Memo-5106

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.

DESIGN OF TWO ELECTROMAGNETIC PUMPS FOR NaK. R. S. Baker and W. J. Fraser. Mar. 25, 1960. 11p. OTS.

Two types of electromagnetic pumps, d-c conduction and a-c linear induction, were designed to pump NaK (78% K) at 650°F at a rate of 354 gpm with a developed pressure of 20 psi. (C.J.G.)

18106 BmI-1409

Battelle Memorial Inst., Columbus, Ohio.

PROGRESS RELATING TO CIVILIAN APPLICATIONS DURING JANUARY 1960. Russell W. Dayton and Clyde R. Tipton, Jr. Feb. 1, 1960. Decl. Apr. 20, 1960. 88p. Contract W-7405-eng-92. OTS.

Solid-state studies of oxide additions to uranium oxides are being conducted in correlation with the high-temperature stability and physical properties of these solid solutions. The program to determine the effects of fast neutron irradiation on properties of AISI Type 347 stainless steel has continued. Cladding materials being studied for possible use in the EBR are unalloyed Nb, Nb-Cr, Nb-Zr, and Nb-Ti-Cr. The evaluation of selected Nb alloys for possible service in pressurized-water reactors was continued. The creep strength of Zircaloy-2 at elevated temperature is to be determined and compared for two test conditions: in-reactor under a fast neutron flux and out-of-reactor. A study is being made of new approaches to the problem of measuring the oxygen content of sodium. The development of Nb-rich Nb-U alloys as high-temperature fuels is reported. Development of Th-U-base alloys with improved radiation stability and corrosion resistance continued. Results of various studies designed to support experiments of fission-gas release from UO_2 during and after irradiation are reported. Cermets of 80 vol.% UO_2 dispersed in stainless steel, Mo, Cr, and Nb are currently being fabricated by pressure-bonding techniques for physical and mechanical testing. An investigation is being made of the mechanism and kinetics of solid-phase bonding of metals under application of heat and pressure. Various methods of preparing UC powder and dense UC bodies by powder-metallurgy techniques are being investigated. Reliable techniques for the production of high-quality cast shapes of UC are being developed. An investigation of the effects of fission and irradiation on the structure and physical properties of UC is in progress. Research was continued on the problem of growing large single crystals of UO_2 by fusion methods. A basic study of the migration of hydrogen in zirconium under the influence of a thermal gradient is being conducted. Work was continued on the determination of Fe in portland cement by means of a complexometric titration with a radiometric end point. The long-term program for determining the creep and stress-rupture properties of Zircaloy-2 sheet material has continued. Investigations on the development of a fuel-element leak detector have continued. Self-welded specimens of the 12 experimental alloys and unwelded specimens of vacuum-metal Hastelloy F were exposed to boiling Sulfex and Niflex solutions for five 24-hr periods. Previous experience with Al-35 wt.% U alloy has shown that improvements in casting and fabricating characteristics can be obtained when suitable ternary additions are used. The effects of

impurities present in commercial-grade materials on the ternary eutectic temperature of Al-U-Ni alloy are being investigated. A program is currently being conducted to determine the changes induced in the properties of UC by irradiation in a test reactor. Work continued on the development of Al_2O_3 -clad UO_2 fuel particles. Data are presented on the room-temperature tensile properties of unirradiated and irradiated Ta. Ceramic-type fuels composed of ~20 vol.% UO_2 in BeO, 20 vol.% UO_2 in Al_2O_3 , 20 vol.% UC in graphite, and 20 vol.% UC₂ in graphite are being considered as potential fuels for the MGCR. Reference materials were selected and fabrication techniques are being evaluated for use in preparing fuel plates and absorber plates for the SM-2 reactor. Pellets of BeO-25 vol.% UO_2 are being prepared for loop and capsule exposures. (For preceding period see BMI-1403.) (W.L.H.)

18202

EMBRITTLMENT OF SOLID METALS IN A LIQUID METAL. W. A. Morgan (Dept. of Mines and Technical Surveys, Ottawa). *Metal Treatment and Drop Forging* 26, 333-9(1959) Sept.

A review is given of the published work on the embrittlement of solid metals by lower melting-point liquid metals. Included in the discussion are some of the theories for intergranular failure resulting from soldering and brazing operations on stressed materials. 57 references. (B.O.G.)

18643 ORNL-858(Del.)

Oak Ridge National Lab., Tenn.

THE AIRCRAFT NUCLEAR PROPULSION PROJECT QUARTERLY PROGRESS REPORT FOR PERIOD ENDING AUGUST 31, 1950. C. B. Ellis and W. E. Thompson, eds. Dec. 4, 1950. Decl. with deletions Oct. 1959. 64p. Contract W-7405-eng-26. OTS.

Stainless steel harps were operated both under thermal connection and with an electromagnetic pump using Na and NaK. Experimental equipment for measuring molten metal heat transfer coefficients was essentially completed. Equipment for measuring the heat transfer to boiling liquids is being designed. Plans were made to irradiate Cu and 316 stainless steel in the 20 Mev proton beam of the Y-12 cyclotron. The possibility of extending earlier thermal xenon cross sections vs. energy measurements to higher neutron energies is being considered. (W.L.H.)

18644 ORNL-919(Del.)

Oak Ridge National Lab., Tenn.

AIRCRAFT NUCLEAR PROPULSION PROJECT QUARTERLY PROGRESS REPORT FOR PERIOD ENDING DECEMBER 10, 1950. C. B. Ellis and W. B. Cottrell. Feb. 27, 1951. Decl. with deletions Nov. 10, 1959. 160p. Contract W-7405-eng-26. OTS.

Design of the Aircraft Reactor Experiment (ARE) is continuing, with particular emphasis on shielding, control, and fuel material. The most promising fuel mixture for the ARE is a solution of UF_4 in NaF, with possible admixtures of other fluorides to lower the melting point to a convenient range. Extensive computations of criticality and thermal xenon coefficients were made for both bare reactors and reflected reactors. Graphs of the spectra of several solid-fuel reactors are included. A preliminary analysis of the fuel kinetics of the NaF- UF_4 reactor shows the existence of oscillation in the reactor power following a change in reactivity, which arises from the coupling between fuel displacement and neutron flux. A resonance at ~49 eV was found from the preliminary neutron cross-section measurements on Mo. Theoretical analyses of heat transfer were completed on three situations which approximate the entrance conditions involved in current ARE core designs.

Equipment was designed for the measurement of thermal conductivity, specific heat, and other high-temperature properties of various liquid metals and molten salts. The specific heat of Li between 550 and 900°C was measured as $1.0 \pm 10\%$. Both 316 and 347 stainless steel convection harps containing liquid Na have operated almost 800 hr at 1500°F without failure. Substances so far found to have good resistance to Na at 1800°F include types 316 and 347 stainless steel and Ni. Fair resistance under these conditions is shown by Mo, Ta, alloy N-155, Inconel, and Inconel X. The equilibrium diagram of the molten salt system LiF- UF_4 has been established, and study of such systems as NaF- UF_4 is underway. Preliminary corrosion studies of numerous metals in NaF- UF_4 at 1300°F for 160 hr show Hastelloy C, Inconel, and Mo to be the least attacked. (W.L.H.)

18645 ORNL-1439(Del.)

Oak Ridge National Lab., Tenn.

AIRCRAFT NUCLEAR PROPULSION PROJECT QUARTERLY PROGRESS REPORT FOR PERIOD ENDING DECEMBER 10, 1952. W. B. Cottrell, ed. Decl. with deletions Nov. 16, 1959. 156p. Contract W-7405-eng-26. OTS.

The most significant ARE modification was the completion of the off-gas system design. Progress is reported on valves, pumps, instrumentation, and other components of the fluoride-fuel and reflector-coolant circuits. A rotameter-type flowmeter and the modified Moore Null-matic pressure transmitter were tested. The heat-transfer coefficient of a sodium-to-air radiator was increased by 20%. General design studies include a performance study on a Sapphire turbojet engine. Reactor physics studies include those of oscillations in a circulating fuel reactor, a technique for reactor calculations, and the temperature-dependence of a cross section exhibiting a resonance. Measurements in several criticality tests are reported. The research on fused-fluoride systems led to selection of the fuel and charging technique for ARE. Continued study of the corrosion characteristics of ZrF_4 bearing mixtures, hydroxides, and liquid metals is reported. Metallurgy and ceramics research includes work on development of spherical solid fuel elements; creep rupture tests of structural metal; welding and brazing techniques; and cermets and ceramic coatings. Heat transfer and physical properties of several fluoride mixtures were studied. Radiation damage studies include irradiation of fluoride fuel samples, in-pile sodium-loop measurements, and in-pile creep measurements. Chemical, spectrographic, and petrographic identification of various impurities, corrosion products, and reduction products are reported. (For preceding period see ORNL-1375.) (J.R.D.)

18646 ORNL-1609(Del.)

Oak Ridge National Lab., Tenn.

AIRCRAFT NUCLEAR PROPULSION PROJECT QUARTERLY PROGRESS REPORT FOR PERIOD ENDING SEPTEMBER 10, 1953. W. B. Cottrell, ed. Nov. 3, 1953. Decl. with deletions Nov. 12, 1959. 124p. Contract W-7405-eng-26. OTS.

A higher value was obtained for the critical mass for the Aircraft Reactor Experiment. The exact value of the critical mass was not determined, but it is expected that the reactor will be able to "go critical." Structural poisons were removed from the core. The increase in the critical mass reduced the heat removal capacity by one-half. Coincident with these changes, both the fuel and sodium systems were revised to operate with only one pump. Vertical-shaft, sump-type, gas-sealed cen-

trifugal pumps are to be employed in both systems. Pump seals with packings of graphite, graphite and metal wood, and beryllium fluoride and various vitreous and frozen seals were tested for use in continuous remote operation. No seals for such an operation were found suitable; however, several seals operated in excess of 1000 hr with leakage rates of less than 10 cm^3 per day. Suitable instrumentation to indicate leaks in the sodium and the fluoride systems was developed. Reliable fluid-flow measurements were made by using two Moore pressure transmitters across a venturi. Several series of reactor and shield designs were made to determine the effects of reactor power, reactor core diameter, and division of the shield on aircraft performance. The activation of various secondary coolants, including Na and K, was measured. Sodium was found superior to K on the basis of total weight of the system, although the activity of the K was about 2 to 5% that of the Na. An analysis of a power plant system external to a reactor was made for a 200,000-lb aircraft with a 100- or a 200-Mw reflector-moderated reactor and two or four Wright turbo-jet engines. The analysis revealed that the off-design, as well as the normal performance and control of these subsonic planes, is satisfactory when four engines are employed with chemical augmentation. The critical experiment facility was used to determine the relation between minimum critical mass and uniform thermal-neutron flux. The assembly investigated consisted of concentric cylindrical aluminum shells filled with varying concentrations of aqueous uranyl fluoride solution. Critical height and mass were measured, based on theoretically determined fuel loadings, and found to be within 2.5% of the corresponding calculated parameters. Phase equilibria studies of UF_4 , UF_3 , ThF_4 , and UCl_4 compounds were conducted. Problems in the preparation and purification of fluoride mixtures were investigated. The corrosion of Inconel by $\text{NaF-ZrF}_4\text{-UF}_4$ (50-46-4 mole %) was studied as a function of time and temperature. The initial corrosion rate ($\sim 1 \text{ mil/day}$) was higher at higher temperatures but decreased after several days by a factor of 10. Creep-rupture data were obtained for both coarse- and fine-grained Inconel in fluorides at 815°C over the stress range 2500 to 7500 psi. The beneficial effect of adding ZrH_2 was demonstrated in additions as small as 0.1 wt. %. The corrosion of Inconel by fluorides at high fluid velocities was no greater than in static tests. Of several stainless steel convection loops tested with circulating lead, only the loop constructed of type 410 stainless steel did not plug. High-conductivity radiator fins were fabricated (copper clad type 310 or 346 stainless steel) and assembled into high-temperature high-performance radiator segments. The high-temperature physical properties of several molten fluorides, chlorides, and hydroxides were measured. The viscosity and density of the system $\text{NaF-ZrF}_4\text{-UF}_4$ (53.5-40-6.5 mole %) were measured. The corrosion of BeO by Na both under the influence of radiation and without radiation was studied. Spectrometric analysis revealed no gross segregation of the U in irradiated fluoride fuels. The determination of Zr in fluorides by a spectrophotometric technique utilizing the zirconium-alizarin red-S complex is described. (For preceding period see ORNL-1556.) (C.J.G.)

18853 NAA-SR-Memo-1552

North American Aviation, Inc., [Downey, Calif.].
SODIUM VAPOR DETECTION TEST. D. L. Whitlock.
Jan. 9, 1956. 8p. OTS.

The Westervelt method of sodium vapor detection (passing an inert gas into the area presumed to contain sodium vapor and bubbling the gas through water containing thymol blue indicator) was evaluated for use in detecting leaks in

the SRE control rods. The method was found unsatisfactory for the proposed use. (C.J.G.)

18892 NAA-SR-Memo-4417

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.

LITERATURE SURVEY ON PROPERTIES OF SODIUM VAPOR. Guy Ervin, Jr. Sept. 25, 1959. 13p. OTS.

A literature survey was conducted to assess the adequacy of published data on the properties of sodium vapor and to obtain information to be used as a basis for recommending experimental work on further measurement of these properties. (J.R.D.)

19055 NAA-SR-Memo-2830

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.

SINTERED METAL FILTERS FOR SODIUM COOLANT SYSTEMS. J. S. McDonald. June 27, 1958. 10p. OTS.

Equations which express the relations between the pressure drop, pore size, flow rate, and filter thickness for sodium flowing through sintered metal filters were derived. (C.J.G.)

19065 PWAC-299

Pratt and Whitney Aircraft Div., United Aircraft Corp., Middletown, Conn.

PERFORMANCE TESTS OF THE AIR TURBINE FOR THE PRATT AND WHITNEY AIRCRAFT LIQUID METAL TURBOPUMP, TP-1. J. S. Murphy and J. Carta. June 24, 1960. 21p. Contract AF33(600)-41233.

Performance tests of the air turbine drive for liquid metal turbopumps of the type TP-1 are reported. It was determined that this type turbopump operating at 1800 rpm and 3000 gpm of 1050°F NaK requires 5.6 lb/sec of air at 1425°F . (auth)

19098 NAA-SR-Memo-3528

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.

EXPERIMENTAL EVALUATION OF CONCENTRIC CYLINDER, SPIRAL-FLOW HEAT EXCHANGER. J. S. McDonald. Mar. 9, 1959. 31p. OTS.

The design, fabrication, and experimental evaluation of a 100 kw model of a concentric cylinder, spiral-flow heat exchanger are discussed. Heat transfer and thermal stress resistance of the unit were investigated in a figure-eight Na system. Expressions for the Nusselt numbers for Na flowing in rectangular passages were derived for effective heat flow through two opposite walls and effective heat flow through only one wall. (C.J.G.)

19109

DEVELOPMENT TESTING OF LIQUID METAL AND MOLTEN SALT HEAT EXCHANGERS. R. E. MacPherson, J. C. Amos, and H. W. Savage (Oak Ridge National Lab., Tenn.). *Nuclear Sci. and Eng.* 8, 14-20 (1960) July.

In order to investigate the design and fabrication problems inherent in compact, high-performance heat exchangers for aircraft nuclear propulsion applications, extensive development testing was done on bifluid (molten salt-NaK) heat exchangers and on liquid metal (NaK-air) radiators. These test units were prototypes of the heat transfer equipment which was to be used in the Aircraft Reactor Test (ART) at ORNL. Five bifluid test loops and one liquid metal test loop were used for performance and endurance testing of these components at simulated reactor operating conditions. The molten salt used was a ternary mixture of composition NaF 50 mole %, ZrF_4 46

mole %, UF_4 4 mole %. The NaK used was 56 wt % Na and 44 wt % K. A total of 47,000 hr of operation at 1200 to 1700°F was accumulated on 18 heat exchangers and 20 radiators. The program demonstrated that the compact heat exchanger geometries tested possessed the performance capabilities and mechanical integrity to meet ART design requirements. (auth)

19311

EVALUATION OF THE PERFORMANCE OF LIQUID METAL AND MOLTEN SALT HEAT EXCHANGERS.

M. M. Yarosh (Oak Ridge National Lab., Tenn.). *Nuclear Sci. and Eng.* 8, 32-43(1960) July.

Heat transfer and pressure drop test data were obtained on liquid metal-to-molten salt heat exchangers and on liquid metal-to-air radiators. The data were correlated to permit predictions of the heat transfer and pressure drop performance of heat exchange equipment to be used on the Aircraft Reactor Test. The test results agreed well with analytical predictions using the Dittus-Boelter and Kaufman-Lubarsky equations except that in the transition region from laminar to turbulent flow marked differences were found in the heat transfer coefficients for flow through round tubes and axial flow between tubes. These differences appeared to stem in part from the irregular geometry of the flow passage between tubes and from the tube spacers employed. (auth)

19310 BMI-1189

Battelle Memorial Inst., Columbus, Ohio.

PROGRESS RELATING TO CIVILIAN APPLICATIONS

DURING MAY 1957. Russell W. Dayton and Clyde R.

Tipton, Jr. June 1, 1957. Decl. Feb. 4, 1960. 59p.

Contract W-7405-eng-92. OTS.

Data are reported on the creep properties of annealed Zircaloy-2 and -3A. Efforts directed toward the improvement of the extrusion-cladding process were continued. A program of research concerned with the development of melting and casting techniques for the production of sound, homogeneous Al-U extrusion billets containing up to 50 wt.% U is in progress. Uranium oxides are being studied to determine how processing variables affect the reactivity of the dioxide in subsequent steps in the production of U. The study of the effects of N_2 on the electrical properties of UO_2 was continued. Investigations were continued on the corrosion of Type 304 ELC stainless steel by chloride- and fluoride-contaminated HNO_3 solutions such as might occur during the recovery of HNO_3 from U processing plants. Hydrogen pickup by U rods heat treated in pilot-plant-scale beta heat-treating salt baths is being studied. The compacting of briquettes of UF_4 and Mg was offered as a means of improving the efficiency of the bomb-reduction process. Nuclear fuel elements utilizing the refractory materials BeO and graphite as matrices for UO_2 are being investigated. Data are reported on the tensile properties of U-Nb alloys containing 7, 10, and 15 wt.% Nb. The mechanism of aqueous U corrosion is being studied in order to develop corrosion-resistant alloys for reactor fuels. Research on the fundamental properties, corrosion resistance, and radiation resistance of U-Zr alloys is reported. Long-term corrosion studies pertaining to the development of corrosion-resistant Zr and Zr-base alloys were continued in elevated-temperature water and steam. Data are reported on the oxidation behavior of binary Nb alloys tested in air at 1000°C. Tensile test data are presented for martensitic U-Ti alloys. The reaction of oxygen and nitrogen with USi_3 , U_3Si_2 , USi_2 , USi , and UAl_2 was investigated. Investigations of corrosion problems associated with the recovery of spent reactor fuel elements were continued. A reflector method of control for a boiling-

water heterogeneous reactor is being investigated. The behavior of Ta exposed to 1200°F peak-temperature sodium is being investigated using forced-convection flow-loop apparatus. Creep testing of annealed Ta sheet was continued. A new and particularly sensitive method for the determination of oxygen in sodium is being developed. (For preceding period see BMI-1181.) (W.L.H.)

19311 BMI-1442(Rev.)

Battelle Memorial Inst., Columbus, Ohio.

PROGRESS RELATING TO CIVILIAN APPLICATIONS

DURING MAY 1960. Russell W. Dayton and Clyde R.

Tipton, Jr. July 12, 1960. 100p. OTS.

The investigation of the stabilizing influence of oxide additions to UO_2 was continued. The effects of fast-neutron irradiation upon the mechanical properties of Type 347 stainless steel are being investigated. Tensile data are reported for alloys of Nb-Cr and Nb-Zr. The major effect of fast-neutron irradiation on the creep properties of Zircaloy-2 is being studied by comparing the in-reactor creep behavior of the alloy with out-of-reactor creep properties. New methods for the determination of low concentrations of oxygen in sodium are being investigated. The mechanisms of wear and friction of various metals in sliding contact in liquid sodium are being studied. Data are presented on corrosion properties, short-time tensile properties, stress-rupture properties, and electrical resistivity for Nb-U alloys. The development of Th and Th-U alloys with improved radiation resistance is being investigated. A program is reported for the determination of diffusion coefficients of Xe in single-crystal UO_2 specimens and the in-pile study of fission-product release from sintered UO_2 . Thermal-conductivity, thermal-expansion, electrical-resistivity, and modulus-of-rupture measurements are being made on 80 vol. % UO_2 cermet. Techniques for the fabrication of compartmented Mo- and Nb-clad UO_2 and cermet fuels are being investigated. Compaction studies of UO_2 were undertaken to provide core materials which will achieve a range of desired densities on pressure bonding. The fabrication of Type 304 stainless steel-clad UO_2 rod, tube, and flat-plate elements and flat-plate assemblies was accomplished by gas pressure bonding. Various methods for economically producing dense UC components by powder-metallurgical techniques are being investigated. A study of the properties of UC is under way. Thermal-gradient experiments are being performed to establish a theoretical basis for the prediction of hydrogen migration in zirconium hydride. Experiments were continued in producing single crystals of UO_2 . Portland cement samples were analyzed for sulfate content using a radiometric method involving the precipitation of $\text{Sr}^{89}\text{SO}_4$. Solution-annealed strips of welding alloys for use with Hastelloy F to contain de-cladding solutions were prepared for welding and corrosion evaluations. A study is being made of the effects of irradiation on cladding- and core-dissolution processes. Uranium carbide shot was coated with 160 μ of carbon by the thermal decomposition of acetylene in a fluidized bed of the shot. Two programs concerned with investigations of Ta and Ta-base materials of interest for containment of molten Pu-alloy fuels are under way. Fission-gas release from BeO- UO_2 is being investigated by heat treating neutron-activated sintered pellets. A study of the radiation stability of ceramic-type fuels under conditions simulating those of the MGCR design is in progress. Further experimental and theoretical studies were carried out to determine the feasibility of coating and preparing U and Th carbides by vapor deposition reactions in a fluidized bed. Methods are being developed for preparing instrumented fuel plates for use in SM-1 type fuel elements for in-pile test evaluation. Mate-

rials were selected and techniques were established for the fabrication of SM-2 reference fuel elements. For the ML-1 Reactor Hastelloy X will be used as the fuel-element cladding material. (For preceding period see BMI-1434.) (W.L.H.)

19660

IONIZATION OF FAST ATOMS OF Na, K, Rb, AND Cs IN COLLISIONS WITH MOLECULES OF H_2 , D_2 , N_2 , AND O_2 . Yu. F. Bydin and A. M. Bukhteev (Inst. of Physics and Tech., Academy of Sciences, Leningrad). *Zhur. Tekh. Fiz.* 30, 546-54(1960) May. (In Russian)

The effective ionization cross sections for interactions of fast atoms of Na, K, Rb, and Cs with H_2 , D_2 , and O_2 were measured at energies of 150 to 1200 ev. The energy thresholds for Cs- H_2 (740 ev), Cs- D_2 (60 ev), Rb- H_2 (490 ev), and Rb- D_2 (280 ev) were observed. The obtained data are analyzed from the point of view of Mecc's quasi-adiabatic hypothesis and the concept of potential curves corresponding to initial and finite energy states of two slowly approaching particles. (tr-auth)

19963 ANL-6124

Argonne National Lab., Ill. and Land-Air, Inc., Chicago. THE INTERNAL FEEDBACK OF EBR-I MARK-III. J. C. Carter, D. W. Sparks, and J. H. Tessier. Feb. 1960. 72p. Contract W-31-109-eng-38. OTS.

The reactor is considered to constitute a closed-loop, nonlinear mechanical system with forcing functions resulting from variations in neutron density and the flow of NaK. The significant sources of internal feedback are found to be the variation in volume of the uranium and the variation in the density of NaK. Resistance to the free motion of uranium in response to thermal expansion accounts for the significant nonlinear properties of the system. This resistance results from the physical characteristics of the redundant structure constituting the core, blankets and containing shell. The mechanical system is transformed into a dynamically similar electronic system which is subject to the transformed operating conditions of the reactor. All the equations defining the time-dependent physical phenomena were developed from an analysis of the mechanical system. Only the constants in the nonlinear equations of motion of the materials of the core and blankets were synthesized from low-power operation of the reactor. The relationship between signal and response of the two systems is in good agreement over all conditions of operation. (auth)

20231 MCW-1410

Mallinckrodt Chemical Works, St. Louis. PROCESS DEVELOPMENT QUARTERLY REPORT. PART I. LABORATORY WORK. Barbara Elliott and John Nelson, eds. Jan. 2, 1958. Decl. May 4, 1960. 108p. Contract W-14-108-eng-8. OTS.

The partial result of a survey of the quantity of HNO_3 insoluble U contained in feed materials is reported. The insoluble contents of lots tested varied from 0.1 to 0.0002% of the U content. Uranium Reduction, Rifle, and Uravan lots contained relatively larger amounts than the Anaconda, Durango, Monticello, Rare Metals, Dawn, and Western Nuclear material tested. Reactions between liquid Na or NaK with hot UO_3 (750°F) or hot UNH (475°F) were found to be violent and extremely exothermic, but in no case was an explosion observed. The reaction between NaK and UNH was most severe of those tested. The phenomenon of "thermal damage" in the hydrofluorination reaction was postulated as due to the sintering of UF_4 under high particle temperatures created from the heat of reaction. The extent to which this effect occurs is believed dependent on

the particle temperature and also on the particle size of the oxides involved. The former factor is a function of the intrinsic reactivity of these solids. Evidence was found that indicated that the reflectivity measurements provide an indication of the surface area and/or the particle size of the UO_3 . The initial product from the pilot plant fluid-bed denitrator was found to be of low reactivity. Sulfation and grinding improved reactivity somewhat. At 900 to 1000°C, 97% of the water can be removed from 70% HF by the water-gas reaction with contact times of 2 to 10 seconds. This range in contact times is dependent on the type of carbon used. Further investigation will be directed toward the search for a means of carrying out the reaction at lower temperatures either through use of a more active carbon, a catalyst, or a more finely divided carbon. Preparation of crude green salt by dissolution of an ore concentrate in dilute H_2SO_4 , filtration, Fe reduction, and precipitation with dilute HF results in appreciable U losses in the residue from the first filtration, and also in the filtrate from the fluoride precipitation. The latter loss can be reduced by precipitation of the double salt, calcium uranous fluoride. The MgF_2 side of the MgF_2 -MgO phase diagram was found to contain a simple eutectic. The eutectic composition is about 5.5% MgO and the eutectic temperature, 1224°C. Hydrogen dissolution into molten U was found to be considerably faster from a H_2 atmosphere than from a water atmosphere at the same pressure. This difference in rate apparently becomes greater as pressure of gases is increased from 18 to 470 mm of Hg. Optimum film thicknesses on Mg were found to be formed by reaction with HF in the temperature range 475 to 525°C. When green salt low in water soluble is employed in bombs with filmed Mg, the firing time of the bomb is dependent on the temperature of filming. Crude U yields and the H_2 content of metal were found to improve with extended firing time. Both properties also depend upon the green salt composition. Of the various techniques tested in laboratory scale bombs for the production of low H_2 metal, the most successful to date was the combination of roasted liner, filmed Mg, and He purge. In this manner metal was consistently produced with H_2 contents comparable to those in vacuum recast metal (0.5 ppm). Unfortunately, yields with this technique were less than desirable. Performance testing of the Isotope Ratio Mass Spectrometer is reported. A gamma spectrometric method for the determination of U^{235} in depleted and normal U was developed. Precision of ± 0.005 weight percent U^{235} at the 95% confidence limit in normal U was obtained. Further modification of the x-ray spectrographic method for U in raffinate is reported. The dry admixture of internal standard was found advantageous. The indicated precision at the 95% confidence limit is $\pm 3\%$ relative to the concentration of U. (auth)

20320

THE APPLICATION OF THE THEORY OF THERMODYNAMIC SIMILARITY TO THE DETERMINATION OF PHYSICAL PROPERTIES OF LIQUID METALS. G. F. Butenko and M. I. Radchenko. *Inzhener.-Fiz. Zhur., Akad. Nauk Belorus. S.S.R.* 3, No. 6, 66-71(1960) June. (In Russian)

It is shown that the Lorents function of fused metals can be expressed by an equation. For liquid metals belonging to one thermodynamic group a relationship was established between the dimensionless Lorents function and dimensionless viscosity. Formulas are given which are suitable for liquid metals contained in one thermodynamic group. Results of calculations are compared with experimental data. (auth)

20627

AN X-RAY STRUCTURE INVESTIGATION OF THE LIQUIDS OF SODIUM, POTASSIUM AND SODIUM-POTASSIUM ALLOYS. B. R. Orton, G. I. Williams, and B. A. Shaw (Fulmer Research Inst., Ltd., Stoke Poges, Bucks., Eng.) *Acta Met.* **8**, 177-86(1960) Mar. (In English)

The x-ray structures of liquid sodium, potassium, and sodium-potassium alloys were investigated by an improved method. By using a reservoir technique, a plane horizontal surface of liquid metal was examined by a monochromatic x-ray beam in a focusing Geiger diffractometer. Thus the absorption correction, which was one of the greatest sources of error in previous work, was constant and omitted from the analysis. The radial distribution method of analysis was used to interpret the results. None of the liquids examined showed evidence of structure other than that associated with a statistical mixture of atoms. In particular the position of the intensity peak was found to depend in a fairly simple way on alloy composition and did not show the marked deviation at compound composition Na_2K as reported by other workers. The use of the radial distribution method was examined critically. It is felt that the method is adequate for interpreting simple liquid structures provided suitable modification functions are used to expose spurious detail. (auth)

21129 NAA-SR-Memo-4372

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.

TEST PROGRAM FOR HNPF PROTOTYPE FREE SURFACE PUMP. R. W. Atz. Sept. 14, 1959. 7p. OTS.

A description of tests to be performed on the prototype pump for use in the sodium heat transfer system in the HNPF is given. The data from these performance tests are to provide information required for pump evaluation. (J.R.D.)

21482

IMPROVEMENTS IN OR RELATING TO THE PURIFICATION OF SODIUM. David Frederick Altimier and Charles Harold Lemke (to E. I. Du Pont de Nemours and Co.). British Patent 837,268. June 9, 1960.

Sodium having high Ca contents up to 1000 ppm can be purified by mixing it in the molten state with a gas mixture of inert gas- O_2 , the O_2 content being less than 2 vol.%, and then settling or filtering. In this way, Ca contents can be reduced to 25 ppm or less. The temperature is below 300°C , and the inert gas can be N_2 , Ar, or He. Various methods of effecting intimate contact between the sodium and the gas are given. The form of Ca separated in this manner is found to be mostly elemental Ca, but the presence of O_2 is necessary in the gas to render Ca separable. Application of this method of sodium purification is given on a batch basis. (D.L.C.)

21881 BMI-1201

Battelle Memorial Inst., Columbus, Ohio.

PROGRESS RELATING TO CIVILIAN APPLICATIONS DURING JUNE 1957. Russell W. Dayton and Clyde R. Tipton, Jr. July 1, 1957. Decl. Mar. 30, 1960. 52p. Contract W-7405-eng-92. OTS.

Progress is reported on the following studies: development of materials for Hanford reactors, developments for Al-clad fuel elements, studies of Zr-U alloys, corrosion studies of Zr, reactor-materials development, physical metallurgy, corrosion problems associated with the recovery of spent reactor fuel elements, evaluation of a reflector-controlled heterogeneous boiling reactor, studies of Na-Ta compatibility at elevated temperatures, and de-

velopment studies for the PWR. (For preceding period see BMI-1189.) (W.L.H.)

21882 BMI-1213

Battelle Memorial Inst., Columbus, Ohio.

PROGRESS RELATING TO CIVILIAN APPLICATIONS DURING JULY 1957. Russell W. Dayton and Clyde R. Tipton, Jr. Aug. 1, 1957. Decl. Mar. 30, 1960. 56p. Contract W-7405-eng-92. OTS.

Investigations are reported in: creep properties of annealed Zircaloy-2 and -3 at high temperatures; burst strength of welded Zircaloy-2 tubes; air oxidation of Nb, Nb-V, Nb-Mo, and Nb-Zr at 1000°C ; vapor deposition of Mo coatings on stainless steel tubing; bonding fundamentals; niobium-hydrogen reactions; creep and stress-rupture of sintered Ta at 1200°F in He; and determination of O in liquid Na by gettering. (For preceding period see BMI-1201.) (T.R.H.)

22069

RESISTIVITY AND KNIGHT DISPLACEMENT IN LIQUID SODIUM ALLOYS. E. Daniel (Physique des Solides, Paris). *Phys. and Chem. Solids* **13**, 353-5(1960) June. (In French)

A model developed for dilute solid solutions of elements of different valences is applied to liquid alloys of elements of the same valence. The model gives values for the resistivity and the Knight displacement simultaneously and in good agreement with experiment for alkali metal alloys. The model does not apply when the electronegativity of the solute differs appreciably from that of the solvent. This suggests that one should in this case consider as a whole the dissolved atom and its nearer neighbors, the electron clouds of which should be strongly perturbed. (tr-auth)

22603 NAA-SR-Memo-2881

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.

DESIGN OF AN EDDY-CURRENT BRAKE FOR A SODIUM-COOLED NUCLEAR POWER REACTOR. R. S. Baker. July 10, 1958. 17p. OTS.

Two eddy-current electromagnets to act as brakes were designed and installed in the sodium-cooled nuclear power reactor SRE to throttle sodium flow throughout the reactor after shutdown in order to maintain a constant reactor temperature gradient. One brake was used on the primary piping system, the other on the secondary system. It was determined that the eddy-current brake should cause a dragging pressure of 0.3 psi at a flow rate of 12 gal/min. The flux density necessary to produce this pressure was calculated, and the coil ampere-turns required to produce this flux density were determined. Both brakes were controlled by thermocouples and performance was satisfactory. (M.C.G.)

22970 NAA-SR-5241

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.

A COMBINATION STRAINER AND BLOCKING VALVE FOR LIQUID METAL SYSTEMS. F. S. Naylor and J. S. McDonald. Aug. 30, 1960. 20p. Contract AT-11-1-GEN-8. OTS.

A 3-in. pipe-size combination valve and strainer device performed satisfactorily when tested in a sodium system. The device provided a means of removing an in-line strainer element from the system without draining the sodium and alternately served as a plug type blocking valve. Tests were conducted over a temperature range of 500 to 950°F and system pressures of 0, 5, and 10 psi at NaO contents of 50 to 400 ppm. The strainer element was

isolated from the system by freezing the sodium around the valve plug. The time required to freeze the sodium was found to be primarily a function of system temperature, a typical value being 75 min for a system temperature of 800°F. (auth)

22972 PWAC-300

Pratt and Whitney Aircraft Div., United Aircraft Corp., Middletown, Conn.

DEVELOPMENT OF AIR TURBINE DRIVE COMPONENTS FOR THE PRATT AND WHITNEY AIRCRAFT LIQUID METAL TURBOPUMP, TP-1. J. S. Murphy, R. S. Lombard, R. G. Haskell, and J. D. Sutherland. June 30, 1960. 64p. Contract AF33(600)-41233.

The components testing program for development of the TP-1 air-turbine drive consisted of (a) full-scale fiberglass model tests of the TP-1 turbine inlet scroll using subsonic air, (b) subsonic air tests of five tangential inlet type fiberglass turbine inlet-scroll models, (c) cold hydrostatic tests of the prototype TP-1 turbine scroll using a stresscoat technique, (d) evaluation tests of three types of carbon-face seals, and (e) a single endurance test of the most promising carbon-face seal. As a result of these component development tests, satisfactory modifications to the prototype turbine inlet scroll were effected, the operating stress levels in the scroll at design conditions were determined to be noncritical, and the performance of the best carbon-face seal tested was found to be acceptable from a leakage standpoint. A successful endurance test of approximately 1400 hr was conducted on this seal with an average leakage of about 0.5 cc/hr. (auth)

23203 LM/TAB-15

MSA Research Corp., Callery, Penna.

LIQUID METALS TECHNOLOGY ABSTRACT BULLETIN FOR PERIOD OF APRIL, MAY AND JUNE 1960. 5p.

Abstracts of current literature on liquid metals are presented. Nine abstracts are included. (J.R.D.)

23301 NYO-9316

Yale Univ., New Haven. Hammond Metallurgical Lab. THE ELECTRICAL RESISTIVITY OF LIQUID SODIUM AND DILUTE SODIUM ALLOYS. Final Report. James F. Freedman and W. D. Robertson. Oct. 1959. 45p. Contract AT(30-1)-1857. OTS.

The factors of atomic size, ion core potential, and charge, which contribute to the increment in electrical resistivity produced by solutes in metallic solutions, were separated and experimentally evaluated in liquid sodium. The results are expressed in a semi-empirical relationship which defines the increment in resistivity of a monovalent solution as the sum of the fractional difference in atomic volume of solute and solvent and the difference in atomic number of Na and the solutes Li, K, Cs, Rb, Ag, and Au. (auth)

23350

NIOBium—PROMISING HIGH-TEMPERATURE REACTOR-CORE MATERIAL. J. A. DeMastry and R. F. Dickerson (Battelle Memorial Inst., Columbus, Ohio). *Nucleonics* 18, No. 9, 87-90; 132; 134(1960) Sept.

The properties of niobium and niobium-base alloys were studied for high temperature reactor use. Results indicated that niobium-based, enriched-uranium alloys may be valuable as fuels for use at 1600 to 2000°F in a nonoxidizing environment. The properties of unalloyed niobium, capture cross sections, high temperature strengths, effects of cold work on hardness, electrical resistivity of annealed alloys, tensile properties, creep and creep rupture properties,

oxygen solubility, and the effects of oxygen on tensile strength were investigated for niobium and its alloys. Hot-hardness values were obtained for niobium-uranium alloys. Rolling and forging tests indicated that the 20 wt. % alloy was most easily forged. Corrosion tests were conducted in air, CO₂, NaK, water, and steam. Data obtained indicated that the niobium-20 wt. % uranium alloy was the best metallic fuel yet developed for high temperature use. (M.C.G.)

23755 NAA-SR-Memo-4802

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.

PROTOTYPE FREEZE TRAP TEST. R. Cygan. Dec. 29, 1959. 6p. OTS.

A performance evaluation was made of a prototype liquid cooled freeze trap with sodium at 350 and 1000°F. The sodium freeze-off function was adequate for all test conditions encountered. The freeze-off occurred satisfactorily with the larger clearance provided by a test modification to provide 0.030 eccentricity to the rotating shaft. Turning the freeze-trap handle was successful in opening the unit for gas venting when 350°F sodium was used. For a seal formed with 1000°F sodium, 16 turns of the trap handle gave no measurable gas venting at pressures up to 30 psi. Melting out the seal opened the vent satisfactorily. All the major problems encountered during the test were mechanical and associated with the rotating feature of the unit. (M.C.G.)

23756 NAA-SR-Memo-4934

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.

14-INCH SWING CHECK VALVE TEST. R. Cygan. Feb. 10, 1960. 5p. OTS.

The check valve for the Hallam Power Reactor uses a knife-edge bearing for the flapper in place of the usual journal-type bearing. Mechanical cycling in sodium at 600°F was used to check operation of this bearing. A total of 309 mechanical cycles was completed with no apparent malfunctioning of the valve. Measured leakage rates were 0.46 gpm at 0.93 psig, 0.73 gpm at 3.4 psig, and 0.32 gpm at 5.9 psig. (M.C.G.)

23757 ORNL-2061(Pts. I, II, and III)(Del.)

Oak Ridge National Lab., Tenn.

AIRCRAFT NUCLEAR PROPULSION PROJECT QUARTERLY PROGRESS REPORT FOR PERIOD ENDING MARCH 10, 1956. June 13, 1956. Decl. with deletions Nov. 10, 1959. 225p. Contract W-7405-eng-26. OTS.

Reactor Theory, Component Development, and Construction. Detailed layouts were completed on all major sub-assemblies of the ART. Recent calculations have indicated that the heat flux through the core shells of the ART will be higher than previously estimated. The thickness of the lead portion of the reactor shield was reduced from 7 to 4.3 in. to obtain space for increased neutron shielding around the pumps. Studies of flow in a full-scale plastic model of the core were continued. Flow diagrams and instrumentation lists were prepared for the Engineering Test Unit (ETU), which is a nonnuclear mockup of the ART. Modifications were made in the proposed ART control system on the basis of information obtained with the reactor simulator. Three separate calculations of the activity that will be produced in the NaK in the fuel-to-NaK heat exchangers of the ART were normalized to the current ART design. An estimate was made of the activity to be expected in the ART radiators because of the deposition on the radiator tubes or header walls of constituents of Inconel that will become activated in the heat exchangers and will be carried to the

radiators in the NaK stream. A calculation of the self-absorption of decay gamma rays in the ART fuel dump tank indicated a value of 90%, and therefore cooling facilities must be provided to remove almost all the decay heat. Disassembly and sectioning of in-pile loop No. 3 which operated in the MTR were completed. Synthetic lubricants in the UCON LB series were investigated to determine their stability as pump lubricating fluids in the ART. Additional tests of the performance of the ART sodium pump with water were made. Difficulties were encountered in high-temperature tests of the fuel pump with NaK. Operations were continued on heat exchanger stands. A stand for testing the thermal stability of the outer core shell of the ART is in operation. Materials Research. Additional phase-equilibrium studies were carried out in several fluoride systems in order to gain a better understanding of the structure and to aid in devising improved fuels. A material containing NaF-ZrF₄-UF₄ was found to show promise as a lower melting, nonsegregating substitute for Na₂UF₆ as a fuel concentrate for reactor systems. Studies were made on the UF₄-UO₂ system which led to a value of 1034°C for the melting point of pure UF₄. Experimental work was carried out in the following Zr-bearing systems: KF-ZrF₄, RbF-ZrF₄, and NaF-KF-ZrF₄. Thermal analysis data were obtained on the RbF-BeF₂ system. The program for studying chemical reactions of molten fluorides was continued. Studies of the reactions of Ta and W with UF₄ in NaK-LiF-KF eutectic showed that neither metal was stable and that they offered little or no advantage over Cr. The effects on corrosion of varying the ratio of hot-leg surface area to volume of fluoride fuel mixture in a forced-circulation Inconel loop were investigated. Examinations of two forced-circulation loops that had operated with the fuel mixture NaF-KF-LiF (UF₄ + UF₃) clearly demonstrated that the presence of U³⁺ in such a mixture is very effective in reducing hot-leg attack. Two Inconel forced-circulation loops in which NaK was circulated completed 1000 hr of operation with a temperature gradient of 300°F and a maximum fluid temperature of 1500°F. Examinations of two Hastelloy B thermal connection loops operated for 500 hr with an alkali metal fluoride mixture containing UF₄ at a maximum temperature of 1500°F showed the maximum attack to be less than 2 mils. Inconel tube-to-header joints brazed with Ni-Cr-Ge-Si low-cross-section alloys were tested in Na, NaK, and NaF-ZrF₄-UF₄ in seewaw apparatus. One specimen of Sm₂O₃ and two specimens of a commercial rare-earth oxide mixture (Sm₂O₃ + Gd₂O₃) were tested in static sodium in Inconel containers at 1500°F. Two type 316 stainless steel thermal-convection loops were operated with Na to study the effect of a diffusion cold trap on the amount of corrosion and mass transfer observed in such a system. A series of differential-thermal-analysis was performed to determine the solubility of Li in NaK. Nine Ni- and Fe-base alloys of special compositions were prepared and were subjected to static corrosion tests in NaOH for 100 hr at 1500°F. Screening tests of elastomers for possible use as valve seat materials in NaK circuits were initiated. A search for a moderator that can be cooled by direct contact with the molten fluoride fuel mixture was initiated. Experiments are underway in which the activation analysis is being used to study the diffusion of Cr in Inconel. Metallographic investigations are under way on NaK-to-air radiators that failed after various periods of service at high temperatures. The creep-rupture testing program for Inconel was nearly completed. The reactions which occur between Inconel and metal borides, oxides, nitrides, carbides, and carbonitrides were determined at temperatures between 1100 and 2000°F. Extensive compatibility tests of UO₂ and Nb, both powdered and wrought, were carried out by heating for 500 hr at 1000°C. Methods are being studied

for preparing compacts of Sm and Gd oxides and cermets of Fe and rare-earth oxides and Ni and rare-earth oxides for use in reactor control elements. Preliminary heat-transfer data were obtained for molten NaF-KF-LiF-UF₄ flowing through Hastelloy B tubes in a pressurized forced-convection system. A study of the effect of composition on heat capacity for NaF-ZrF₄ salt mixtures was investigated. The effects of irradiation on the corrosion of Inconel exposed to a fluoride fuel mixture and on the physical and chemical stability of the fuel mixture were investigated. A spectrophotometric method for the determination of trace amounts of Ti in mixtures of fluoride salts was developed. Studies were continued on the bromination method for the determination of combined oxygen in fluoride salts. (W.L.H.)

23838 ORNL-1375 (Del.)

Oak Ridge National Lab., Tenn.

AIRCRAFT NUCLEAR PROPULSION PROJECT QUARTERLY PROGRESS REPORT FOR PERIOD ENDING SEPTEMBER 10, 1952. W. B. Cottrell, ed. Nov. 19, 1955. Decl. with deletions Nov. 16, 1959. 146p. Contract W-7405-eng-26. OTS.

Progress is reported on the following studies: circulating fuel aircraft reactor experiment (fluid circuit, reflector coolant, pressure-shell stress analysis, off-gas system); experimental reactor engineering (pumps, valves, heat exchangers, instrumentation, fluid dynamics, technology of fluoride handling); reactor physics (oscillations in the circulating fuel reactor, effect of gas on reactivity); critical experiments (direct-cycle reactor, ARE critical assembly); nuclear measurements (fission cross section of U²³⁴ and U²³⁶, total cross section of N¹⁴); chemistry of high-temperature liquids (fuel mixtures containing UF₄ and UF₃, alkali fluoborate systems, differential temperature curve of NaF-ZrF₄-UF₄, x-ray studies of complex fluoride systems, simulated fuel mixture for cold critical experiment, coolant development, hydrolysis and oxidation of fuel mixtures, reaction of fuels with alkali metals); corrosion research (parametric studies of fluoride corrosion, fluoride corrosion in thermal-convection loops, compatibility of BeO with fluoride mixtures, hydroxide corrosion, liquid-metal corrosion, fundamental corrosion research); metallurgy and ceramics (welding, tests of brazing alloys, reduction of MoS₂); heat-transfer and physical properties research (viscosity of fuel mixtures, heat capacity of LiOH, thermal conductivity of fluoride salt mixtures, vapor pressure of fuel constituents, convective heat transfer in liquid NaOH, boiling heat transfer in Hg); radiation damage (radiation of fused materials, creep under irradiation); and analytical chemistry (analytical studies of components of fluoride mixtures, analytical studies of impurities in fluoride mixtures, determination of C in ZrF₄ and Zr-NaF-C mixtures). (W.L.H.)

24062 NRL-Trans-788

France. Commissariat à l'Énergie Atomique, Paris.

TITRATION OF SODIUM OXIDE IN SODIUM. THE MERCURY METHOD: ITS USE IN THE CASE OF VERY LOW VALUES. (Dosage de l'Oxyde de Sodium Dans le Sodium. La Méthode au Mercure: Son Utilisation Dans le Cas de Très Faibles Teneurs). L. Champeix, R. Darras, and J. Duflo. Translated by A. Pingell (Naval Research Lab.) from Report CEA-835, 1958. 16p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 17781.

24216 CF-60-3-164

Oak Ridge National Lab., Tenn.

DEVELOPMENT TESTING AND PERFORMANCE EVALUATION OF LIQUID METAL AND MOLTEN SALT HEAT EXCHANGERS. R. E. MacPherson and M. M. Yarosh. Mar. 17, 1960. 43p. OTS.

Development testing was done on prototype, bifluid (molten salt-NaK) salt exchangers and on liquid-metal (NaK-air) radiators in support of the ANP program. The molten salt was a Na-Zr-UF₆ mixture, and the NaK was 56 wt.% Na and 44 wt.% K. Performance tests were conducted on prototypes of the main heat exchangers for the Aircraft Reactor Test. The flow range on the molten-salt side of the exchanger varied from Reynolds numbers of 1000 to 6000, and the NaK-flow operating range varied from Reynolds numbers of 15,000 to 200,000. Data were taken on 20-25-, and 100-tube bundles at start-up and after 500 and 1000 hr of operation. No deterioration of the salt coefficient occurred with time of operation. In general, the data were found to lie ~40% below the Dittus-Boelter line in the Reynolds range of interest. The effects of tube spacer arrangements on the unit performance were investigated. Pressure-drop data are presented for 1.75- and 0.5-Mw Aircraft Reactor Test prototype radiator units. (C.J.G.)

24217 NP-9184

North Carolina State Coll., Raleigh.
LUBRICATION BEHAVIOR OF LIQUID METALS. Progress Report No. 7 [for] May 1960 to August 1960. Patrick H. McDonald. Aug. 1960. 23p. Project No. 8-(8-7022). Contract AF33(616)-5885.

The assembly and check-out of the hydrodynamic-lubrication test apparatus (liquid metal and Argon loops) was completed. A method for obtaining a level suspension system for the test bearing was developed. A trolley system for moving the assembled bearing housing into and out of the support piping was designed and built. The fabrication of an apparatus to evaluate the effectiveness of liquid metals in the boundary-lubrication region was completed. (C.J.G.)

24488 ORNL-2080(Del.)

Oak Ridge National Lab., Tenn.
METALLURGY DIVISION SEMI-ANNUAL PROGRESS REPORT FOR PERIOD ENDING APRIL 10, 1956. Nov. 2, 1956. Decl. with deletions Nov. 13, 1959. 209p. Contract W-7405-eng-26. OTS.

Tests of materials for use in liquid-metal and fused-salt systems were continued. Corrosion tests, penetrability tests, thermal tests, and solubility tests were conducted on structural alloys, brazing alloys, special alloys, cermets, carbides, nitrides, and rare-earth oxides. Progress in loop design and testing is reported. Hastelloy W creep and stress testing and general welding and brazing tests and investigations are reported. Development work is reported in nickel-molybdenum base alloys and iron-zirconium alloys and the fabrication of control rods. Research in the physical chemistry of corrosion, fundamental and applied metallurgy, and ceramics is reported. Development of alloys, fuel assemblies and fuel alloys, and brazing and welding techniques for the Homogeneous Reactor Project (HRP) and the Army Package Power Reactor (APPR) and testing of these materials in the Materials Testing Reactor (MTR) are described. (W.L.H.)

24489 ORNL-2685

Oak Ridge National Lab., Tenn.
[PAPERS PRESENTED AT] ANP MATERIALS MEETING NOVEMBER 16-18, 1954, [WRIGHT AIR DEVELOPMENT CENTER, DAYTON, OHIO]. Mar. 26, 1959. Decl. May 9, 1960. 168p. Contract W-7405-eng-26. OTS.

Screening tests were conducted on materials for pump

bearings, valves, and seals for fluorides and sodium. The specimens were loaded into Inconel containers along with a sodium or fluoride bath. Ceramics and cermets were dynamically tested in fluorides and sodium. Stress-rupture data are presented for Inconel in fused fluoride salts. Joining methods and procedures are reported for the fabrication of compact and relatively complex radiators and heat exchangers for circulating fuel reactors. Typical radiator designs are shown. The fabrication of control rods and reactor shielding is described. The corrosion of stainless steel and Inconel by Li, Na, and Rb is reported. The compatibility of Be, Na, and Inconel is discussed. Requirements of container materials for circulating-fuel reactors are presented. It is shown that Inconel is a successful container material for reactors of this type. The corrosion of various metals by molten fluorides is discussed. A study was made of the mass transfer and corrosion characteristics of a number of metals and alloys in liquid lead. (W.L.H.)

24508 NAA-SR-5282

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.
CARBURIZATION OF AUSTENITIC STAINLESS STEEL IN LIQUID SODIUM. W. J. Anderson and G. V. Sneesby. Sept. 1, 1960. 32p. Contract AT-11-1-GEN-8. OTS.

Results are presented of experimental research concerned with carbon transfer in liquid sodium-304 stainless steel systems. The general nature of the reactions is discussed, and experimental techniques are described. The reaction rates in the liquid sodium system were found to be rapid, and carburization rates for the steel were governed by diffusion rates. The carbon content of 304 stainless steel in equilibrium with carbon-saturated sodium varies from 2.68% at 1000°F to 4.35% at 1600°F. Sodium containing 15 to 18 ppm carbon is in virtual equilibrium with uncarburized 304 stainless steel at 1200°F, when the oxygen concentration in the sodium is less than 40 ppm. Diffusion coefficients for carbon in 304 stainless steel are presented in the temperature range of 1000°F to 1600°F. A method of using micro-hardness data from carburized stainless steel specimens for indirectly determining the carbon content of sodium is described. (auth)

24509 NMI-1220

Nuclear Metals, Inc., Concord, Mass.
PROCEEDINGS OF THE NINTH ANNUAL AEC CORROSION SYMPOSIUM, MAY 10-12, 1960. J. Paul Pemsler. July 18, 1960. 55p. OTS.

Abstracts are presented for the unclassified papers given at the symposium. The classified papers are listed by title only. The papers covered the following subjects: zirconium; hafnium, niobium, and aluminum; new concepts in corrosion research; fundamental studies; liquid metals; gas-cooled reactors; and in-pile corrosion, contamination and decontamination. (W.L.H.)

24510 ORNL-2391

Oak Ridge National Lab., Tenn.
CORROSION RESISTANCE OF VARIOUS CERAMICS AND CERMETS TO LIQUID METALS. W. H. Cook. June 13, 1960. 27p. Contract W-7405-eng-26. OTS

The procedures used for the corrosion screening testing of ceramics and cermets in liquid Li, Na, and Pb are discussed briefly. The results of such tests on various ceramics and cermets exposed for 100 hr to the liquid metals at 1500°F are given. These include various borides, carbides, nitrides, oxides, and silicides for the ceramics. The major part of the cermet screening corrosion tests reported are on tungsten carbide- and titanium carbide-base cermets.

Some present and future uses for corrosion resistant ceramics and cermets are outlined. (auth)

24570 AEC-tr-4198

ON THE BEHAVIOR OF LITHIUM TO SODIUM, POTASSIUM, TIN, CADMIUM AND MAGNESIUM. G. Masing and G. Tammann. Translated for Oak Ridge National Lab. from *Z. anorg. Chem.* 67, 183-99(1910). 37p. (Includes original, 17p.). JCL.

The reactions of Li to Na, K, Sn, Cd, and Mg in a H current were studied. Temperatures of crystal formation were determined. Cooling curves were analyzed. (C.J.G.)

25586 IS-188

Ames Lab., Ames, Iowa.

PERFORMANCE CHARACTERISTICS OF AN ELECTROMAGNETIC PUMP. David H. Thompson and Ray W. Fisher. Aug. 1960. 55p. Contract W-7405-eng-82. OTS.

The performance characteristics of small linear-induction electromagnetic pumps suitable for high-temperature liquid-metal test-loop operation were examined. Also, methods by which the performance of such pumps may be improved were investigated. The phenomenon of fluid wetting of the pump duct wall and the use of side bars provide powerful tools for improving the linear-induction-pump performance characteristics. Full advantage of the improved performance can be obtained if the hydraulic losses are minimized by using a pump section with large duct width, which also improves the power factor and decreases the phase current requirements of the pump. (auth)

25601

IMPROVEMENTS IN OR RELATING TO ELECTROMAGNETIC INTERACTION PUMPS SUITABLE FOR LIQUID METALS. Dudley Albert Watt (to United Kingdom Atomic Energy Authority). British Patent 847,492. Sept. 7, 1960.

An electromagnetic interaction pump for pumping liquid metals, single-phase conduction type incorporating a transformer, is designed for producing high pressures and comprises closed and air-gap iron circuits with a duct in the gap for the liquid metal. The flux in the gap may be further increased by an auxiliary winding on the air-gap iron circuit. (D.L.C.)

25618 AEC-tr-4218

HEAT TRANSFER TO LIQUID METALS IN TURBULENT FLOW WHEN THE THERMAL LOAD IS DISTRIBUTED SINUSOIDALLY ALONG THE LENGTH OF THE PIPE. (Teplootdacha k Turbulentnomu Potoku Metalla pri Sinusoidal'nom Raspredelenii Teplovoi Nagruzki po Dline Truby). V. I. Petrovichev and L. S. Kokorev. Translated from *Inzhener.-Fiz. Zhur., Akad. Nauk Belorus. S.S.R.* 2, No. 12, 20-5(1959). 11p. JCL or LC.

This paper was previously abstracted from the original language and appears in *NSA*, Vol. 14, as abstract No. 6417.

26099

ON THE DISPERSION OF A CONDUCTING GAS FLOWING IN A MAGNETIC FIELD. V. B. Baranov. *Izvest. Akad. Nauk S.S.S.R., Otdel. Tekh. Nauk, Mekh. i Mashinostr.* No. 4, 14-18(1960) July-Aug. (In Russian)

The problem of the dispersion of a conducting gas flowing in a magnetic field is considered in the basic equations of magnetohydrodynamics. Formulas and calculated graphs are obtained for the distribution of velocities, density, pressure, and temperature along the canal length for three cases: the dispersion in a canal of constant cross section, isothermal dispersion, and dispersion in a slowly broadening canal. The cases are considered when the magnetic field induced in the conducting gas may be neglected and the viscosity is not taken into account. In the engineering of the well-known pumps for pumping liquid metals, the electromagnetic force is utilized to move the liquid metals along a pipe. One of these pumps was designed at the Institute of Physics of the Latvian Academy of Sciences. For pumping liquid sodium, an inductor was utilized, originally flowing along a canal in a magnetic field whose direction was perpendicular to the direction of its motion. The rate of the spreading of the field may be increasing through the frequency rise caused by the induced electrical current. A weakly conducting gas with velocity of the order of 10-12 km/sec is required to investigate the possibility of dispersion. The strength of the external electric field E is believed equal to zero. All quantities taken into consideration depend only on the coordinate X along the canal. (TTT)

26455 LAMS-2462

Los Alamos Scientific Lab., N. Mex.

QUARTERLY STATUS REPORT ON LAMPRE PROGRAM FOR PERIOD ENDING AUGUST 20, 1960. Samuel Glasstone, comp. and ed. Sept. 1960. 23p. Contract W-7405-eng-36. OTS.

The LAMPRE-I project is summarized in terms of capsule development, sodium system, LCX-III, gas system, and fuel transfer and storage. The 2-Mw Sodium Test Facility was initially placed in operation on Mar. 15, 1960. Since startup, operation has been continuous except for 12 forced shutdowns required for maintenance of auxiliary steam-system equipment and repair of refractory setting in the gas-fired sodium heater. Essentially no maintenance or adjustment has been required on sodium components or the steam generator. The steam-generating unit is illustrated and design heat-transfer criteria and observed heat-transfer data are given. The intermediate sodium heat exchanger, centrifugal sodium pumps, gas-fired sodium heater, sodium flow-control valves, and purification cold trap are discussed briefly. Research and development activities for the LAMPRE Program are reported in the core-development program, core-test facility, mobile-blanket studies, fuel-alloy development, container-materials development, and fuel processing. (For preceding period see LAMS-2438.) (W.D.M.)

Volume 15, 1961

644 AEC-tr-4202

ON THE VISCOSITY OF LIQUID METALS. (O Vyazkosti Zhidkikh Metallov). A. M. Korol'kov. Translated from *Izvest. Akad. Nauk S.S.S.R., Otdel. Tekh. Nauk, Met. i Toplivo* No. 5, 123-6(1959). 7p. OTS.

Data on the viscosity of several metals and relations between the magnitude of their kinetic viscosity and other physical properties are presented. It is concluded that atomic volume and the entropy value can be used in objective viscosity evaluation of metals. (J.R.D.)

908 NDA-2133-1

Nuclear Development Corp. of America, White Plains, N. Y.

FAST NEUTRON CROSS SECTIONS OF MANGANESE, CALCIUM, SULFUR, AND SODIUM. Quarterly Progress Report No. 1 Covering the Period December 1, 1959-February 29, 1960. E. S. Troubetzkoy. Mar. 31, 1960. 18p. Contract DA 18-108-405-CML-295. (AD-236431).

Progress is reported on the compilation of neutron-cross-section data for manganese, calcium, sulfur, and sodium. Preliminary values are reported for some of the sulfur and sodium cross sections. (auth)

909 NDA-2134-2

Nuclear Development Corp. of America, White Plains, N. Y.

FAST NEUTRON CROSS SECTIONS OF THORIUM-232, PROTACTINIUM-233, URANIUM-233, BERYLLIUM, SODIUM, AND IRON. M. H. Kalos and E. S. Troubetzkoy. Sept. 1, 1960. 30p. Contract AT(30-1)-2303. OTS.

The work was performed as part of the $U^{233}-Th^{232}$ fast breeder reactor feasibility study. All cross sections required for neutron diffusion calculations were considered. These included total, fission, capture, (n,2n), elastic, and inelastic scatter. (W.D.M.)

1105 ANP-60(Del.)

Oak Ridge National Lab., Tenn.

AIRCRAFT NUCLEAR PROPULSION PROJECT QUARTERLY PROGRESS REPORT FOR PERIOD ENDING MARCH 10, 1951. W. B. Cottrell, ed. June 19, 1951. Decl. with deletions Jan. 7, 1960. 262p. Contract W-7405-eng-26. OTS.

Progress is reported on the design of the 200 Mw Aircraft Reactor, design of the Aircraft Reactor Experiment, reactor physics, critical experiments, nuclear measurements, chemistry of liquid fuels, corrosion experimentation, liquid metal and heat transfer research, components of liquid metal systems, metallurgical processes, radiation damage homogeneous circulating-fuel and circulating-moderator reactors, vapor-cycle and helium-cycle systems, supercritical-water cycle, and supersonic tug-tow system. (W.L.H.)

1108 ORNL-1771(Del.)

Oak Ridge National Lab., Tenn.

AIRCRAFT NUCLEAR PROPULSION PROJECT QUARTERLY PROGRESS REPORT FOR PERIOD ENDING SEPTEMBER 10, 1954. A. W. Savolainen, ed. Oct. 29, 1954. Decl. with deletions Dec. 2, 1959. 152p. Contract W-7405-eng-26. OTS.

Progress is reported on the Circulating-fuel Aircraft Reactor Experiment, Reflector-moderated Reactor, experimental reactor engineering, critical experiments, chemistry of molten materials, corrosion research, metallurgy, heat transfer and physical properties, radiation damage, and analytical studies of reactor materials. (W.L.H.)

1109 ORNL-1896(Del.)

Oak Ridge National Lab., Tenn.

AIRCRAFT NUCLEAR PROPULSION PROJECT QUARTERLY PROGRESS REPORT FOR PERIOD ENDING JUNE 10, 1955. A. W. Savolainen, ed. July 28, 1955. Decl. with deletions Nov. 13, 1959. 179p. OTS.

Progress is reported on the reflector-moderated reactor, experimental reactor engineering, critical experiments, chemistry of reactor materials, corrosion research, metallurgy and ceramics, heat transfer and physical properties, radiation damage, analytical chemistry of reactor materials, and recovery and reprocessing of reactor fuel. (W.L.H.)

1110 ORNL-2106(Pts.1-5)(Del.)

Oak Ridge National Lab., Tenn.

AIRCRAFT NUCLEAR PROPULSION PROJECT QUARTERLY PROGRESS REPORT FOR PERIOD ENDING JUNE 10, 1956. A. W. Savolainen, ed. Sept. 4, 1956. Decl. with deletions Dec. 2, 1959. 257p. Contract W-7405-eng-26. OTS.

Progress is reported on the Aircraft Reactor Test (ART) design; ART physics; ART instruments and controls; component development and testing; ART, ETU, and in-pile loop operations; phase equilibrium studies; chemical reactions in molten salts; physical properties of molten materials; production of fuels; compatibility of materials at high temperatures; analytical chemistry; dynamic-corrosion studies; general-corrosion studies; fabrication research; welding and brazing investigations; mechanical-properties studies; ceramic research; nondestructive-testing studies; heat transfer and physical properties; radiation damage; fuel recovery and processing; and critical experiments. (W.L.H.)

1396

TRANSPORT PROCESSES IN LIQUID ALLOYS. II. THE ELECTRICAL FORCE ON AN ION. Paul C. Mangelsdorf, Jr. (Univ. of Chicago). *J. Chem. Phys.* 33, 1151-61(1960). Oct.

The electrolytic migration velocities of impurity ions in liquid metals suggest the existence of strong net electrical forces on these ions, although other mechanisms are possible. On the basis of a detailed model of a liquid metal, the early theory of Skaupy is revived and revised. In dilute solution a total electrical force, proportional to the conductivity increment produced by a solute, is exerted on the solute and on nearby solvent when the electric field is applied. The part of the force on the solute ion may be opposed to the part on the solvent. Implications for the resistivity of liquid alloys are discussed, including a possible effect in very dilute solutions when the solute ions are further apart than one mean free path. The effective number of free electrons in pure liquid mercury is provisionally estimated to be 0.3 per atom. (auth)

1475 NAA-SR-Memo-3984

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.

NaK FREE CONVECTION COOLED SHAFT FREEZE SEAL FOR SRE PUMPS. F. Perez. June 18, 1959. 22p. OTS.

An investigation was conducted to determine the feasibility of using an NaK free-convection-cooled shaft freeze seal on the SRE main sodium pumps. The use of sodium in this application instead of tetralin eliminates the carburization hazard present should the seal coolant (tetralin) leak into the sodium system. Results and recommendations are included. (J.R.D.)

1490

A MECHANISM OF TURBULENT HEAT TRANSFER IN LIQUID METALS. N. Z. Azer (Univ. of Alexandria, UAR (Egypt)) and B. T. Chao. *Intern. J. Heat and Mass Transfer* **1**, 121-38(1960) Aug. (In English)

A mechanism of turbulent heat transfer is proposed based on a modification of Prandtl's mixing-length hypothesis. It is assumed that there is a continuous change of momentum and energy during the flight of the eddy. Two expressions are obtained for the eddy diffusivity ratios for heat and momenta for fully developed pipe flow. One is for fluids of Prandtl number 0.6 to 15 and the other is for liquid metals. Both correctly predict the influence of Reynolds number, Prandtl number, and radial location across the pipe on the diffusivity ratio when compared to trends revealed by limited published data. Computations of Nusselt number and temperature profile in liquid metals were carried out under conditions of constant wall flux using the deduced expression for the diffusivity ratio. The computed values agree well with experimental results. For practical calculations of film coefficients of heat transfer, the following interpolation formula may be used: $N_{Nu} = 7 + 0.05 N_{Pr}^{0.25} N_{Pe}^{0.77}$, which fits the calculated data with a maximum deviation of <12% for $N_{Pr} < 0.1$ and $N_{Pe} < 15,000$. Limiting values of Nusselt number as $N_{Pr} \rightarrow 0$ and $N_{Re} \rightarrow \infty$ are discussed. (auth)

1802

EMBRITTEMENT BY LIQUID METALS. W. Rostoker, J. M. McCaughey, and H. Markus. New York, Reinhold Publishing Corporation, 1960. 169p. \$7.95.

Published data on embrittlement by liquid metals are collected, reviewed, and evaluated. In addition, unpublished results of the latest research in this field are given. The seven chapters cover literature reviews, occurrence of liquid-metal embrittlement, crack propagation, factors influencing embrittlement, delayed failure, theory of metal fracture, and mechanism of liquid-metal embrittlement, respectively. (D.L.C.)

1886

THE SURFACE TENSIONS OF LIQUID METALS AT THEIR MELTING POINTS. Simon W. Strauss (U. S. Naval

Research Lab., Washington, D. C.). *Nuclear Sci. and Eng.* **8**, 362-3(1960) Oct.

In an attempt to correlate surface tensions of liquid metals with other properties, an investigation was made to determine if the Hildebrand and Scott equation or a modification of it could be applied to a large number of liquid metals at their melting points. The results were plotted as $\log \gamma$ (surface tension) vs. $\log s$ (energy of vaporization per unit volume). This plot could not be improved by using as Hildebrand and Scott did, $\log (\gamma/v^{2/3})$, where v is molecular volume, for the ordinate. (M.C.G.)

2721 (PWAC-298) DEVELOPMENT OF PUMP COMPONENTS FOR THE PRATT AND WHITNEY AIRCRAFT LIQUID METAL TURBOPUMP, TP-1. J. S. Murphy, R. S. Lombard, J. D. Sutherland, and J. Farquhar. Pratt and Whitney Aircraft Div., United Aircraft Corp., Middletown, Conn. Oct. 20, 1960. 186p. Contract AF33(600)-41233.

The tests conducted on TP-1 turbopump components consisted of mixed flow impeller tests, full scale TP-1 impeller and scroll-matching tests in water, cold hydrostatic tests of prototype TP-1 pump scroll, and evaluation of cermet type face seals. The water and hot liquid metal TP-1 mechanical center section test units are described. Mechanical and hydraulic performance is estimated for the pump from the results of the component tests. (See also PWAC-297.) (C.J.G.)

2746 HEAT TRANSFER TO LIQUID METALS WITH VARIABLE PROPERTIES. R. Viskanta and Y. S. Touloukian (Purdue Univ., Lafayette, Ind.). *J. Heat Transfer* **82**, 333-40(1960) Nov.

The problem of heat transfer to liquid metals with variable physical properties for the case of fully developed turbulent flow in cylindrical tubes of constant diameter was studied. The fluid under consideration was heated or cooled by a constant and uniform heat flux at the wall. The similarity theory between momentum and heat transfer was used. The von Karman universal velocity profile was used to solve the differential equations for turbulent flow with heat transfer for the Prandtl number and the kinematic viscosity, each having five different sets of temperature-dependent exponents of a_1 and a_2 . Calculated temperature distributions and mixing-cup temperatures, as well as relations between Nusselt versus Peclet numbers, are presented for the cases of heat addition, heat extraction, and the nonvariable-property case. (auth)

3082 (NAA-SR-Memo-3103) GRAPHITE DILATION UPON EXPOSURE TO LIQUID SODIUM. J. J. Gill. Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif. Aug. 25, 1958. 3p. OTS.

Graphite dilates anisotropically on uptake of liquid sodium. There is apparently no significant difference in dilation between the graphites ranging in density from 1.6 to 2.0. It is recommended that in fabrication of dummy element cans the clearances between the graphite and can walls be 1.2 and 2% in the parallel and perpendicular directions to the extrusion axis, respectively, for the CS type graphite. (J.R.D.)

3083 (NAA-SR-Memo-5588) A COMPILATION OF ROOM TEMPERATURE AND 1200°F PROPERTIES OF METALLIC MATERIALS WITH SPECIFIC REFERENCE TO THEIR USE AS FUEL CLADDING IN SODIUM COOLED THERMAL REACTORS. H. E. Kline. Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif. Aug. 16, 1960. 39p. OTS.

A compilation is presented of room temperature and 1200°F properties of a large number of alloys which might be considered for use in a sodium-cooled reactor. Spe-

cific consideration is given to the use of such materials as fuel cladding. The arbitrary basis for property comparison is type 304 stainless steel. The study was made of 10 classes of alloys. These alloys are alloy steels, ferritic stainless steels, austenitic stainless steels, iron and iron-aluminum alloys, precipitation-hardening stainless steels, austenitic superalloy, nickel-base alloys; cobalt-base alloys; copper-base alloys, and refractory metals and alloys. (W.L.H.)

3189 (ANL-6246) THE THERMODYNAMIC AND TRANSPORT PROPERTIES OF SODIUM AND SODIUM VAPOR. E. L. Dunning. Argonne National Lab., Ill. Oct. 1960. 32p. Contract W-31-109-eng-38. OTS.

The thermodynamic properties for the saturated and superheated phases of sodium are presented in tabular form and as a Mollier diagram. The density, thermal conductivity, viscosity, specific heat, and surface tension of the metal are given by tables and charts. The methods used in determining the properties are discussed. (auth)

3957 (GEAP-3328) EXPERIMENTAL INVESTIGATIONS OF THE REMOVAL OF SODIUM OXIDE FROM LIQUID SODIUM. G. Billuris. General Electric Co. Atomic Power Equipment Dept., San Jose, Calif. Jan. 18, 1960. 57p. For Atomics International. Div. of North American Aviation, Inc. Contract N8-S-452. OTS.

Information was obtained on the growth and characteristics of sodium oxide deposits in liquid sodium which could lead to system plugging, and the removal of sodium oxide from molten sodium by the cold trap method was studied. The data confirmed that the deposits are formed more rapidly with an increased amount of oxygen in the sodium, cooling of the deposit area, and fluid agitation. In general, the deposits at 300°F appeared to be silver in color with patches of liquid adhering to irregular crystalline-like structures. At room temperature the deposits were relatively hard and brittle and broken pieces of the structure appeared porous. During operation of the purification loop the apparent rate of solution of sodium oxide in sodium appeared to be much slower than the rate of removal in the cold trap. The data from the cold trap deposit indicated that up to 20 vol. % sodium monoxide could be collected in the trap before significant flow restriction was apparent. The most effective packing material tested was knitted wire mesh. With any of the packings tested, and operating with a residence time of about 8 minutes or longer, the effluent sodium from the cold trap did not appear to be supersaturated with oxygen. (auth)

4078 (NAA-SR-4336) PERFORMANCE OF HNPF PROTOTYPE FREE-SURFACE SODIUM PUMP. R. W. Atz. Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif. June 30, 1960. 26p. Contract AT-11-1-GEN-8. OTS.

A free-surface centrifugal pump, incorporating a hydraulic bearing running in sodium, was operated at the conditions required for service in the Hallam Power Reactor. After difficulties arising from inadequate shaft clearances were alleviated, the pump performed properly at a flow rate of 7200 gpm of 945°F sodium at 150-ft head. Results indicate that this pump should perform satisfactorily in the Hallam plant. (auth)

4079 (NAA-SR-4387) TESTING OF HNPF FREEZE-SEAL PUMP. R. W. Atz. Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif. Nov. 1, 1960. 48p. Contract AT-11-1-GEN-8. OTS.

A centrifugal pump performed adequately at a flow rate of 7200 gpm of 945°F sodium at a 150-ft head. A two-region

freeze seal was developed and used successfully as a shaft seal on this pump. The results indicate that this pump could perform satisfactorily in the Hallam Power Reactor. (auth)

4080 (NAA-SR-Memo-2184) LIQUID METAL SEAL FOR SODIUM PUMP SHAFTS. S. C. Carniglia. Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif. Oct. 4, 1957. 7p. OTS.

Several liquid metal sealants were investigated for sodium-pump shafts. (W.L.H.)

4081 (NAA-SR-Memo-2616) A GAS SHAFT SEAL FOR THE HNPF SODIUM PUMP. B. W. Admire and F. S. Naylor (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). June 30, 1958. 6p. OTS.

Lip type, oil labyrinth gas shaft seals were tested for use on Hallam Power Reactor sodium pumps with a 5-in.-diameter rotating shaft. The seals were not recommended for use owing to excess helium leakage and short life. (C.J.G.)

4082 (NAA-SR-Memo-4411(Rev.)) A DESCRIPTION OF SGR TEST INSTALLATIONS AVAILABLE AT ATOMICS INTERNATIONAL. (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). June 15, 1960. 51p. Contract AT-11-1-GEN-8. OTS.

Illustrations and descriptions of component test loops and sodium laboratories available at the Nuclear Field Test Laboratory of Atomics International are presented. (C.J.G.)

4083 (NAA-SR-Memo-4742) THEORETICAL ANALYSIS OF THE HELICAL ROTOR ELECTROMAGNETIC PUMP. R. S. Baker (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). May 3, 1960. 78p. OTS.

An equation is derived that relates the magnetic flux density and the resultant pressure in the helical rotor electromagnetic pump. Rudenberg's derivation of the equation for braking force in an eddy-current brake is presented. Based on the work of Rudenberg, equations are derived for the pressure developed by the pump. The method employed consists of calculating the eddy-current power loss in a given volume of a liquid metal conductor that is exposed to a traveling magnetic field, then to calculate the pressure by dividing the power loss by the velocity of the field relative to the liquid metal. (C.J.G.)

4084 (NAA-SR-Memo-5004) NaK PUMP EVALUATION. R. S. Baker and W. J. Fraser. Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif. Feb. 18, 1960. 30p. OTS.

Four types of electromagnetic pumps were considered, from an efficiency and weight standpoint, for the task of pumping 11 gpm of 78%K NaK having a temperature of 1000°F with a pressure rise across the pump of 4 psi. The d-c conduction electromagnetic pump appeared to be the most suitable. Characteristics of all four types are listed. (W.D.M.)

4085 (NAA-SR-Memo-5433) WOUND-ROTOR ELECTROMAGNETIC PUMP FOR NaK. R. S. Baker and W. J. Fraser. Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif. June 22, 1960. 15p. OTS.

Design sheets were prepared for an electromagnetic wound-rotor pump developing 4 psi at 13 gpm pumping 1000°F NaK. Computations showed an efficiency of 2.8%

and a weight of 71 lb. The design sheets describe the method of designing this type of pump and calculation of pump performance. (W.D.M.)

4107 (NAA-SR-Memo-3328) DRIVER AND DETECTOR CIRCUIT FOR PRECISION SODIUM LEVEL PROBE. J. R. Campbell. Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif. Jan. 13, 1959. 9p. OTS.

A driver and detector circuit was designed which provides a satisfactory indication of the sodium level in a vessel as a dip-stick probe traverses the sodium surface. (C.J.G.)

4249 (NAA-SR-Memo-2414) INVESTIGATION OF VARIABLES AFFECTING BELLOWS LIFE IN LIQUID SODIUM. J. S. McDonald (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Jan. 27, 1958. 20p. OTS.

Bellows are used in valves and other components in sodium graphite reactors at and below 1000°F. A study was made of the variables which can affect the life of bellows in sodium systems. A study was also made to determine which variable can be investigated experimentally. (W.L.H.)

4250 SOME OBSERVATIONS ON THE INTERACTION OF LIQUID SODIUM WITH CAST IRONS AND PLAIN CARBON STEELS. A. A. Smith and G. C. Smith (Univ. of Cambridge, Eng.). *J. Iron Steel Inst. (London)* 196, 29-42(1960) Sept.

The decarburizing action and allied effects of molten sodium on ferrous materials were investigated, and it is shown that decarburization by sodium depends on the presence of a sink in which the carbon removed from the specimen may be deposited. Cast irons are rapidly penetrated by the sodium, and modification of the microstructure in the interior of the specimen may result, even where there is no removal of carbon from the iron. The formation of surface layers and crystals was noted on steels immersed in sodium and was ascribed to the transport of material from the container in which the test was carried out. Some measurements were made on the rate of decarburization of plain carbon steels by sodium over the temperature range 600 to 850°C, and the results were correlated with the iron-carbon phase diagram and the diffusion rates of carbon in ferrite and austenite. (auth)

4284 (NAA-SR-Memo-2576) THE EFFECT OF CARBIDE PRECIPITATION AND CARBURIZATION ON THE MECHANICAL PROPERTIES OF TYPE 304 STAINLESS STEEL. O. C. Shepard (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Mar. 11, 1958. 9p. OTS.

An investigation was made of the possible carbide precipitation and carburization of the surface of stainless steel in a sodium system. Stainless steel at temperatures as low as 850°F becomes carburized in sodium contaminated with carbon. Carburization of stainless steel in sodium takes place mainly by grain-boundary diffusion in the 750 to 1000°F temperature range, while at 1200°F and above volume diffusion predominates. Mechanical property tests of type 304 stainless steel which has been carburized in sodium at volume diffusion temperature range show increased strength and reduced ductility. (W.L.H.)

4316 (UCRL-Trans-378) THE STRUCTURE OF LIQUID METALS. I. V. Radchenko. Translated from

Uspekhi Fiz. Nauk 61, 249-76(1957). 89p. (includes original, 28p.). JCL or LC.

This paper was previously abstracted from the original language and appears in *NSA*, Vol. 11, abstract No. 7208.

4762 (NAA-SR-Memo-3407) AN INVESTIGATION OF POSSIBLE FLOWMETER TYPES FOR THE LARGE HNP PIPING. G. E. Turner (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Dec. 11, 1958. 14p. OTS.

Various types of flowmeters were evaluated for use on large sodium piping of the Hallam Power Reactor relative to availability, cost, and relative merits. Permanent magnet flowmeters were found most applicable. (C.J.G.)

5137 (NP-9612) RESEARCH ON LIQUID METALS AS POWER TRANSMISSION FLUIDS. Progress Report No. 7 [Covering]: Period May 1, 1960–November 1, 1960. R. C. Kumpitsch (General Electric Co. Light Military Electronics Dept., Schenectady, N. Y.). Nov. 1960. 29p. Project No. 8-(1-7331). Contract AF33(616)-5917.

The progress made on the liquid metals program toward proving the feasibility of using the liquid metal NaK-77 as a high-temperature power transmission fluid is reported. Assembly and installation of the test flow loop console in the liquid metals test area was completed, and the high pressure-temperature NaK-77 pump in the liquid metals test area was delivered and installed. Initiation of both the NaK loop console debugging tests and the NaK pump thermal cycling tests is reported, and operational difficulties in both the loop console and the high pressure pump were corrected. Problems encountered in both the thermal cycling and loop debugging tests necessitated changes in the liquid metals program schedule. (auth)

5157 INVESTIGATION OF NATURAL CONVECTION HEAT TRANSFER IN LIQUID SODIUM. John S. McDonald (Atomics International, Canoga Park, Calif.) and T. J. Connolly. *Nuclear Sci. and Eng.* 8, 369-77(1960) Nov.

An experiment was performed to investigate the transfer of thermal energy by natural convection from molten sodium to a cold plate. A large tank of sodium was used to simulate a semi-infinite mass of sodium. A horizontal circular plate in intimate contact with the sodium surface was cooled by flowing tetralin which caused its temperature to be lower than the sodium bulk temperature. As a result, natural convection occurred in the sodium and thermal energy was transferred from the sodium to the plate. Data were collected at steady-state conditions for values of the Rayleigh number from 4.8×10^6 to 4×10^7 . It was found that the experimental results could be correlated by the expression $Nu = 0.0785 Ra^{0.32}$, where Nu is the Nusselt number, and Ra is the Rayleigh number. The calculated probable error in the Nusselt number given by this equation is 1.08, and the multiple correlation coefficient for the experimental results and the equation is 0.954. This result is shown to be consistent with the results of other investigators who used different fluids in physical systems somewhat similar to that used in this experiment with sodium. (auth)

5199 RESISTIVITY MONITOR TO INDICATE OXIDE CONTENT OF SODIUM. L. R. Blake (Dounreay Experimental Reactor Establishment, Caithness, Scotland). *Proc. Inst. Elec. Engrs. (London)*, Pt. A, 107, 383-94(1960) Aug.

The electric resistivity of sodium or sodium-potassium is continuously measured while flowing at operating temperature in a pipe to provide an indication of impurity level, particularly of oxygen. The meter is designed to be sensi-

tive to a change of one part in 10^6 in oxygen level, corresponding to a change in resistivity of about one part in 10^4 . Two types of resistivity meters are described, both of which have been installed in the Dounreay Fast Reactor. (auth)

5623 (NDA-2133-2) FAST NEUTRON CROSS SECTIONS OF MANGANESE, CALCIUM, SULFUR, AND SODIUM. Second Quarterly Progress Report Covering the Period March 1–May 31, 1960. E. S. Troubetzkoy (Nuclear Development Corp. of America, White Plains, N. Y.). June 30, 1960. 17p. Contract DA18-108-405-CML-295 (Phase II).

Progress is reported on the compilation of neutron cross section data for manganese, calcium, sulfur, and sodium. Preliminary values are reported for σ_t , σ_{ny} , σ_{na} , $\sigma_n[E, \theta]$, $\sigma_n'(E, E')$, $\sigma_n'\gamma[E, E']$ for manganese and for $\sigma_n[E, \theta]$ for sodium. (For preceding period see NDA 2133-1.) (auth)

5814 (NAA-SR-Memo-3295(Rev.)) DESIGN AND PERFORMANCE OF INDUCTION PUMP FOR SRE MODERATOR SYSTEM. R. S. Baker (Atomics International, Div. of North American Aviation, Inc., Canoga Park, Calif.). Dec. 20, 1958. 32p. OTS.

A three-phase linear induction pump was designed, constructed, and installed in the Sodium Reactor Experiment to control moderator temperature. A maximum flow rate of 91 gpm was obtained at 760°F, at 12.4 psi, and an efficiency of 1.7%. (C.J.G.)

5856 (ORNL-1515(Del.)) AIRCRAFT NUCLEAR PROPULSION PROJECT QUARTERLY PROGRESS REPORT FOR PERIOD ENDING MARCH 10, 1953. W. B. Cottrell, ed. (Oak Ridge National Lab., Tenn.). Apr. 16, 1953. Decl. with deletions Dec. 14, 1959. 147p. Contract W-7405-eng-26. OTS.

The present status of the Aircraft Reactor Experiment No. 1 is discussed and illustrated by photos. Tests of valves, seals, pumps, etc., are described. Preliminary results with an ARE fuel-circuit mock-up are reported. The following studies on the Aircraft Reactor Experiment No. 2 (reflector moderated, circulating-fuel reactor) are reported: static physics of the reactor, including the effect on the reactor of core size and the use of various materials in the core and reflector; results of critical experiments; and mechanical design envisioned and developmental work initiated to provide a basis for the detailed design of a full-scale reactor. Research on fused-fluoride systems concerned with purifying and preparing ARE fuel and fuel carrier is reported. Corrosion characteristics of various fluoride mixtures are discussed. Metallurgy and ceramics research reported includes the fabrication of various reactor components for use at high temperatures; creep rupture tests of structural metals; development of special alloys, cermets, and ceramic coatings; and tests of welding and brazing alloys. The fabrication of control and safety rods are described. Physical property measurements of various fluoride mixtures and heat-transfer studies of experimental systems as well as aircraft components are presented. Chemical, petrographic, and x-ray-diffraction studies of impurities, corrosion products, and constituents of reactor fuels are reported. (W.L.H.)

6074 (PWAC-297) PUMP TESTS CONDUCTED FOR THE DEVELOPMENT OF THE PRATT AND WHITNEY AIRCRAFT LIQUID METAL TURBOPUMP, TP-1. H. V. Marman, R. S. Lombard, P. G. Standley, C. W. Grennan, and C. E. Fuchs (Pratt and Whitney Aircraft Div., United Aircraft Corp., Middletown, Conn.). Dec. 15, 1960. 164p. Contract AF33(600)-41233.

Initial development tests of the electric drive versions of the TP-1 turbopump were conducted in both water and liquid metal in the Pump Turbine Laboratory at CANEL. The hydraulic characteristics of this 3000 gpm NaK turbopump were established at approximately half design speed during 276 hr of water tests. In addition, calibration of the gas sweep and lubrication circuits was accomplished. It was established that the over-all pump efficiency was 74% at a flow rate of 1500 gpm for a speed of 4000 rpm. A total of 60.1 hr was accumulated in hot NaK which included 26.8 hr at a temperature of 1050°F. The pump speed during these latter tests was restricted to 3000 rpm because of vibration problems caused by the test facility jack-shaft. These first liquid metal development tests were prematurely stopped because of test-facility problems and pump-assembly errors. However, these tests served to indicate that no major design deficiencies exist in the temperature range investigated. To support the above TP-1 turbopump development effort, a series of tests was conducted on an available 400 gpm NaK pump, designated Model S-1, which was modified to incorporate the essential design features of the sealing scheme of the TP-1 unit. A total of 1541 hr of hot NaK testing and 195 hr of water testing was completed on this model pump. The liquid metal tests included a successful endurance test of 1148 hr at 1000°F. Limited water testing of two other available model pumps with capacities of 1600 gpm and 2000 gpm were accomplished to obtain basic hydraulic information on cavitation, head-flow, efficiency and radial thrust characteristics. The data taken on the 1600 gpm Model P-6 pump indicated a severe mismatch between the diffuser vanes and the impeller with resulting inferior performance. The tests of the 2000 gpm Model P-9 pump were more satisfactory, and a peak pump hydraulic efficiency of 73% was obtained at a flow rate of 1350 gpm and a shaft speed of 3500 rpm. (auth)

6081 (WADC-TR-59-764) LUBRICATION BEHAVIOR OF LIQUID METALS. Period covered: July 1958 through September 1959. Patrick H. McDonald (North Carolina State Coll., Raleigh). Jan. 15, 1960. 77p. Project No. 7022. Contract AF33(616)-5885. OTS.

The lubricating behavior of liquid metals in two categories, hydrodynamic and boundary lubrication, is described. The basic theory of the hydrodynamic study is that of the Reynolds equation. This theory has been extended, after the manner of Christopherson, to a new state of development. An experimental device has been designed and constructed for confirming this theory as it relates to liquid metals. The complex and elaborate aspects of this apparatus are described in detail in the report. The study of a variety of liquid metals with this apparatus is anticipated. A macroscopic theory of the boundary lubrication region has been employed. This theory has been applied to a cylinder-flat combination, and the lubricating behavior has been seen to depend upon the state of contact stress for this configuration. An apparatus for these investigations is also described in the report. (auth)

6104 HEAT TRANSFER TO AN Na-K ALLOY IN AN ANNULUS. E. M. Khabakhpasheva and Yu. M. Il'in. *Atomnaya Energ.* 9, 494-6(1960) Dec. (In Russian)

Heat transfer coefficients in annuli were determined by measuring the temperature at a considerable distance from the channel entrance. The experiments were carried out with two-side and one-side heat supplies to 2.5, 3.5, and 4.5 mm annuli. The Nusselt criterion for narrow annuli ($d_1/d_2 \approx 1$) is about 25 to 30% less than for round tubes with identical Peclet values and is in good agreement with

theoretical data. The Nusselt value for annuli (two-side heat supply at Peclet number exceeding 500) also agrees with theoretical data and exceeds by 1.3 to 1.5 folds the Nusselt number for round tubes. Consequently, the experiments confirm the theoretical postulation that the geometry of the channel and the means of heat supply influence heat transfer in heat carriers with small Prandtl numbers. (R.V.J.)

6405 EFFECT OF SODIUM EXPOSURE ON THE MECHANICAL PROPERTIES OF ZIRCONIUM. J. C. Bokros (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Corrosion 17, 31t-4t(1961) Jan.

It was found that surface oxides which developed on zirconium in impure sodium significantly lowered the fatigue life at elevated temperatures. Hydrogen absorption had little effect on the fatigue life at elevated temperatures but lowered the fatigue life at room temperature. Critical recrystallization which occurred above 950°F in zirconium (a phenomenon unrelated to the presence of sodium) reduced the fatigue life at elevated as well as low temperatures. The effects attributable to sodium (i.e., the formation of surface oxide and absorption of reasonable amounts of hydrogen), did not significantly alter the tensile properties of zirconium at high temperatures. (auth)

6410 INVESTIGATION OF THE ELECTRIZATION AND RHEOLOGICAL PROPERTIES OF NA-LUBRICANT. Yu. F. Deĭnega and A. V. Dumanskiĭ (Inst. of General and Inorganic Chemistry, Academy of Sciences, Ukrainian SSR). Dopovidi Akad. Nauk Ukr. R.S.R. No. 7, 926-8(1960). (In Ukrainian)

An investigation was carried out on the kinetics of the change in the shearing stress and the electric potential of sodium lubricants under conditions of transition from elastic deformations through the ultimate strength to a steady flow. The nature of the change in potential and shearing stress is shown to depend essentially on the initial orientation of the structure. (auth)

7469 A SYSTEM OF CONVEYING LIQUIDS OR MIXTURES OF LIQUIDS. Jiri Drasky. British Patent 848,572. Sept. 21, 1960.

A system for conveying liquid metals and radioactive liquids without the disadvantages of mechanical and electromagnetic pumps is described in which the vapors of the liquid are used to drive an injector-type pump in the circuit. Three configurations of the system are described for a liquid-metal-cooled reactor using a mixture of two metals with different boiling points (miscible and immiscible) and for pumping radioactive liquids from one container to another. (D.L.C.)

7512 (NAA-SR-Memo-5777) TEST OF LINEAR INDUCTION ELECTROMAGNETIC PUMP FOR HNPFF. R. S. Baker (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Oct. 26, 1960. 4p.

Investigations to determine the characteristics of electromagnetic pumps constructed for the Hallam Nuclear Power Facility are described. Resulting data are incorporated in curves of pressure vs. flow, and efficiency vs. flow obtained with sodium at 600°F. (J.R.D.)

7551 DETECTING LIQUID METAL LEVELS. A. Stead and F. G. Latham (United Kingdom Atomic Energy Authority, Capenhurst). Nuclear Power 5, 107-8(1960) Dec.

An instrument was developed to measure the level of sodium-potassium coolant for the Dounreay Fast Reactor in a sealed system. The inductive or eddy-current method was used to design a dipstick and an instrument for defining fixed levels in a standpipe. Because of the high temperature, the transformers are wound on a heat-resistant core. The wire is nickel-plated copper, insulated with silicon-impregnated glass fiber. (M.C.G.)

7693 LIQUID METALS. (Office of Technical Services, Washington, D. C.). Aug. 1960. 10p. (SB-424). \$0.10(OTS).

A bibliography of 179 reports listed in the two OTS monthly abstract journals: U. S. Government Research Reports and Technical Translations. This bibliography includes reports added to the OTS collection during the period 1950 to September 1960.

7701 (CF-53-12-42) THE RADIATION INDUCED CORROSION OF BERYLLIUM OXIDE IN SODIUM AT 1500°F. W. E. Brundage and W. W. Parkinson (Oak Ridge National Lab., Tenn.). Dec. 3, 1953. Decl. Dec. 6, 1959. 9p. OTS.

Beryllium oxide specimens of various densities, immersed in sodium, were irradiated in the LITR for 328 hr at 1500°F plus 110 hr at 750°. The exposure at the higher temperature was about 1.8×10^{19} thermal nvt and 0.9×10^{19} fast. Control specimens were subjected to the same heat treatment in sodium and the average weight loss was found to be 0.0007 g (0.037%) with no significant difference between the irradiated and control groups. The surface-to-volume ratio was roughly $2.5 \text{ cm}^2/\text{cm}^3$. (auth)

7788 (AEC-tr-4404) APPROXIMATE ESTIMATION OF CRITICAL TEMPERATURES OF METALLIC LIQUIDS. S. N. Zadumkin. Translated from Inzhener.-Fiz. Zhur., Akad. Nauk Belorus. S.S.R. 3, No. 10, 63-5(1960). 4p.

An approximation of critical temperatures of metals based on elementary statistical theory of the surface tension is given. Critical temperatures of several metals were calculated and were found to correspond approximately to the relation $T_{cr} \approx 3T_{boil}$. (J.R.D.)

7806 THERMODYNAMIC PROPERTIES OF SODIUM. Munzer Makansi, W. A. Selke, and C. F. Bonilla (Columbia Univ., New York). J. Chem. Eng. Data 5, 441-52(1960) Oct.

Data are tabulated for the thermodynamic properties of sodium at saturated pressures at 426 to 1856.3°K and in the superheated region at 426 to 2600°K for pressures of 10^{-8} to 50 atm absolute. The temperature-entropy chart covers the regions 200 to 4200°F and 0 to 3.3 entropy units. A specific volume as a function of temperature curve is given for pressures of 10^{-4} to 50 atm absolute. 39 references are cited. (B.O.G.)

8268 (NAA-SR-Memo-5798) INVESTIGATION OF SODIUM LEAK PLUGGING. M. L. Peelgren and J. S. McDonald (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Oct. 20, 1960. 16p.

A program is reported to investigate a method of stopping sodium leaks at 1200°F by reacting the leaking material with a gas such as carbon dioxide or oxygen. Such a plugging mechanism would be useful in preventing shut-downs due to sodium leaks such as those in the shell of a calandria core. Results indicate little likelihood of success for this mechanism above 600°F. (J.R.D.)

8345 (LAMS-2487) QUARTERLY STATUS REPORT ON LAMPRE PROGRAM FOR PERIOD ENDING NOVEM-

BER 20, 1960. (Los Alamos Scientific Lab., N. Mex.). Dec. 1960. 29p. Contract W-7405-eng-36.

A decision was made to begin fabrication for the initial core loading of LAMPRE-1 with capsules from the tantalum on hand. Fuel for the first loading will be the cast Fe-Pu alloy from LCX III capsules and will contain carbon and stabilizer. Certification and melt-freeze tests are continuing on LAMPRE type capsules. The filling of the reactor sodium system is described. The cover gas system operated satisfactorily during the sodium shakedown phase. Four of the 15 core thermocouples have operated improperly since the sodium system was filled. The capsule charges were operated to remove dummy capsules and insert tantalum capsules containing test coupons. The 2000-kw Sodium Test Facility, including test steam generator, was operated continuously from Aug. 20 to Nov. 20, except for 159 hr of shutdown required for maintenance of auxiliary steam system equipment. Mercury-water flow systems were set up and are being operated to study both lift and jet pumping. A second fuel pumping experiment using Co-Ce-Pu fuel was set up and tried without success. The effects of various additives on the properties of Fe-Pu fuels are being studied. The fabrication of LAMPRE-1 capsules by impact-extruding a rod-slug into a starting cup followed by six ironing stages is described. Materials that were corrosion tested as fabricated capsules include arc-melted and electron-beam-melted high-purity tantalum and Ta-0.1 wt. % W alloy. Corrosion tests are in progress on experimental deep-drawn capsules made from Ta-0.1 wt. % W-0.2 wt. % Y. An x-ray fluorescence spectrographic method was developed for determining hafnium in Ta-Hf and Ta-W-Hf alloys. Work is in progress on the development of a solvent extraction method for the recovery of plutonium residues from various pyrometallurgical processes. (For preceding period see LAMS-2462.) (W.L.H.)

8657 TERNARY LAMELLAR COMPOUNDS OF LITHIUM OR SODIUM WITH GRAPHITE. Marceline L. Dzurus, Gerhart R. Hennig, and George L. Montet (Argonne National Lab., Ill.). p.165-8 of "Proceedings of the Fourth Conference on Carbon." New York, Pergamon Press, 1960.

Lamellar compounds of graphite are formed by the heavy alkali metals potassium, rubidium, and cesium. Some doubt exists as to whether lithium and sodium can also form such compounds with graphite. Considerations of the energy of formation indicate that neither of these two substances should form concentrated lamellar compounds with graphite. It was found that very pure sodium does not appear to react with graphite at temperatures up to 450°C. However, reactions can be promoted by small amounts of impurities such as sodium hydroxide, sodium oxide, barium oxide, and ammonia. It is believed that the impurities occupy so-called "spacer" positions in the lattice and thus facilitate the intercalation of sodium. However, it seems likely that very low concentrations of impurity act as catalysts. Experiments with lithium seem to indicate that it will also react with graphite only when impurities are present. (auth)

8668 (GEAP-3273) COLLECTED METHODS FOR ANALYSIS OF SODIUM METAL. H. E. Perrine (General Electric Co. Atomic Power Equipment Dept., Pleasanton, Calif.). Oct. 15, 1959. 24p. For Atomics International. Div. of North American Aviation, Inc. Subcontract N8-S-452.

Methods for analyzing chemical impurities in sodium metal samples are presented. Chemical analysis was used to determine impurities in calcium, carbon, chromium, iron, lithium, nickel, oxygen, potassium, and zirconium.

Spectrographic analysis was used to determine other impurities. Sodium samples obtained from experimental apparatus were analyzed by these methods. (auth)

8926 (NAA-SR-Memo-5615) SPACE HANDBOOK TURBINES. [J.] Grimaldi (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Aug. 29, 1960. 5p.

Turbine specific weight vs. power plant output was investigated for rubidium, potassium, and sodium at several inlet temperatures to obtain order of magnitude performance and weight of possible nuclear power plant systems. (W.L.H.)

8935 THERMOELECTRIC PUMPS FOR MOLTEN METALS. Dietrich Rex. VDI Zeitschrift, 103: 17-19 (Jan. 1961). (In German)

Thermoelectric pumps for molten metals are suitable for maintaining the operation of sodium-cooled reactors in the event of failure of the main pump or, in general, for pumping molten metals. The theoretical principles of such pumps are simple and they permit the essential operational data to be quickly estimated. A large sodium plant is above all intended to elucidate the influences of the dimensions, the flow pattern of the circulating metal, and the structure of the channel walls on the operation of thermoelectric pumps. (auth)

8962 HEAT TRANSFER TO SODIUM-POTASSIUM ALLOY IN POOL BOILING. Niels Madsen (Rhode Island Univ., Kingston) and C. F. Bonilla. Chem. Eng. Progr., Symposium Ser., 56: No. 30, 251-59(1960).

Film coefficients are presented for sodium-potassium alloy (44 wt.% K) boiling on a horizontal surface. The heat transfer at the boiling surface was calculated by subtracting the heat loss to the surroundings from the electrical input to the heater. Temperatures in the boiling liquid and the vapor space above it were also determined. The best temperature differential for computing the heat-transfer coefficients was found to be the difference between the boiling surface temperature and the equilibrium boiling point of the sodium-potassium alloy at the pressure of the vapor space. A correlating equation was derived statistically for heat velocity as a function of pressure and temperature differential. (auth)

9345 THE PROMISE OF LIQUID METALS. J. H. Amman and T. S. Sprague (Babcock and Wilcox Co.). Nuclear Energy, 11, 13-16(Jan. 1961).

Research and development work carried out on liquid metal reactor coolant systems is reviewed. Some of the problems of generating steam with sodium and how they were met in specific designs are discussed. The chemical activity of sodium and its radioactivity acquired in passing through the reactor created special problems in design and materials. The Submarine Intermediate Reactor Program, which led to the design and installation of the Seawolf power plant, is described. All the development work and lessons learned in operation of the Atomic Power Development Association and Sodium Reactor Experiment units were incorporated into designs of the single-wall tube type. (M.C.G.)

9971 (UCOL-P-503) STUDIES OF GAMMA RAYS FROM NEUTRON INELASTIC SCATTERING. David A. Lind and Robert B. Day (Los Alamos Scientific Lab., N. Mex.). [nd]. Contract AT(11-1)-535.

Measurements of the γ rays excited by neutron inelastic scattering in B^{11} , Na, Si, K, Sc, Zr, In, I, Ta, Au, Tl, and

Pb^{206} were carried out by use of the conventional ring scatterer geometry within a neutron energy range from 0.2 to 3.5 Mev. The studies were used to obtain information on level structure, to determine cross sections for γ excitation, and to make a test of the predictions of inelastic scattering cross sections computed by a combination of the statistical and optical models. New levels and information on the decay schemes were found in zirconium, iodine, gold, and Pb^{206} . Excitation functions in terms of absolute cross sections are presented for the prominent γ rays in the spectra of all the elements studied except scandium and thallium. Studies of the γ rays from Pb^{206} gave experimental verification of the level scheme for the low spin states calculated by True and Ford. Statistical model calculations are presented which give reasonably good agreement with the experiments on Pb^{206} , provided the penetrabilities are calculated using parameters obtained from an analysis of elastic scattering data specifically for Pb^{206} . The analysis shows that the imaginary part of the optical potential is abnormally low for Pb^{206} , compared to that for neighboring nuclei at comparable energies. The agreement in magnitude and shape between the experimental and calculated excitation functions can be improved if the imaginary part of the potential is permitted to increase with neutron channel energy. (auth)

10251 HYDROMAGNETIC EQUILIBRIUM EXPERIMENTS WITH LIQUID AND SOLID SODIUM. S. A. Colgate, H. P. Furth, and F. O. Halliday (California. Univ., Livermore. Lawrence Radiation Lab.). *Revs. Modern Phys.*, 32: 744-7 (Oct. 1960). (UCRL-5752)

A liquid metal in a very rapidly oscillating magnetic field behaves essentially like a fluid of infinite conductivity in a static magnetic field. An experiment was conducted which consisted of passing an oscillating current along a vertical rod into a pool of oil and liquid sodium. The oscillating magnetic field B_0 generated about the rod creates an outward magnetic pressure, which forms a funnel-shaped depression in the surrounding sodium. The sodium was frozen while in a state of hydromagnetic equilibrium, the rod and oil were removed, and sealing wax castings were made of the depression. Comparison is made of a sectioned casting with a theoretical curve derived from $\langle B_0^2/8\pi \rangle = I^2/200\pi r^2 = g(\rho_{Na} - \rho_{oil})(z - z_0)$, where I is the rms current in amperes and the surface of the sodium is at $z = z_0$, ρ is the fluid mass density, g is the acceleration of gravity, and z is the depth of the sodium. It is shown that theory and experiment agree quite well as soon as a modest depth is attained. Instability growth was demonstrated as possible at the magnetic energy densities used in the experiment by applying an oscillating field in intermittent bursts using a relaxation oscillator. Near $z = z_0$, where the magnetic pressure is weak, the instabilities are largely inhibited, but deeper in the depression instabilities of millimeter wavelength grow readily. Experiments with a solid sodium billet proved successful in demonstrating the short-wave Kruskal-Schwarzschild instabilities expected during the inward acceleration phase and the basic long-wave instability expected to develop in the equilibrium state. (B.O.G.)

10593 (BMI-1423) PROGRESS RELATING TO CIVILIAN APPLICATIONS DURING FEBRUARY 1960. Russell W. Dayton and Clyde R. Tipton, Jr. (Battelle Memorial Inst., Columbus, Ohio). Mar. 1, 1960. Decl. Apr. 13, 1960. 94p. Contract W-7405-eng-92.

Preliminary results from electrical studies indicate that the "valence-compensated", air-fired U_3O_8 - La_2O_3 solid solutions containing greater than equimolar amounts of La_2O_3 are poor conductors. Progress is reported on work devoted to fabrication and evaluation of U_3O_8 solid

solutions containing 40, 50 and 60 mole % La_2O_3 , and a sample containing 25 mole % Y_2O_3 and MgO each. In an investigation on the effects of combined ultrahigh pressure and high temperature on the uranium-oxygen system and on the reaction of the oxides with various mixed oxides, it was found that U_3O_8 has an oxygen-to-uranium ratio of $UO_{2.12}$. Corrosion testing of niobium alloys in 600 and 680°F water and 750°F 1500-psi steam was continued, and results for exposure times ranging up to 308 days are tabulated. In development of niobium-uranium fuels, corrosion test results were obtained in 224-day exposure to 600°F water and in 1500°F sodium for 500 hr. In investigations to improve the corrosion resistance and irradiation stability of thorium-uranium alloys, tensile and creep tests were performed at 600 and 700°C. In general fuel element development, techniques were developed for sub-bonding of niobium. In uranium dioxide compaction studies, results of flasi. roasting to attain off-stoichiometry uranium dioxide powders are tabulated. Progress is reported in the uranium carbide skull-casting process. In research on methods of preparing high-purity crystals of UO_2 , success is reported by methods involving vapor deposition. The determination of iron by titration to a radiometric end point was found to be very sensitive to the concentration of the tartaric acid complexing agent and sodium acetate buffer. Esters of the methacrylate group were studied to determine the relation of total radiation dose and free-radical-site formation to ester-group structure. Stress-rupture tests are reported at 200°C and stresses of 7,000 to 11,000 psi on aluminum-35 wt.% uranium alloy and on similar alloys containing 2 and 3 wt.% tin or zirconium. Metallographic study of foiled titanium steam coil sections from Purex acid-recovery evaporator showed no structural differences which could account for the fracture; it is thought that failure was caused by mechanical rubbing. Results of 5000 Mwd/t uranium burnup in capsule specimens containing 4.8 wt.% carbon are comparable with those for 4.6 and 5.0 wt.% carbon specimens. Data from neutron activation studies of vapor-deposited Al_2O_3 -clad uranium dioxide particles show that uranium contamination in the cladding surface probably accounts for the Xe^{133} release at low temperatures, and that claddings are not damaged during sphere fabrication or thermal cycling. Study of tantalum and its alloys under irradiation reveals alterations of properties such as strength and hardness, although ductility is not seriously impaired. Results of static tests in MTR of uranium dispersions in BeO or Al_2O_3 and dispersions of UC or UC_2 in graphite are tabulated. (For preceding period see BMI-1409.) (J.R.D.)

10828 (AERE-R-3037) A POSSIBLE GALVANIC CELL METHOD FOR MONITORING THE ACTIVITY OF OXYGEN IN A HOT-TRAPPED SODIUM COOLANT CIRCUIT. G. W. Horsley (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). Nov. 1959. 15p.

A hypothetical cell: $Na(\text{saturated with } Na_2O)/\text{anionic}(O^=)$ electrolyte/ $Na(\text{unsaturated with } Na_2O)$, is examined from the theoretical standpoint assuming that the activity of dissolved oxygen in sodium is proportional to its concentration. Provided that it is thermodynamically reversible, such a cell should give for example at 500°C changes in emf for changes in oxygen concentration from 1 to 2 ppm and 9 to 10 ppm, of ≈ 23 and ≈ 3 mv, respectively. Furthermore fluctuations in temperature of $\pm 10^\circ C$ at 500°C would in the concentration range 1 to 10 ppm cause errors of about $\pm 12\%$ in the concentration deduced from the cell voltage. The practical possibilities of building such a cell and incorporating it in a sodium coolant circuit as a monitor are discussed. (auth)

10835 (NDA-2154-3) DEVELOPMENT OF A HIGH SENSITIVITY ANALYTICAL METHOD FOR OXYGEN IN SODIUM METAL. Quarterly Progress Report for the Period October 1, 1960 to December 31, 1960. H. Steinmetz (Nuclear Development Corp. of America, White Plains, N. Y.). Mar. 1, 1961. Contract AT(30-1)-2303(XV) Scope 2. 12p.

The experimental apparatus was completely assembled. The design of the apparatus was described in the previous quarterly report. All components were tested and found to be operating satisfactorily. The gas handling system for preparing standard oxygen in sodium samples was calibrated. In addition, the necessary reagents and solvents were prepared, purified, and standardized. Tests show that traces of zirconium or zirconium oxide do not interfere with the analytical procedure. (For preceding period see NDA-2154-2.) (auth)

10947 MEASUREMENT OF THE SPEED OF ULTRASOUND IN MOLTEN ALKALI METALS. Yu. S. Trelin, I. N. Vasil'ev, and V. V. Roshchupkin. *Atomnaya Energ.* 9: 410-11(Nov. 1960). (In Russian)

The pulse interferometer method was used in measuring the ultrasonic speed in sodium and eutectic Na-K at 700°C. Calculations show that sonic absorption in molten alkali metals with the ratio of thermal conductivity coefficient to viscosity higher by the order of two than in water, acetone, and other liquids depends on the thermal conductivity. The contribution of α_1^1 (sonic absorption coefficient specified by the friction and thermal conductivity in molten metal) in the absorption coefficient of sodium at 100 to 700°C is 10 and 1.3%, and 23 and 1.5% in eutectic Na-K. It is also shown that ultrasonics can be efficiently used for testing construction material wetting by alkali metals. (R.V.J.)

11052 (HW-66562) NPF MECHANICAL CELL NaK DISPOSAL AND FUME ABATEMENT. G. Rey (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Sept. 6, 1960. 14p. Contract AT(45-1)-1350.

Some of the fuels originally scheduled for processing in the nonproduction fuel (NPF) processing program incorporated sodium or sodium-potassium alloy (NaK) as the bonding material between stainless-steel cladding and the uranium or uranium-molybdenum alloy core. Because of the special hazards involved in handling NaK, studies were made to determine safe methods for processing NaK-containing fuels. An underwater NaK dispensing system was installed, and tests were made to determine the characteristics of the NaK-water reaction. The equipment consisted of a dispenser, reaction pan, and off-gas scrubber. After initial studies, a prototype test was made wherein U-Mo canned slugs containing NaK reservoirs were hack sawed underwater. The studies demonstrated that the NaK reservoirs can be safely deactivated by hack sawing under a submerged hood in a shallow water bath. (W.L.H.)

11496 TERNARY LAMELLAR COMPOUNDS OF LITHIUM OR SODIUM WITH GRAPHITE. Marceline L. Dzurus, Gerhart R. Hennig, and George L. Montet (Argonne National Lab., Ill.). p.165-8 of "Proceedings of the Fourth Conference on Carbon held at the University of Buffalo, Buffalo, New York." New York, Pergamon Press, 1960.

Lamellar compounds of graphite are formed by potassium, rubidium, and cesium. Some doubt exists as to whether lithium and sodium can also form such compounds with graphite. Considerations of the energy of formation indicate that neither of these two substances should form concentrated lamellar compounds with graphite. It was

found that very pure sodium does not appear to react with graphite at temperatures up to 450°C. Reactions can be promoted, however, by small amounts of impurities such as sodium hydroxide, sodium oxide, barium oxide, and ammonia. It is believed that the impurities occupy so-called "spacer" positions in the lattice and thus facilitate the intercalation of sodium. It seems likely, however, that very low concentrations of impurity act as catalysts. Experiments with lithium seem to indicate that it will also react with graphite only when impurities are present. (auth)

11618 (JPLAI-TR-16) SURFACE TENSION AND HEAT VAPORIZATION OF METALS. S. N. Zadumkin. Translated by Joseph L. Zygielbaum from *Doklady Akad. Nauk S.S.S.R.*, 112: 453-6(1957). 8p.

This report was previously abstracted from the original language and appears in *NSA*, Vol. 11, abstract no. 6400.

12053 THERMAL NEUTRON ABSORPTION CROSS SECTIONS BY THE PULSED SOURCE METHOD. J. W. Meadows and J. F. Whalen (Argonne National Lab., Ill.). *Nuclear Sci. and Eng.*, 9: 132-6(Feb. 1961).

The thermal neutron absorption cross sections of 21 naturally occurring elements and B^{10} were determined by comparing the time dependence of the neutron flux in water with the time dependence of the neutron flux in a water solution of the sample with the same geometric buckling. After making some small corrections arising largely from the change in the number of hydrogen atoms per cm^3 in the solution, the decay constant of the ratio curve gave the macroscopic absorption cross section averaged over the neutron flux spectrum. For a $1/\nu$ cross section, the 2200 m/sec cross section could be directly computed. For non- $1/\nu$ cross sections, the effective 2200 m/sec cross section was obtained. (auth)

12090 GAMMA RAY PRODUCTION IN INELASTIC SCATTERING OF 3 Mev NEUTRONS. A. L. Androsenko, D. L. Broder, and A. I. Lashuk. *Atomnaya Energ.* 9: 403-6(Nov. 1960). (In Russian)

Gamma rays produced in inelastic scattering of 3-Mev neutrons on B, C, F, Na, Mg, Al, Si, P, S, Fe, Co, Ni, Cu, Zn, Se, Zr, Nb, Mo, Cd, Sn, Sb, La, Ta, Pt, Au, and Pb were studied. The data obtained are tabulated, and the pulse spectra of γ rays in inelastic scattering of 3-Mev neutrons on platinum, gold, and lanthanum are plotted. (R.V.J.)

12475 (TID-11295) NUCLEAR FUELS AND MATERIALS DEVELOPMENT. (Division of Reactor Development, AEC). Feb. 1961. 172p.

A summary is presented of work being done under the Nuclear Technology program of the Division of Reactor Development to increase knowledge of and effect improvements in reactor materials. The mechanism of swelling in irradiated metallic fuel elements is being investigated. Feasibility of producing uranium alloys of improved irradiation stability by applying a novel fabrication technique is under investigation. The development of Zr-U-Th, Th-U-Mo, and Th-U-Zr-Nb alloys possessing improved elevated temperature and mechanical properties for power reactor applications is presented. It was demonstrated that considerable savings in cost may be achieved in aluminum plate type fuel elements which are limited to 20% U^{235} enrichment. The coating of UO_2 fuel particles with Cr-Nb, W, Mo, Nb, Nb-V, and Al_2O_3 and dispersion of the fuel particles in various matrices are reported. The development and testing of fully enriched, homogeneous ceramic fuel are reported. The application of UO_2 -ZrO₂-CaO fuel to boiling-water reactors is discussed. The effects of additives on the

thermal conductivity of UO_2 are being investigated. Research is reported on the Th-U²³³ fuel cycle. A program is described for developing methods of producing improved aluminum-base fuel elements in which the fuel is contained in Fiberglas embedded in an aluminum matrix. An investigation is reported on the synthesis and fabrication of uranium carbide, uranium nitride, and uranium silicide. The preparation and properties of PuO_2 , PuC , Pu_2C_3 , and PuN are under study for power reactor applications. The development of cladding and container materials is reported. The existence of a body-centered cubic phase in beryllium at temperatures above 1260°C was confirmed. Factors influencing the ductility of Fe-Al alloy were studied. The effect of O_2 , N_2 , and H_2 on the mechanical properties of niobium was investigated. The effect of environment on the creep properties of type 304 stainless steel was investigated at elevated temperatures. The corrosion of cladding material in high-temperature water and liquid metal was investigated. The thermal stress fatigue behavior of Zr and Zr alloys was investigated. The preparation and properties of yttrium are being investigated. The properties and characteristics of pressure vessel materials and stress analysis methods for pressure vessels are reported. The preparation and properties of the following control rod materials are reported; rare earths, rare-earth oxides, metal borides, Hf, In, Ag, Ta, and Au. Research on reactor moderator materials included water, heavy water, beryllium oxide, beryllium, graphite, and metal hydrides. Fabrication techniques are reported for various types of reactors fuels. Methods for nondestructively testing reactor components are reported. (W.L.H.)

12840 (NAA-SR-Memo-2061) THE DETERMINATION OF OXYGEN IN SODIUM—A CRITICAL REVIEW OF ANALYTICAL METHODS. C. R. F. Smith (Atomic International. Div. of North American Aviation, Inc., Canoga Park, Calif.). [nd]. 56p.

Seven methods of measuring the sodium monoxide content of liquid sodium are reviewed. Data relating to the solubility of sodium monoxide in sodium are collected. Methods and data are criticized from the standpoint of precision and systemic interferences. It is concluded that there is no proved method which is free from systemic interferences and which is capable of measuring oxygen in sodium in quantities of 400 ppm or less. It is recommended that a program be undertaken to make comparative tests of all analytical methods and to determine the solubility of Na_2O in Na from 10 to 2000 ppm oxygen. (auth)

12901 (DEG-Memo-826) SOME PROPERTIES OF THIN OXIDE FILMS ON SODIUM-POTASSIUM ALLOY SURFACES. D. Sutherland and A. W. Smith (United Kingdom Atomic Energy Authority. Development and Engineering Group, Dounreay, Caithness, Scotland). May 1960. 8p.

The reaction of oxygen at low concentrations in nitrogen with sodium-potassium alloy was investigated. It was found that a thin, almost insoluble, oxide coating forms on the alloy. The coating inhibits the absorption of oxygen at concentrations of 1 to 300 ppm. (J.R.D.)

12927 ELECTRICAL RESISTIVITY OF LIQUID SODIUM, LIQUID LITHIUM, AND DILUTE LIQUID SODIUM SOLUTIONS. J. F. Freedman (IBM Research Center, Yorktown Heights, N. Y.) and W. D. Robertson. J. Chem. Phys., 34: 769-80(Mar. 1961).

The three factors of atomic size, ion core potential, and charge, which contribute to the increment in electrical resistivity produced by solutes in metallic solutions, were separated and experimentally evaluated in liquid sodium.

The results may be expressed in a semiempirical relation defining the increment in resistivity of a monovalent solution, $\Delta\rho = 0.063[\Delta \text{Atomic Number}] + 0.53 (\Delta V/V)^2$, $\mu\text{ohm cm/at.}\%$, where $\Delta V/V$ is the fractional difference in atomic volume of solute and solvent and the first term involves the absolute value of the difference in atomic number of sodium and the solutes lithium, potassium, cesium, rubidium, silver, and gold. (auth)

12929 STRUCTURE OF ALKALI METALS IN THE LIQUID STATE. N. S. Gingrich and LeRoy Heaton (Argonne National Lab., Ill.). J. Chem. Phys., 34: 873-8(Mar. 1961).

Neutron diffraction patterns were obtained for the alkali metal liquids; lithium (180°C), sodium (100°C), potassium (65°C), rubidium (40°C, 160°C, 240°C, and 360°C), and cesium (30°C, 300°C, and 575°C). It was found necessary to correct intensities for scattering by a free atom for lithium and sodium, but not for the heavier atoms. Atomic distribution curves were computed for all the above cases and compared with results from x-ray diffraction. Just above melting temperatures, the nearest-neighbor distances are for lithium, 3.15 Å; sodium, 3.82 Å; potassium, 4.64 Å; rubidium, 4.97 Å; and cesium, 5.31 Å. The number of nearest neighbors is, within one-half atom, about 9.0 to 9.5 atoms in each case. At elevated temperatures with rubidium and cesium, a weak subsidiary concentration of atoms appears between the usual first and second neighbor concentration. (auth)

13062 (NP-tr-576) HEAT TRANSFER INTO A SINGLE PIPE IN THE TRANSVERSE CURRENT OF A LIQUID WITH LOW PRANDTL NUMBER. A. A. Andreevskii (Andreyevskiy). Translated from Inzhener. Fiz. Zhur. Akad. Nauk Belorus. S.S.R., No. 10, 46-51. 11p.

Results are presented of an investigation into the heat transfer of a 22-mm-diameter single pipe in the ambient flow of molten metal with Prandtl number close to 0.03. Experiments covered the range $Pe = 300$ to 700. (auth)

13063 ANALYTICAL STUDY OF HEAT TRANSFER RATES FOR PARALLEL FLOW OF LIQUID METALS THROUGH TUBE BUNDLES: II. Aaron J. Friedland and Charles F. Bonilla (Brookhaven National Lab., Upton, N. Y.). A.I.Ch.E. Journal 7: 107-12(Mar. 1961).

A theoretical analysis of heat transfer to liquid metals in parallel flow through a tube bundle, following the method of Lyon, results in an equation that agrees within 10% with the calculated values. The conditions are fully developed turbulent flow, constant heat flux at the wall, and an infinite number of tubes arranged on an equilateral triangular pitch. The hexagonal flow area assignable to any tube is approximated by a circle of equal area, and the velocity distribution of Bailey for an annulus is assumed to apply from the inner wall to the circle of maximum flow. The range of conditions is: pitch-to-diameter ratio, 1.375 to 10; Reynolds number, 10^4 to 10^6 ; Prandtl number, 0 to 0.1; and Peclet number, 0 to 10^5 . Laminar and slug flow Nusselt numbers are also determined. (auth)

13269 (NASA-TN-D-769) NASA-AEC LIQUID-METALS CORROSION MEETING, DECEMBER 7-8, 1960, WASHINGTON, D. C. (National Aeronautics and Space Administration, Washington, D. C.). Feb. 1961. 109p.

Eighteen papers on liquid-metal corrosion and the related areas of purification and chemical analysis are given. A summary of information is also included. All papers are covered by separate abstracts. (M.C.G.)

13270 (NASA-TN-D-769(p.3-13)) HIGH-TEMPERATURE CORROSION BY COOLANTS. David H. Gurinsky

and Carl J. Klamut (Brookhaven National Lab., Upton, N. Y.).

Materials were investigated for boiling mercury and sodium content. For mercury containment effort was confined to an investigation of carbon steels clad with high-temperature-strength oxidation-resistant alloys using inhibitors such as titanium and zirconium and an investigation of refractory-metal alloys. The experimental program consists of capsule, natural-convection loop, forced-circulation loop, and solubility studies. Only refractory materials were considered for containment of boiling sodium at temperatures up to 2400°F. The experimental program consists of capsule tests, boiling natural-convection loops, boiling forced-circulation loops, and a small, alloy development program. (M.C.G.)

13272 (NASA-TN-D-769(p.25)) LIQUID-METALS CORROSION RESEARCH. Vincent J. Rutkauskas (Argonne National Lab., Ill.).

Refractory metals and alloys were exposed to flowing sodium at 650°C to select suitable materials for fuel jackets of future EBR-II fuel loadings. The effects of oxygen concentration and temperature on the corrosion resistance of refractory metals and stainless steels were studied. An experiment is planned to determine the effects of heat transfer and fluid flow in two-phase sodium systems. (M.C.G.)

13273 (NASA-TN-D-769(p.27-31)) LIQUID-METAL CORROSION RESEARCH. K. J. Kelly (Pratt and Whitney Aircraft Div., United Aircraft Corp. Connecticut Aircraft Nuclear Engine Lab., Middletown).

The corrosion and mass-transfer behavior of commercial structural alloys and advanced refractory metals and alloys were evaluated in various liquid metals under nonboiling conditions. The effects of temperature, thermal gradient time, flow, and dissimilar metals were studied. The magnitude and temperature-dependence of the solubility of a number of elements in lithium was measured. Electrical resistivities of a 56Na-44K alloy and of lithium were measured in the range from room temperature to 1600°F. A method for the determination of total carbon in lithium was developed. Work was also carried out to find a better method for the determination of oxygen in lithium. (M.C.G.)

13274 (NASA-TN-D-769(p.33-44)) LIQUID-METAL CORROSION RESEARCH IN THE SNAP DEVELOPMENT PROGRAM. M. A. Perlow and J. R. Crosby (Atomic International. Div. of North American Aviation Inc., Canoga Park, Calif.).

The development of the three systems SNAP-2, SNAP-8, and SNAP-10 and liquid-metal corrosion conditions presented by each are discussed. The materials selected for core fabrication tests were stainless steels, Hastelloy, Haynes 25, Inconel X, molybdenum, and niobium. Thermal-convection loops were designed to contain the specimens in a NaK environment and to operate at temperatures from 1200 to 1500°F. The duration of testing and type and rate of attack are given for each specimen. An in-core compatibility study was made of beryllium specimens sandwiched between stainless steel 347 and Hastelloy N, both with and without interfaces of chromium and titanium. Results indicated that the chrome-plated beryllium interface withstood corrosion better than the others. (M.C.G.)

13281 (NASA-TN-D-769(p.73-4)) SODIUM LIQUID-AND VAPOR-PHASE CORROSION STUDIES AT HIGH TEMPERATURE USING RADIOCHEMICAL METHODS. Thomas A. Kovacina (Naval Research Lab., Washington, D. C.).

Various high-temperature properties of sodium in both the liquid and vapor phases to 2500°F were determined.

The solubility of Nb-1% Zr alloy in liquid sodium and the transport rate of Nb-1% Zr alloy by condensing sodium vapors were also investigated. The possibility of utilizing tracer techniques to determine the gravity of the corrosion process caused by sodium is discussed. Two different methods for the separation of sodium from dissolved niobium and zirconium were investigated using tracer quantities of Nb⁹⁵-Zr⁹⁵ mixtures. (M.C.G.)

13284 (NASA-TN-D-769(p.83-6)) LIQUID-METAL BOILING SYSTEMS. J. W. Mausteller (MSA Research Corp., Callery, Penna.).

Potassium was manufactured by reacting KCl with sodium in a stainless steel column packed with Raschig rings. Columns were not replaced because of corrosion but because of thermal fatigue. Sodium was evaporated under reduced pressures using a NaK heating loop. Operation totaled 650 hr with sodium vapor velocities up to 3000 ft/sec through the nozzle. No corrosion or erosion was visually evident in the nozzle. Oxygen effects were considered in an oscillating-flow, isothermal sodium system at 925°F, holding oxygen to 0.003, 0.005, and 0.010 wt.%. Nitriding was investigated in a number of sodium systems at temperatures to 1300°F. Stainless steels were used to hold liquid lithium and lithium-salt mixtures at 2000°F for days and sodium-salt mixtures for months at 1600 to 1800°F with no drastic failures. (M.C.G.)

13285 (NASA-TN-D-769(p.87-9)) DYNAMIC LIQUID-METAL CORROSION STUDIES. W. D. Weatherford, Jr. (Southwest Research Inst., San Antonio).

A dynamic corrosion test apparatus was designed for studying the corrosion characteristics of selected liquid metals in turbulent flow and at temperatures approaching 2000°F and for an investigation of compatibility properties of fluids. The apparatus consists of a gravity-flow two-phase test loop mounted within a pressurized shell containing an inert-gas atmosphere. This inert gas is circulated along the exterior of the loop, countercurrent to the liquid-metal flow by means of an internal blower. (M.C.G.)

13286 (NASA-TN-D-769(p.91-2)) LIQUID-METAL RESEARCH. J. M. McKee (Nuclear Development Corp. of America, White Plains, N. Y.).

Heat-transfer coefficients to lithium from a tantalum wall at 2000 to 2400°F were measured. No significant corrosion was observed. Equilibrium solubility and solution rates for iron in lithium are being measured at 1100 to 1600°F using radiochemical techniques. A method for determining the oxygen content of sodium at levels below 10 ppm is described. Past work with liquid-metal systems is reviewed. (M.C.G.)

13357 (TID-11882) STRUCTURE OF LIQUID METALS. R. B. Gordon (Yale Univ., New Haven). Mar. 1, 1961. Contract AT(30-1)-2029. 14p.

The compressibilities of alloys in the liquid sodium-potassium system were measured and found to be slightly greater than the weighted average of the compressibilities of the pure components. The deviation is in the opposite direction to that predicted by free-electron theory and must be explained in terms of charge transfer effects. Several cells for Hall effect measurements on liquid metals have been constructed and tested, as yet without satisfactory results. (auth)

13924 (NAA-SR-Memo-5472) NaK PRECIPITATION INDICATOR TEST SYSTEM AND EXPERIMENTS TO DATE.

G. M. Kikin (Atomics International, Div. of North American Aviation, Inc., Canoga Park, Calif.). July 13, 1960. 37p.

A test loop was constructed and developed in which the solubility relations of potassium-sodium oxides and hydrides in potassium-sodium alloys at 1000°F were determined. Other tests conducted in the loop included those for evaluation of the SER and HNPF precipitation indicator capabilities to determine the precipitation temperatures of the eutectic hydride and oxide as functions of hydride and oxide concentrations. Plugging in the potassium-sodium system was also investigated. (J.R.D.)

14271 THE SOLUBILITY OF METALS IN LIQUID METALS. D. H. Kerridge (University Coll., Legon, Ghana). J. Nuclear Energy, Pt. B. Reactor Technol., 1: 215-20 (Feb. 1961).

An account is given of some general conclusions reached from an examination of all available data on the solubility of metals in liquid metals. Solubility values were determined from published binary-phase diagrams. Solubilities show periodic variation with increase in atomic number of the solute, and this periodicity is broadly independent of the nature of the liquid metal. A correlation of solubility (x) is found with the solute lattice energy which, in turn, is proportional to the latent heat of fusion (L_f). Using as solutes any two transition elements which are horizontally adjacent in the periodic table, the value of $(\log_e x_2 - \log_e x_1) / (L_{f1} - L_{f2})$ is nearly proportional to the absolute temperature for nine of the lower melting liquid metals. This fact may be used to estimate solubility values for which no measurements exist. A number of such estimates are given. (auth)

14382 (NAA-SR-5661) EXPERIMENTAL EVALUATION OF A SODIUM-TO-SODIUM HELIFLOW HEAT EXCHANGER AT TEMPERATURES UP TO 1200°F. J. S. McDonald (Atomics International, Div. of North American Aviation, Inc., Canoga Park, Calif.). Feb. 28, 1961. 41p. Contract AT-11-1-GEN-8.

A 100-kw model heliflow-type intermediate heat exchanger was subjected to steady state and transient tests with sodium at temperatures of 1200°F. Using multiple correlation techniques, functional relationships were obtained which described steady state behavior of the model. The general performance characteristics were found, by effectiveness comparisons, to be between those of pure counterflow and multipass overall counterflow. The unit was found to be relatively safe from structural damage from rapid thermal transients. (B.O.G.)

14383 (NAA-SR-Memo-1328) HEAT TRANSFER ANALYSIS AND DESIGN OF A PLUGGING INDICATOR SYSTEM FOR SRE. H. L. Sletten (North American Aviation, Inc., Downey, Calif.). Apr. 1, 1955. 15p.

The analysis was performed on a system comprising a counterflow, concentric-pipe economizer, heat exchanger, flowmeter, plug, and connecting pipe. The system was assumed to be at some initial temperature equal to the inlet sodium temperature and suddenly loses heat to a medium in the heat exchanger. Design and operating data are presented. A cooling rate curve is given where the nitrogen flow rate is decreased when the plug temperature reaches 400°F. The time variation of minimum temperatures is given for various values of thermal capacitance with constant equilibrium temperature, and the economizer parameter with constant equilibrium temperatures and thermal capacitance. The variation in heat exchanger parameter with economizer parameter for a constant equilibrium minimum temperature of 250°F, and a constant inlet temperature of 750°F is indicated. (B.O.G.)

14391 (TID-12266) FORCED CONVECTION LIQUID METAL INPILE LOOP PUMP PERFORMANCE CHARACTERISTICS. C. R. Nelson (Pratt and Whitney Aircraft Div., United Aircraft Corp. Connecticut Aircraft Nuclear Engine Lab., Middletown). Mar. 24, 1959. 25p. (TIM-476)

Data are presented on the performance of a liquid metal pump for use with a forced-convection liquid-metal in-pile loop in the C-66 J-13 core test facility of the Engineering Test Reactor. The data are based on water tests run with two prototype stainless steel impellers for various axial clearances between the impeller discharge face and the diffuser for a constant radial clearance between the labyrinth seals and the transition block. It is concluded that the pump will produce the required head and flow rate and will perform satisfactorily at both room temperature and the design operating temperature. (D.L.C.)

14661 (TID-12268) COMPATIBILITY OF MATERIALS IN LIQUID METAL AND COMPOSITION 30. H. P. Leeper (Pratt and Whitney Aircraft Div., United Aircraft Corp., Hartford, Conn.). Mar. 26, 1956. Decl. Sept. 18, 1959. 29p. (TIM-251)

Data are presented for compatibility tests of various material combinations under conditions of static or rubbing contact in 1500°F NaK and 1200 to 1500°F ORNL No. 30 fluoride salt. The materials used in the tests included metals, cermets, and ceramics. W, Co-bonded WC, and Fe-, Co-, and Ni-Mo-bonded TiC cermets were found to be resistant to corrosion by NaK; ceramics, except possibly BeO, are not resistant to NaK. Ni- and Co-base alloys, Ag, Au, Pt, and WC and TiC cermets with Ni and Co binders are fairly resistant to No. 30 salt, while Fe-base thermanols are not. Surface film formation reduces the tendency to weld in static tests. In NaK, metal-metal or metal-cermet combinations will weld together unless a surface film is formed before contact is made. Ni-base alloys are not resistant to welding to other metals and cermets in No. 30 salt or NaK, while WC-TiC cermets are weld-resistant in No. 30 salt. The combinations Mo-WC in NaK and Mo-Mo and TiC-WC are weld-resistant and exhibit small surface roughness changes in No. 30 salt. Metal-metal combinations and ceramics are not compatible in dynamic tests in both NaK and No. 30 salt. One combination, Mo-WC, shows promising dynamic compatibility in NaK. (D.L.C.)

14730 (TID-11894) TYPE 316 STAINLESS STEEL MATERIAL PROPERTIES SUMMARY. James Nassau (Pratt and Whitney Aircraft Div., United Aircraft Corp., Hartford, Conn.). Nov. 1, 1957. 41p. (FXM-3140)

A summary is presented of the properties of type-316 stainless steel determined at 1200 to 1800°F in air and sodium. The properties are short time yield, ultimate tensile strength, stress-rupture and total creep strengths (in air and sodium), modulus of elasticity, and coefficient of expansion. A comparison is made of tube bursts with uniaxial rupture strength at 1350, 1570, and 1650°F; the agreement is good. (D.L.C.)

16201 (UCRL-Trans-634(L)) ON THE IONIZATION OF ALKALI ATOMS BY SLOW ELECTRONS. Hans Funk. Translated by Forrest Baker from Ann. Physik, 4: 149-84 (1930). 43p.

An investigation was conducted to design an arrangement for impacting slow electrons on atomic beams. Such an arrangement would allow the order of magnitude estimation of measurable effects, and would provide for determination of excitation and ionization yields. Potassium and sodium were selected for investigation. The yield, obtained as the

ratio of the sum of ionization cross-sections to the sum of kinetic cross sections, for potassium was about 20% compared with maximum theoretical of 54%. Sodium yielded 70% compared with 50% theoretical. The numerical values for ionization cross sections were $29 \text{ cm}^2/\text{cm}^3$ for sodium and $11 \text{ cm}^2/\text{cm}^3$ for potassium. (J.R.D.)

16517 ELECTRON COLLISIONS WITH Na ATOMS.

A. Salmona (Inst. Henri Poincaré, Paris) and M. J. Seaton. Proc. Phys. Soc. (London), 77: 617-29 (Mar. 1, 1961).

Results of calculations for energies above the 3p excitation threshold and also for the limit of zero kinetic energy, ($K = 0$) are given. For the higher energies the Bethe approximation is used to calculate partial wave integrals and the transmission matrix is then obtained by two different conservation-preserving methods. The only potential considered is $V(3s, 3p)$. For energies not too close to the 3p threshold these calculations give good results for the 3s-3p cross section and fairly good results for the total cross section. This shows that a substantial part of the elastic scattering is due to the process $3s \rightarrow 3p \rightarrow 3s$. At very low energies exchange effects and polarization effects are both large and a much more elaborate theory is required. The coupled integro-differential equations, of Hartree-Fock type, are discussed. It is shown that the coupling between 3s and 3p accounts for 99.4% of the atom polarizability. Solutions of the coupled equations for 3s and 3p are obtained for the case of $K = 0$. The calculated zero-energy elastic cross section is $380\pi a_0^2$ and the exchange cross section is $440\pi a_0^2$. (auth)

16656 NATURAL CONVECTION FLOW IN LIQUID-METAL MOBILE-FUEL NUCLEAR REACTORS. Frederick G. Hammitt and Elayne M. Brower (Univ. of Michigan, Ann Arbor). J. Eng. Power, 83: 170-6 (Apr. 1961).

No directly applicable theoretical or experimental results are available for natural convection in vertical liquid-metal filled ligaments encountered in mobile-fuel fast power reactor concepts. However, it is possible to delineate the general nature of behavior expected with respect to temperature, velocity, and wall heat flux profiles from limiting analyses and available experiments. It is shown that natural convection may be of importance from the viewpoints of perturbation of wall heat flux distribution (a limiting design condition), and motivation of velocities important as a possible mechanism for mass transport, and hence is also an influence on fission gas disposition. It does not appear that natural convection will substantially affect temperature differentials in the cases of interest. These can be estimated assuming pure conduction. (auth)

16923 ELECTRICAL-RESISTIVITY METER MONITORS OXYGEN CONTENT OF LIQUID METALS. L. R. Blake and A. R. Eames (United Kingdom Atomic Energy Authority, Caithness, Scotland). Nucleonics, 19: No. 5, 66; 68; 70; 72 (May 1961).

A device is described for continuously detecting and measuring gaseous impurities, mainly O but including C and H, entrained in liquid metals (Na, NaK, etc.). The meter is sensitive to impurity changes of 1 ppm, and is insensitive to temperature changes. It operates on the principle that impurities increase the resistivity of the metal. Such an instrument is used in the Dounreay Fast Reactor.

17074 (NAA-SR-Memo-2825) CONTINUOUS SODIUM LEVEL INSTRUMENTS. G. E. Turner (Atomic International, Div. of North American Aviation, Inc., Canoga Park, Calif.). June 4, 1958. 8p.

An attempt was made to verify the theory of operation of two types of continuous sodium level devices and to determine the optimum design parameters for each. The theory of operation of both types of level device was verified by various tests, with these tests also showing that an accuracy of better than ± 1 in. is possible. The construction and testing of each instrument are recommended. (auth)

17825 (APDA-142) REMOVAL OF SODIUM FROM CORE SUBASSEMBLIES WITH WHITE OIL AND ULTRASONICS. Z. R. Kanaan and C. R. Nash (Atomic Power Development Associates, Inc., Detroit). Mar. 1961. 46p.

A method for removing sodium from fuel and blanket subassemblies that have been irradiated in the Enrico Fermi Atomic Power Plant reactor is described. In this method, the subassemblies are flushed with white oil aided by ultrasonic agitation, and the sodium is carried away from the surfaces of the subassemblies by the oil. Data gathered from experimental studies of the method are described; conceptual flow diagrams, materials balance sheets and equipment arrangements applicable to the Fermi plant are discussed; and sodium cleaning methods currently used are summarized. (D.L.C.)

17983 (ANL-6287) CHEMICAL ENGINEERING DIVISION SUMMARY REPORT, OCTOBER, NOVEMBER, DECEMBER 1960. (Argonne National Lab., Ill.). Mar. 1961. Contract W-31-109-eng-38. 208p.

Chemical-metallurgical processing studies were made of pyrometallurgical development and research, and fuel processing facilities for EBR-II. Fuel-cycle applications of fluidization and volatility techniques included laboratory investigations of fluoride volatility processes, engineering-scale development, and conversion of UF_6 to UO_2 . Reactor safety studies consisted of metal oxidation and ignition kinetics, and metal-water reactions. Reactor chemistry investigations were conducted to determine nuclear constants and suitable reactor decontamination methods. Routine operations are summarized for the high-level gamma-irradiation facility and waste processing. (B.O.G.)

18218 (NAA-SR-4537) DEVELOPMENT OF A RAPID-OPERATING PLUGGING METER. K. Davis (Atomic International, Div. of North American Aviation, Inc., Canoga Park, Calif.). Aug. 1, 1959. Contract AT(11-1)-GEN-8. 17p.

An air-cooled plugging meter for rapid determination of sodium oxide concentration in liquid sodium was tested in an experimental system. Approximately 200 plugging tests were performed, with results indicating good repeatability and a relatively fast operating time compared to other plugging meters. A typical operating time for making a determination with a system temperature of 725°F was 5 minutes. (auth)

18369 (NYO-4812) AIR CLEANING STUDIES. Progress Report for July 1, 1957 to June 30, 1958. Richard Dennis, Leslie Silverman, Edward Kristal, David M. Anderson, Charles E. Billings, Felix Stein, and Philip Drinker (Harvard Univ., Boston. Air Cleaning Lab.). Mar. 14, 1961. Contract AT(30-1)-841. 54p.

Mikro-Pulsaire Dust Collector Performance. The collector resistance of the Mikro-Pulsaire at 500 cfm was measured for fly ash and vaporized silica aerosols at various dust loadings, cleaning pressures, and pulse rates. The results indicate that relatively large loading variations do not cause extreme deviations in operating resistance, doubling the jet pressure gives a nearly fourfold reduction in the resistance, and doubling the pulse rate (except for

vaporized silica) reduced the resistance by a factor of 1.5. For vaporized silica, the primary mechanism for duct dislodgement appears to be associated with the initial pressure impulse. Aerosol Filtration by Fixed and Fluidized Beds. The merits of charged granule beds are compared with those of non-charged beds. It was found that bipolar effects are an adjunct of collection efficiency only when the granule diameters exceed 0.4 mm and that the actual interstitial or jet velocity in granular media is several (up to 40) times greater than the face velocity. The impact effect in granular fixed beds was determined and found to agree well with other work, and the effect of fluidizing velocity on the collection efficiency was studied for an uncharged polystyrene bed (50%-50% mixture of heated and unheated granules). An evaluation of charged polystyrene granule bed performance indicates that, relative to grounded media, net target efficiencies were increased fivefold and the air handling capacity was more than doubled for the same resistance to air flow. Incinerator Gas Cleaning Studies. A filter unit containing slag wool fiber in a 55-gallon drum was substituted for the glass filter bags in an incinerator and tested with burning sawdust charges. The results indicate that (1) lining of combustion chamber walls with fire brick gives improved combustion, (2) ratios of overfire to underfire air in the range of 1.5/1 to 1/1.5 do not affect the combustion products, (3) incinerators should be operated continuously, (4) slag wool fiber is satisfactory for particulate filtration at gas temperatures of 300 to 800°F, and (5) wet charges should be pre-dried or diluted with dry combustibles. NaK Fume Filtration. A filter unit composed of 3 and 6 denier bonded Dynel fiber was tested in the field. Other devices for NaK fume filtration are discussed. Blast Effects on Filter Systems. Damage to AEC absolute type filters was studied at the Nevada Test Site; field pressure measurements were made on both sides of each collecting device. No observable physical damage occurred in AEC high-efficiency filters exposed to shock pressures of 1.6 psig or lower, whereas glass fiber roughing filters located normal to the direction of the approaching shock wave were completely destroyed at overpressures >1.5 psi. The results show that roughing or precleaning filters retain 20 to 60% of the dust blown off the high-efficiency collectors and that wire screen viscous filters may be a practical means of restricting dust re-entrainment. Filtration Studies. Preliminary test results on several types of synthetic fibrous media with aerosols are presented. Iodine Collection Studies. Several coated forms of 4- μ slag wool fibers were tested with respect to their collection efficiency for I^{127} ; Ag coatings were found to give the highest efficiency (99.9%) and lowest resistance. Tests with Sn and Cu ribbons and Zn granules indicate for Cu a high efficiency (99.99%) and a low resistance for iodine concentrations of 50 to 500 mg/m³. The tests made with Cu ribbons indicate that (1) iodine collection increases significantly at higher gas temperatures (300 to 350°C), (2) water vapor increases iodine collection efficiency, (3) Cu collectors once used at high temperatures are no longer functional at room temperature, and (4) service life at high temperatures is ~25 hr. Ag-plated Cu mesh was also studied; the efficiency at room temperature is slightly lower than for Cu alone but increases at 300°C. Over a test period of 100 hr at 300°C, collection efficiency remained above 99.6% with no apparent damage to the surface. The presence of H₂S or HNO₃ in the gas stream does not impair the efficiency. Water-Jet Scrubbers. The merits of water-jet scrubbers and Venturi scrubbers are compared. Collection efficiency measurements made on a Penberthy Hydraulic Ejector No. 67A with fly ash indicate that the hydraulic type ejector is not suitable for fume scrubbing applications. (D.L.C.)

18436 (CF-61-4-77) EXAMINATIONS OF PUMP IMPELLERS FROM SODIUM AND FUSED SALT PUMP EN-

DURANCE TESTS. J. H. DeVan (Oak Ridge National Lab., Tenn.). Apr. 10, 1961. 13p.

Examinations of three Inconel pump impellers were made to establish the extent of cavitation damage and degree of carburization sustained during pump endurance tests. The pumps, two of which circulated fluoride salt and one sodium, operated for the bulk of the test programs in the temperature range 1000 to 1250°F. Cavitation damage was manifested in each of the impellers by the formation of deep pits (in excess of 1/4-in.), the location of damaged areas varying with impeller geometry. Pit formation appeared to have occurred by uniform rather than preferential removal of metal components. Each of the impellers exhibited heavily carburized zones along exposed surfaces. The cause of carburization may be associated with the type of gas purge utilized for these pumps. (auth)

18493 (LM/TAB-17) LIQUID METALS TECHNOLOGY ABSTRACT BULLETIN, FOR THE PERIOD OCTOBER 1960 TO APRIL 1961. (MSA Research Corp., Callery, Penna.). 20p.

An annotated bibliography is presented consisting of 40 references to liquid metals technology. Chemical Abstracts and Nuclear Science Abstracts references are included. (B.O.G.)

18503 (NP-10124) PRESSURE DEPENDENCE OF THE HALL CONSTANT OF THE ALKALI METALS. Technical Report HP-6. Thomas Frederick Deutsch (Harvard Univ., Cambridge, Mass. Gordon McKay Lab. of Applied Science). July 1, 1960. Contract Nonr-1866(10). 116p.

The distortion of the Fermi surface of the alkali metals by pressure was studied by measuring the Hall voltage in the alkalis as a function of hydrostatic pressure up to 15,000 kg/cm². In each case the Hall voltage decreases with increasing pressure, the size of the decrease ranging from 2 to 37% at 15,000 kg/cm² for Li and Cs, respectively, before compressibility corrections are applied. The Hall constant R can be written as $1/Necn^*$ where n^* expresses the deviation from the free electron value of the Hall constant. In all of the alkalis except cesium, n^* decreases monotonically with increasing pressure; the decreases range from 5 to 8% at 15,000 kg/cm² for Li and Rb, respectively. In the case of Cs, n^* passes through a minimum at 5,000 kg/cm² and rises to a value of 1.2 at 15,000 kg/cm². The change of n^* between room and liquid nitrogen temperatures was also measured and found to be less than 3% for all the alkalis except Li. In Li, n^* decreases by ~25%. The pressure results are explained in a semi-quantitative manner using a scattering time that varies by a factor of 3 over the Fermi surface. The warping of the Fermi surface is small; with the exception of Cs, the electron wave vector at the Fermi surface deviates from the free electron value by less than 10%. An approximate expression for the anisotropic scattering time $\tau(k)$ is derived and the factors contributing to the anisotropy in τ are considered. (D.L.C.)

18731 (NDA-2133-4) FAST NEUTRON CROSS SECTIONS OF MANGANESE, CALCIUM, SULFUR, AND SODIUM. Final Report Covering the Period December 1, 1959-December 31, 1960. E. S. Troubetzkoy, M. H. Kalos, H. Lustig, J. H. Ray, and B. H. Trupin (Nuclear Development Corp. of America, White Plains, N. Y.). Jan. 31, 1961. Contract DA-18-108-405-CML-295. 73p. (NDL-TR-5)

A set of neutron cross sections for manganese, calcium, sulfur, and sodium was prepared for energies up to 18 Mev. The cross sections tabulated include σ_T , σ_{nn} , $\sigma_{nn'}$, σ_{nx} , σ_{ny} , σ_{np} , $\sigma_{\alpha n}$, $\sigma_{n,2n}$, $\sigma_n(\theta)$, $\sigma_{nn}(E, E')$, and $\sigma_{nx}(E, E')$. (auth)

19378 AN EXPERIMENTAL EQUATION OF STATE FOR SODIUM. R. I. Beecroft and C. A. Sewnson (Ames Lab., Ames, Iowa). *Phys. and Chem. Solids*, 18: 329-344 (Mar. 1961).

An equation was obtained for pressures to 20000 atm and from 20°K to the mp. Various experimental details are given of an apparatus with which it is possible to obtain pressure-volume data which are reliable to ± 0.002 in $\Delta V/V_0$ over this range of temperature and pressure. The equation of state can be represented to within the above accuracy by an expression which is derived from the assumption that the isothermal compressibility is linear with volume and has no explicit temperature dependence. A discussion is given of the effect of these assumptions on the validity of calculations of the variation with volume of the temperature dependent contribution to the thermodynamic functions. Grueneisen constants as obtained from various definitions are calculated as functions of temperature and volume, and the validity of the Mie-Grueneisen equation of state as it applies to Na appears open to question below room temperature. Recent high pressure ultrasonic experiments on Na are interpreted as being in agreement with this conclusion. (auth)

19392 POLARIZATION AND TRANSPORT OF OXYGEN IN LIQUID SODIUM. B. A. Nevzorov. *Zhur. Fiz. Khim.*, 35: 620-3 (Mar. 1961). (In Russian)

Polarization and anodic transport of oxygen are revealed on passing a 2 amp direct current through liquid sodium at 300°C from 1 to 6 hours. It is shown that in different runs the amount of transported sodium for 1 amp/hr is practically constant. The mean transport number of oxygen for uni- and divalent ions is calculated. It is proposed that the divalent oxygen ion in the form of a solvated complex is the one to polarize and to be transported. The assumption is also made that all liquid metals facilitate the dissociation of polar molecules of dissolved non-metallic impurities. (auth)

19492 (NAA-SR-Memo-5951) STATIC SODIUM TEST OF WESTINGHOUSE FLOW CONTROLLER BEARING. R. Cygan (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Dec. 8, 1960. 7p.

Tests were carried out to determine the action of a static sodium environment on a special high-temperature ball bearing while operating at the specified speed and loading. The test bearing was operated at 85 rpm and 870 pounds axial load for 385 hr at 1000°F. Visual inspection of the test bearing showed a very marked increase in roughness of both the balls and the ball races. Details of the measurements and a photograph of the bearing parts after test are given. On the basis of this test it did not appear that this bearing will be satisfactory for the service intended. (M.C.G.)

19493 (NAA-SR-Memo-6072) COST REDUCTION OF SCR SODIUM PUMPS. R. W. Atz (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Jan. 25, 1961. 10p.

A method was sought to reduce the costs of mechanical pumps used for sodium in sodium-cooled reactors. A comparison was made between the free-surface pump purchased for the HNPF test program and a hypothetical unit designed for equal duty, to circulate 7200 gpm of 945°F sodium against a head of 150 ft. The pump produced by this study was the same length as the experimental unit but smaller in diameter. For equivalent performance, it appeared that a cost reduction of 10% may be realized when the pump speed is raised from 1100 to 1700 rpm. (auth)

19737 (NAA-SR-6094) SODIUM-GRAPHITE INTERACTION AND GRAPHITE PROTECTIVE COATINGS. J. J. Gill (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). May 1, 1961. Contract AT-11-1-GEN-8. 23p.

Molten sodium attacks artificial graphites, causing dilation and, under some conditions, decrepitation. Because of the anisotropy of extruded graphite, dilation perpendicular to the extrusion axis is slightly greater than parallel to the extrusion axis. At 600 to 1000°F, sodium is initially nonwetting to graphite, but becomes wetting in a matter of minutes. The liquid soaks into the pores of the graphite through chemisorption and intergranular penetration; interlamellar compounds or complexes may also be formed. Coatings and coating techniques were investigated for the protection of graphite from attack by molten sodium. The coatings examined included chromium, nickel, zirconium, zirconium carbide, tungsten carbide, silicon carbide, silicon nitride, and molybdenum disilicide. None of the coatings, tested by soaking in static sodium at 1000°F, gave satisfactory protection. Failure in all cases resulted from continuous porosity or cracks in the coating material. (auth)

19887 (AEC-tr-3971(p.287-332)) THE STRUCTURE OF LIQUID METALS. I. V. Radchenko. Translated from *Uspekhi Fiz. Nauk*, 61: No. 2, 249-76 (1957).

On the basis of the data from x-ray and neutron diffraction studies, it was determined that the packing of atoms in a liquid metal is related in a certain manner with the packing in the solid state. The character of this relation depends on the kind of metal. The characteristics of the arrangement of atoms in liquids are the average coordination number and the most probable radius of the coordination sphere. The experimental conditions necessary for x-ray studies of liquid metals are discussed. Results of structure studies of liquid metals are given for Hg, Au, Pb, Tl, In, Cd, Al, Zn, Na, K, Li, Rb, Cs, Ga, Bi, Ge, Sb, Se, Te, and Sn. (M.C.G.)

19904 COOLING BY LIQUID METALS. PROBLEMS OF COMPATIBILITY. R. Darras (Commissariat à l'Energie Atomique, [Paris]). *Energie nucléaire (France)*, 3: 128-38 (Mar.-Apr. 1961). (In French)

The properties of liquid metals as coolants are reviewed; corrosion and structural problems encountered in the use of these liquid metals are discussed. Purification and oxygen content control are considered, especially in the case of Na and Na-K alloys. (auth)

20052 (NAA-SR-5904) REACTIVITY WORTH OF SODIUM IN SODIUM COOLED REACTORS. R. W. Keaten (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). June 1, 1961. Contract AT(11-1)-GEN-8. 14p.

A simple and accurate method for determining sodium worth in sodium-cooled reactors is an analysis of the measured critical mass with and without sodium in the reactor. Application to both the first and second core loadings of the SRE shows that the amount of control available is more than sufficient to shut down the reactor with the sodium removed. (auth)

20477 (BNL-646) NUCLEAR ENGINEERING DEPARTMENT PROGRESS REPORT, MAY 1-AUGUST 31, 1960. (Brookhaven National Lab., Upton, N. Y.). 66p.

Reactor Physics. Work is reported on reactor physics studies of the BBRR, on PWR reactor physics evaluations, and on Pu-fueled reactors. Further work on the detailed

comparison of theory and experiment for water lattices was carried out. The equal charge displacement rule was applied to calculations of fission product poisoning. Results are reported on the effect of temperature on Xe instability, on flux trap reactors, on analysis of the Snell experiment, on neutron thermalization, and the effect of anisotropic scattering for various cases. The importance of the spatial distribution of neutron sources on the asymptotic neutron spectrum was demonstrated. Monte Carlo calculations of the fast effect in U and Be systems were completed. Work was continued on the water lattices, Dy^{164} and Eu^{151} cross section measurements, pulsed neutron experiments, and the BBRR critical experiments. The activation cross section of Dy^{164} in the energy region 0.06 to 2.0 ev was also measured. Pulsed neutron measurements of GBF graphite and Bi continued. Chemistry and Chemical Engineering. Radiation experiments on aromatic fluorocarbons were started. A new technique for measuring the absorption spectra of very strongly absorbing materials is being developed for particular application to fused salts in the ultraviolet. Films of a micron or less are sandwiched between silica flats. Spectra were so far obtained on PbCl_2 and KI. Thermodynamic properties of liquid Na-Bi alloys in the high-sodium region were obtained by a vapor pressure technique. A satisfactory Re-graphite thermocouple was constructed and operated up to 2300°C. Experiments were performed to determine whether Xe or I diffuse through reactor cladding. Preliminary postirradiation meltdown studies were performed to simulate a reactor temperature excursion leading to a fuel element meltdown. Specifically, the fission products I and Xe were investigated as to the effect of meltdown temperature, time of meltdown, and the resulting distribution of these fission products in the experimental apparatus. An investigation was completed in which it was established that the predominant mechanism by which Xe is sorbed into graphite at high temperatures is that of pore entrainment and thus dependent on the porosity of the graphite. Work was initiated on the adsorption of I on graphite at high temperatures. As part of an analytical study of heat transfer to liquid metals flowing in concentric annuli, results were obtained for the case of heat transfer through the outer wall only. Fuel material consisting of uranium carbide in graphite was successfully treated with the Nitrofluor reagent, NO_2 -HF mixture. The solid disintegrated to a powder and the U went into the liquid phase, from which it was recovered in nearly 100% yield. The liquidus line of the freezing-point vs. composition diagram of the system NO_2 -HF was determined in the region 0 to 45 mole % HF. Heavy gamma irradiation was found not to impair the subsequent ability of NO_2 -HF to dissolve Zircaloy. Infrared absorption spectra indicate the existence of strong interaction, if not compound formation, between NO_2 and HF in mixtures of the vapors. A decontamination factor of 1.1×10^6 was demonstrated for Cs^{137} removal from a high salt content waste stream. Development work is continuing on aqueous processes for Zircaloy and SS-clad UO_2 fuels. Observance of a long induction period before the reaction of UO_2 with a calcium amalgam persisted. Equipment is being assembled and tested for high temperature physical property measurements. Preliminary results are presented in the N_2 - O_2 system and the NH_3 - H_2O system. A research irradiator is being constructed. A low-level source for dose distribution studies in finite targets was prepared. Investigation of the Zr-HCl reaction in an Al_2O_3 fluidized bed was continued. Results are also given for an experiment in which SS was reacted with Cl_2 in a static bed. Methods were studied for suppressing bulk ion interference in the processing of Purex type waste by absorption on mineral ion exchange materials. A program was started to study the

formation of phosphate glasses as a means of incorporating the fission products in stable media. Hot Laboratory. Dowex-50-W was shown to perform similarly to Dowex-50 with respect to the elution of Y^{90} in a Brookhaven Y^{90} generator. Experiments not yet completed indicate that calcium phthalocyanine (Ca-Pc) is not as unreactive as the original experiments indicated. Satisfactory reproducibility was firmly established for a flame photometric procedure for determining Ca in mixtures of water-cyclohexanone-TTA, and for the extraction of Ca from such mixtures by water and by hydrochloric acid. Very rough preliminary measurements indicate a cross section around 10 ± 30 mb for the $\text{Ti}^{50}(\text{n},\alpha)\text{Ca}^{47}$ reaction with 14-Mev neutrons. Two full-scale preparations of Cu^{67} were made via the $\text{Ni}^{64}(\alpha,\text{p})\text{Cu}^{67}$ reaction using enriched Ni^{64} . The 61-hr half-life of Cu^{67} was confirmed. The $\text{Sb}^{121}(\alpha,\text{n})\text{I}^{124}$ reaction was used to produce about $1/4$ mCi I^{124} with a yield of about 100 mC/mah. The production of pure Sc^{47} from CaO was shown to be feasible. In assaying Ar^{38} for isotopic content via mass spectrograph, it was found that the normal Ar contamination occluded inside glass itself is sufficient to vitiate the analysis when the sample is introduced into the spectrograph by melting the glass capillary tube containing it. An electroplate having a thickness of a few microns is required as a protective cover over an alpha-emitting needle which is being fabricated. A technique involving the use of the electron microscope was developed for measuring the thickness of such a plate to within a fraction of a micron. The preparation of several Curies of very pure $\text{Kr}^{83\text{m}}$ is being undertaken for Project Matterhorn. Development of a procedure for milking the positron-emitting Ga^{68} from its long-lived Ge^{68} parent was begun. Calculations and preliminary tests indicate that the use of fully enriched Mg^{28} instead of natural Mg in the production of Mg^{28} is both feasible and economical. A direct comparison is being made of the ≥ 13 Mev neutron flux produced by thermal neutron irradiation of Li^6D and of U^{235} . Experiments were begun to test a proposal for continuously measuring B concentration in blood and a modification of this proposal which will allow the continuous production of very short-lived radioisotopes and the use of such isotopes for localized irradiation of selected sites *in vivo*. The reaction between tri-n-octylamine (R_3N) and 2-thenoyl-trifluoroacetone (HT) has been investigated and found to be $\text{R}_3\text{N} + \text{HT} \rightleftharpoons \text{R}_3\text{N} \cdot \text{HT}$. Radioactive tracers established the validity of an ashing procedure for the spectrographic determination of Mg in blood. The flame photometric estimation of fluoride in solutions of Zircaloy proved infeasible. An investigation of the feasibility of molten sulfate as a medium for electrochemical studies was begun. The density of Li_2SO_4 - K_2SO_4 eutectic at 625°C was found to be 2.12 ± 0.01 g/ml. Titration of Cl^- released when the sulfate was passed through the chloride form of Dowex-1, readily gave accurate assays of the eutectic. A low-melting LiNO_3 - KNO_3 eutectic affords the possibility of using Hg electrodes for electrochemical studies. The apparatus for such studies was assembled, and preliminary experiments indicated that the half-wave potential for Pb and Cd are identical. Investigation of the Bi-pool electrode demonstrated that Bi metal and LiCl - KCl eutectic can be purified so that oxide contamination is no longer a problem. The Zn-Bi system was studied, and the diffusion coefficient of Zn in Bi was found to be $5.2 \times 10^{-5} \text{ cm}^2 \text{ sec}^{-1}$ at 450°C. The diffusion coefficient of Li in Bi at the same temperature was found to be $2.1 \times 10^{-5} \text{ cm}^2 \text{ sec}^{-1}$, and the activity coefficient was found to be 4×10^{-7} . The stability, resolution, and reproducibility of the new incremental polarograph are excellent. The applicability of contact radiography in identifying active electrode sites at which electron transfer processes may selectively occur is being studied. Well-

defined contact radiograms were produced by Tl^{204} tracer in deposits which had an average thickness ranging from 10 to 1500 Å. Optimum conditions for activation analysis of Au in biological tissue were determined. Exploratory studies of organic disulfide compounds indicated that disulfide-sulphydryl reduction in compounds like cystine and glutathione disulfide can be carried out coulometrically with 100% current efficiency. Prices of all processed isotopes in routine production have been reviewed and adjusted in order to put this production on a self-supporting basis. The Waste Concentration Plant was shut down for approximately 1 month while leaks were located in an auxiliary steam coil and a new coil fabricated and installed. Metal-lurgy. Nearly all thermal convection loops containing U-Bi were shut down; emphasis was shifted to loops containing Hg and Na. Steel thermal convection loops containing inhibited Hg under pressure operated at ΔT for over 1500 hr without detectable corrosion or precipitation. At high velocities, corrosion and cavitation-like attack by inhibited Bi were much more severe on $2\frac{1}{4}$ Cr-1 Mo steel than on $1\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo steel. Measurements of the emf between steels immersed in Bi as a function of Cr content showed a pronounced electropositive maximum at ~5% Cr. Solubilities of Mg and Sm in Bi were redetermined. Stripped films formed on steels by reaction with Zr-Bi melts possibly contain carbides and nitrides (of Si, Cr, Fe) along with the ZrN. Ion bombardment of a steel surface, followed by Bi-vapor deposition on the surface, did not appear to improve uniformity and reproducibility of Zr-bearing surface films on steels after contact with Zr-Bi melts. The rate of formation of Zr film appeared to be diffusion-controlled. The Radiation Loop has operated in-pile for 1817 hr, of which 1552 hr were at ΔT condition, without difficulty. Modification of the Hot Cell to permit cryogenic testing of irradiated specimens is proceeding. A revised graphite monitoring and Radiation Damage Program for the graphite in the BNL reactor was made. Pore volume studies with natural graphite powder showed that the volume available to Hg penetration is inversely proportional to the compacting pressure. Hg that penetrated the pores under pressure was only partially released upon release of pressure. Approximately $\frac{1}{3}$ of the total pore volume of AGOT graphite outgassed 1 hr at 500°C is inaccessible. A program to measure the rate of release of gaseous fission products from uranium carbide powders was initiated. Blisters that appear on the surface of the fuel elements for the graphite reactor during storage probably result from inclusions in the U-Al alloy meat which penetrate the clad during rolling. Heat treatment improved the properties of the steel used in the telescope plates of the Greenbank Observatory by refinement of the grain size. Fission fragment damage to thin evaporated films resulted in tracks visible under transmission electron microscopy. A high temperature vacuum furnace was built to produce the high purity Fe. Development work on Mo brazing of graphite continued. An apparatus was built to determine the effects of cycling temperature gradients on the fuel elements for the BBRR. Capsule experiments show that migration of Th and U through slurries of their inter-metallic compounds in Bi is due to the temperature coefficient of solubility and to convection currents in the slurry. Mechanical Engineering. The new 7-ft spherical containment vessel was designed for the critical experiments. It is intended to use the existing pump, piping, etc., and couple directly to the spherical tank by means of flanged joints. The design for the control rod plate locations and accessory equipment is in progress. Modification were made to the tank for the BBRR Fuel Handling Mockup. All equipment for the BBRR Fuel Element Test Loop was delivered. Erection of the Mercury Test Loop-Mark IV framework

and piping was completed and all components were installed. Pipe and fittings for the NaK Heat Transfer Loop were received. A reference design for the test section was completed. A conceptual design was completed for a Laminar Fluidized Bed Reactor. An evaluation of the economics of this system was made. A preliminary flow sheet and cost estimate was made for a High Temperature Critical Facility. All three fans for the Brookhaven No. 1 Research Reactor were installed. Early indications show that the power savings will amount to about \$10,000/month. Cell layouts and equipment specifications were completed for the High Level Radiation Development Laboratory. New control rod mechanisms and supporting framework were designed, fabricated, and installed for the Facility for Criticality Measurements of Slab Lattices. A measurement platform for the UO_2 Rod Lattice Assembly was designed, fabricated, and installed. The in-pile hole mockup assembly for the Dry Irradiation Facility-Mark IV was fabricated and installed in the basement of the Graphite Reactor Building. The production cost estimate of the Nitrofluor Process was completed. A cost estimate and plant design was prepared for a reprocessing facility utilizing the method of halogenation and fluorination of fuel elements in a fluidized bed. The Irradiation Facility is to be used by MIT to establish dose rates and other basic data for the irradiation of foods and other materials. Reactor Evaluation. The review of the status of direct conversion programs was completed. Theoretical work and exploratory experiments were initiated on a pulsed fission plasma device. The chemonuclear studies were directed toward the investigation of the radiation polymerization of ethylene. Evaluation of the suspended fuel concepts continued. (auth)

21078 A SKIMMING PROCESS FOR THE REMOVAL OF OXIDE FROM THE SURFACE OF SODIUM-POTASSIUM ALLOY. E. K. Inall (Australian National Univ., Canberra). Brit. Chem. Eng., 6: 386-7 (June 1961).

Most of the oxides of sodium-potassium alloy (Na-K) float on the surface at room temperature, therefore, it is difficult to entrain the oxides in the flow to a filter. A method used to skim the oxide from the main storage tank of a system handling 1000 gal of Na-K is described that avoids any moving parts within the Na-K system. A filter which is very suitable for holding a large load of filter cake from the Na-K without blocking is also described. (auth)

21099 (NP-tr-510(p.1-7)) THE BEHAVIOR OF ALLOYS DURING A CONTACT WITH SODIUM. S. T. Kishkin and G. P. Benediktova. Issledovanie Splavov Tsvetnykh Metal., Akad. Nauk S.S.S.R., Inst. Met. im. A. A. Baikova, No. 2, 19-23 (1960).

The durability of a number of alloys (containing Cr, Ti, Mo, W, and B in amounts not specified) in contact with Na at high temperatures was investigated. (C.J.G.)

21148 (NP-10184) PRESSURE DEPENDENCE OF THE HALL CONSTANT OF THE ALKALI METALS. Technical Report HP-6. Thomas Frederick Deutsch (Harvard Univ., Cambridge, Mass. Gordon McKay Lab. of Applied Science). July 1, 1960. Contract Nonr-1866(10). 74p.

Band structure calculations by Ham indicate how the Fermi surface of the alkali metals, which is expected to be nearly spherical under normal conditions, may change when the lattice constant is decreased through hydrostatic pressure. Since direct measurement of the distortion of the Fermi surface is difficult, its magnitude was studied by measuring the Hall voltage in the alkalis as a function of hydrostatic pressures to 15,000 kg/cm². In each case the Hall voltage decreases with increasing pressure, the size

of the decrease ranging from 2% in 15,000 kg/cm² for lithium to 37% in 15,000 kg/cm² for cesium before compressibility corrections are applied. The Hall constant, R , can be written as $1/Necn^*$ where n^* is a factor of the order of unity which expresses the deviation from the free electron value of the Hall constant. The data, with all explicit volume dependence removed, are expressed in the form of curves of n^* vs. pressure. In all of the alkalis except cesium, n^* decreases monotonically with increasing pressure; the decreases range from 5% in 15,000 kg/cm² for lithium to 8% in 15,000 kg/cm² for rubidium. In the case of cesium n^* passes through a minimum at 5000 kg/cm² and rises to a value of 1.2 at 15,000 kg/cm². The change of n^* between room and liquid nitrogen temperatures was measured. In all of the alkalis except lithium the change is less than 3%. In lithium n^* decreases by about 25% between room and liquid nitrogen temperature. The warping of a nearly spherical Fermi surface is described by Kubic harmonics and the effect of the warping on n^* considered. Increases in the warping parameters increase n^* ; since the band structure calculations indicate that increasing pressure increases the warping parameters, the data cannot be explained on the basis of anisotropic Fermi surfaces alone. If anisotropic scattering times as well as warped Fermi surfaces are considered, then increases of the warping parameters can cause decreases in n^* . The pressure results are explained in a semi-quantitative manner using a scattering time that varies by a factor of three over the Fermi surface. By contrast, the warping of the Fermi surface is small; with the exception of cesium, the electron-wave vector at the Fermi surface deviates from the free electron value by less than 10%. An approximate expression for τ (k) is derived and the factors contributing to the anisotropy in τ are considered. The most important factors are the anisotropy of the velocity of sound and the dependence of the size of the phonon-wave vector used in umklapp processes upon the initial electron state. A crude calculation shows that with appropriate forms for the electron-phonon scattering matrix element, the latter factor alone can give a scattering time that varies by nearly 70% over the Fermi surface. (auth)

21163 (NP-tr-672) APPLICATION OF THE THEORY OF THERMODYNAMIC SIMILARITY TO DETERMINE THE PHYSICAL PROPERTIES OF HOT METAL (MOLTEN METALS). G. F. Butenko and M. I. Radchenko. Translated from *Inzhener.-Fiz. Zhur.*, Akad. Nauk Belorus. S.S.R., 3: No. 6, 66-71 (June 1960). 8p.

This paper was previously abstracted from the original language and appears in *NSA*, Vol. 14, abstract no. 20320.

21310 THE USE OF ELECTRON GAS MODIFICATION IN THE EVALUATION OF THE VIBRATION FREQUENCIES AND THE SPECIFIC HEATS OF SODIUM AND POTASSIUM. B. Dayal and B. Sharan (Banaras Hindu Univ., India). *Proc. Roy. Soc. (London)*, A262: 136-44 (June 13, 1961).

Earlier work on the determination of the specific heats of lithium by the use of deLaunay's model is extended to sodium and potassium. A new technique is introduced in which the contributions of the central and the outer parts of the Brillouin zone to C_v are calculated separately from different distribution densities of 8000 and 1000 points per zone, respectively. The agreement between the calculated and the experimental values of C_v is found to be very good except at very low temperatures where the deviations can be ascribed to the presence of phase transformation. The effect of using a finer mesh of points on C_v is examined. In order to get accurate values of C_v the density of points in the central region has to be increased considerably. In the outer region, however, a low density of eight points per zone as in Raman's theory is found to be reasonably satisfactory. (auth)

21726 (NDA-2147-6) FAST REACTOR SAFETY. Quarterly Progress Report for the Period Ending March 31, 1961. J. Agresta and F. Beers (Nuclear Development Associates, Inc., White Plains, N. Y.). Apr. 30, 1961. Contract AT(30-1)-2303(XIII). 16p.

Sodium Coolant. Exploratory investigations of transient forced convection heat transfer and a generalized fuel channel study were begun. **Reactivity Coefficients.** Results are presented for a delayed negative power coefficient of the conduction type acting in conjunction with a prompt (positive or negative) power coefficient. For the negative prompt coefficient, instability never occurs, although finite resonances are possible in the transfer function above some threshold power. For the positive prompt coefficient, instability occurs above a threshold power corresponding to a transfer function resonance of infinite height, and the resonance peak is considerably higher and occurs at lower frequencies than for the negative prompt coefficient. (D.L.C.)

22300 THE SOLUBILITY OF NICKEL IN SODIUM BY A TRACER TECHNIQUE. T. A. Kovacina and R. R. Miller (U. S. Naval Research Lab., Washington, D. C.). *Nuclear Sci. and Eng.*, 10: 163-6 (June 1961).

The solubility of nickel in liquid sodium of known purity under static near isothermal conditions was determined by a radioactive technique using Ni^{63} as the tracer. The solubility varied from 0.004 to 0.20 ppm over the temperature range 200 to 600°C. (auth)

22439 STUDIES OF LIQUID METALS. L. Vautrey and J. Gollion. *Bull. inform. sci. et tech. (Paris)*, No. 50, 21-8 (Apr. 1961). (In French)

The use of liquid metals, such as sodium, for reactor cooling gives rise to a set of new problems of circulation, shielding, and obtention of high temperatures. The industrial-size installations at the Section of Liquid Metals for the study of thermal and mass transfer are described. (J.S.R.)

22640 (NP-tr-615) LIQUID METAL RESEARCH IN THE INSTITUTE OF NUCLEAR RESEARCH IN 1956-58. M. Pasek. Translated from *Jaderná energie*, 5: 363-7 (1959). 20p.

The results are given of research work in liquid metals, done in the Institute of Nuclear Research of the Czechoslovak Academy of Sciences in 1956-1958. The results are focused mainly on tests of pumping and circulating of liquid metals in cooling systems, on studies of heat transfer, and on the measurements of flow and viscosity of liquid metals. (auth)

22651 (NAA-SR-Memo-6064) CALCIUM NITRIDE IN SODIUM. Theron L. MacKay (Atomics International, Div. of North American Aviation, Inc., Canoga Park, Calif.). Jan. 20, 1961. 8p.

Below 300°C, nitrogen did not react with Ca dissolved in sodium. In the range 355 to 720°C, dissolved Ca reacted with nitrogen in the cover gas, forming a relatively insoluble compound, probably Ca_3N_2 . Calcium nitride precipitation continued until the reactant present in the least amount was exhausted. Saturation solubility of calcium nitride in sodium appears to be between 100 and 200 ppm, and does not appear to be a function of temperature in the range of these experiments. It is possible that the numbers represent particulate Ca_3N_2 suspended in sodium. The solubility of calcium in sodium as reported was verified. (auth)

22655 (NP-tr-665) PROBLEMS OF CORRODING STRUCTURAL MATERIALS BY LIQUID METALS.

Alois Dvorak. Translated from *Jaderná energie*, 6: No. 6/5, 155-62(1960). 20p.

This paper was previously abstracted from the original language and appears in *NSA*, Vol. 14, abstract no. 16968.

22739 (R60FPD358-A) THERMODYNAMIC PROPERTIES OF ALKALI METAL VAPORS AND MERCURY. C. J. Meisl. Revised by A. Shapiro (General Electric Co. Flight Propulsion Lab. Dept., Cincinnati). Second Revision, Nov. 9, 1960. 179p.

The thermodynamic properties of Na, K, Rb, Cs, Hg, and Li are presented for the saturated liquid, saturated vapor, and superheated vapor phases as a function of temperature in °R. The following properties are included: enthalpy, entropy, molecular weight, specific volume, equilibrium sonic velocity, frozen sonic velocity, equilibrium specific heat, frozen specific heat, and frozen isentropic exponent. (auth)

23641 ANALYTICAL STUDY OF HEAT TRANSFER RATES FOR PARALLEL FLOW OF LIQUID METALS THROUGH TUBE BUNDLES. PART I. O. E. Dwyer and P. S. Tu (Brookhaven National Lab., Upton, N. Y.). *Chem. Eng. Progr.*, 56: Symposium Ser. No. 30, 183-93(1960).

Nusselt numbers were calculated for fully developed, turbulent, and parallel flow of liquid metals through staggered tube bundles by a method analogous to that of Lyon for flow of liquid metals inside circular tubes. The tubes were assumed to be arranged on an equilateral triangular pitch. A constant heat flux from the outer surfaces of the tubes was assumed, and the model of an annulus was used; i.e., the heat leaving each tube was assumed to be picked up by the flowing metal in an imaginary annulus surrounding the tube, the outer circumference of the annulus circumscribing an area equal to the total cross-sectional hexagonal area associated with each tube. The results were based on the velocity distribution data of Rothfus, Walker, and Whan for flow in concentric annuli. The effects on the Nusselt number of Prandtl number, Peclet number, tube diameter, pitch-to-diameter ratio, and the ratio of eddy diffusivity for heat transfer to that for momentum transfer were determined. (auth)

23649 PUMPS FOR HIGH TEMPERATURE LIQUID SYSTEMS. H. W. Savage and A. G. Grindell (Oak Ridge National Lab., Tenn.). [Paper No.] 1743-61. Presented at "Space-Nuclear Conference, May 3-5, 1961, Gatlinburg, Tennessee." New York, American Rocket Society. 29p.

High temperature pumps are required for several mobile and stationary nuclear reactor power plant applications using sodium, NaK alloy, or fused salt as coolants. Some of these pumps must operate at temperatures above 1500°F for periods well in excess of 20,000 hours. The incidence of failures is low. A summary and evaluation of the incentives, courses of development, present status, and applicability of the various types of pumps used in the past or now under development are given, which indicate design features that may be of use in developing equipment for space vehicles. The designs and special features of these pumps, primarily centrifugal pumps, are discussed. These features provide a descriptive background of the problems inherent in bearings, seals, lubrication, hydraulic performance, cavitation inception, choices of materials, fabrication procedures, drives, liquid expansion, and size and maintenance considerations. (auth)

23839 (LM-TAB-16) LIQUID METALS TECHNOLOGY ABSTRACT BULLETIN, FOR PERIOD OF JULY, AUGUST AND SEPTEMBER, 1960. (MSA Research Corp., Callery, Penna.). 9p.

Eighteen abstracts from current material on liquid metals are presented. (P.C.H.)

24538 (NP-tr-642) LIQUID-METAL COOLANTS IN NUCLEAR REACTORS. (Zhidkometallicheskiye Teplonositeyaye Yadernykh Reaktorov). P. A. Andreev (Andreyev), A. A. Kanaev (Kanayev), and E. (Ye.) D. Fedorovich. Translated from a Russian Publication, Leningrad, 1958. 463p.

Information on the properties of liquid metals used as coolants in nuclear reactors is presented. Topics discussed include heat transfer in the liquid phase or during boiling and condensation, the interaction of liquid metals with structural materials, methods for removing impurities from liquid metals, and the peculiarities of design and operation of systems with liquid metals as coolants. The requirements to be met by heat transfer media used in nuclear reactors and ways to raise the efficiency of atomic power plants employing liquid metal coolants are outlined. (M.C.G.)

24926 A PUMP FOR PUMPING MOLTEN LOW-MELTING METALS AND SALTS. A. I. Noskov and D. V. Gorshkov. *Byull. Izobretnii*, No. 16, 37(1960).

This pump is made of a hollow body and a shaft with two helical worms, right- and left-hand, and is designed to achieve normal working at a high revolution speed without lubrication. The bearings are made of hard alloys. (OTS)

24945 (NAA-SR-Memo-6374) TORQUE TUBE SEAL-OIC FLOW CONTROLLER. D. J. Hovley (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). May 8, 1961. 6p.

A torque tube seal for a sodium flow controller is tested by being cycled 1000 times each at temperatures of 1000 and 1200°F in a flowing sodium system at a pressure of 100 psig. The tests are conducted in a test loop of the Hallam Power Reactor. No indication of leakage through the seal is noted under the test conditions. (T.F.H.)

24953 SODIUM AND SODIUM-POTASSIUM ALLOYS AS HEAT TRANSFER MEDIA FOR STEAM REHEAT AND TECHNOLOGICAL PROCESSES. P. L. Kirillov. *Teplotenergetika*, No. 10, 40-2(1960).

Sodium and alloys of sodium and potassium may be considered as heat transfer media. Their physical properties are given. Published data covers the range of 0-700°C and the data for higher temperatures are obtained by extrapolation. Reaction between sodium and water would have to be prevented, but that between sodium and steam is not so dangerous. Oxidation of the sodium must also be prevented for two reasons: the oxides are corrosive and they may form solid deposits in the tube. Before filling the system it would have to be heated to a temperature higher than the melting point of sodium which is 97°. This would not be required if the eutectic alloys of sodium and potassium were used, the melting point being below 20°C. A possible reheat circuit using sodium metal or sodium potassium alloy is illustrated schematically and the main characteristics are given. Various items of secondary equipment are described, including, for example, measurement of sodium oxide. If sodium or alloy leaked into the furnace it would quickly burn, forming oxides and carbonates most of which would be removed with the flue gases. The sodium does not come into contact with water. The pressure of the steam is much higher than that of the sodium and if any leak occurred it would be of steam into the sodium. Various kinds of protective measures that would be required are mentioned. The use of electromagnetic pumps for metallic sodium is recommended. A number of the advantages claimed are

mentioned. Ordinary ferrite steels can be used in contact with sodium up to 450-500°C and austenitic steel up to 800°C, provided that the oxygen content does not exceed 0.005% by weight. (OTS)

25218 (KAPL-2146) APPLICATION OF THE EWING EQUATION FOR CALCULATING THERMAL CONDUCTIVITY FROM ELECTRICAL CONDUCTIVITY. A. E. Powers (Knolls Atomic Power Lab., Schenectady, N. Y.). Apr. 7, 1961. Contract W-31-109-Eng-52. 21p.

The usefulness of the Ewing equation for calculating the thermal conductivity of reactor metals and alloys from electrical resistance, specific heat, density, and atomic weight was investigated. The alloys investigated were Zircaloy-2, HSZA, Nb-5.5 wt % V, Inconel, 18-8 stainless steel, and eutectic NaK. The Ewing equation was found to give calculated values with a degree of confidence similar to that of actual measured values. (auth)

25222 (NAA-SR-6385) THEORY OF METAL SURFACE TENSIONS. AN IONIC-SALT MODEL FOR LIQUID METALS. S. W. Mayer (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). June 30, 1961. Contract AT(11-1)-GEN-8. 10p.

It is shown that the surface tension of molten metals can be calculated by applying the statistical-thermodynamic liquid theory of Reiss *et al* to an ionic-salt model for alkali, alkaline earth, Group IVB, and Group VB metals. The surface tensions of transition, Group IB, and Group IIB metals were treated on the basis of a monatomic model and the theory of Reiss *et al*. The melting points of the alkali metals followed a corresponding states law when the ionic-salt model was used. (auth)

25231 (PWAC-349) THE ELECTRICAL RESISTIVITY OF LITHIUM AND SODIUM-POTASSIUM ALLOY. Samuel M. Kapelner (Pratt and Whitney Aircraft Div., United Aircraft Corp. Connecticut Aircraft Nuclear Engine Lab., Middletown). June 30, 1961. Contract AT(11-1)-229. 33p.

The electrical resistivities of lithium and sodium-44 wt % potassium alloy were measured to 864 and 854 C, respectively, by means of a high precision modified Kelvin bridge circuit. Expressions for the electrical resistivity as a function of temperature were derived by a least squares fit of the data. Estimates of the thermal conductivity of lithium computed from the electrical resistivity data by the Wiedemann-Franz relation indicate a positive temperature coefficient. (auth)

26020 (NP-tr-727) THE MELTING POINTS OF LITHIUM AND SODIUM UNDER PRESSURES UP TO 30,000 KG/CM². E. (Ye.) G. Ponyatovskii (Ponyatovskiy). Translated from Fiz. Metal. i Metalloved., 11: 476-7 (1961). 4p.

Pressure was developed by compressing a mixture of isopentane with n-pentane in a superhigh pressure multiplier. The melting point was determined by the thermal analysis method with photographic recording of the cooling and heating curves of the specimen. A table is given showing the dependence of the melting point of lithium, sodium, and potassium on pressure. (P.C.H.)

26171 (NP-tr-702) HEAT TRANSFER AND THERMODYNAMIC MODELING. (Teploperedacha i Teplovoye Modelirovaniye). Translated from a publication of the Publishing House of the Academy of Science, Moscow, 1959. 554p.

Included is a collection of papers on the theory of similarity and thermodynamic model analysis of heat transfer.

The papers discuss studies of: criterional values of the theory of the regular thermal regime of the second kind; theoretical foundations for electrical cable cluster design for shipboard use; thermal regime of electrical cable clusters for shipboard use; determining thermal conductivity of molten metals by successive steady states; thermal conductivity and specific weight of heavy water; heat transfer of metals flowing in tubes; calculation of heat transfer of liquid metals; hydraulic resistance of liquid metals flowing in tubes; effects of thermophysical properties of heat transfer agents on heat transmission in conditions of natural convection; mean heat transfer of fluids flowing in tubes; heat transfer of fluids flowing in annular and slit ducts; heat transfer by convection at high pressure; heat transfer in viscous flow of a liquid in tubes for substantial variations in viscosity; heat exchange in the initial section of a tube for mixed boundary layers; heat transfer of a cylinder in cross flow; heat transfer during fluid flow across tube banks; heat transfer in free motion; heat transfer of boiling water in forced convection; steam-content measurements in boiling with subcooling; determination of heat transfer coefficients for vapor condensation of viscous substances; heat transfer in steam condensation on vertical tubes; similarity conditions of molecular processes; generalization of experimental data on viscosity and heat conduction of steam; methods for calculating integral and local angle factors of thermal radiation; application of similarity theory to the analysis of radiation effects in furnaces and combustion chambers; and thermo-optical modeling of radiative heat transfer. (B.O.G.)

26269 LOW IMPEDANCE BRIDGE FOR THE MEASUREMENT OF LEVEL OF LIQUID METALS. Julius Hyman, Jr. (Rocketdyne, Canoga Park, Calif.). Rev. Sci. Instr., 32: 833-7 (July 1961).

A means is described whereby the liquid level of sodium or other conducting liquids may be determined within a sealed metal system. The measurement obtained is that of electrical resistance in an attached drain tube used as a metal "sight tube." A large alternating current is induced for the measurement by using the sealed metal system itself in conjunction with the "sight tube" as a one turn secondary of a transformer. Techniques necessary for application and temperature compensation are discussed. (auth)

26535 (BMI-1536) DEVELOPMENT OF NIOBIUM-URANIUM ALLOYS FOR ELEVATED-TEMPERATURE FUEL APPLICATIONS. John A. DeMastry, Donald P. Moak, Seymour G. Epstein, Arthur A. Bauer, and Ronald F. Dickerson (Battelle Memorial Inst., Columbus, Ohio). Aug. 9, 1961. Contract W-7405-eng-92. 64p.

As a continuation of studies reported in BMI-1400, fabrication characteristics, physical and mechanical properties, and corrosion behavior in NaK, sodium, and water of niobium-uranium binary alloys containing up to 60 wt.% uranium were investigated. Alloys were cast by a skull melting and consumable and nonconsumable arc-melting methods. Fabrication difficulties with alloys containing greater than 25 wt.% uranium were related to coring-type microsegregation during casting. Tensile tests indicated 0.2% offset yield strengths of 16,880, 22,370 and 28,600 psi for niobium-4.38, -14.3, and -20 wt.% uranium alloys, respectively, at 2000°F. Additional tensile data were obtained for alloys from 1600 to 2400°F. Stresses to produce minimum creep rates of 0.001, 0.01, and 0.1%/hr at 1600, 1800, and 2000°F were also determined. Both tensile and creep strengths were found to be sensitive to oxygen content. All alloys appeared compatible with NaK at 1600°F and with sodium at 1500°F. In 600°F water, most of the alloys tested exhibited

negligible weight changes after 336 days' exposure. Weight changes were greater after 140 days' exposure to 680°F water, but corrosion rates were considered satisfactory for a clad fuel. The thermal and electrical conductivities of niobium are lowered by the addition of uranium, while the thermal-expansion characteristics are essentially unaffected. Recrystallization temperatures for 90% cold-reduced niobium-4.38, -14.3, -20, -25.0, and -30 wt.% uranium alloys are 2300, 2300, 2400, 2300, and 2200°F, respectively. No appreciable effect of oxygen contents ranging from 100 to 1000 ppm was observed on the composition limits of the gamma immiscibility gap in the niobium-uranium system. (auth)

27721 POWER LOSS AND INITIAL SHAFT TORQUE IN SEALS OF FROZEN SODIUM. A. V. Drobyshev and N. M. Turchin. *Atomnaya Energ.*, 10: 386-7 (Apr. 1961). (In Russian)

The friction power loss of frozen sodium seals was analyzed as a function of the number of shaft rotations. The power loss in frozen sodium seals is 0.7 to 1% of the power used in sodium pumping. The rate of sodium loss is 2 to 3 cm³/day. Considering laminar flow and pressure, the evaluated liquid sodium film is 15 to 20μ. The temperature distribution at a condensation point at various cooling temperatures is plotted as well as the tangential intensity τ of the initial shaft rotation moment as function of temperature. (R.V.J.)

27748 HEAT TRANSFER IN A TURBULENT FLOW OF LIQUID METAL. V. I. Subbotin, M. Kh. Ibragimov, M. N. Ivanovskii, M. N. Arnol'dov, and E. V. Nomofilov. *Atomnaya Energ.*, 10: 384-6 (Apr. 1961). (In Russian)

The turbulent heat transfer coefficient, the ratio of E for liquid metals, and the effects of heat conductivity are determined. The turbulent heat transition distribution coefficient along the cross section of a tube is plotted for various Re numbers, and correlation curves of analytical and experimental data on the temperature field in heavy liquid metal are given. (R.V.J.)

27753 TURBULENT HEAT TRANSFER IN LIQUID METALS. FULLY DEVELOPED PIPE FLOW WITH CONSTANT WALL TEMPERATURE. N. Z. Azer (Univ. of Alexandria, Egypt) and B. T. Chao. *Intern. J. Heat and Mass Transfer*, 3: 77-83 (Sept. 1961). (In English)

Nusselt number and temperature profile for low Prandtl number fluids of constant properties flowing in a smooth pipe with constant wall temperature are evaluated. Use is made of the theoretical expression for the ratio of eddy diffusivities for heat and momentum. For practical calculation of film coefficient of heat transfer, an interpolation formula is proposed: $N_{Nu} = 5 + 0.05 N_{Pr}^{0.25} N_{Pe}^{0.77}$, which fits the calculated data with a maximum deviation of less than 11% for $N_{Pr} < 0.1$ and $N_{Pe} < 15,000$. Temperature profiles for several Prandtl and Reynolds numbers are compared with the case of constant wall flux. (auth)

27835 IMPROVEMENTS IN OR RELATING TO APPARATUS FOR INDICATING THE METAL OXIDE CONTENT OF A LIQUID METAL. Leslie Reginald Blake (to United Kingdom Atomic Energy Authority). British Patent 873,912. Aug. 2, 1961.

An apparatus is described for measuring small changes in the electrical resistivity of a liquid metal due to the presence of metal oxide, impurities, or gas bubbles. The device consists of electrodes which cause the passage of an alternating current through the liquid metal in a metal pipe included in the pipework. There are probes for deriving two

voltages, one being that due to the current through the liquid metal in the pipe and the other being a reference voltage which is derived from a sealed tube containing the same liquid metal but having a fixed oxide, impurity, and gas bubble content. (N.W.R.)

28205 ELECTRON WAVE FUNCTIONS IN METALLIC SODIUM. Joseph Callaway (Univ. of California, Riverside). *Phys. Rev.*, 123: 1255-6 (Aug. 15, 1961).

Wave functions to order k^2 are presented for electrons in metallic sodium. The calculation is an application of the cellular method. The empirical potential of Prokofjew was employed. (auth)

28654 LAMINAR NATURAL CONVECTION FLOW IN MAGNETO-HYDRODYNAMICS. G. Poots (Bristol Univ., Eng.). *Intern. J. Heat and Mass Transfer*, 3: 1-25 (Aug. 1961). (In English)

The two-dimensional laminar natural convection flow of an electrically conducting viscous fluid, such as mercury or liquid sodium, in the presence of electric or magnetic fields, is discussed. The first example considered is the steady fully developed natural convection flow, with and without heat sources, between two long parallel plane surfaces with uniform magnetic field applied normal to the surfaces. The plane vertical surfaces are open at both ends to the ambient fluid and are maintained at constant temperatures different from that of the ambient fluid. Tables are given from which the fully developed temperature, velocity and induced magnetic fields may be found. Flow characteristics such as the net mass flow and wall Nusselt numbers are also evaluated. The second example is the steady two-dimensional natural convection flow set up by Joule heating when a direct current flows in the axial direction through a horizontal circular tube filled with an electrically conducting viscous fluid. The outside surface of the tube is maintained at constant temperature by a coolant which is assumed to be a non-conductor and non-magnetic. The influence of the non-uniform convection flow on the temperature distribution and wall Nusselt number is calculated. (auth)

29123 (NDA-2154-6) EXPERIMENTAL DETERMINATION OF CONTAMINANTS IN SODIUM. H. Steinmetz and B. Minushkin (United Nuclear Corp. Development Div., White Plains, N. Y.). Aug. 30, 1961. Contract AT(30-1)-2303. 39p.

An analytical method for the determination of oxygen in sodium was developed. The sodium was amalgamated with mercury and removed from the sodium oxide. The sodium oxide was then dissolved in an alcohol and finally reacted with an organic acid. The sodium oxide was thereby converted into an equivalent amount of water. This water was then titrated with Karl Fischer reagent. The method has the advantage of not requiring a complete separation of the sodium from the sodium oxide. The method was checked with samples containing known amounts of oxygen. The analysis of a series of samples of zirconium-gettered sodium gave a mean value of 3 ppm of oxygen with a standard deviation of ± 1.5 ppm. Three samples of sodium were analyzed for their carbon contents by a wet combustion method. The method used and the analytical results are described. (auth)

29372 HEAT TRANSFER FOR TURBULENT FLOW OF A LIQUID METAL IN A TUBE. V. I. Subbotin, M. Kh. Ibragimov, M. N. Ivanovskii, M. N. Arnol'dov, and E. V. Nomofilov. *Atomnaya Energ.*, 11: 133-9 (Aug. 1961). (In Russian)

The radial temperature distribution in a -30 mm stainless steel tube was determined for alkali metal at Reynolds number of 16,200 and 24,700 and at heat flows of 40,000 and 39,500 kcal/m²/hr, and for heavy metals at Reynolds numbers of 24,200 and 204,000 and at heat flows of 17,800 and 41,000 kcal/m²/hr. The wall temperature which was required to calculate the heat transfer coefficient was determined by extrapolating the temperature profile of the liquid metal to the temperature of the wall. The data fit the formula of R. Lyons over a wide range of Peclet numbers of 100 to 12,000: $Nu = 7 + 0.025 Pe^{0.8}$. However, if the contact thermal resistance due to the oxide film on the heavy metals is taken into account, the points for the heavy metals fall below the curve for the liquid alkali metals on a plot of Nusselt numbers versus the Peclet numbers. The contact thermal resistance for the heavy liquid metal is plotted as a function of the Reynolds number. Chemical analysis showed that the content of oxide near the wall was about a factor of ten greater than the content of oxide in the main stream of the heavy metal. (TTT)

29545 (PWAC-347) LIQUID METAL FIRE CONTROL. JUNE 15, 1961. T. P. McGrath and E. E. VanBrunt, Jr. (Pratt and Whitney Aircraft Div., United Aircraft Corp. Connecticut Aircraft Nuclear Engine Lab., Middletown). July 1, 1961. Contract AT(11-1)-229. 84p.

The feasibility of a drain and sump system as a method for controlling burning liquid metal without the use of an extinguishing agent was demonstrated in tests performed with lithium and NaK. The effectiveness of Met-L-X (NaCl plus protective coating agent) in controlling and eventually extinguishing lithium fires on metal floors when the depth of lithium was approximately one-half inch was also demonstrated. A large fraction of the liquid metal discharged on to the drainage system flowed to the sump when the floor and V-trough were sloped seven degrees. In three tests with lithium during which a fire occurred, 75 to 80% of the burning lithium ran into the sump and extinguished itself. One test was made with floor and V-trough slopes of five and three degrees, respectively. With this configuration the flow of lithium was very poor and no lithium was collected in the sump. In the two NaK tests performed (floor and V-trough sloped seven degrees), 40 and 55% of the NaK ran into the sump where it was extinguished. It was assumed that with fires involving large amounts of liquid metal, even greater percentages of liquid metal would be collected and extinguished provided a minimum floor and V-trough slope of seven degrees was used. One-eighth inch and one-quarter inch thick mild steel floors proved satisfactory for use in the drainage system. The burning liquid metal did not damage the floor and the slight warpage of the plates was not great enough to impede the flow of the liquid metal. Ignition of the liquid metal in air apparently depended to a large degree on the amount of spattering of the metal. More rapid ignition was observed when extensive spattering occurred. The NaK, which produced a greater degree of spattering than the lithium, burned more readily. High temperature insulation (Johns-Manville "Superex" and 85 percent magnesia) was completely destroyed when exposed to a stream of 1200F lithium. When lithium or NaK at ambient temperature was mixed with each of the three ambient organic materials, JP-5 jet fuel (MIL-J-5624E), lubricating oil (MIL-L-7808) and monoisopropylbiphenyl (MIPB), the only reaction observed was the very slow formation of gas bubbles on the surface of the NaK as it was added to the JP-5 and lubricating oil. When the organics at 200F were added to the lithium or NaK at ambient temperature the results were essentially the same as in the previous tests with the following exceptions: gas bubbles were formed when MIPB

was added to the NaK; also, there was no visible reaction between the lubricating oil and NaK. When organic materials at 200F were added to burning lithium or NaK, typical oil fires resulted on the surfaces of the metals. Various extinguishing agents were applied to these fires to test their effectiveness. Dry Chemical (NaHCO₃ plus a drying agent to provide a free flowing material) effectively extinguished lithium-JP-5, NaK-JP-5, and NaK-MIPB fires. Dry Chemical was not effective on lithium and NaK lube oil fires, the former because of an apparent lube oil-lithium reaction, Met-L-X also proved ineffective on a lithium-lube oil fire in the one test made. However, Dry Chemical followed immediately by Met-L-X did extinguish a lithium-lube oil fire. Application of Dry Chemical to burning lithium alone caused the fire to increase in intensity. It was concluded that Dry Chemical should not be used on lithium fires. A test of Dry Chemical on burning NaK was not run. In facilities where both liquid metal and organics and their attendant fire hazards are present at the same time, fire protection systems should be provided to handle both types of fires. It was not determined whether a single piped system using a mixture of Dry Chemical and Met-L-X would operate satisfactorily. (auth)

29703 (LAMS-2604) HINDERED SETTLING RATES OF CONCENTRATED SUSPENSIONS OF URANIUM DIOXIDE IN SODIUM. Alexander Sesonske (Los Alamos Scientific Lab., N. Mex.). Aug. 14, 1961. Contract W-7405-eng-36. 15p.

Hindered settling rates were measured at 500°C for suspensions in sodium of dense UO₂ in the concentration range of 10 to 30 vol % solids. The data as correlated by Steiour's solidity function indicated agglomeration with a ratio of volume of liquid envelope to volume of solids equal to 1.2. Supplementary room temperature measurements with suspensions of UO₂ in either acetone or benzene gave similar results with a liquid envelope solid volume ratio of 0.8. (auth)

29743 STUDY OF LIQUID METAL ALLOYS. F. Sauerwald (F. Zauervald). Izvest. Akad. Nauk S.S.S.R., Otdel. Tekh. Nauk, Met. i Toplivo, No. 3, 115-16 (May-June 1961). (In Russian)

It has been assumed that property isotherms do give a reliable indication on the occurrence of limited solubility or immiscibility in liquid eutectic systems. However, it has been found later that systems which have a limited solubility in the liquid phase exhibit positive coefficients of surface tension; this has been noticed even in cases in which the limited solubility region could not have been clearly defined and which showed their tendency toward such behavior only by the inflection of the liquidus curves. The appearance of the limited solubility probably coincides with the start of eutectic crystallization so that these systems may not be considered as being completely homogeneous. On the basis of these considerations the following classification is suggested: 1) V-systems containing a compound with a stable intermetallic bond in the solid state which causes divergences in the property isotherm from the average values; 2) L-systems without a stable bond between the components (typical ideal solutions) having simple property isotherms; 3) E-systems exhibiting limited solubility in the liquid state resulting ultimately in the separation of the components; and 4) less sharply defined or intermediate Z-systems. However, this classification does not solve all the problems of systematization of liquid alloys. (TTT)

30667 AN EMPIRICAL SURFACE TENSION-TEMPERATURE RELATION FOR LIQUID METALS. S. W.

Strauss (Naval Research Lab., Washington, D. C.). *J. Nuclear Energy, Pts. A and B. Reactor Sci. and Technol.*, 15: 28-29 (Sept. 1961).

The surface tension-temperature relation $\gamma = 0.59 S^{3/4} (T_c - T)(T_c - T_m)^{-1}$ for liquid metals, is derived from the relation $\gamma_m = 0.59 S^{3/4}$. In the derivation, the almost linear temperature dependence of surface tension and the vanishing of the surface tension at the critical temperature are considered. It was found that for the temperature ranges plotted, the differences between the experimental and calculated surface tensions were less than 11%. (L.N.N.)

31197 (NP-10795) THE LIQUID RANGE OF METALS AND SOME OF THEIR PHYSICAL PROPERTIES AT HIGH TEMPERATURES. A. V. Grosse (Temple Univ., Philadelphia, Research Inst.). Sept. 5, 1960. 42p.

The liquid range of metals is outlined. The critical properties and the liquid range of mercury, the only metal so far investigated experimentally, are discussed. Critical temperatures, vapor pressures and critical pressures, liquid range diagrams of typical metals, relationship between the density temperature coefficients and critical temperatures of metals, viscosity of liquid metals, empirical relationship between the activation energy of viscosity and the melting point of the metal, the self-diffusion coefficient of liquid metals, electrical conductivities of liquid metals, chemistry of metals at high temperatures, and new electrical heating methods are discussed. (M.C.G.)

31910 (BNL-671) NUCLEAR ENGINEERING DEPARTMENT PROGRESS REPORT, JANUARY 1-APRIL 30, 1961. (Brookhaven National Lab., Upton, N. Y.). Aug. 1961. Contract [AT(30-2)-Gen-16]. 73p.

Reactor Theory. Results are reported on the theoretical analyses of reactor experiments on: BNL slab water lattice experiments; the anisotropic neutron migration in uranium oxide, steel-clad, rod lattices; the Snell and Campbell-Poole experiments; Be-moderated critical experiments; and U-D₂O lattices. Progress is reported on studies of: the physics of the HFBR; of settled-bed fuel reactors; gamma irradiation facilities; fast Pu-Bi solution reactors; high conversion ratio, thermal, Pu-fueled reactors; temperature coefficients in reactor lattices; fission product poisoning; spatial Xe instability; and neutron thermalization. Experimental Reactor Physics.

Work was continued on the exponential and miniature slab and rod lattices, pulsed neutron experiments, and HFBR. Neutron Cross Section Evaluation. A general program for calculating fast neutron cross sections was developed. Chemistry. Studies are continuing on the mechanism of solid state polymerization, on the kinetics of radiation-induced polymerization, and the mechanism of the radiolysis of aromatic compounds. Preparative-scale gas chromatography has been used for the purification of fluorocarbons. When C₆F₆ was irradiated with Co⁶⁰ γ-rays in a Ni cell, the polymer yield (G_{polymer}) was 2.6; this is about the same as the value found in a Pyrex cell although the gas yield in Ni was much smaller than in Pyrex. The thickness of 0.1-μ films between silica plates has been measured approximately. Additional data have been obtained in the relative extraction coefficients of Na and Cs as ion association complexes and on the preparation of tetravalent uranium salts by precipitating uranyl sulfide. Chemical Technology. The x-ray diffraction equipment has been calibrated against Pt to 1500°C. Data have been taken for ThO₂ to 1500°C. Multicomponent Xe and Kr adsorption experiments were performed for concentrations from 0.025 to 0.93% and 0.025 to 0.10%, respectively,

in a He stream maintained constant at 2000 cc/min. Adsorption in the multicomponent runs seems to be the same as observed with the respective single components. Experiments using the technique of equilibrating a graphite sample in a sealed capsule with iodine vapor and subsequent determination of the iodine concentration by wet chemical analysis have been completed. Work was begun with a technique using a sodium iodide scintillation probe to measure directly the concentration of I¹³¹ tracer on a graphite sample. In the study of the ultimate disposal of high level waste, emphasis is being placed on the formation of phosphate glasses as a means of incorporating the fission products in stable media. Leaching studies with phosphate glass show they compare favorably with other glasses made with basically different composition. Data are presented on the production of carbon monoxide from carbon dioxide, the production of hydrazine aqueous ammonia, and on the polymerization of ethylene. In a series of four fluidized bed fluorination experiments, the recovery of U from an Al₂O₃ bed was 98.4%. Chlorination of SS coupons was carried out within a static Al₂O₃ bed in which the temperature difference between the central portion of the bed and the reactor wall was 75 to 175°C. No reaction between UO₂ and Cl₂ at ≈700°C was noted. Studies were continued on development of the Nitrofluor process for recovering U and Pu from reactor fuel. The freezing and boiling points of the compound NOF·3HF were measured and the dissolution behavior of Zr and U in this compound was studied since it may be a constituent of high-boiling point fractions found in NO₂-HF solutions. The existence of nonvolatile U residues following fluorination of the complex U salt produced during dissolution was investigated. The behavior of fission product fluorides in NO₂-HF solution was examined using a U-fissium alloy as source material. Long-term corrosion tests on Monel specimens fully and partially immersed in NO₂-HF solution at temperatures to 80°C showed very low corrosion rates. The root pass of welded specimens was as resistant as the base metal. Tests involving the addition of H₂O to NO₂-HF solution were studied. Work was conducted on development of the Phosfluor process, which involves fuel dissolution in anhydrous H₂PO₃F (monofluorophosphoric acid) and several alternate methods of process completion. Experiments were conducted to determine the diffusion of Te in 2S Al using an Al-cylindrical, and Al-foil diffusion specimens. Released I and U were found in the cold zones after the meltdown of an irradiated U-Mo fuel, and showing that no definite I/U ratio exists. The percent I release is strongly temperature-dependent. Experimental evidence indicates that Ba¹⁴⁰ and La¹⁴⁰ are released independently. Engineering. A project to study mass transfer and mixing phenomena in fused salt-liquid metal extraction columns is discussed. The chemical system to be used is the Bi-Mg-Zr-Ce/NaCl-KCl-MgCl₂ system. The distributing solute is Ce for which the distribution coefficient is known as a function of the concentration of Mg in Bi with good precision. Data are presented on experimental build-up factors in water from Co⁶⁰ slab sources. Heat transfer factors involved in shipping large quantities of Co⁶⁰ have been experimentally investigated using 83000 c Co⁶⁰. A research irradiator has been constructed and tested. Construction is proceeding on the High Intensity Radiation Development Laboratory. A second series of runs was made with test element No. 2 in the new Hg heat transfer loop, located in the center of a 13-rod, unbaffled, rod bundle. A high-temperature loop is being built to determine heat transfer coefficients to alkali metals, under conditions similar to those being studied in the Hg loop. Empirical equations have been obtained, based on theoretical calculations, for expressing heat transfer coef-

ficients for turbulent flow of liquid metals through concentric annuli, under different operating conditions. An experimental heat transfer research project has been started to obtain fundamental information on forced convection boiling and condensing of K, for the design of components for those auxiliary power plants for space vehicles which use alkali metals as working fluids. The maximum boiling temperature will be 1800°F, and the maximum vapor quality will be in the neighborhood of 50 wt%. Hot Laboratory. Isotopes development work performed on various aspects of eight isotopes is discussed. Research and development work in radiochemical analysis includes studies of: the extraction behavior of Th in the TTA-TOA system; the analysis of "fissionium," a synthetic spent fuel element by emission spectroscopy and wet chemistry procedures; microwave excitation of samples for emission spectroscopy; the controlled-potential coulometric stripping of 900 ppm U from molten U-Bi in a fused chloride eutectic; a nitrate eutectic of the stable species of Cu in the presence and absence of Cl^- ; contact autoradiography of radioactive Ag electroplates; the adsorption of Te on alumina; the use of internal conversion x rays from a Cs^{137} standard to standardize samples of I^{125} ; and a photometric method for determining the end point in the conventional Th titration. Metalurgy. Corrosion of materials by boiling Hg and Na is being studied. Corrosion and mass transfer in all-liquid Hg loops are being compared with these phenomena in boiling loops. An inert atmosphere welding chamber and an inert atmosphere loop operating chamber are being tested for their use in studying corrosion of refractory metals by boiling Na. Fe and Fe alloys containing less than 10 ppm each of C and O have been prepared by vacuum melting in MgO crucibles, holding the liquid just above the melting point of Fe, and cold trapping the vacuum chamber. The experimental technique for measuring release of fission gases from UBi_2 slurries in Bi was modified to eliminate effects of particle growth, and preliminary diffusion coefficients for Xe^{133} out of UBi_2 at 800°C were obtained. Attempts to simulate fission concentrations in U metal by alpha-particle bombardment were not successful in producing reproducible results, possibly because of stringers of inclusions in the U metal. The first of three fuel element tests for the HFBR has been irradiated to 40 to 50% burnup in ETR and is awaiting examination. The emf of the Fe-liquid Bi thermocouple has been measured in Bi containing 0.5 ppm Fe, and appears to be strongly influenced by the concentration of Fe in the Bi. An apparatus to measure quantitatively the diffusion of Fe in Bi and the effects of d-c currents on this diffusion is being tested. Carbide, nitride, and silicide particles in steels appear to be the least corroded by uninhibited Bi, as indicated by electron reflection-diffraction of the corroded surface of a steel specimen. The precision of the film formation techniques now being used has been determined; the number of specimens required to detect small effects with certainty appears to be prohibitively high. Liquidus curves of Bi with Hf, Pt, and Co were measured. Os, Ir, and Re were found to be difficult to alloy with Bi: Ir has a measurable solubility but is very slow in dissolving; Os and Re were not detected in Bi up to 600 and 500°C, respectively. The apparatus for measuring the magnetic susceptibility of liquid alloys has been determined to give the sensitivities required, to distinguish between Fe^{++} and Fe^{+++} in a 10 ppm Fe-Bi alloy and is now being built. The theory of metals is being modified to include certain p-type atomic orbitals, and the required calculations are being programmed for the BNL computer. Fission fragment tracks in Pt films from localized deposits of uranium oxide have been shown to have a periodicity of 207 Å from center to center of the vaporized regions, in

agreement with the 200 Å calculated mean free path of a fission fragment between major collisions. The out-of-pile radiation loop has been removed from the reactor building and the samples examined metallographically without observation of corrosive attack. A failed (melted) fuel element from the Graphite Research Reactor showed evidence of U segregation throughout the failed plate. Effects of neutron irradiation and grain size on the low-temperature properties of as-received "pure" Fe have been measured. Graphite samples from the Graphite Research Reactor showed no stored energy release up to 650°C after the most recent reactor anneal, which occurred at temperatures above 300°C. Growth recovery of all samples checked for this anneal averaged 105% of the growth since the previous anneal. At 1400°C, the thermal conductivity of AGOT graphite specimens (placed in the pile in 1951) recovers 45 to 50% of its original value. Water soaking of graphite specimens, followed by vacuum drying at room temperature, appears to increase their oxidation rates by a factor of 1.1 to 3.3; no striking difference was found between those samples soaked and those ultrasonically cleaned. Preliminary diffusion coefficient calculations for Xe^{133} out of uranium carbide powder have suggested the activation energy for diffusion to be approximately 32 kcal/mole. The corrosion in welded SS plates in the pilot plant dissolver, exposed to HNO_3 -HF solutions, was found to be caused by carbide precipitation in the heat-affected zones adjacent to the welds. Cb-stabilized SS welds were not corroded. An Al ultracentrifuge housing failed during operation by stress-corrosion penetration of Hg vapor condensing on the housing from a Hg electrical contact. A water-cooled graphite-tube resistance furnace has been built for the deposition of pyrolytic graphite from the pyrolysis of methane and it is possible to reach 3265°C. Mechanical Engineering. Developments are discussed for: the High Flux Beam Reactor project; the HFBR Fuel Handling Mock-up; the HFBR Critical Experiments; the HFBR Flow Reversal Test Loop; the Low Mass Critical Assembly; handling equipment for the Animal Tunnel in the graphite reactor; a mirror mount for the Arc Image Furnace; the Slow Neutron Chopper; the NaK Heat Transfer Loop; Boiling Potassium Heat Transfer Loop; evaluation of Internal Pressurization for PWR application; the proposed High Temperature Critical Facility; the circulating system for the Chemonuclear Loop; components for the High Intensity Radiation Development Laboratory; Mark I Research Irradiator conveyor system; and the Mark II Research Irradiators. Reactor Evaluation. Studies of large power reactor systems utilizing settled fuels were initiated. The studies covered both thermal and fast reactor designs, and utilize alkali metals as coolant. Revision of the chemonuclear report on nitrogen fixation has been completed and studies of other chemonuclear systems such as for CO production are under way. The reactor coolant properties table has been completed and is ready for publication, as well as studies of internal pressurization and steam generator materials for PWR reactors. (B.O.G.)

32066 (BMI-1534(Del.)) PROGRESS RELATING TO CIVILIAN APPLICATIONS DURING JULY 1961. Russell W. Dayton and Clyde R. Tipton, Jr. (Battelle Memorial Inst., Columbus, Ohio). Aug. 1, 1961. Contract W-7405-Eng-92. 92p.

Progress is reported for various reactor fuel projects. Observations on the behavior of U_3O_8 -CaO, U_3O_8 -CdO, and U_3O_8 - Al_2O_3 mixtures held at 1200°C and 6×10^4 atm for 24 hr are reported. The sliding friction of type 304 stainless steel surfaces at 80 to 1200°F decreased when sodium was introduced between the surfaces. X-ray diffraction studies of the phases existing in cast Nb-40.2 wt % Pu-1.2 wt % Si

and Nb-23.7 wt % Pu-2.8 wt % Si alloys are reported. U-10 wt % Nb base alloys were found to increase their hardness with increasing Pu content. Development of tubular fuel element fabrication by explosive forming and expansion of seam-welded flat plates is described. Fractional areas of contact of Ni-Cu couples vacuum hot-pressed at 1000°F and pressures of 2000 and 4000 psi are reported. Skull arc-melting techniques were developed for the melting and casting of uranium carbide. The physical properties of uranium carbide compacts irradiated to 0.7 at. % burnup are described. Limitations of Al_2O_3 coatings on fuel particles are discussed. The densities of pyrolytic carbon coatings on fuel powders were determined. Postirradiation studies were made on coated fuel particles in graphite spheres. Evidence was found for migration or recrystallization in NaCl crystals and for decoration of dislocations by precipitated Ag in AgCl crystals exposed to fission recoils. Studies were made on the reactions of UC with pyrolytic carbon coatings and of UO_2 with Al_2O_3 coatings. Results of studies of BeO coating deposition on UO_2 shot are given. Development of oxide-coated UO_2 particles was continued. Corrosion studies were made in the Fluoride Volatility process on INOR-8, Hastelloy X, and W-5 wt % Cu-5 wt % Ni alloy with ZrO_2 additions and a HF sparge at 700°C, and on HyMu-80 in LiF-NaF-ZrF₄ melt sparged with F₂ at 500°C. Work on joining of type 410 stainless steel to Zircaloy-2 is described. Studies of irradiation effects on Hastelloy X-clad UO_2 and UO_2 -BeO specimens were carried out. Corrosion resistance of soldered Th-Th, Th-U, and U-U joints plated with Ni was evaluated by exposure to 100% humid air and subsequent bend tests. (D.L.C.)

32276 LUBRICATION SYSTEM FOR DEVICES WORKING AT HIGH TEMPERATURES OR EXPOSED TO NUCLEAR RADIATION. (to Advance House, Inc.). French Patent 1,204,448. Jan. 26, 1960.

For devices working at high temperatures or exposed to radiation, so that the use of organic lubricants is impossible, the contiguous lubricated surfaces, moving relatively to each other, are separated by a lubricating film which may be constituted by a molten metal normally solid at the ambient temperature and indifferent to these surfaces. This metal is held in the molten state by heating means which may be mounted equally well inside the piece bounded by one of the lubricated surfaces or outside the lubricated system. The lubricant may also be constituted by a mixture of molten metal and an inorganic salt indifferent to this metal and to the surfaces. Particles of another solid lubricant can also be dispersed in the molten metal film. (NPO)

32490 (HW-TR-29) COOLING BY LIQUID METALS. PROBLEMS OF COMPATIBILITY. R. Darras. Translated for General Electric Co. Hanford Atomic Products Operation, Richland, Wash. from *Energie nucléaire*, 3: 128-38 (Mar.-Apr. 1961). 26p.

This paper was previously abstracted from the original language and appears in *NSA*, Vol. 15, abstract no. 19904.

32547 (NYO-9640) THE COMPRESSIBILITY AND INTERNAL FRICTION OF CERTAIN BINARY LIQUID ALLOYS. Final Report. Gerald Abowitz and Robert B. Gordon (Yale Univ., New Haven. Hammond Metallurgical Lab.). Aug. 1961. Contract AT(30-1)-2029. 307p.

The velocity of sound, mass density, and thermal expansion coefficient were measured in dilute bismuth, lead, tin, zinc, cadmium, indium, and potassium amalgams as a function of composition. Measurements in the mercury-thallium system extended over the range 0 to 40 atomic % thallium.

The sonic velocity determinations are also made as a function of temperature. The computed adiabatic compressibility, β_{ad} , is found to decrease more rapidly than is expected on the basis of a linear variation with composition. Two possible hypotheses are suggested to explain the experimental results. One is a change in the Debye characteristic temperature, Θ_d , of mercury on alloying; the other is a change in the bonding of mercury itself which is assumed to have some covalent bonding. The velocity of sound was measured in several sodium-potassium alloys as a function of temperature. It is found to change in a nearly linear manner with composition. The behavior of β_{ad} , because of the volume contraction on alloying, cannot be explained in terms of a free electron model of the compressibility. It is hypothesized that changes in the electronic charge density occur upon solution giving rise to a volume contraction and the slight positive deviation in β_{ad} . Attenuation of sound measurements were carried out in mercury, sodium, and mercury-thallium alloys. Attenuation measurements as a function of frequency, 15 to 115 mc/s, and temperature, -13 to 72°C, indicate that the entire loss in mercury is caused by the sum of the shear viscosity and thermal conductivity losses. Within experimental error, α/ν^2 is constant and of the magnitude predicted by the classical theories. The temperature dependence of α is also found to obey the classical prediction. The measured attenuation in liquid sodium is approximately 25% greater than the calculated classical value. The frequency and temperature dependence apparently follow the predicted classical behavior; it is only in the absolute magnitude of the attenuation that there is disagreement. The reasons for the discrepancy are not known at the present time. An excess attenuation in liquid mercury-thallium alloys is observed. Measurements as a function of frequency and temperature in the more concentrated alloys are indicative of the presence of a relaxation effect. An analysis of this apparent relaxation phenomenon yields, for a 40 atomic % thallium alloy, an activation energy for the process of 3600 ± 300 calories per mol and a τ of about 10^{-12} seconds. The relaxation mechanism appears to be diffusion limited. It is hypothesized that the mechanism responsible for the relaxation is that of a localized rearrangement of atoms in the liquid induced by the dilatational component of the longitudinal sound wave. (auth)

32565 SURFACE PROPERTIES OF LIQUID SODIUM AND SODIUM-POTASSIUM ALLOYS IN CONTACT WITH METAL OXIDE SURFACES. D. H. Bradhurst and A. S. Buchanan (Univ. of Melbourne). *Australian J. Chem.*, 14: 397-408 (Aug. 1961).

Dissolved oxygen was shown to be surface active in liquid sodium from measurements of surface tension and of contact angle of the liquid on various oxide surfaces. When sufficient oxygen was present wetting of UO_2 by liquid sodium was brought about at temperatures above approximately 300°C. Observations on the wetting of several solid oxides by sodium gave some support to the hypothesis that wetting was more effective on these oxides with larger cations. Sodium-potassium alloys showed non-wetting contact angles when relatively free of oxygen but wetting occurred when the oxygen content of the liquid was increased. (auth)

32849 (AEC-tr-4509(p.228-35)) EXPERIENCE IN DEVELOPING ELECTROMAGNETIC PUMPS AT THE INSTITUTE OF PHYSICS OF THE ACADEMY OF SCIENCES OF THE LATVIAN SSR. P. G. Kirillov, Ya. Ya. Lielpeteris, A. E. Mikel'son, and G. A. Okunev. Trans-

lated from Voprosy Magnit. Gidrodinamiki i Dinamiki Plazmy, Trudy Konf., Akad. Nauk Latv. S.S.R., Inst. Fiz., Riga, 1958, 262-8(1959).

Several electrical, magnetic, and hydrodynamic approximations are described that may be used in the design of

electromagnetic pumps of the induction and conduction types. The characteristics of plane-linear, helical, and direct-current pumps constructed using these approximations are outlined. Pump cooling methods are discussed. (T.F.H.)

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