MINE SAFETY APPLIANCES COMPANY

TECHNICAL INFORMATION DIVISION

LIQUID METALS TECHNOLOGY ABSTRACT BULLETIN

LM/TAB-2

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Issued by the Technical Information Division of Mine Safety Appliances Company as a service to industry.

NOTICE

This and subsequent Liquid Metals Technology Abstract Bulletins will be issued without covers and printed on punched paper so that they may be inserted in suitable binders. A binder will accompany the next issue.

MINE SAFETY APPLIANCES COMPANY

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LIQUID METALS TECHNOLOGY ABSTRACT BULLETIN

This is the second issue of a series of abstract bulletins covering current literature on liquid metals, which are being prepared by the Technical Information Division as a service to industry.

The quickening pace of research and development in liquid metals has led to an increasing amount of literature in the field. Mine Safety Appliances Co., as a pioneer in liquid metals technology, feels that other interested companies could benefit from a current and up-to-date abstract bibliography on liquid metals literature.

These bulletins will be issued at approximately monthly intervals, depending upon the volume of literature to be covered. Existing abstracts will be used unless they are not adequate with respect to the subject scope.

Interested parties may be placed on the mailing list by writing to Mine Safety Appliances Co., Technical Information Officer, Callery, Pa.

Eugene P. Meckly

Eugene P. Meckly
Technical Information Officer

1
Liquid Metal as Heat Transfer Media
Anonymous
Nuc. Eng. 1, 238-40 (1956).

Many processes which have been developed specifically for atomic energy applications will be taken over and further developed by other industries. The extension of the use of NaK as a heat transfer medium to conventional chemical engineering fields can lead to considerable advances in the overall technology. Possible applications of NaK as a heat transfer medium are summarized and the primary elements of a NaK heat transfer system are briefly described. Diagrams are given showing the detail of a cold trap used for purifying NaK and performance data of a Frazer-Nask EM induction pump. The advantages and disadvantages of double skin heat exchangers are discussed and the problems inherent in a single skin heat exchanger are mentioned. Basic safety precautions to be followed in the use of NaK are outlined.

2
Electromagnetic Pumps for Liquid Metals
Anonymous
Metallurgia 53, 277-8 (1956). June.

Several types of electromagnetic pumps are described for use with liquid metals of high and low density, viscosity and resistivity.

3
Electrical Conductivity of Germanium-Silicon Alloys in the Liquid State
Ablova, M. S. and Elpat'evskaya, O. D. and Regel, A. R.
Zhur. Tekh. Fiz. 26, 1366-8 (1956).

Samples containing 100, 92.8, 85.6, 78.4 and 51.4 mole % Ge were investigated. The gas $\triangle$ E increases from 0 to 50% Si and then remains stationary. There is a maximum of conductivity in the liquid state σ_{c} and a maximum change in conductivity σ_{c} / σ_{s} at 50% Si. In the system Na-K this increase in the difference of conductivities has a minimum at 50% K.

4
KAPL-P-1512
An Evaluation of the Sodium-Water Reaction in Heat Transfer Systems
Adams, D. D., G. J. Barenborg and W. W. Kendall
Knolls Atomic Power Laboratory, Schenectady, N. Y. Contract W-31-109-Eng-52
32p. (1956).

A review of sodium-water reaction experiments forms a basis for estimating the effects of chemical reaction resulting from potential leakage. System design recommendations to minimize the effects of leakage are also presented.

5
A Report on the Calibration of Two Eight-Inch Magnetic Flowmeters - Mark 1-2 and Mark II
Astley, Eugene R.
General Electric Company, 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 $\pm$3% of the full scale of 3400 gal/min.

6
BNL-395
Static Corrosion Behavior of Materials in Bismuth and Uranium-Bismuth Solution at 550°C
Atherton, J. E., O. F. Kammerer, C. J. Klamut and J. Sadofsky
Brookhaven National Lab., Upton, N. Y., Aug. 1954. 10p. (LMFR-9).

It has been shown that the intermediate Cr steels corrode in Bi or U-Bi solutions. The addition of small amounts of Mg and Zr to the Bi makes this corrosion negligible. A Zr nitride layer has been identified on the surface of inhibited static samples.

7
Calculation of Developed Pressure and Fluid Power in Linear Polyphase Induction Liquid Metal Pumps.
Baker, R. S., Mine Safety Appliances Co., Callery,Penna. Technical Report No. 48 Contract NObs-65426. 67p. March 24, 1956

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.

8
Removal of Entrained Gas From a Sodium System
Barker, K. R. and J. W. Mausteller
Mine Safety Appliances Company, Callery, Penna. Technical Report No. 50 Contract NObs-65426. 14p. July 12, 1956.

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.

9
Nitrogen Containing Two Percent Oxygen as a Sodium System Cover Gas
Batutis, E. F., J. W. Mausteller and C. A. Palladino
Mine Safety Appliances Co., Callery, Pa., Technical Report No. 49
Contract NObs-65426. 22p. April 10, 1956.

Nitrogen containing 2 vol. % O_2 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.

10
NAA-SR-Memo-557
Compatibility of Sodium and Various Materials of Interest in Reactor Construction
Bowman, F. E.
North American Aviation, Inc., Downey, Calif. Jan. 5, 1953. Decl. June 6, 1956

Available data relative to the compatibility of Na and various materials of interest in reactor construction are summarized.

11
NAA-SR-Memo-1115
The Investigation of the Effects of Sodium on SRE Core Materials
Bowman, F. E.
North American Aviation, Inc., Downey, Calif. Oct. 4, 1954. Decl. June 6, 1956. 5p.

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

12
Filter with Fractional Crystallization Means
Bruggeman, W. H. 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 Na_2O crystals from a molten sodium heat exchanger system. Oxygen entering such a system through leaks will combine with Na to form Na_2O which will deposit in cooler portions of the system and choke the flow. This filter installed in a by-pass will remove the Na_2O and other solid impurities that may be present in the molten sodium. The by-passed streamis 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 minutes and the capacity is 7500 lbs/hr. The cooling surfaces must be periodically cleaned of deposits and the steel wool renewed as needed.

13
KAPL-P-1511
Recleaning Sodium Heat Transfer Systems
Bruggeman, W. H., H. F. Karnes and F. C. Hanny
Knolls Atomic Power Laboratory, Schenectady, N. Y.
Contract W-31-109-Eng-52. 31p. (1956).

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.

14
The Decomposition of Sodium Amalgam
Calistru, Constantin et al
Acad. rep. populare Romine (Iasi), Studii cercetari stiint. 5, No. 1/2, 189-96 (1954).

Conditions were investigated in which external electric current was applied to the graphite-Na-amalgam local cells to decompose the latter. The decomposition speed of Na amalgam could be doubled. The external electric current was useful only when the current, through each graphite electrode, was below $\sim$ 0.700 amp. The thickness of the amalgam layer on the electrode could not exceed 5 mm. This method permitted the utilization of a smaller amount of Hg and a higher concentration of NaOH in the industrial cells, even with external electric energy. If the initial current on each electrode and the amalgam layer thickness did not exceed a predetermined value, for the decomposition of Na amalgam by the conventional effect of graphite, the speed was an inverse function of the initial potential difference between graphite and amalgam. It was proposed that this potential difference could be diminished by lowering the graphite in amalgam more than is usual at present.

15
Kinetic Decomposition of Sodium Amalgam in Solutions of Sodium Hydroxide
Calistru, Constantin et al
Acad. rep. populare Romine (Iasi), Studii cercetari, stiint. 5, No. 1/2, 197-213 (1954).

The average speed of decomposition of Na amalgam was variable, but it occurred unexpectedly during degradation. This phenomenon was observed during the decomposition of amalgam by H_2O or diluted and concentrated solutions of NaOH at 25-50° in a cell-insoluble electrode | NaOH solution | amalgam, (short-circuit caused by the container as in the decomposition of the same unit in direct short-circuit, where the insoluble electrode was placed in the amalgam). The variation was graphically traced as a function of time-amalgam | NaOH solution.| insoluble electrode (as short circuit) with ammeter. The decomposition speed could be promoted generally, if, in some cases, the existence of a period was considered when the amalgam preponderantly decomposed at the faster rate, independent of the insoluble electrode. The factors which promoted the H overvoltage decreased at the insoluble electrode and facilitated the decomposition speed during the most active period of the process. On the base of the modification periods of decomposition speed, amalgam and NaOH solution circulation could be concurrent or countercurrent. After the abrupt decrease in the de-

composition speed, the Na sediment could be linked to the amalgam layer, thereby decreasing its initial thickness which, in turn, generally could shorten the final decomposition time. SiC and graphite were used as insoluble electrodes. A partial or total substitution of the graphite by silicon carbide increased the decomposition speed of the amalgam, but in case of substitution the time variations in the speed of decomposition had to be considered as well as the thickness of the amalgam layer.

16
Behavior of Na-24 and Mo-99 as Water Contaminants Leaking from a 550 F, 2000 Psig System.
Campana, R. J. and J. W. Mausteller
Mine Safety Appliances Co., Callery, Penna., Technical Report No. 46
Contract NObs-65426. 22p. February 15, 1956

The behavior of Na^{24} and Mo^{99} in water leaking from a 550°F, 2000 psig system into a 4000 cu. ft. enclosure has been studied over a range of 1 to 100 lph leak rates Leakage sites used were 7 and 10 mil holes in lagged and bare pipe, gaskets between flanges, valve glands and a valve seat. Air activities always reached a maximum level in $\sim$ 5 hours of leakage, with 85% of the activity carried in dry particles of 0.4 to 0.7 microns, and essentially none associated with water. The less soluble Mo^{99} gave air activities $\sim$ 10 times higher than Na^{24}. Na^{24} air activities were lower than Mo^{99} activities. Ranges were $<$ 0.5 to 90 $\mu\mu$c Na^{24}/ml with 0.5 μ c/ml concentration in the leaking water. Mo^{99} air activities ranged from 3 to 800 $\mu\mu$ c/ml at the same water activity. The NBS maximum permissible activity level for Na^{24} (2 $\mu\mu$ c/ml) was generally exceeded but that for Mo^{99} (2000 $\mu\mu$c/ml) was never exceeded. Insulation or valve packing attenuated the air activities associated with bare leaks by factors of 30 to 5, and extended surfaces at the leak sites also resulted in reduced air activities. Relative humidity had no discernible effect on air activity until 100% was exceeded, when precipitated moisture swept activity from the air. Fall-out coefficients after leakage varied from 0.1 to 0.8/hr.

17
PR-P-28
Atomic Energy of Canada Ltd. Chalk River Project, Chalk River, Ontario
Physics Division Progress Report for October 1 to December 31, 1955,
88p. (AECL-282).

... Relative intensities of the γ rays from the β decay of Na^{25} are tabulated...

18
A Survey of Three Heat Exchangers for a Liquid Metal Fuel Reactor
Clark, M.
U. S. Atomic Energy Commission BNL-178, 85pp. (1952). Declass. Nov. 24, 1955.

The conventional "tubular heat exchanger" cooling system is compared with a novel "spray heat exchanger" system for a nuclear power-producing reactor that uses a liquid U-Bi alloy as a fuel-primary coolant mixture. The tubular heat exchanger system is examined with "thermal pumping", i.e. primary coolant circulates by reason of density difference in hot and cold legs, and with "thermal pumping"

were considered to discuss the characteristics of metals and alloys showing a high corrosion resistance to liquid metals. The experimental evidence indicated that inert systems have a difference of at least 50 in the Hildebrand solubility parameters of the 2 components. The rate of attack by solution of the solid in the liquid was considered in detail for the first time. Five possible processes for the attack of a liquid metal on a solid metal were presented. 200 references.

24
Metal Foam
Elliott, John C.
U. S. 2,751,289. June 19, 1956

A strong, light metal alloy having small, gas-filled, closed cells is produced by grinding a gas-forming solid or a metal hydride, such as ZrH_2 or TiH_2, in a molten metal, such as Mg, Al, and their alloys, bringing the mixture to a temperature and for a time sufficient to decompose the gas former, and cooling the composition to the solid state before the foam has dissipated.

25
Density and Surface Tension of Liquid Titanium
Elyutin, V. P. and M. Maurakh
Izvest. Akad. Nauk S.S.S.R. Otdel. Tekh. Nauk No. 4, 129-31 (1956). April
(In Russian)

To determine the surface tension of liquid Ti tests are made lifting the liquid through a capillary tube. The apparatus is described. A sample containing 98.7% Ti, 0.1% Fe, 0.2% Si, 0.1% Ca, and 0.5% Mg was used. The mean density of Ti with 0.6 to 0.8% of carbon at the melting point was 4.11 ± 0.08 g/cm^3. To calculate the surface tension g was taken as 980 cm/sec^2, crucible diameter was 3.5 cm, and the tension was taken as g 980 cm/sec^2, crucible diameter was 3.5 cm and the density of liquid metal 4.11 g/cm^3. The mean value of the surface tension of Ti at crystallization temperature was 1510 ± 19 dynes/cm. Results of the experiment indicated the suitability of the method and apparatus for testing the surface tension of Ti, Ti alloys, or any other high-melting point, chemically active metal.

26
Sodium-Aluminum Equilibria in Cryolite-Alumina Melts
Feinleib, Morris and Bernard Porter (Kaiser Aluminum and Chemical Corp., Permanente, California
J. Electrochem. Soc. 103, 231-6 (1956) April.

A qualitative and quantitative study of sodium-aluminum equilibria in cryolite-alumina melts was undertaken to shed more light on the cathode reactions in the aluminum cell. Measurements were made in alumina crucibles from 940° to 1010°C. Lead was used as an auxiliary sodium "sink". Results show that, while aluminum is more noble than sodium their deposition potentials are not far apart (of the order of 0.1 to 0.2 v), and that, under the non-equilibrium conditions existing in an industrial cell, some sodium may be codeposited with aluminum at the cathode.

27
Turbulent Free Convection Heat Transfer Rates in a Horizontal Pipe
Frazer, J. P. and D. J. Oakley
Knolls Atomic Power Laboratory, Schenectady, N. Y.
Contract W-31-109-Eng-52. February 28, 1956. KAPL-1494

Heat transfer rates are reported for turbulent free convection in a finite length of horizontal pipe containing Na. Heat is added at one end and removed at the other. A generalized equation which correlates the data is proposed giving the ratio of heat transfer with turbulent convection to that based on pure conduction in terms of the L/D ratio, Prandtl number, Grashoff number and Reynold's number. The solution is extended to inclined pipe with one or both ends open to plenums.

28
Production of High-Purity Metallic Calcium. X. Evaluation of Refining Metallic Calcium by Thermal Reduction and Vacuum Distillation
Fujita, Eiichi
Repts. Govt. Chem. Ind. Research Inst., Tokyo 49, 233-6 (1954).

The two refining methods were compared in detail.

29
Isotope Separation by Current Passing Through a Liquid Metal
Gennes, Pierre G. de
J. phys. radium 17, 343-6 (1956).

Analysis of ion-electron collisions in a liquid metal, containing 2 isotopes, proves that the lighter isotope has a higher cross section than does the heavier one. Hence the lighter isotope is carried by the electrons toward the plate. The quantitative computation of the isotope separation assumes as known the number of free electrons in the liquid metal, the ratio of diffusion and viscosity coefficients, and the mean oscillation frequency of an ion, without considering the electron mass. The computed result is half as large as the experimental measurements by Nief and Roth for Ga. The discrepancy is ascribed to the choice of the perturbing potential, the assumed free flight time of electrons, the indeterminate ratio of diffusion and viscosity coefficients, and the nonharmonic character of the ion vibration.

30
Recovery of Sodium and Calcium Metals from Electrolytic Sludge
Gruber, Bernard A, Emanuel Gordon, and Robert A. Jermain
U. S. 2,735,668. February 21, 1956.

A normally hermetically sealed apparatus is described for separately recovering Na and Ca metals by distillation from electrolytic sludges obtained as a by-product in the electrolytic production of Na metal. The apparatus is adapted for use in a continuous or semicontinuous operation.

31
The Isotope Effect of a Direct Electric Current Through Liquid and Solid Metals
Haeffner, E., Th. Sjoborg. and S. Lindhe
Z. Naturforsch. 11a, 71-5 (1956). January

The isotope separation effect of a direct electric current in a liquid metal is demonstrated by passing a current through mercury, which is enclosed in a capillary tube. The second part of the paper deals with an attempt of establishing an isotope effect when a direct current is passed through a uranium wire.

32
The Use of Sodium and Sodium-Potassium Alloy as a Heat Transfer Medium. Part I
Hall, W. and T. I. M. Crofts
Atomic Eng. and Technol. 7, 167-72 (1956).

Applications of liquid metals in heat transfer problems are discussed. Some circuits are described. Forced-convection heat-transfer with liquid metals is discussed.

33
The Use of Sodium and Sodium-Potassium Alloy as a Heat Transfer Medium. Part II
Hall, W. B. and T. I. M. Crofts
Atomic Eng. and Technol. 7, 189-93 (1956).

Applications of liquid metals in heat transfer are discussed. Operating Na and Na-K circuits are described. Data on forced-convection heat-transfer with liquid metals are given, along with recent results concerning cavitation in NaK eutectic flowing through a constriction in a pipe.

34
UCRL-1094
The Effect of Gases on the Wetting of Steels by Liquid Bismuth
Heckman, R. A.
California Univ., Berkely Radiation Laboratory
Contract W-7405-eng-48. January 17, 1951. Decl. January 27, 1956.

The effect of air, N_2, He, A, and a mixture of twenty volume percent of H_2 in A on the wetting of a stainless steel (Type 446), a 2% Cr-1/2% Mo steel, and a plain carbon type steel by liquid Bi was investigated. Irreversible wetting may be obtained by preheating the steel to 1500°F in an He atmosphere and then immersing into molten Bi at 1000°F. Reversible wetting (i.e., de-wetting takes place) may be obtained by preheating the steel to 1500°F in an A atmosphere and then immersing into liquid Bi.

35
Velocity of Evaporation of Liquid Potassium Amalgam
Heitmann, G. and O. Knacke
Z. physik. Chem. 7, 225-35 (1956).

By aid of the Knudsen dropping method the evaporation coefficient of Hg in liquid K amalgam at room temperature was determined; it is $\alpha = 1$. It is shown theoretically that this result can be generalized, the evaporation coefficient being approximately 1 for the evaporation of most mixed phases. The connection between diffusion and phase transition is discussed theoretically by aid of the heat conductivity equation.

36
Use of Numerical Analysis in the Transient Solution of Two-Dimensional Heat-Transfer Problems with Natural and Forced Convection
Hellman, S. K. et al
Trans. Am. Soc. Mech. Engrs. 78, 1155-61 (1956).

In order to determine thermal stresses in a nuclear reactor during power build-up and decay, it is necessary to derive a method of evaluating the transient temperature involved. An analysis of a 2-dimensional metallic structure containing many flow channels is presented. Cooling is accomplished through natural and forced convection.

Heat generation and conduction are considered as functions of time and 2-space variables, while the laminar motions of the liquid metal are expressed by means of transient 1-dimensional flow-rate equations, derived from Euler's equation. The system is set up as a thermal network so that the resulting finite difference equations can be solved by a digital computer.

37
The W-K $\propto$ Diffraction Pattern of Liquid Antimony
Hendus, H. and H. Muller
Z. Naturforsch. 10a, 254-5 (1955.

The W-K $\propto$ diffraction pattern of liquid Sb was obtained at 645°. The periods, d, which were calculated, agree well with the ones for amorphous Sb. Some of those that are present in the latter, however, are missing in the liquid. The distribution of atoms in the 2 structures, therefore, must differ.

38
Waves in a Heavy, Viscous, Incompressible, Electrically Conducting Fluid of Variable Density, in the Presence of a Magnetic Field.
Hide, R.
Proc. Roy. Soc. (London) A233, 376-96 (1955). December 29. (AERE)

The equilibrium of a horizontal layer of a heavy incompressible fluid of variable density ϱ_o in the vertical direction is stable or unstable according as $\alpha \varrho_o/dz$ (z being the upward vertical is everywhere negative or is anywhere positive. In the unstable case, the rate n at which the system departs from equilibrium depends on the total wave number k of the initial disturbance, and there is, in general, one mode characterized by n_m and k_m which grows more rapidly than any other. In the stable case, after an initial disturbance the equilibrium may be restored either periodically or aperiodically, depending on the values of k. The periodic type of motion gives rise to horizontally propagated 'gravity waves'. The influence of viscosity and hydromagnetic forces on the hydrodynamical motion produced by a small disturbance of the equilibrium situation is examined. The appropriate perturbation theory is developed initially for any density field ϱ_o (z) and kinematical viscosity ν (z) for a fluid of constant electrical conductivity σ e.m.u. and magnetic permeability k in the presence of a uniform magnetic field of strength H_0 in the direction of gravity, acceleration g. The solution is expressed in the form of integrals, and is shown to be characterized by a variational principle. Based on the variational principle an approximate solution is obtained for the special case of a fluid of finite depth d stratified according to the law $\varrho_o = \varrho_1 \exp(\beta z)$, and for which ν is constant. It is shown that if n and k are measured in suitable units, they are related by an equation involving three dimensionless parameters: $R = (\eta \pi s/2dV_A)$, $S = (\nu \pi s/2dV_A)$ and $B = (g \beta d^2/\pi^2 s^2 V^2_A)$, where $\eta = (4\pi k\sigma)^{-1}$, $V^2_A +)kH_0^2/4\pi\varrho_1)$, and s is an integer involved in the description of the velocity field. Explicit solutions may be obtained in 3 cases, namely, (a) $R \to \infty$, (b) = O, (c) R = O. Only cases (b) and (c) are considered.

39
Surface Tension of Aluminum and its Alloys
Karol'kov, A. M.
Izvest. Akad. Nauk S.S.S.R., Otdel Tekh. Nauk 1956, No. 2, 35-42.

The surface tension of pure aluminum was found in tests of 99.99% aluminum, kept covered with a molten flux composed of LiCl and KCl, to be 860 $\pm$ 20 dynes/cm. Lithium, clacium, magnesium, antimony, tin, lead and bismuth lower the aluminum

surface tension greatly. The lowering is greater, the lower is the difference in atomic volumes of the metal added and the solvent (Al). The effect is greatest with additions capable of forming layered systems in the liquid state. This property is very important in production of powdered metal and with liquid metals are used as heat carriers. The surface tension was measured from the maximum pressure of an air bubble forced out of a quartz tube dipped into molten aluminum to 700-740°, with the flux covering the aluminum surface, with outside diameter of 0.013 cm. average, and an average wall thickness of 0.034 cm. Thinner and thicker capillaries than 0.48 and 0.2 cm. give inaccurate results.

40
CT-3726
Effect of Sodium-Potassium Alloy on Various Materials at Elevated Temperatures
Kelman, LeRoy R.
Argonne National Laboratory, Lemont, Illinois
Contract W-31-109-Eng-38. Dec. 1, 1946. Decl. Dec. 20, 1955. 26p.

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.

41
Two Inch Stop Valve Tests with Sodium
Kennedy, G. E. and E. C. King
Mine Safety Appliances Company, Callery, Penna.
Contract NObs-65426. Memo Report 107. March 5, 1956

The integrity of the bellows of the 2 inch 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.

42
ORNL-360
A Discussion of Liquid Metals as Pile Coolants
Kitzes, A. S.
Contract W-7405-eng-26. August 10, 1949. Decl. Jan. 5, 1956. 41p.

Criteria given for evaluating liquid metal coolants are corrosion, nuclear properties, availibility 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.

43
The Thermodynamic Properties of the Moderately Dilute Liquid Solutions of Copper, Silver and Gold in Thallium, Lead and Bismuth
Kleppa, O. J.
J. Phys. Chem. 60, 446-52 (1956).

Some new measurements are reported. Most of the experiments were made at 450°, although a few runs were also made at 350°. The heats of formation of the intermetallic phases Au_2Pb and Au_2Bi were determined at 350° by dissolving the alloys in pure liquid Pb and Bi. Some new observations were also reported on the solubility of solid Ag in liquid Th, Pb, and Bi at temperatures up to 500°. The new heat data were compared with earlier data from calorimetry and from e.m.f. investigations, and with thermodynamic data derived from the equilibrium phase diagrams. In order to facilitate this correlation an analytical method was proposed which in certain cases will permit a derivation of important free-energy, heat, and entropy data from phase diagram information alone. A summary was presented of all available thermodynamic data for the moderately dilute solutions of Cu, Ag, and Au in Th, Pb, and Bi.

44
Heat Exchange to a Flowing Vapor-Liquid Mixture in Horizontal Tubes
Korneev, M. I. and B. N. Puganov
Teploenergetika 3, No. 6, 39-44 (1956).

An experimental investigation was made where mixtures of Mg, Hg (liquid), and Hg (vapor) and H_2O-air were led through horizontal pipes. It was found that the coefficient of heat exchange through the wall depends on the amount of heat, the inner diameter of the tubes, and the rate of flow of liquid and vapor. The flow rate at which equilibrium in heat exchange is established depends on the heat, tube diameter, and rate of flow of vapor. It was found that the best results were obtained if the vapor flowed 2-4 m./sec. Two empirical formulas are presented, one for the Mg, Hg; the other for a steam-air mixture. If the tubes are inclined, the maximum permissible rate of flow of the liquid must be decreased.

45
Electron Spin Resonance in Metals and Metal-Ammonia Solutions
Levy, R. A.
Phys. Rev. 102, 31-7 (1956).

Electron-spin-resonance measurements were made at 300 Mc./sec. on frozen metal NH_3 solutions, liquid metal-NH_3 solutions, and liquid metals. The experiments on frozen solutions have shown that the metal is precipitated out in small particles. Nuclear resonance experiments have corroborated this finding. The frozen solutions are used as a convenient source of small particles, and observations were made of relaxation times in Na, Li, K, and Cs. Resonances in the liquid NH_3 solutions of Li Na, K, Rb, Cs, and Ca, and also in a solution of Li in $MeNH_3$ were observed. The data are consistent with the theoretical model of Kraus. Bulk metal resonances were observed to temperatures above the m.ps. on Li and Na. The results of Na corroborate the Elliott theory of relaxation, and the Li results indicate resistivity-dependent relaxation time. No resonance was observed in bulk K, Rb, or Cs, carried to temperatures above their melting points.

46
AECD-3925
Experimental Breeder Project Report for the Period March 1, 1945 through January 31, 1950.
Lichtenberger, H. V., Argonne National Laboratory, Lemont, Illinois
Contract W-31-eng-38. March 13, 1950. Decl. with deletions Dec. 14, 1955. 31p.

This report covers the status of EBR constructions; measurements of Co^{66}, Na^{24}, 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-H_2O) 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.

47
Interatomic Potential Functions of Sodium and Potassium
Ling, Rufus C.
J. Chem. Phys. 25, No. 4, 609-13 (1956).

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

48
X-Ray Scattering by Liquid Metal Alloys (A Kinetic Approach)
Ling, R. C.
J. Chem. Phys. 25, No. 4, 614-616 (1956).

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.

49
The Wetting Properties of Solid Oxides and Carbides by Liquid Metals
Livey, D. T. and P. Murray
Plansee Proc. 1955, 375-404 (Pub. 1956)(In English)

By using a Pt-wound horizontal furnace, the contact angles between liquid metals and solid refractory oxides and carbides were measured photographically in vacuo and A. Nonreactive oxide-metal systems show nonwetting properties for metals of higher atomic number, such as Cu, Bi, Pb, and Sn. This is assumed to be due to the domination of the oxide surface by the large O anions and the resulting electronegative surface; repulsion thus occurs between the negative electron cloud of any nonreactive metal and the oxide surface. This interpretation is supported by the ready wetting of oxides by metals of low atomic number, such as MgO, exhibit a higher contact angle with a given metal than those with a ratio closer to unity (e.g., CdO). The contact angle of Ag on MgO, CdO, ZnO, and ThO_2 is 90° and remains invariant with temperature and time. The surface energy of UO_2 is estimated

from the experimental data as 510 ergs./sq.cm. at 1050°. The contact angle of Cu-Al alloys on UO_2 exhibits a maximum at the composition Cu_2Al at 1100°. The carbides are, in general, more readily wetted than the oxides. The relation between contact angle and radius ratio permits the estimation of the surface energies of ZrC, UC, TiC, TaC, and VC; the estimated values are, 1100°, 800 ± 250, 1000 ± 300, 1190 ± 350, 1290 ± 390, and 1675 ± 500 ergs./sq.cm., respectively. For oxides and carbides, the contact angles are lower in vacuo than in A. The work of adhesion is greatest for carbides of high surface energy such as TiC, TaC, VC and WC because of their better wetting properties.

50
Temperature Dependence of the Isotopic Effects on Passage of Current in Molten Indium Metal
Lodding, Alex, Arnold Lunden and Hans von Ubisch
Z. Naturforsch. 11a, 139-42 (1956). February. (In German)

At various temperatures direct current was conducted through a capillary tube of molten In whereby In^{113} was concentrated on the cathode and In^{113} on the anode. This so-called Haeffner effect showed a distinct functional relationship with temperature. The increase of the mass effect μ (10^{-5} at 210°; 6×10^{-5} at 820°C) with temperature was of the theoretical prediction of order of magnitude.

51
The Isotopic Effect of Passage of Current in Molten Potassium
Lunden, Arnold et al
Z. Naturforsch. 10a, 924-6 (1955). December (In German).

Direct current of 2900 A/cm density was passed through a 40-cm-long capillary tube with molten K for 14.8 days and K^{41} was formed on the cathode and K^{39} on the anode. The separation factor between the anode and cathode was 1.12, and the mass effect of $U \geq 9 \times 10^{-6}$.

52
Heat Transfer in Liquid Metals
Lykoudis, Paul S.
Univ. Microfilms (Ann Arbor, Mich.), Publ. No. 16478, 200pp.

Dissertation Abstr. 16, 936 (1956).

53
Selection of Canning Materials for Reactors Cooled by Sodium/Potassium and Carbon Dioxide.
McIntosh, A. B. and K. Q. Bagley
U. S. Atomic Energy Authority (Industrial Group), Calcheth, Lancs. England).
J. Inst. Metals 84, 251-70 (1956). March.

Theoretical considerations and experimental investigations indicate such metals as beryllium, zirconium, niobium, vanadium, tungsten, and molybdenum will be used for canning materials provides difficulties in extraction and fabrications can be overcome.

54
The Decay of Potassium 40
McNair, A. et al (Univ. of Glasgow, Scotland).
Phil Mag. (8) 1, 199-211 (1956), February.

The decay of K^{40} has been reinvestigated and values of the branching ratio, defined as the ratio of gamma or electron capture to beta transitions, have been determined by two methods, giving the values 0.124 ± 0.002 and 0.121 ± 0.004 respectively. The absolute beta and gamma decay rates and the half life have been measured, the value of the latter being $1.28 \pm 0.02 = 10^9$ years. A fresh determination of the gamma energy is described, and evidence as to the mode of decay is discussed. Finally, the results are given of experiments on the reflection of electrons by solid source supports.

55
Liquid Ammonia as a Solvent. XII. An Investigation of Metal-Ammonia Systems by Means of Their Vapor Pressures
Marshall, Philip R. and Herschel Hunt
J. Phys. Chem. 60, 732-8 (1956).

The vapor pressures of binary systems of Ca, Sr, Ba, Li, and Na with NH_3 were determined as a function of concentration and temperature. The compounds of Ca, Sr, and Ba in equilibrium with the metal contained nonintegral values of the NH_3/metal ratio of 5.67, 4.89, and 7.49 respectively at -63.8°. The activities of the NH_3 and the relative activity coefficients of the metals were calculated for the Li and Na solutions and compared with one another and to the corresponding values for K and Cs solutions calculated from literature data. The relative lowering of the fugacity was determined for each of the alkali metal solutions and compared with one another and with the ideal curves for 1-1 electrolytes and nonelectrolytes. The results were considered inconsistent with the uni-univalent electrolytic hypothesis generally given for more dilute solutions.

56
Lead-Sodium Alloy for Tetraethyllead Manufacture
Mattison, Edwin L.
U. S. 2,744,126. May 1, 1956.

A stream of molten Pb-Na alloy containing 9.9-10.1 wt. % Na is passed through an orifice in a quenching chamber. The resulting slurry contains 2-4 parts of EtCl per part of the alloy which forms a bright, solid particle of a uniform size up to 8-mesh. A well-defined induction period varying from 0.5 minutes at 90° to 20 minutes at 13° exists before the reaction between the alloy and the EtCl occurs. During this period, the alloy is separated from the EtCl or the slurry is transferred to a reactor in continuous operation for the manufacture of Et_4Pb.

57
Third Fluid Tube Sheet Hazard Test
Milich, W., E. A. Schultz, E. C. King and R. E. Lee
Mine Safety Appliances Company, Callery, Penna.
Contract NObs-65426. Memo Report 101. December 25, 1955. 9p.

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.

58
Corrosion of Low Alloy Steel in Hot NaK
W. Milich and E. C. King
Mine Safety Appliances Company, Callery, Penna.
Contract NObs-65426. Memo Report 109. March 30, 1956.

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 accomodate 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. % O_2. All results of the tests run isothermally at 850°F indicated a rate of attack less than one mil/yr.

59
γ -Radiation of Sodium-25
Nahmias, M. E. and T. Yuasa
J. phys. radium 17, 373-4 (1956).

Study of anomalies related to magic numbers led the writers to new experimental research of γ -rays emitted by Na^{25}, because some inaccuracies could have been introduced to previous experiments by the presence of γ -rays from Mg^{27}. Tests within the energy range of 270 e.kv. to 1.6 m.e.v. showed 3 γ -lines of Na^{25}: 370 $\pm$ 10 e.kv.; 580 $\pm$ 10 e.kv., and 975 $\pm$ 10 e.kv., with intensities of 1.8:1:0.74 respectively. Strong intensity ascribed by Maeder and Staehelin to the 3rd γ -line could be due to interference of the 1.01-m.e.v. line of Mg^{27}, possibly produced by $Mg^{26}(n, \gamma)$ near the betatron target.

60
AECD-4009
National Bureau of Standards Progress Report to the Atomic Energy Commission July 1, 1950 to September 30, 1950. Decl. Jan. 12, 1956. 31pp. (NBS-P-28).

Progress is reported on the ... heat capacities of Na-K alloys ...

61
Diffusion in Molten Metals. I. Diffusion Coefficient of Tin in the Lead-Tin System.
Niwa, Kichizo et al
Nippon-Kinzoku-Gakkai-Shi (J. Japan Inst. Metals) 18, 271-3 (1954).

Diffusion coefficients of Sn in molten Pb were measured in the temperature range from 450° to 600°. Since the concentration of Sn was chosen at a comparatively dilute value in the present investigation, the coefficients were estimated as constants

independent of the concentration. Thus, D = 0.0012 exp(-5,900/RT) sq.cm./sec. was obtained. This result showed that cations of Sn diffused in the molten Pb-Sn (Sn 10%) solution, because the activation energy of diffusion was of the same order as in the nonmetallic solutions. Finally, the theoretical value of diffusion coefficient, which was calculated roughly by the atomistic theory of diffusion based upon the intuitive free volume model in liquid, was compared with experimental results.

62
Determination of the Mean Free Path of Conduction Electrons in Potassium
Nossek, R.
Z. Physik 142, 321-33 (1955).

K atoms were condensed on a cooled (90°K) glass surface and the electrical cond. measured as a function of layer thickness. By assuning no electron loss by reflection at boundary surfaces the mean free path of the conduction electrons in K at 273°K was determined as 360 ± 20 A., by using the theory of Fuchs and Chambers. The exponential decline of the electrical resistance in the thickness region up to a monolayer was interpreted by the assumption of islands whose conductivity was affected by a tunnel effect. The temperature coefficient of the layers was always positive and varied between 2.5 and 6 x 10^{-3} per degree.

63
Self-Diffusion in Liquid Gallium
Petit, Jean and Norman H. Nachtrieb
J. Chem. Phys. 24, 1027-8 (1956).

Self-diffusion in liquid Ga at atmospheric pressure is described by the equation:

$$D = 1.07 \times 10^{-4} \exp\ (-1122/RT)\ \text{sq.cm./sec.}$$

At 30° the effect of pressure on the rate of self-diffusion is: log D = -4.7793 - 9.529 x 10^{-6}P (kg./sq.cm.). The activation volume at this temperature is 0.55 cc./g.-atom. Although the Stokes-Einstein radius agrees well with the ionic radius of Ga^{+++}, the temperature coefficients of viscosity and diffusivity differ somewhat.

64
Mine Safety Appliances Company, Callery, Penna. Progress Report No. 33 for Febraury and March 1956. W. J. Posey, ed.
Contract NObs-65426. April 9, 1956.

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 5 1/2-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 O_2 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 H_2O 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 H_2O.

65
Mine Safety Appliances Company, Callery, Penna. Progress Report No. 34 for April and May 1956. W. J. Posey, ed.
Contract NObs-65426, June 11, 1956. 77p.

Testing of the 3 Mw steam generator and leak plugging experiments were continued. The development of liquid metal system components (high temperature pressure gage and Na-heated evaporator) was outlined. The nitriding of stainless steel, tool steel, and Be in Na with N_2 cover gas was studied. The corrosive properties, heat transfer, and stability of isopropyl biphenyl under neutron irradiation were investigated; heat transfer properties of biphenyl were also studied.

66
Water-Reactive Alloy
Pfefferkor, Otto, T.
U. S. 2,731,342. January 17, 1956.

An alloy which reacts with water to produce energy is composed of Al, Li, and Na or K. A preferred composition having a high heat of reaction and a low melting point (near 350°F) is Li 74, Al 21 and Na 5%. The alloys are useful in the field of hydropropulsion, in compact steam generators, etc.

67
AERE-M/R-1889
Fission-Product Concentrations and Poisoning in a Homogeneous Reactor with Chemical Processing, March 10, 1956. 51p.
Porter, W.H. L. , Gt. Brit. Atomic Energy Research Estab., Harwell, Berks, Eng.

Tables and graphs are presented giving the steady-state fission product concentrations and total capture cross sections in the core of a homogeneous reactor for various rates of chemical processing. The results are as general as possible, otherwise they are detailed for the specified system of a liquid metal homogeneous reactor based on U dissolved in Bi. Estimates are also given of the rate of production of inert gases in the main circuit. The transient condition when the reactor is first started up is not considered.

79
AERE-M/TR-35
Inhibition of Liquid-Metal Corrosion
Taylor, J. W.
Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England
February 10, 1956. 9p. (MSWP-N/19).

From a consideration of the common mechanisms of liquid metal corrosion, additions to liquid metals which inhibit corrosion are classified as scavenging or diffusion-barrier types. Desirable characteristics of both classes of inhibitor are discussed and possible limitations to the zirconium nitride inhibitor, proposed for liquid metal fuelled systems based on bismuth, are considered. Suggestions are made for overcoming such limitations and it is recommended that surface layers of the metals molybdenum, tantalum, niobium and possibly beryllium be tested as alternative inhibitors of the diffusion-barrier type.

80
Inhibition of Liquid-Metal Corrosion
Taylor, J. W.
Atomic Energy Research Establishment (Gt. Brit.) MTN 35, 7 pp. (1956).

The use of a Zr nitride barrier inhibitor for Bi-U melt in Fe channels is discussed.

81
Conceptual Design for Internally Cooled LMFR
Teitel, Robert J. (Brookhaven Nat'l. Lab., Upton, N. Y.)
Nucleonics 14, No. 4, 72-7 (1956). April.

A conceptual design is given of the internally cooled, liquid metal fuel reactor which includes breeder and coolant functions in one stream. The design characteristics are also tabulated. Single-pass graphite heat exchangers were used in the design, and core size and the Bi-to-C ratio were determined by heat-transfer requirements. Fuel processing systems and the breeder-coolant system are also described in some detail.

82
Report No. 1 on 1000 KW System
Tidball, R. A., F. L. Mangold and S. N. Tower
Mine Safety Appliances Company, Callery, Penna.
Memo Report No. 49. October 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 flowmeter 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 flowmeter, 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,

89
KAPL-M-WW-2
Thermal Stress in a Beryllium Washer
Witzig, Warren F. and William A. Riemen
Knolls Atomic Power Lab., Schenectady, N. Y.
Contract W-31-109-eng-52. July 1, 1949. Dec. Feb. 8, 1956. 17p.

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 washer maintained its principle dimensions, but developed small radial cracks. There was a 2 mg. wt. gain despite obvious corrosion.

90
Intermetallic Compounds Between Lithium and Lead. II. The Crystal Structure of Li_8Pb_3
Zalkin, A. and W. J. Ramsey and D. H. Templeton
J. Phys. Chem. 60, No. 9, 1275-1277 (1956).

The compound Li_8Pb_3 has been characterized by a single crystal and powder x-ray diffraction data. It is monoclinic, space group C2/m, with a = 8.240, b = 4.757, c = 11.03 A., β = 104° 25', and Z = 2. There is a body centered cubic pseudocell with a = 3.364 A. and containing two atoms. The structure consists of ordered substitution in these sites in such a way that one-third of the Pb atoms have 8 Li neighbors each and two-thirds have one Pb and 7 Li neighbors each.