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LOS ALAMOS SCIENTIFIC LABORATORY
OF THE UNIVERSITY OF CALIFORNIA ○ LOS ALAMOS NEW MEXICO

QUARTERLY STATUS REPORT ON LAMPRE PROGRAM
FOR PERIOD ENDING NOVEMBER 20, 1960

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The following corrections should be made to LAMS-2487, "Quarterly
Status Report on LAMPRE program for Period Ending November 20, 1960:"

Page 5, line 9, the word falling should be changed to galling.

Page 10, line 6, the word stem should be changed to steam.

LAMS-2487
REACTORS - GENERAL
TID-4500, 15th Ed.

LOS ALAMOS SCIENTIFIC LABORATORY
OF THE UNIVERSITY OF CALIFORNIA LOS ALAMOS NEW MEXICO

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QUARTERLY STATUS REPORT ON LAMPRE PROGRAM
FOR PERIOD ENDING NOVEMBER 20, 1960

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All LAMS reports are informal documents, usually prepared for a special purpose. This LAMS report has been prepared, as the title indicates, to present the status of the LASL LAMPRE program. It has not been reviewed or verified for accuracy in the interest of prompt distribution. All LAMS reports express the views of the authors as of the time they were written and do not necessarily reflect the opinions of the Los Alamos Scientific Laboratory or the final opinion of the authors on the subject.

CHAPTER I

LAMPRE I

CAPSULE DEVELOPMENT AND PRODUCTION

Initial Core Loading

A decision has been made to begin fabrication for the initial core loading of LAMPRE I with capsules from the tantalum on hand. Further certification tests will be made to determine temperature limitations rather than the material for the first core loading. Fuel for the first loading will be the cast iron-plutonium alloy from LCX III capsules and will contain carbon and stabilizer. The difference between the 24 kg of LCX III fuel and that needed for the initial loading will be made up by pure iron-plutonium fuel with carbon and stabilizer added. Consequently, the next certification test will contain five capsules made from electron-beam melted tantalum containing 0.1 w/o tungsten with cast iron-plutonium fuel, and five with pure iron-plutonium fuel; all will have carbon and stabilizer additions.

Certification Tests. Certification tests (LAMS-2438, p. 15 and LAMS-2462, p. 2) using impacted and ironed capsules have been continued, and the results with capsules made from an arc-melted tantalum ingot containing 0.1 w/o tungsten have been consistently good. Occasional trace leakage, found only by alpha counting and sensitive autoradiographic techniques, have not prevented continued operation. Further exposure of these capsules has indicated that leakage has proceeded slowly and in some cases appears to have been arrested. Many of the capsules have shown no leakage after 2800 hr at 625°C.

Results obtained with capsules made from a beam-melted tantalum ingot containing 0.1 w/o tungsten have not been so encouraging. Annealed capsules only have resisted corrosion. A higher annealing temperature than that actually required for recrystallization has been found to be beneficial. Capsules annealed at lower temperature (1050°C) have been exposed at 525°C without leakage, but will not withstand operation at 625°C. Capsules annealed at 1200°C and at 1350°C have shown increased corrosion resistance.

Melt-Freeze Tests. Six LAMPRE-type arc-melted capsules with 0.1% tungsten in annealed condition were loaded with plutonium-cast iron fuel. In four capsules stabilizer was added to the fuel in two different concentrations. The vacuum furnace conditions were adjusted to provide at least a 25°C

differential along the capsule length, with the top being coldest. In this condition it is reasonably certain that the fuel would freeze from the top down, imposing the worst freeze-up condition on the capsule. During heating, the furnace temperature was such that the top of the fuel melted before the bottom.

After 12 controlled melt-freeze cycles, a malfunction occurred in the test equipment which caused the furnace to cool below the freezing point of the fuel and then to cycle through its melting point several times. Under these conditions the fuel must have frozen from the top down and melted from the bottom up, both "worst" conditions. During this period, both temperature and furnace vacuum were recorded, and from analysis of these records it appears that the capsules experienced at least four melts and four freezes. On the fourth melt, a coinciding pressure jump indicated capsule rupture.

After the run was shut down, and the furnace opened, the two capsules containing unstabilized fuel were found to have ruptured in the bottom section of the capsules. Considerable fuel was lost in both cases and was sprayed on the other four capsules. Dimensional measurements made throughout the experiment show that there is an advantage to adding stabilizer to the fuel, and the fuel specifications have been changed to incorporate the addition.

Capsule Production. Forty of the 110 capsules on hand for the initial core loading were delivered for a shakedown of the loading and handling procedures. The capsules were visually inspected and ten were rejected for the following reasons:

1. Cracks occurring at the mouth of the capsules; in one instance there was complete penetration of the wall.
2. Falling, resulting in a significant decrease in wall thickness.
3. Folds in the wall, usually at the top; however, one was found at the lower end with complete folding through the capsule wall.

REACTOR SYSTEM

Sodium System. Preheating of the system was started October 9, and filling accomplished on October 10. The system was filled with 300°C sodium and the temperature increased by the Calrod trace heating and the heating transformer. The temperature was raised to 475°C and on October 14 the sodium was returned to the dump tank. A plugging indicator run was made to test the purity of the sodium. As plugging was not observed at 115°C, it was decided the purity of the system was satisfactory and so it was refilled. Since the second filling the sodium loop has been run continuously at temperatures varying from 250°C to 540°C.

Capacity tests have been performed on the sodium pumps. Although one of the pumps can be run to over 200 amp with no noise, the other pump, at no flow through the first, starts getting noisy at about 120 amp. The maximum flow available was determined to be about 230 gpm before pump noise became objectionable. Immediately thereafter it was noted that the head developed between the reactor and surge tanks was excessive and the no flow limitation will be imposed by the pressure drop to less than 200 gpm.

A run was made at no flow with all power off the sodium system, with the exception of the hot traps, to determine the time available in case of a power failure. It was determined that from 450° to 400°C about 30 min were available. However, to drop the temperature until freezing of the sodium became a problem would require at least 6 hours.

A window of 0.060 in. stainless steel has been inserted in the pressure equalizing line of the cover gas system to permit monitoring for gaseous fission products.

Cover Gas System. The gas system has been operating satisfactorily during this phase of sodium shakedown. One shortcoming that has become apparent is that the addition of gas to the system is comparatively slow, the maximum addition rate being controlled by the small diameter tubing in the helium supply system.

The importance of maintaining heat on the piping, valves, etc., in the cover gas system, was demonstrated when the two motor-operated valves, or the adjacent piping, became plugged. The valves had been operating at temperatures below 100°C during the first week of operation and were open for long periods of time.

The first analysis of the cover gas, taken October 25, indicated a hydrogen concentration of 0.1 to 1% by volume. By flushing the gas phase, that is, by raising the pressure to 22 psig, venting to 2 psig, then repeating the process, the hydrogen concentration was markedly decreased. This procedure reduced the hydrogen content of the cover gas to as low as 100 ppm, but in time it would rise again to as high as 450 ppm.

Since it was felt that removing all of the hydrogen by this method would be a long and inefficient solution to the problem, it was considered that the system could be evacuated and continuously purged with a stream of high-purity helium. However, it was found that sodium vapor was plating out and oxidizing on the surfaces of the reactor in the region of the 10 in. slide valve. Although the hydrogen concentrations were lower, there was still a build-up comparable to that observed with the method described above.

There are also indications that a concentration gradient may exist from the sample point to the surge tank

gas phase. Observations have been made at 350° and 450°C of the rate of hydrogen build-up in the gas phase but no correlation of data has yet been made.

Core Thermocouples. Four of the 15 core thermocouples have been operating improperly since the sodium system was filled. The probable cause is a break in the sheath at the time of assembly. The four will be replaced as soon as new thermocouple rods can be fabricated.

Capsule Charger. The capsule charger has been operated to remove dummy capsules and insert tantalum capsules containing test coupons. This has been the first operation of the charger with sodium in the reactor (250° to 450°C).

The threads which attach the capsule to the lifting handle are completely filled with solidified sodium which must be sheared when the capsule is unscrewed. Torque presently available at the wrench is marginal for this operation (about 15 lb-in.), and will be increased by doubling the voltage on both the reference and control windings of the Brown motor and by optimizing the capacitance in the reference winding. The present drive gear ratio of 12 to 1 will then provide about 80 lb-in. at the wrench. (Approximately 350 lb-in. torque would be required to shear the 5/16-18 thread.)

All flat gaskets on the Lucite windows of the capsule charger have been replaced with O-ring seals. Several

small leaks were found in gaskets by helium leak detection and have been repaired.

One dummy capsule was transferred to a steel container filled with mercury as a means of sodium removal from the capsule surface. No reaction was observed as the capsule was lowered into the mercury. The only sodium remaining was on the threaded section above the mercury level. A sodium-mercury amalgam was formed on the capsule which was considerably less reactive with air or water than metallic sodium.

FUEL STORAGE FACILITY

All sleeves have been installed and the concrete forms are 90% complete. Pouring of the magnetite concrete will commence on November 22. To date, the construction is 4 days behind work planning schedule.

CHAPTER II

SODIUM TEST FACILITY

OPERATING EXPERIENCE

Summary

The 2000-kw Sodium Test Facility, including the test stem generator, was operated continuously during the report period from August 20 to November 20, except for 159 hours of shutdown required for maintenance of auxiliary steam system equipment. No maintenance has been required on the steam generator or on any of the sodium system equipment. As of November 20, the following total running hours have been logged on major items of equipment:

<u>Item</u>	<u>Total Operating Time (hr)</u>
Steam Generator	3503
Intermediate Sodium Heat Exchanger	5155
Primary Loop Sodium Pump	5155
Secondary Loop Sodium Pump	5980

Gas-Fired Sodium Heater	4543
Sodium Cold Trap System	6068
Air-Operated Sodium Flow Control Valves:	
Primary Loop (two valves)	5155
Secondary Loop (two valves)	5980

Steam Generating Unit

The steam generating unit has been operated satisfactorily at load level ranges from 1000 kw (50% of design) to 2000 kw (100% of design). Some instability has been observed in the unit when operated at less than 50% of design load rating and at full pressure and temperature of 890 psig and 925°F. This instability is exhibited by fluctuating steam flow resulting in pressure and temperature transient conditions. At less than 50% of design load, a marked difference exists between superheated steam temperature out of the top and bottom tubes in the evaporator steam outlet header. Thus, it has been observed that the steam coming from the top tube has often been as high as 75°F higher than steam from the bottom tube. This low-load instability phenomenon will be given further study during the proposed cycle testing program and the results of such study will be presented in a future report.

Intermediate Sodium Heat Exchanger

Operation of the intermediate sodium heat exchanger has continued to be entirely satisfactory.

Centrifugal Sodium Pumps

Operation of the centrifugal sodium pumps has been satisfactory; however, the lubricating oil leakage rate through the primary pump shaft seal has increased during the past 2200 operating hours from about 2 cc/day to about 6 cc/day.

CHAPTER III

RESEARCH AND DEVELOPMENT FOR THE LAMPRE PROGRAM

DIRECT CONTACT CORE DEVELOPMENT

General

The components of a direct contact core are the critical region, which is a nearly structureless container; the pump, in which momentum is transferred to the fuel and heat is transferred to the sodium; and the separator, in which the two phases are collected into different outlet channels. Experimental work so far has been limited mostly to the pump. For this component two general types are available: the lift pump and the jet pump. The lift pump operates by injection of sodium into one leg of a fuel loop, producing a difference of density and hence of head between the two sides of the loop. The jet pump produces a head difference in the fuel loop by direct momentum transfer to fuel from sodium.

Mercury-water flow systems have been set up and are being operated to study both lift and jet pumping. An

important objective of these tests is the measurement of the particle size of the dispersed mercury phase under varying conditions by means of flash photography. As anticipated, it was found that the higher turbulence of the jet pump produced smaller particles of mercury. It might be expected that nozzle arrangements and velocities could be found which produce flow partly by density difference and partly by momentum transfer. This was verified experimentally, and a smooth transition between the two types of pumping was obtained. There appears to be a useful range of mixed stream velocities near 15 ft/sec in which highly effective pumping is obtained without producing extreme subdivision of the mercury. The latter effect is to be avoided if possible since it might make the separation of the dispersion too difficult.

The apparatus recently completed for pumping studies allows a wide and rapid change of nozzle arrangement and flow conditions. A preliminary series of nozzle experiments is now under way, to be followed by a more thorough investigation of the most promising types.

The phase separation step has been under consideration, but very little experimental work has been done. At the extremes, gentle lift pumping has been shown to produce mercury slugs which disengage rapidly without producing

dispersions, whereas at velocities of about 20 ft/sec a single right angle turn will centrifuge most of the mercury out of the mixed stream. The remainder, however, is present as an unrecoverable fog. Parameter studies have shown that a high-performance, direct contact core must use jet pumping and some form of centrifugal separation. There is considerable temptation to prefer the milder conditions of lift pumping for the earlier versions, but there are two factors which may make this a poor choice. One is the greater uncertainty in the location of the active material in a lift pump, and the other is the possible formation of stable fuel-sodium emulsions. Emulsions could be broken by centrifugal separators, but not by a simple settling basin.

Fuel Pumping Experiments

A second fuel pumping experiment using cobalt-cerium-plutonium fuel was set up and tried without success. An internal leak or blockage of the circuits was suspected, but the available diagnostic instruments could not identify the fault, so the equipment had to be shut down without operation. A third version is now being built. Larger scale experiments are planned using cobalt-cerium eutectic liquid without plutonium. Compatibility experiments using plutonium will be confined to a small scale for the present.

FUEL ALLOY DEVELOPMENT PROGRAM

Effects Of Additives To Plutonium-Iron Fuel

The beneficial effects of carbon addition have been confirmed, but there is now evidence that the temperature of exposure must be high enough to convert graphite to plutonium carbide in order to provide protection to the capsule, unless PuC is added instead of graphite. There is also evidence that carbon added at the plutonium reduction step is not effective.

The presence of calcium or magnesium in the fuel has been shown to be strongly detrimental to the tantalum container, even in the presence of carbon. These impurities should be excluded as much as possible from future lots of fuel. Aluminum and especially silicon have proved to be beneficial as fuel additives. Further tests are under way to verify these indications.

A layer of sodium on top of the fuel in the capsule gave very good results in one test, and poor results in another. The inconsistency is not yet understood, and more tests are to be made.

Good correlation continues to be obtained between metallographic observations and the bend test results. This has made it possible to reduce the number of metallographic examinations of samples by eliminating many of those which are revealed by the bend tests to be strongly attacked. Autoradiography, however, while effective in revealing actual

leakage, has not been found reliable in indicating the extent of attack unless complete penetration has occurred. Several samples that were examined autoradiographically showed no evidence of attack, but metallographic examination revealed that they had suffered severe penetration.

Other Fuel Alloys

Binary fuel alloys made of plutonium with manganese and with osmium both performed relatively better than high purity plutonium-iron. The possibility of dilute fuels of this type will be investigated.

Plutonium-Cerium-Cobalt Alloys. The liquidus valley of the low plutonium, high cerium corner of the Pu-Ce-Co ternary diagram has been mapped. The alloy compositions at the lowest melting points are as follows:

<u>Atomic Percent</u>			<u>m.p. (°C)</u>
<u>Pu</u>	<u>Ce</u>	<u>Co</u>	
0	70	30	423
20	56	24	432
30	45	25	442
40	35*	25*	442*

* Incomplete data.

X-ray investigation has revealed the existence of three ternary compounds, designated as phases A, B, and C, in the plutonium-cerium-cobalt system. Phase A is found in

alloys having compositions in the range from 25 to 35 a/o cerium and from 25 to 30 a/o cobalt. Phase B occurs in alloys containing from 40 to 50 a/o cerium and 30 a/o cobalt, and phase C in alloys having compositions in the vicinity of 10 a/o cerium and 40 a/o cobalt.

Metallographic examination of thermal analysis specimens has revealed that cerium is the primary phase in alloys lying on the cobalt-poor side of the liquidus valley in the range of 0 to 70 a/o plutonium, and that slow rates (about 1°C/min.) of heating and cooling such alloys result in the segregation of cerium at the top of the melt. It is conceivable that once the cerium has segregated it might be difficult to redissolve it at temperatures below its melting point (804°C). This condition may be an important consideration in selecting alloy compositions for use as reactor fuels. Thus it would seem advisable that alloys precipitating primary cerium be avoided in favor of alloys having compositions that are richer in cobalt; i.e., containing about 2 a/o more cobalt than those at the bottom of the valley.

Although complete information concerning the phase relationships on the cobalt-rich side of the liquidus valley is lacking, it is believed that no segregation problem would exist if the cobalt content were kept low enough to avoid the

formation of primary (Pu, Ce) Co₂. A very small amount of (Pu, Ce) Co₂ has been observed in alloys containing 30 a/o cobalt and 10, 15, and 20 a/o plutonium, but none has been seen in alloys containing 30 a/o cobalt and 30, 35, and 40 a/o plutonium. The melting points of phases A and B, which are primary in the latter alloys, have not yet been determined accurately but existing data indicate that they lie at temperatures below 500°C.

Plutonium-Cerium-Nickel Alloys. Four plutonium-cerium-nickel alloys, all containing 80 a/o plutonium, have been examined by means of thermal analysis, x-ray, and metallographic methods. The results have not revealed many details of the 80 a/o plutonium isopleth, mainly because of the complex behavior of these alloys in which the $\delta \rightarrow \epsilon$ transformation changes from a eutectoid to a peritectoid reaction as cerium replaces nickel, but sufficient information has been obtained to establish the location of the liquidus valley. The bottom of the valley occurs at 473°C and at 80 a/o plutonium-5 a/o cerium-15 a/o nickel. An alloy of this composition is completely solid below 455°C.

Alloy Production

In addition to the production, fabrication or encapsulation of certain of the alloys listed in LAMS-2438 (p. 50), required for fuel applicability and corrosion testing,

procedures were developed for the preparation of Pu-8.5 w/o Os, Pu-49 w/o Ce- 10 w/o Co and Pu-44 w/o Ce-10 w/o Co alloys.

CONTAINER MATERIAL DEVELOPMENT PROGRAM

Fabrication

LAMPRE I capsules have been fabricated by two methods: 1) deep-drawing sheet through 13 stages, and 2) impact-extruding a rod-slug into a starting cup followed by six ironing stages. The second process has been adopted for production items as it requires fewer operations and conserves material.

All fabrication steps are performed at room temperature, with an intermediate anneal prior to the first ironing stage and a stress relief treatment after the fourth impact stage. For various tests capsules have been used in the final as-drawn condition and in the fully annealed condition.

Factors Influencing Corrosion

The data from corrosion studies have given somewhat ambiguous results, and it is not clear what factors are the prevalent ones influencing the test results. Materials which have been corrosion tested as fabricated capsules include arc-melted and electron-beam melted high-purity tantalum and Ta-0.1 w/o W alloy. Corrosion tests are in progress on experimental deep-drawn capsules made from Ta-0.1 w/o W - 0.2 w/o Y.

Yttrium has been added to tantalum during melting to act as a scavenging agent, but although the Y addition is reduced from 0.2 w/o to <40 ppm during melting, analyses of three ingots, K588 (0.1 w/o W), K589 (0.1 w/o W + 0.2 w/o Y), and K590 (0.2 w/o Y), do not show an appreciable reduction in C, N₂, H₂, or O₂. It has been found, however, that the residuals in the ingot having the yttrium addition increase the temperature of recrystallization some 200°C above that required to fully anneal the Ta-0.1 w/o W alloy. The effect of yttrium on the recrystallization temperature has been confirmed by several studies made to substantiate the first experience. Precisely how the effect is produced by <40 ppm yttrium is not known; but that this small quantity effectively inhibits recrystallization seems quite definite.

The arc-melted capsules have demonstrated definitely superior corrosion resistance to LAMPRE I fuel, both in the annealed and as-worked condition, and some difference in the metallographic structure is also apparent in that the beam-melted tantalum appears cleaner.

Since the presence of yttrium in the original arc-melt was the only known variable present, some small ingots have been prepared at Los Alamos to test the significance of yttrium addition, even if it is not retained in observable amounts in the final ingot. The three ingots, made by

consumable electrode arc melting, are listed below, showing the additives present before melting. In each case the tungsten was fully retained, and the yttrium removed.

<u>Alloy</u>	<u>Lowest temp. for complete recryst. in 1 hr</u>	<u>As-rolled DPH</u>	<u>Annealed DPH</u>	<u>Grain Size, (Microns)</u>
K588 (Ta-0.1% W)	1100°C	189	88.6	18
K589 (Ta-0.1% W-0.2% Y)	1300°C	199	103	13
K590 (Ta-0.2% Y)	1200°C	184	94.2	18

The effects on hardness and recrystallization temperature from yttrium addition appear to be additive to similar effects from tungsten addition. The superior corrosion resistance has not yet been verified from the ingots listed above, but the large number of tests made with the capsules prepared from similar tantalum and the good performance of the coupons from button ingots are strong evidence that a beneficial effect exists.

Tantalum-Tungsten Alloys

Early compatibility studies in the search for a metal which could contain molten plutonium for long periods of time pointed to W as a possibility. The difficulty of fabricating W seemed to preclude its use to form the LAMPRE I

capsule chape. To realize some benefit from the corrosion resistance of W, additions of this metal to Ta have been made. Alloys having the nominal compositions Ta-0.1 w/o W and Ta-1.0 w/o W have received attention.

In fabricating these alloys, it has been found that the increase in tungsten content from 0.1 w/o to 1.0 w/o increased the force required to impact-extrude the starting cup from a rod-slug by some 10 to 20%. The Ta-1.0 w/o W-0.2 w/o Y alloy has been fabricated successfully into LAMPRE I capsules by deep-drawing sheet and by impact-extrusion and ironing. Corrosion tests on an experimental lot of Ta-1.0 w/o W-0.2 w/o Y alloy capsules are under way.

Consideration of other designs for succeeding LAMPRE reactors requires that a study be made of various tantalum base metals in respect to forming and joining properties. Ingots have been vacuum arc-cast containing tungsten in various amounts up to 10 w/o. Tantalum containing other elements, i.e., Hf, Th, Y, either alone or in combination with tungsten, has been arc-cast into ingot and processed into sheet. The sheet is under test to determine proper annealing time and temperature to secure recrystallization, drawability as indicated by the cup test, procedures by which the sheet can be fusion welded, resistance welded, or joined by other means, and tensile strength properties. The several materials will be examined metallographically to see if the various element additions influence structure.

Results are available from preliminary annealing tests on 0.150-in. thick plate for ingots K591 (Ta-0.5 w/o W), K592 (Ta-6.0 w/o W), and K593 (Ta-0.2 w/o Hf). These are given in the accompanying table.

<u>Sample No.</u>	<u>Annealing Temp. and Time</u>	<u>% Recrystallized</u>	<u>Hardness DPH</u>
K591-1	1300°C for 1 hr	100	94
K592-1	1300°C for 1 hr	60	205
K593-1	1300°C for 1 hr	90	105
K592-2	1400°C for 1.5 hr	100	169
K593-2	1400°C for 1.5 hr	95	100

Plate from these billets will be rolled to 30-mil sheet for additional annealing tests, cup tests, tensile tests, and welding tests.

Tantalum with 10% tungsten is available commercially, and can be obtained principally as rolled sheet or cast bars. Deep forming methods are not suitable for this alloy, but shapes obtainable by bending and welding sheet would be suitable for large versions of LAMPRE using direct contact. One LAMPRE size capsule has been made from this alloy and is now under test. The longitudinal weld necessary turned out to be sound and easy to make. No corrosion information is yet available.

Internal Flow Baffles

The direct contact core concept will require internal flow baffles in addition to overall container material. Such baffle material need not be completely impervious nor thermally conducting, and could be made of ceramic. Several ceramic bodies shown to be resistant to plutonium melting operations are being prepared for test. The first tests will be with static fuel, but an apparatus is being constructed which will allow high-velocity impingement testing with molten fuel. An entirely new series of container tests will be initiated using the dilute fuels of interest for the direct contact cores. This work will begin as soon as an improved LAMPRE I capsule is obtained and tested.

An X-Ray Method For Hafnium In Tantalum

An x-ray fluorescence spectrographic method was developed for determining hafnium in Ta-Hf and Ta-W-Hf alloys. Chemical separation of the elements in solutions of the samples is not required. Coefficients of variation of 7.9, 1.8, and 0.9%, respectively, were found for 0.1, 1.0 and 10% of Hf.

FUEL PROCESSING

Work is in progress for the development of a solvent extraction method for the recovery of plutonium residues from various pyrometallurgical processes. The solvent under

study is a mixture of a secondary amine (LA-1) and tetrachloroethylene (TCE). Further experiments directed toward the elimination of solids formation and gassing has shown that either TCE or Gulf Solvent BT (GBT) are acceptable diluents from this standpoint if low-acidity, high-nitrate feed solutions are utilized, e.g., 2M acid and 6.5M total nitrate. Acidities in the range of 4M, at 6.5M total nitrate, appear to be the worst condition with respect to solids formation. Batch equilibration studies with the low-acidity system have shown the TCE solvent to be superior to GBT in the respect that extraction coefficients are higher for plutonium, settling times are faster, and no third liquid phase formation takes place. TCE is also attractive since it is nonflammable.

Continuous countercurrent extractions with the low-acidity and TCE systems have shown that plutonium extraction is excellent but that stripping efficiency is not exceptional. A continuous run with the same system using a feed spiked with neutron-irradiated plutonium indicated that cleanup of fission products is essentially complete with the exception of zirconium and niobium which are carried into the product stream in considerable quantities.

CHAPTER IV

CORE TEST FACILITY

The Core Test Facility as now planned is a flexible plant capable of testing molten plutonium fast reactor systems in the 1 to 20 thermal Mw range.

It is now generally agreed that the facility will include the following features:

1. Two steel-clad reactor cells, below grade.
2. One steel-clad room, below grade, for all radioactive sodium equipment, including a 5 Mw and a 15 Mw loop in parallel.
3. One steel-clad room for processing reactor cover gas.
4. One steel-clad room for the disassembly of reactor systems. Space will be provided in which complete core systems can be dismantled. Only the bare essentials will be included in the initial CTF design. Machinery to do specific jobs will be designed later as individual needs arise. This room will also provide pits for the long-term storage of

contaminated or activated components. Only gross disassembly and storage of reactor systems is planned for this cell. Detailed examination of components will be carried out in other LASL facilities now under construction (Wing 9, CMR Building).

5. One steel-clad room for integral fuel cycle experiments.

6. Space both inside and outside of the main structure for non-activated sodium components, including the air-cooled heat exchangers.

7. A control room integral with the facility.

8. Necessary change room, mechanical equipment spaces and access alleys.

In order to simplify the containment problem and minimize hazards from sodium leakage, a nitrogen (up to 2% oxygen) atmosphere will be maintained in the reactor cells and the radioactive sodium room. Atmospheric requirements in the other steel-clad rooms are not yet established.

The CTF construction will be broken down into two phases. Phase A includes the basic structure with associated utilities, ventilation equipment, and site preparation. Shielding, the disassembly cave and storage facilities will be included to the extent that design criteria can be established. For Phase A an Architect-Engineer (A-E) will be engaged to do the Title I,

II, and III design work and construction will be by a general contractor on a fixed price bid.

Phase B will comprise the remainder of the facility, including all parts of the sodium system, blanket, reflector, and control elements, and instrumentation and fitting out of the control room. It will be designed and Title II drawings prepared by the LASL. It is expected that specific design contracts with outside firms might be used to expedite the work. Construction work under Phase B will be by Los Alamos Constructors, Inc., with supervision and proof testing by the LASL.

All present efforts are being directed toward establishing design criteria for Phase A. General arrangement of the building has now been accepted and drawings suitable for use in selecting an A-E are being prepared. It is expected that an A-E will be selected early in 1961.