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TO: J. C. Stearns
FROM: Methods and Materials Section
DATE: November 7, 1944

A memo was written (MUC-JC-162) to Mr. Allison describing a general program of metallurgical, fabrication, and physical studies which ought to be carried out as intensively as possible starting immediately, in order to provide information for the design of efficient methods of using atomic power. This present memo becomes more specific in mentioning lines of work which the Methods and Materials Section believes to be of importance. It also tells names of people and places where useful equipment is available. The studies may be divided into 5 parts:

I. Phases of Special Metals and Their Alloys
II. Fabrication
III. Corrosion
IV. Heat Transfer and Fluid Flow
V. Special Physical Tests

I. Phases of Special Metals and Their Alloys (Written by E. Creutz and J. Gurinsky)

At the present time it appears that this work could be conveniently divided into alloys of uranium, beryllium, and thorium. Uranium alloys of particular promise whose phase diagrams should be completely and thoroughly studied are U-Mo, U-Cb, U-Si, U-Zr, U-Be, U-Ta, U-W, U-Pt, and U-Th. The physical properties of at least the stable phases should be thoroughly understood. This should include not only the usual mechanical measurements but electrical, thermal, and magnetic properties. A study of the magnetic susceptibilities might lead to discovery of "invar" uranium useful in internally cooled uranium systems. A study of diffusion phenomena of these alloying elements into uranium should be made in an attempt to find methods of applying them for surface protection.

Be systems of particular interest will include Be-O, Be-Zr, Be-Th, Be-Ti, and Be-Si. Possible deoxidizers of interest should include Si, P, Li-Ca mixtures, Na, and Th. Reduction and purification methods for the metal should be sought and the usefulness of distillation should be determined. Snedding's work on Be reduction and casting and Chipman's casting research at M.I.T. should be encouraged by assigning higher priority to this work. A study of the physical properties with special reference to malleability should be carried out. Work on the electrodeposition from non-aqueous solutions and molten salts should be continued. The work on Be plating of copper at Westinghouse should be followed closely.

Thorium alloys should be sought both with lower melting point (to provide easy casting) and with higher corrosion resistance. Interesting possibilities are Th-Zr, Th-Al, Th-Si, Th-Pb, and Th-Bi.

Work on these alloy phases should continue at Chicago, Bureau of Standards, M.I.T., Ames, Battelle, Y-12, and Y. Work should also be promptly commenced at Metals Research Laboratory at Carnegie Institute of Technology under the direction of R. F. Mehl, as suggested in MUC-JC-162. This will require an extention of an already existing contract. The work at that laboratory should be correlated with the general program by F. Seitz, whose other interests keep him in contact with both laboratories.

II. Fabrication (Written by E. Creutz and J. Gurinsky)

Casting work should include the development of satisfactory crucible materials for all of the metals of interest. Vacuum, centrifugal, and special atmosphere casting

uld be investigated, especially in the case of Be. The use of Be carbide as a liner as an entire crucible should be examined.

Hot and cold working methods should be extended to the alloys and adapted to existing commercial equipment insofar as possible. Extrusion work at Wolverine Tube Division, Detroit, Michigan (J. F. Schumar or J. S. Rogers) should be continued. The availability of the extrusion press ordered by the Bureau of Mines at Ottowa, Canada (contact W. W. Watson at Montreal) should be investigated. Presses already used by the Project at B and T Metals in Columbus, Ohio (M. S. Smith), Revere Brass and Copper in Detroit (F. N. Todt), Aluminum Company of America at New Kensington (F. J. Fletcher or F. R. Marshall), and Extruded Metals Company at Grand Rapids, Michigan (Curt Ziehm) should be kept available. Hot piercing equipment is available to the Project at Wolverine and probably at Globe Steel Tubes in Milwaukee (H. K. Ihrig or H. A. Hoffman). Cold rolling facilities which have been used on uranium exist at Westinghouse in Bloomfield, New Jersey (J. W. Marden), Callite Tungsten Company, Union City, New Jersey (M. Fox), Site Y (Cyril Smith), and National Bureau of Standards (T. R. Thomason). Hot rolling work has been done at Joslyn Manufacturing and Supply Company, Ft. Wayne, Indiana (L. G. Fry). Facilities have been offered for our use at Conmerweld Company, Glassport, Pennsylvania (L. Whitney). This company has had particular experience in rolling compound billets. Forging of special metals has been done for the Project at Dow Chemical Company, Midland, Michigan (W. Loose), and Westinghouse at Bloomfield (J. W. Marden). Drawbench equipment is available at Wolverine, Extruded Metals, Globe, Alcoa, and Commerweld (experimental hot drawing equipment available). Light walled stainless steel has been made for the Project by Sumneril Tube Company, Bridgeport, Pennsylvania (A. S. Williamson). Experiments should continue with the "self-lubricating draw die" along lines already discussed with Mr. Chapin. [Deep drawing of sheet has been done at Midwest Manufacturing Company, Galesburg, Illinois] (S. S. Battles), and equipment is available at Dow, Westinghouse at Bloomfield, and Site B. Swaging equipment is available at Bureau of Standards, Westinghouse at Bloomfield, and at the Armory. [Tube reducing machines could be used at Tube Reducing Corporation, Wallington, New Jersey (J. B. Coe).]

Welding techniques for new alloys as well as for Be and Th should be developed. The high frequency brazing technique for aluminum should be further investigated. Powder-forming should be applied to the making of extrusion and forging billets, for instance, of beryllium and thorium. The making of rods and tubes of refractory metals by the "continuous powder press" has already been discussed with Mr. Chapin. Equipment for this is available at Site B. Hydrostatic pressing, in use at Westinghouse, the Armory, and West Stanis, should be further explored.

Special requests for fabricated articles have come frequently in the past not only from the Chicago Project but also from Berkeley, Wilmington, and Sites X, Y, and W. It is very important in the interest of the project that a group be available, for instance at Chicago, to attempt new methods of fabricating specific articles requested by these other parts of the Uranium Project. Many of these requests come through Sgt. Rodin of the Special Materials Section. Another type of special request is that which comes from the theoretical group. Since the fulfilling of these requests will frequently lead to the development of entirely new ideas in fabrication and use of materials for the atomic power work, they should be given the most prompt attention and pursued with vigor. To aid in the correlation of the theoretical group with those actually carrying out the fabrication, it is highly important that a person conversant with both fields (for example, F. Seitz) should be very active in the direction of this work. One purpose of the Methods and Materials Section in the past has been to act as consultants with various members of the Project to aid in finding sources of materials and special equipment. Such a group should continue to exist and should remain in close contact with the shops, so that it can suggest and follow up special machining procedures.

III. Corrosion (Written by N. Goldowski)

Project studies on the corrosion of metals have been conducted under such pressure that only particular problems were considered and no general study has been undertaken.

Tube Reducing - NLC - Date ?

TECHNICAL DIVISION BIMONTHLY TOPICAL SURVEY

TUBE FORMING PROCESSES

The present practice for producing hollow uranium fuel elements is to drill solid bar stock which has been cast and then rolled. Although this technique has been improved in efficiency and unit cost, still further cost reductions in fuel fabrication represent the motive for development of tube forming processes. The competitive position of existing industrial tube forming processes supports the belief that a variety of hollow fuel element cores can best be fabricated via this route.

The feasibility of producing tubing by several methods is under investigation at the National Lead Company of Ohio. Basically these methods involve the reduction and elongation of hollow feed stock by one or more forming operations. Hollow stock is provided by static casting or horizontal centrifugal casting. The latter method involves the casting of long tubes in a horizontal mold which is rotated during pouring. This process has been demonstrated at the Oregon Metallurgical Corporation in Albany, Oregon, under the auspices of National Lead Company of Ohio.

Tube forming methods under study include the Roto-roll, Hamiroll, Assel Mill, and reducing mill processes.

Tubes have been "Roto-rolled" at the Tube Reducing Corporation in Wallington, New Jersey. This process utilizes semicircular,

taper-grooved dies which are rocked back and forth along a tube to compress the metal against a tapered mandrel. The outside diameter, inside diameter and wall thickness of the tube are reduced by this action. Although Roto-rolled uranium tubing exhibited some OD and ID cracking, the feasibility of the process was shown. However, more work is required to demonstrate its production capabilities.

Cast hollow billets have been Hamiroll swaged under a National Lead Company of Ohio contract at the Watertown Arsenal in Watertown, Massachusetts. Such a machine utilizes four dies which reduce tubing by hammering against a solid mandrel. Scoping results revealed good tube surfaces and generally close dimensional control. The process warrants further investigation.

Rolling on an Assel tube mill is being evaluated as a major step in the fabrication of uranium tubing. During Assel mill rolling, hollow billets are elongated and reduced over a mandrel by three rolls aligned at a skewed angle. An assel mill test has been conducted at the Westinghouse plant in Bloomfield, New Jersey. Results indicated the feasibility of this process although further development is required.

The testing of a reducing mill is being formulated. Such a mill employs a series of rolls through which hollow stock is passed. This process has the advantage of rolling to close