INTRODUCTION

The purpose of this research program is to ascertain the production tooling and the proper process sequences for prototype production of 0.005-inch-diameter beryllium wire and thin-wall Ti-6Al-4V titanium-alloy tubing in sizes ranging from about 1/4 to 1-inch OD. The production technique to be used will be hydrostatic extrusion-drawing. This Battelle-developed technique*, called HYDRAW, consists of applying a hydrostatic pressure to the unreduced stock while simultaneously applying a controlled drawing stress at a predetermined drawing speed.

Present-day conventional techniques for producing beryllium wire and titanium tubing are quite costly. The results obtained in an earlier program[1]** at Battelle on Air Force Contract No. 33(615)-1390 indicate that the techniques outlined for this program offer the prospect of reducing fabrication costs substantially as well as possibly improving product quality. The current program is divided into three phases, each subdivided for beryllium wire and seamless Ti-alloy tubing with the following general objectives:

Phase I

Part (a). To establish the various parameters which affect the hydrostatic extrusion-drawing of fine beryllium wire and seamless titanium tubing with existing tooling.

Part (b). To design and construct prototype production tooling for extrusion-drawing of beryllium wire and titanium tubing for the Phase II effort.

Part (c). To establish the various die design parameters which influence the hydrostatic extrusion of brittle materials without the use of a fluid counter-pressure system.

Phase II

To ascertain the processing techniques and conditions necessary for producing high-quality, 0.005-inch-diameter beryllium wire and aircraft-quality Ti-6Al-4V tubing with the prototype production tooling.

Phase III

To produce a sufficient quantity of the beryllium wire and titanium tubing to verify the processing sequence and to enable evaluation by users.

* U. S. Patent No. 3,328,998, "High Reduction Drawing", A. M. Sabroff and R. J. Fiorentino, Issued July 4, 1967.

** References given at end of report.

The design and construction of tooling for extrusion-drawing of beryllium wire [in Phase I, Part (b)] is being funded independently by Battelle-Columbus. However, in the interest of furthering the tooling design technology developed in the past program[1], complete details of the proposed tooling design are included in this report.

During this first quarter much of the effort was devoted to procuring the equipment, materials, and tooling necessary to conduct the process parameter investigations. In addition, the design specifications for the 7-inch-bore container to be used in the Phases II and III efforts on beryllium wire, have been completed. A preliminary design analysis of the side-bore container which might be used for the Phases II and III efforts on titanium tubing has been conducted.

HYDRAW STUDIES

The Phase I process parameters studies on the HYDRAW of both beryllium wire and titanium alloy tubing are to be conducted in tooling constructed for the Air Force Materials Laboratory on Air Force Program No. AF 33(615)-1390. This tooling, which is described in detail in Reference (1), has a design pressure capacity of 250,000 psi on a bore 2-3/8-inch diameter x 20 inches long. The chamber volume is adequate for handling sufficient quantity of material for the evaluation of the initial process variables. Preliminary details of the design of prototype production containers for the Phases II and III effort are given later in the report.

HYDRAW of Beryllium Wire

Experimental trials on the HYDRAW of beryllium wire are soon to be conducted. In an earlier program[1], beryllium wire was hydrostatically extrusion-drawn from 0.020 to 0.0124-inch diameter (a reduction of 60 percent) at a speed of about 40 fpm. In the forthcoming trials, the following parameters will be evaluated:

(a) Lubrication. In an earlier program only one wire lubricant, PTFE, was evaluated. This was quite satisfactory but several wire lubricants are now to be evaluated with the aim of possibly improving lubrication efficiency and reducing the cost of application and removal. Initially, the selected wire lubricants will be evaluated at a reduction of 60 percent.

(b) Reduction ratio. Dies have been ordered which will enable reduction of 60, 70, 75, and 80 percent. Data obtained in another program have indicated that reductions up to 80 percent are possible within the available pressure capacity, providing efficient lubrication can be obtained.

(c) Temperature. Workpiece temperatures lower than the presently established 500-550 F range will be used to determine their effect on pressure requirements and material properties.