CENTRAL RESEARCH LABORATORIES
AIRCO, INC.
MURRAY HILL, N.J. 07974

MASTER

FINAL REPORT ON WORK DONE UNDER
LLL P.O. # 3964609

PREPARED BY: CARY SPENCER

SEPTEMBER 21, 1979

DISCLAIMER

[illegible]

SU-79-108

FINAL REPORT ON WORK DONE UNDER

LLL P.O. # 3964609

Prepared by: Cary Spencer

September 21, 1979

INTRODUCTION

Two second extrusion billets have been processed as agreed upon in Lawrence Livermore Laboratories' (LLL) P.O. # 3964609. One billet was an HFTF monolith design conductor and the other was an alternate design from which cable strands could be made. We describe the results of the work done on these billets.

Previous work done under LLL P.O. # 3237409 yielded a 187 filament extrusion 38.1 mm o.d. in 3 pieces: 4.0 m, 3.4 m, and 2.5 m in length. This first extrusion material was drawn to 16.5 mm o.d. and divided equally into two lots: one to be processed into a 1777 hex second extrusion billet and the other to be processed into an 85 hex second extrusion billet. The extruded Teledyne Wah Chang Albany (TWCA) niobium filaments were measured to have a UTS of 338 MPa (49 ksi), a yield strength of 241 MPa (35 ksi), and a microhardness of 126 knoop. No signs of filament nonuniformity were observed in the extruded material after the first extrusion.

1777 HEX SECOND EXTRUSION

One half of the 187 filament billet was drawn to 3.45 mm (0.136") f-f hex stock and cut into 1777 rods, each 213 mm (8.4") in length. These hexes were given a heat treatment under inert atmosphere to strain relieve the Nb filaments and then carefully cleaned and assembled into a 1777 rod pack.

This pack was inserted into a 161.4 mm (6.353") o.d. x 157.3 mm (6.191") i.d. OFHC copper can which was then surrounded with a Ta barrier and placed into a 188 mm (7.4") o.d. OFHC copper extrusion can. The voids around the circumference of the hex pack were filled with partial hexes cut of solid bronze. The Nb filament mechanical properties were measured before and after strain relief in the 3.45 mm (0.136") hex rods and are tabulated in Table I. The heat treat was seen to noticeably strain relief the Nb filaments.

After evacuating and sealing the billet, extrusion was done in a 3600 ton press to a rod diameter of 47.6 mm (1.875") and a length of 2 m. After the end effects had been trimmed away, a sample was metallographically prepared and the filament pattern is shown in Figure 1. Filament nonuniformity is so severe as to totally mask the original hex pattern of the billet. Because success for a 1777 monolith billet was deemed minimal, it was decided in discussions with D. Cornish and R. Scanlan of LLL that we should pursue the alternate 85 hex billet to be used in later compacted cable superconductor development.

65 HEX SECOND EXTRUSION

The remaining half of the TWCA first extrusion was drawn to 13.9 mm (0.549") f-f hex and cut into 85 rods, each 318 mm (12.5") in length. These hex rods were given the identical heat treatment to strain relieve the Nb filaments as the 3.45 mm (0.136") f-f rods were given. After heat treatment the 13.9 mm (0.549") f-f rods were carefully cleaned and arranged into an 85 rod pack which was inserted into a 152.4 mm (6.000") o.d. x 146.3 mm (5.760") i.d. OFHC copper extrusion can. Voids around the periphery were filled with partial hex rods of solid bronze. After welding on an extrusion cap and cone, the billet was evacuated and carefully sealed.

Concern over the filament nonuniformity prompted many measurements of the mechanical properties of the filaments. The average of the measurements are listed in Table I before and after the strain relief heat treatment. However, the mechanical properties were nonuniform among filaments, with the UTS varying from 455 MPa (66 ksi) to 551 MPa (80 ksi) and the yield strength varying from 338 MPa (49 ksi) to 455 MPa (66 ksi).

The billet was extruded in a 3600 ton press to a rod diameter of 25.4 mm (1.000") and a length of 9 m. A sample was taken from the center of the rod length and prepared metallographically. A photomicrograph of the extruded rod is shown in Figure 2. Severe nonuniformity is readily identifiable, though not nearly so extreme as in the 1777 hex TWCA extrusion.

After extrusion, a Ta diffusion barrier was added to the 85 x 187 filament core and approximately 30 volume % stabilizing copper was added to the barrier protected bronze-niobium core. This composite is being drawn into wire suitable for cabling and will be used to produce prototype lengths of the alternate HPTF conductor.

CONCLUSION

Comparing the results of the second extrusions consisting of TWCA Nb with those consisting of KBI Nb (reports under LLL P.O. # 5227009 and P.O. # 3964609), one notices that the filament non-uniformity in the TWCA extrusions is much more severe than in the KBI extrusions. This correlates readily with the results of the mechanical properties of the Nb. The KBI Nb has been measured to have lower ultimate and yield strengths than the TWCA Nb, even though both lots of Nb were given identical extrusion, cold work, and heat treatments. We are uncertain at this time why KBI Nb strain hardens less than the TWCA Nb, but we feel strongly that the impurity levels are different

because of different manufacturing schedules followed by TWCA and KBI. R. Scanlan of LLL is having chemical analysis done on the Nb used in these billets which may help answer the questions posed.

TABLE ITWCA Nb (GS 4-9)

	UTS		YIELD		<u>Hardness Knoop</u>
	<u>(MPa)</u>	<u>(ksi)</u>	<u>(MPa)</u>	<u>(ksi)</u>	
6.93 mm o.d. (as received)	193	28	103	15	73-83
1.45 mm o.d. (as extruded)	338	49	241	35	126
0.57 mm o.d. as drawn	655	95	548	80	177
strain relieved (alt. hex)	551	80	400	58	154
0.13 mm o.d. as drawn	806	117	---	---	243
strain relieved (monolith hex)	710	103	---	---	226

Figure 1 Photomicrograph of the cross section
of the 1777 hex second extrusion
using TWCA Nb in the first extrusion
(50X)

FIGURE 2 Photomicrograph of the cross section
of the 85 hex second extrusion using
TWCA Nb in the first extrusion.

(25X)