TABLE XXXI. EXPERIMENTAL DATA FOR 80 F HYDROSTATIC EXTRUSION AND RE-EXTRUSION OF T-SECTIONS OF AISI 4340, Ti-6Al-4V, AND Cb 752 COLUMBIUM ALLOY

Fluid – Castor Oil

Trial	Extrusion Ratio	Die[(a)] Design	Stem Speed, ipm	Billet Surface Finish, Microinches	Billet Lubricant[(b)]	Extrusion Pressure, 1000 psi: Breakthrough Stem	Extrusion Pressure, 1000 psi: Breakthrough Fluid	Extrusion Pressure, 1000 psi: Runout Stem	Extrusion Pressure, 1000 psi: Runout Fluid	Type of Curve (Fig. 26)	Length of Extrusion, inches	Comments
AISI 4340 Round-to-T-Section												
147[(c)]	2.5	SA1	1	--	C1-L11	245	214	228	196	D1	12	
316	3.0	SA1	6	50-100	L17	232	210	--	--	C4	2-1/4	Die broke at breakthrough
387	3.0	SA1	6	60-120	L48	283	244	--	--	--	--	Die cracked
341	3.0	CA1	6	Grit	L17	256	236	--	--	--	--	P_b not reached
342	3.0	CA1	6	Grit	L17	274	246	--	--	--	--	P_b not reached
497	2.5	CA1	6	60-120	L31	192	186	--	--	--	--	Die cracked and leaked before breakthrough
Re-extrusion of 1/4-Inch-Thick Ti-6Al-4V T-Section[(d)]												
511	2.0	RD1	6	60-120	C3-L17	--	--	--	--	--	--	Woods metal failed to seal
531	2.0	RD1	6	60-120	C3-L17	165	144	--	--	--	--	Fluid leak past extrusion just after breakthrough; Woods' metal seal
516	4.0	RD2	20	60-120	C3-L17	300	261	--	--	--	1/2	P_b not achieved; Woods' metal seal
Re-extrusion of 1/16-Inch-Thick Cb 752 Columbium Alloy T-Section												
530	2.0	RD3	6	50	L38	116	105	--	--	--	--	Seal leaked at onset of extrusion
533	2.0	RD3	6	50	L38	115	105	--	--	B1	12	Extruded too rapidly to record runout conditions

(a) See Figures 31 and 33 for die design details.
(b) Billet lubricants listed in Table III, coatings in Table IV.
(c) Trial conducted in earlier program; billet coating was zinc phosphate.
(d) Thickness given refers to nominal leg thickness of T-profile.

Re-extrusion of Ti-6Al-4V Alloy T-Sections

Three trials detailed in Table XXXI were conducted to evaluate the reduction by hydrostatic extrusion of 1/4-inch-thick Ti-6Al-4V alloy T-sections previously produced by conventional hot extrusion. As with the re-extrusion of 7075-0 aluminum T-sections, Wood's alloy was used to seal against leaks between the machined T-billet nose and the re-extrusion die. At an extrusion ratio of 2:1, a successful seal was achieved (Trial 531) but, just after breakthrough, fluid leaking prevented further extrusion. An examination of the billet and extrusion after disassembly revealed that the T-billet had shifted laterally relative to the die during extrusion, and sufficiently to cause leaking. The shift was believed to be due to unbalanced lateral pressures exerted on the billet during extrusion into the die orifice. It appeared that a slightly longer leg of the T-billet would have ensured sealing during extrusion. The breakthrough pressure of 144,000 psi obtained in Trial 531 was about 22 percent higher than that required for solid rounds. The high pressure was most likely due to lubricant breakdown by the Wood's metal sealing operation.

At an extrusion ratio of 4:1, the Wood's alloy again ensured sealing, but the pressure requirements for this reduction were evidently too high. This was not unexpected in view of the high pressure requirements for solid rounds at that ratio.

Re-extrusion of Cb-752 Columbium Alloy T-Section

Trials were conducted to establish the re-extrusion characteristics of T-sections of previously hot extruded and drawn by conventional techniques from Cb-752 columbium alloy. The experimental data for these trials are shown in Table XXXI. The columbium alloy was reduced from a 1/16-inch T-section to a 1/32-inch T-section. Figure 34b shows the resulting extrusion. The PTFE lubricant was removed during reduction; Wood's alloy was used to seal at the die-billet interface. In Trial 533, the sealing technique worked successfully yet in Trial 530 under identical conditions the seal leaked just after extrusion had started. No explanation could be found for this difference in behavior.

The pressure-displacement curve obtained in Trial 533 was unable to indicate the runout conditions because, due to the large ratio of stem area-to-extrusion area, the stem displacement required for extrusion to take place was only 1/10 inch. It is seen in Figure 34b that the extrusion is not straight. Attempts were made to straighten the extrusion but it was apparent that the distortion was permanent and was most likely caused by "shimmying", or movement from side to side, on exit.

It is considered significant, particularly from the standpoint of a potential manufacturing process to produce thin-section structural shapes from aerospace materials, that this Cb alloy was reduced from a 1/16-inch T-section to a 1/32-inch T-section in a single pass at a ratio of 2:1 (Trial 533).

It is believed that by imposing a controlled drawing stress and drawing speed on the extrusion as in the HYDRAW operation, the extrusion would be constrained to move axially. This would help prevent the axial distortion which apparently occurs in plain extrusion. The straight 7075-0 aluminum T-section shown in Figure 34a was produced by HYDRAW. The HYDRAW operation is described below.