close to 135,000 psi; the minor variations in temperature did not appear to markedly affect the P'+D values. (P', the stem pressure, is used here because in these trials at 500 F the fluid pressure gage was out of order.) In Trials 1028 and 1032, almost all of the wire within the container was reduced, resulting in a total length of 33 feet.

In the remaining three trials with the ingot wire, the wire exited at a very low speed and true runout conditions were not achieved. The reason for the low exit speed is not clear but in two of the trials, it appeared to be connected with tangling of the wire in the container.

HYDRAW of Beryllium Wire of Powder Metallurgy Origin

Data for two trials with powder-metallurgy beryllium wire are given in Table XXXIII. In both trials, true breakthrough conditions (where full control over the exit velocity is achieved) were not obtained. In both cases, at a value of P' + D of 136,400 psi, wire exited at a very low speed and raising pressure above this value did not affect the exit velocity of the wire. There was no apparent hold-up in the container. After producing 2 ft of wire in Trial 1033, the fluid pressure was slowly increased until, at P' + D = 237,000, the wire freely extruded at a rapid rate. More work will be required to investigate the causes of the failure to achieve sustained runout conditions. Apparently tangling in the container bore did not occur. It may have been due to lubrication break-down or build-up of the PTFE lubricant in the die orifice.

Tensile Data on Beryllium Wire

The tensile data in Table XXXIV for the ingot-origin wire are the averages of several tests and for the powder-metallurgy material, one test.

TABLE XXXIV. AVERAGE TENSILE PROPERTIES OF BERYLLIUM WIRE BEFORE AND AFTER HYDROSTATIC EXTRUSION DRAWING AT 500 F

Wire Source Material	Condition	0.2 Percent Yield Strength, psi	UTS, psi	Elongation, percent in 2 inches
Ingot (Berylco)	As received	47,000	88,000	9.0
	60 percent reduction by HYDRAW	124,000	131,000	0.2-0.9
Powder (Brush)	As received	88,000	142,000	12.0
	60 percent reduction by HYDRAW	186,000	198,000	0.4

Both wire materials increased in tensile strength by close to 40 percent and the yield strength more than doubled as a result of the 60 percent single-pass reduction. The ductility of the wire produced was markedly lowered but was still high enough to permit continuous coiling round a 3-inch-diameter pulley while under the draw stress.

HYDRAW of TZM Molybdenum Alloy Wire

Data are given below for a single trial in which 0.10-inch-diameter TZM wire was reduced by 60 percent in area by the HYDRAW process. The 15 feet of wire produced was of excellent surface quality and no problem was experienced in handling the material. The extrusion conditions were identical to those used for beryllium wire and given in Table XXXIV. The fluid temperature was 500 F.

Trial	Stem Pressure, P', psi	Draw Stress, psi		P'+D, psi
		Breakthrough	Runout	
536	159,000	18,600	18,000	177,000

The pressure plus draw stress requirements were about 30 percent higher than the pressure requirements for the extrusion of solid rounds. These higher pressures may have been partly due to the "size effect" and other factors discussed earlier. However, the energy required to uncoil the stiff 2-inch-diameter coil of 0.1-inch wire must have constituted a large proportion of the excess pressure requirements.

The wire was pointed by chemical etching and in one case (Trial 524), uneven etching caused fluid leaks between the wire and die.

HYDRAW of 7075-0 Aluminum T-Sections

A 1/4-inch-thick T-section of 7075-0 aluminum was reduced to a 1/8-inch thick section, representing a ratio of 2:1, by the HYDRAW process (Trial 526). A photograph of a short length of the extrusion is given in Figure 34. The draw force was applied to the billet through a 7075-0 aluminum alloy tab which was fusion welded to the nose of the billet. The nose of the T-section billet had been machined to approximate the die entrance entrance contours. A seal between the billet and die was ensured by casting Wood's alloy around the billet in the die prior to extrusion-drawing. A two-piece die described in Figure 33 was used in these trials.

The drawing force was applied to the end of the extrusion by a variable torque motor through a cable into a pinload fixture attached to the tab. During the application of the draw force, the cable tended to untwist. The untwisting torque caused the extrusion and die insert to turn slightly relative to the die case and the reduced T-section scraped the die case on exit. The scraping action caused the extrusion pressure + draw stress (P+D) requirements to be higher than the pressure requirements for straight hydrostatic re-extrusion under the same conditions (50,500 psi versus 40,500 psi).

In Trial 526, the draw stress applied to the extrusion cross section was limited by the strength of the tab or point to a value of 3,300 psi. However, even this low draw stress enabled some control over the exiting extrusion. In a production operation, it would be a relative simple matter to fusion weld a short length of section which had already been extrusion-drawn through the die to be used for applying a draw stress to the next extrusion. This would simplify the sealing problem and enable the application of a draw stress of about 30,000 psi, which would reduce the fluid pressure required to about 10,000 psi.