Significant strides were made toward reducing the level of the breakthrough pressure peak and minimizing the runout pressure level. This can be seen quite clearly in Figure 14 which compares the pressure-displacement curves obtained with earlier lubrication system, L17 (20 wt percent MoS_2 in castor wax) to the best system developed in this program, L53 (20 wt percent MoS_2 in stearyl stearate). In addition, a further improvement is shown for L53 by replacing the fluid castor oil with silicate ester. A billet lubricant which was as equally effective in reducing pressures as L53, was L38 (PTFE) but the finish obtained was not as good. Other billet lubricants which showed marginal improvements over L17 were L31 (fluorocarbon telomer) and L33 (55 wt percent MoS_2 and 6 wt percent graphite in sodium silicate). Of particular significance was the excellent surface finish obtained with L53. While finishes were not measured, comparisons on a sensory basis showed L53 to give one of the best surfaces. The surface finishes obtained with the other lubricants mentioned above, however, were still quite good.

Several trials were conducted with the stearyl-stearate based billet lubricants. Three of these trials (453, 454 and 472) were conducted to evaluate tandem billet design and are presented here for comparison purposes. Details of the tandem billet design are given later. As discussed earlier, the repeatability of these results was good, only small variations in breakthrough pressure being observed. The initial stick-slip encountered with L53 in Trial 432 was due to improper lubrication on the billet nose. The remaining trials with this lubricant demonstrated the importance of careful billet lubrication.

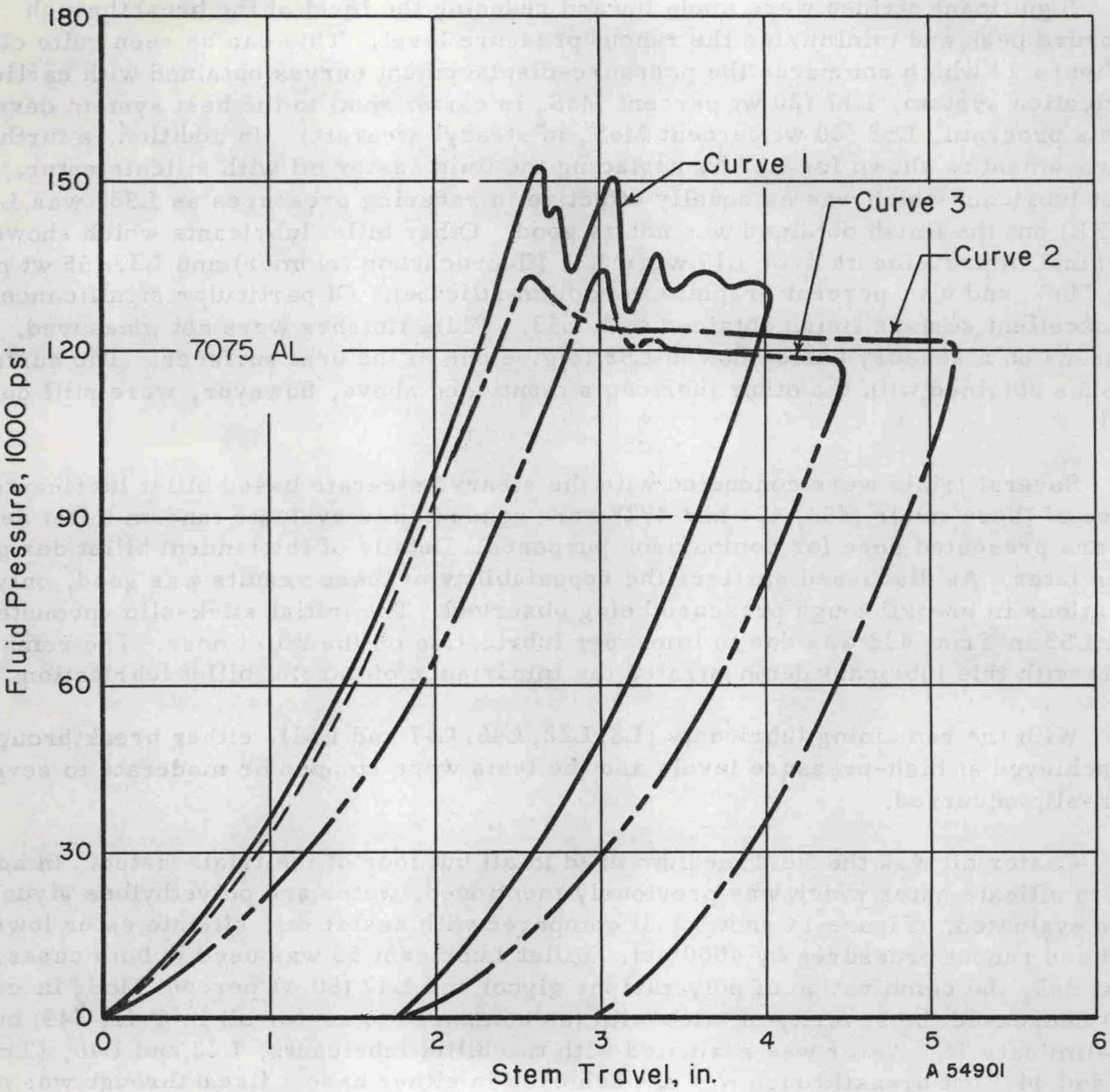
With the remaining lubricants (L8, L22, L46, L47 and L51), either breakthrough was not achieved at high-pressure levels and the tests were stopped or moderate to severe stick-slip occurred.

Castor oil was the fluid medium used in all but four of the trials listed. In addition to silicate ester which was previously mentioned, water and polyethylene glycol were evaluated. Figure 14 shows that compared with castor oil, silicate ester lowered fluid and runout pressures by 4000 psi. Billet Lubricant 53 was used in both cases. In Trial 365, the combination of polyethylene glycol and L47 (50 wt percent MoS_2 in carbowax) decreased the severity of stick-slip (as compared to castor oil in Trial 345) but did not eliminate it. Water was evaluated with two billet lubricants, L22 and L46, (Trials 343 and 344) but breakthrough was not achieved in either case. Breakthrough was not however achieved when castor oil was used with L46 (Trial 346).

At an extrusion ratio of 40:1 and a stem speed of 20 ipm, severe stick-slip always occurred when the standard billet nose configuration was used. Lubricants L53 and L38 which proved to be efficient lubricants at a ratio of 20:1 failed to eliminate stick-slip though L38 caused some lowering of pressure levels. In spite of the stick-slip, however, the extruded surface finish obtained with these lubricants was very good. Again, silicate ester (Trial 468) resulted in marginal reductions in pressure obtained with castor oil (Trial 435), but stick-slip was not eliminated.

Billet Nose Design

In an attempt to reduce the high breakthrough pressure peaks, billet nose design was changed. In Trial 463 conducted at a ratio of 20:1, a stepped billet nose consisting of a 1.25-inch diameter step about 1/4 inch long located at the juncture between the



Extrusion Conditions:	Extrusion ratio	20:1
	Stem speed	20 ipm
	Die angle	45 degrees included

Curve	Trial	Fluid	Billet Lubricant
1	347	Castor oil	20 wt. % MoS_2 in castor wax (L17)
2	454	Castor oil	20 wt. % MoS_2 in stearyl stearate (L53)
3	464	Silicate ester	20 wt. % MoS_2 in stearyl stearate (L53)

FIGURE 14. EFFECT OF FLUID AND BILLET LUBRICANT ON PRESSURE-DISPLACEMENT CURVES OBTAINED IN THE HYDROSTATIC EXTRUSION OF 7075-0 ALUMINUM AT A RATIO OF 20:1