and L33 (55 wt % MoS_2 and 6 wt % graphite in sodium silicate) provided only marginal reductions in extrusion pressures. In Trials 432, the lubricant (L53) was not applied properly on the nose causing stick-slip to occur. Further trials with L53, in which stick-slip did not occur, demonstrated the importance of careful billet lubrication. Also in Trial 433, inadequate billet nose lubrication with Lubricant 54 (20 wt % MoS_2 and 10 wt % graphite in stearyl stearate) is believed to have caused the stick-slip observed.

At a stem speed of 80 ipm, stick-slip occurs at breakthrough only and is completely eliminated during runout by all of the lubricants evaluated to date including the new Lubricants 31, 53 and 54. Stick-slip during runout is prevented because the high stem speeds do not allow the billet to stop at the end of fluid decompression during slip after breakthrough, thus maintaining kinetic friction conditions. The surface of the products here were not cracked and had a good finish in all cases. The product exit speed was almost 250 fpm whereas in conventional commercial extrusion of 7075-0 aluminum exit speeds are kept roughly to below 2-3 fpm to avoid product cracking.

All lubricants evaluated thus far at 80 ipm have given extrusion curves of Type B2 with a sharp fluid P_b peak of about 150,000 psi and a P_r of about 125,000 psi. These pressure levels were obtained with L17, L53 and L54, whereas L31 gave readings about 5 percent higher.

At an extrusion ratio of 40 : 1 and a stem speed of 20 ipm, severe stick-slip always occurred in previous trials in the program. Lubricants L53 and L38 failed to eliminate it though L38 showed 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 resulted in marked reductions in pressure obtained with castor oil as shown by comparison of Curves 1 and 2 in Figure 4.

Billet Nose Design

In an attempt to reduce breakthrough pressure peaks, two special billet nose designs were evaluated; they are shown in Figure 5 below with the standard nose.

Trials with these special billet nose designs were conducted with 7075 aluminum at a stem speed of 20 ipm and L53 as the billet lubricant. At an extrusion ratio of 20 : 1 (Trial 463), the stepped-nose design did not reduce the P_b peak but appeared to have effected a multi-stepped, more gradual transition from the maximum pressure to the runout pressure.

This observation led to the design of the compound-angle nose which was evaluated at the higher ratio of 40 : 1 (Trial 467), where the likelihood of stick-slip is even greater. The lubricant used was again L53. In Figure 4, Curve 3 shows the extrusion curve obtained with this design compared with the standard nose design. Clearly the compound-angle design not only reduced the P_b peak by about 70,000 psi but the severe stick-slip, which is normally present at this extrusion ratio, was completely eliminated. These results are explained as follows:

(1) The second or upper angle on the compound-angle nose provides for more efficient "thick-film" lubrication at breakthrough, thereby reducing the coefficient of static friction, μ_s, and thus, the P_b peak.

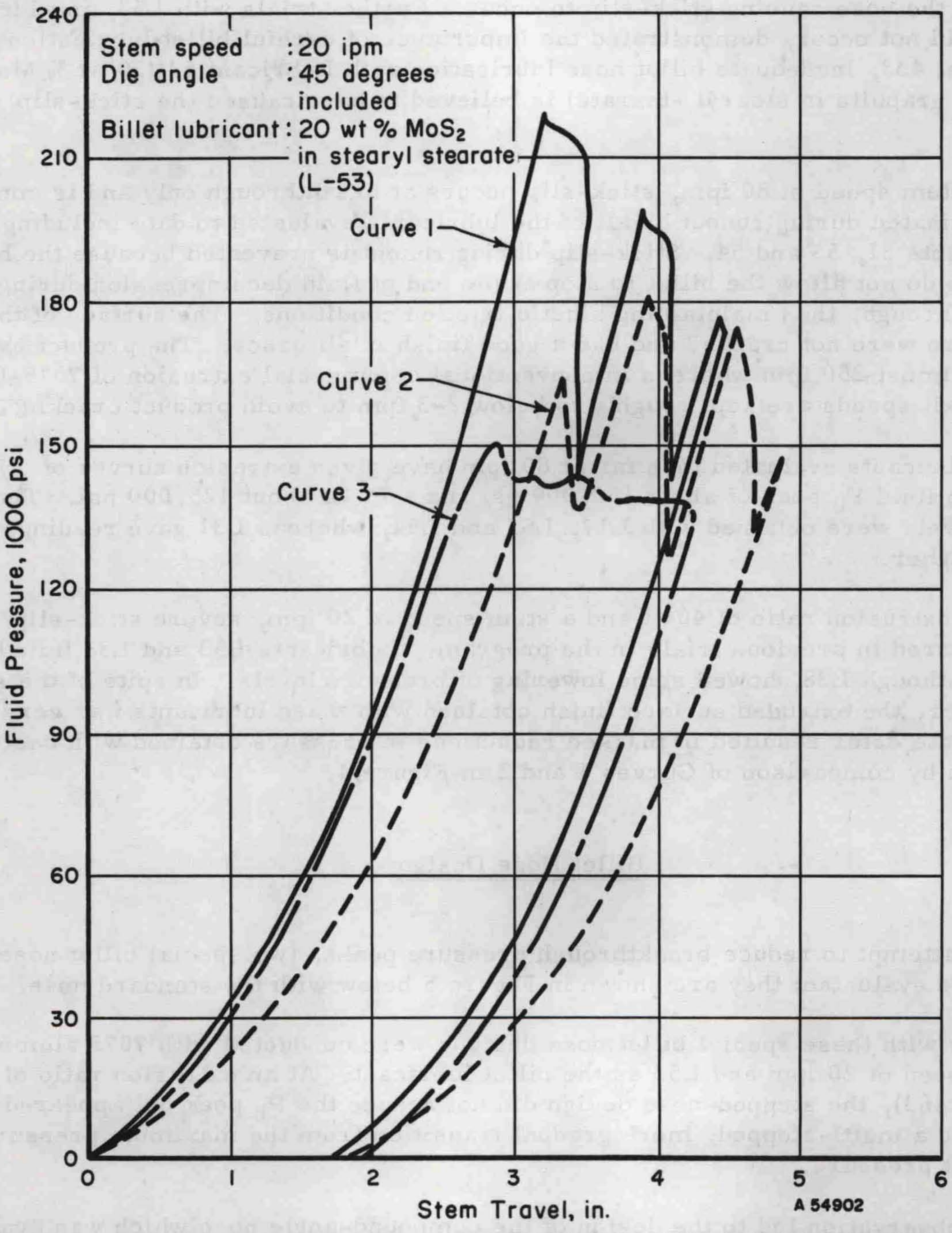

FIGURE 4. EFFECT OF BILLET NOSE SHAPE AND FLUID ON PRESSURE – DISPLACEMENT CURVES OBTAINED IN THE HYDROSTATIC EXTRUSION OF 7075-0 ALUMINUM AT A RATIO OF 40:1

Extrusion Conditions:

Curve	Trial	Fluid	Billet Shape
1	435	Castor oil	Standard
2	468	Silicate ester	Standard
3	470	Castor oil	Compound angle nose