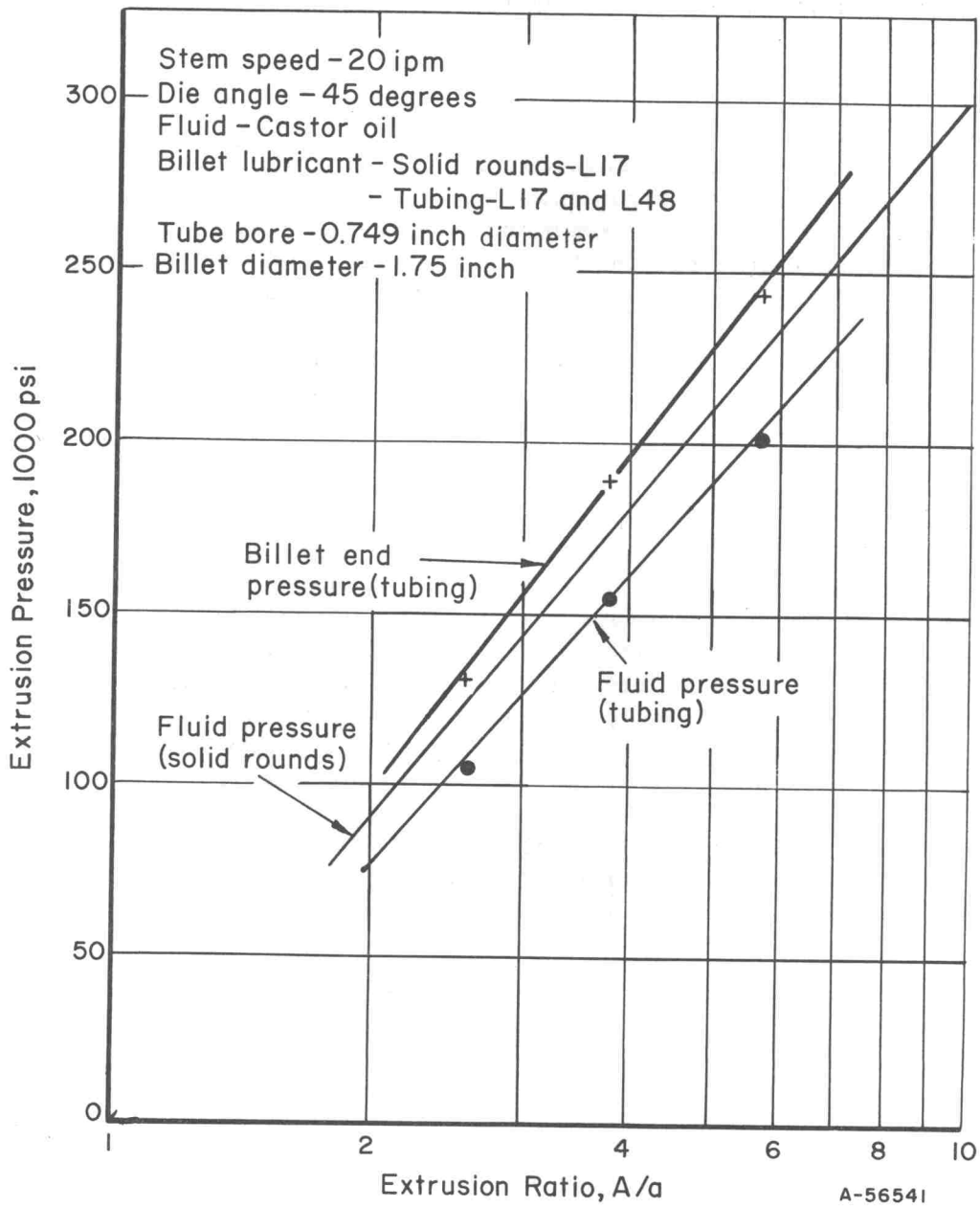

FIGURE 29. EFFECT OF EXTRUSION RATIO ON PRESSURE FOR COLD HYDROSTATIC EXTRUSION OF AISI 4340 TUBING AND ROUNDS

ratio had an excellent surface finish. Lubricant L48 was a modification of L17 (20 wt percent MoS_2 in castor wax), to which lead, copper, and graphite were added. These additions were intended to minimize friction on the billet and mandrel at the higher ratios. This modification did not, however, prevent momentary seizure at the ratios of 5.7 and 7:1 where lubrication breakdown apparently occurred. Despite this occurrence, at 5.7:1 the extruded product finish was quite good.

Effect of Mandrel Taper

In Trial 336, the runout pressure was uniform at first, indicating that lubrication was good. Towards the end of extrusion, the runout pressure began to rise continually without any evidence of stick-slip. Examination of the extrusion after disassembly revealed that the pressure rise was due to excessive frictional drag of the tubing over the mandrel. Consequently, the taper on the mandrel was increased for the remaining trials with AISI 4340 from 0.0003 in./in. to 0.0011 in./in. on diameter, to provide greater clearance between it and the extruded tubing. With this modification, no further problems arose.

Re-Extrusion of As-Extruded Tubing

In Trials 386 and 390, tubing which had been extruded previously by the hydrostatic process was further reduced in size without an intermediate anneal. The extrusion ratio was 3.2:1 which gave a total accumulative reduction of 92 percent and final wall thickness of 0.063 inch. In one trial at 6 ipm (Trial 386), only about 1-1/2 inches were extruded. However, at 20 ipm (Trial 390), a 4-3/4 inch length of tubing was produced. In both cases, lubrication breakdown occurred, which resulted in rapidly rising pressures and a scored product. It is possible that this problem may be overcome with further improvements in lubrication and perhaps mandrel design.

However, it is still quite significant that AISI 4340 tubing can be reduced 92 percent in just two passes without in-process anneals. The hardness levels obtained by hydrostatic extrusion are as follows:

	Tube Blank	Extruded Tubing	
Accumulative Reduction, percent	0	74	92
Hardness, R_C	11	31	39

Ti-6Al-4V Titanium Alloy Tubing

The experimental data given in Table XXIX describe the results obtained in reducing Ti-6Al-4V tube to extremely thin-walled tubing of excellent surface quality. The tube blank of 0.750-inch OD x 0.069-inch wall was produced by Wolverine Tube Company under Air Force Contract No. AF 33(615)-3089. It was hydrostatically extruded at a ratio of about 2.7:1 to a 0.663 OD x 0.030-inch wall tube.

In the reduction of this thin-walled tube, several interesting features were revealed. The extrusion conditions chosen happened to coincide with the threshold