of the beryllium extrusion (Trial 495) are shown in Figure 25. The severely elongated grains in the longitudinal section are typical of a heavily cold-worked microstructure. In the preparation of the specimens shown in Figure 25, a single hairline crack about 0.15 inch long was seen in the longitudinal section. No corresponding crack was seen in the surface of the mating specimen. It is believed that this crack may have been a direct result of sectioning and not of extrusion.

The second double-reduction die evaluated with beryllium was Die D5. As discussed in the previous section on TZM, Die D5 was modified from D3 by reducing the entry angle to the second reduction from 45 to 22 degrees. This was done with aim of retaining the lubricant at the second bearing. Trials with this die were also conducted to obtain further lengths of crack free-extrusion for tensile evaluation.

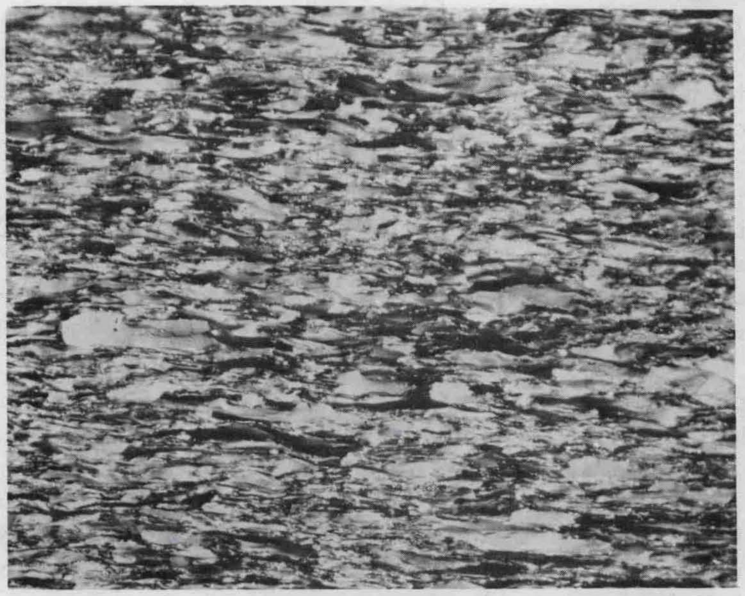
A die-entry plug was designed to stop the billet at a point where the unextruded billet length was about 1 inch. This would leave a long length of extrusion for evaluation. The purpose of the plug was to seal the die entry from fluid at pressure thus preventing further extrusion. Manual press control techniques were normally used to stop the extrusions, but the stem travel plotter could not indicate the billet position accurately enough during extrusion. The plug was mounted on the rear of the billet and was designed to move with it during extrusion.

However, the plug outside diameter of 2.313 inches apparently did not allow sufficient clearance between it and the container wall. During pressuring action by the ram, the plug apparently acted as a throttle to fluid flow which tended to cause unequal pressures above and below it. Thus at the point of breakthrough in Trial 519, irregularities in the pressure-ram travel curve were observed and the trial was stopped. A 2-inch length of crack-free extrusion was obtained.

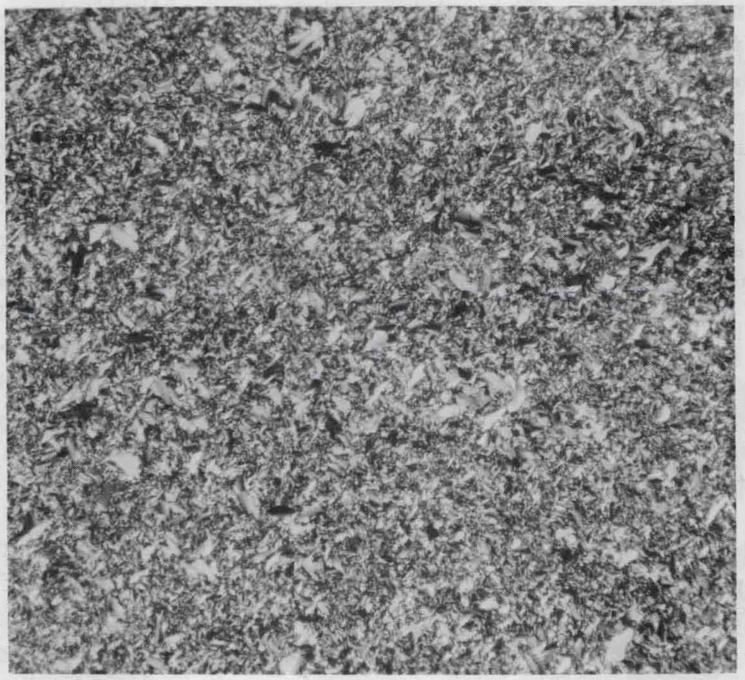
In three further trials with beryllium and double reduction Die D5, the die entry plug was not used. In Trial 520 a crack-free product having a similar finish to that in Trial 495 was obtained. Unfortunately, the extrusion bent slightly on exit and broke up on hitting a protrusion below the die. This caused fluid pressures to rise towards the end of runout. However, several continuous lengths of sound extrusion were obtained for tensile evaluation. A comparison of the pressure data obtained in these trials with Dies D5 and D3 is given in Table XXVII. A 3-1/2-percent reduction in runout pressure was achieved by reducing the angle at the second reduction but breakthrough pressures were equal because the size of the first reduction was unaltered. The small reduction in runout pressures was probably due to improved lubrication at the second reduction or due directly to the change in die angle.

The protrusion below the die was removed for the remaining two trials (528 and 529) with Die D5 in case these extrusions also bent on exit. In the first, the press was stopped unintentionally after a low breakthrough pressure had been achieved and only 1 inch of crack-free product was obtained. In the following trial, however, high breakthrough pressures occurred, the exiting extrusion was badly cracked and an uneven increasing runout pressure was obtained. An examination of the die after removal of the extrusion revealed that heavy seizure or galling had occurred at the entry surface of the second bearing.

The reason for seizure occuring at the second bearing in this particular trial was unaccountable since the conditions here were unchanged from those in which sound extrusions were produced. The greater friction caused by galling at the second bearing



100X a. Longitudinal 6B551



100X b. Transverse 6B007

FIGURE 25. PHOTOMICROGRAPHS OF BERYLLIUM COLD HYDROSTATICALY EXTRUDED AT A RATIO OF 4:1 THROUGH BATTELLE'S DOUBLE-REDUCTION DIE