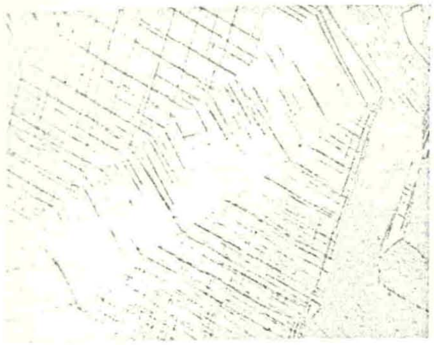
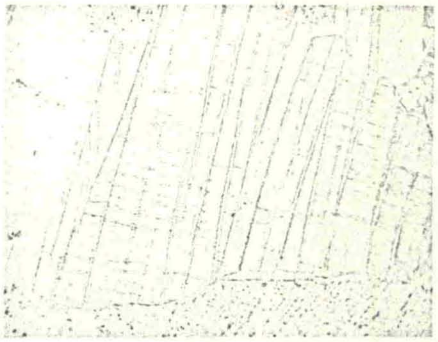
Fig. 3—Photomicrographs of specimens of gold-silver alloy subjected to explosive loading at a pressure of 510 kbars. X1000. Reduced approximately 52 pct for reproduction.

mation during explosive loading is on a scale inaccessible to the optical microscope. He proposed a model according to which the interface at the shock front consists of a planar network of dislocations; the latter move diagonally to the shock front and leave a lattice of a different density, but otherwise undisturbed. He pointed out, however, that the presence of sources and sinks for dislocations distributed in the lattice would result in interacting dislocations remaining after the passage of the shock front. These can increase the hardness and can also contribute to the energy stored in the metal.

The presence of deformation twins in a metal suggests the presence of stacking faults. Further, the number of stacking faults may be expected to have some relation to the number of observable twins. It is suggested, therefore, that the increase in stored energy which occurs in the pressure range of 120 to 150 kbars may be due in part to an increase in the number of stacking faults, although the contribution of dislocations to the stored energy must be significant and other imperfections may also contribute to the stored energy.

Four measurements of the stored energy of specimens exposed to a shock pressure of approximately 340 kbars, but not fired into water gave a value of 16 ± 2 cal per g-atom. This value is significantly smaller than those for the specimens explosively loaded at pressures of 150 kbars and above, but fired into water and thus quenched immediately. The hardness values of the air-cooled specimens were between those of specimens loaded at 290 and 510 kbars and quenched into water. No metallographic evidence of recrystallization of the air-cooled specimens was observed. The difference in stored energy of approximately 12 cal per g-atom between air-cooled and water-quenched specimens is attributed to a recovery process which must have occurred owing to a rise in temperature of the air-cooled specimens. The loss of stored energy by recovery may involve the annealing out of the stacking faults which are believed to contribute significantly to the stored energy of the water-quenched specimens.

In comparing the effects of explosive loading with those of conventional deformation processes, it should be noted that in the latter strain and strain rate are important variables. For example, in wire drawing at moderate strain rates, the stored energy increases with strain in a nearly linear manner to a value of about 25 cal per g-atom at a true strain of approximately 0.8; above this, the energy increases only slightly with increasing strain,[6] see Fig. 1. The energy stored in torsion depends on the strain in a similar manner[7] and the same general relation between stored energy and strain has been found for gold-silver alloys deformed by other processes in which the strain has been measured.[2,3] At the highest drawing speeds investigated the stored energy in wire drawing is 25 cal per g-atom at a strain of about 0.6 and 30 cal per g-atom at a strain of 3.5; at this level of strain rates the stored energy is decreasing with increasing strain rate, presumably owing to heating.[6] A comparison of these values with the energy stored by explosively loaded specimens (either cooled in air or quenched in water) shows that explosive loading, wire drawing, and torsion result in stored energy values of the same order of magnitude. The strains in explosive loading, however, are small by comparison.

The hardness of the explosively loaded specimens is comparable to that of specimens of the same alloy deformed to larger strains by wire drawing,[6] see Fig. 1, and torsion.[7] This finding agrees with Smith's[1] observations on copper. The attainment of large hardness values at the relatively small transient and permanent strains involved in explosive loading again emphasizes the difference of the mechanisms of hardening in conventional deformation processes and in explosive loading.

The effects of explosive loading and wire drawing can be compared by plotting the stored energy against the microhardness. As can be seen in Fig. 4, these properties increase together. However, the rate of increase of the energy stored during explosive loading is larger than in wire drawing at hardness levels of

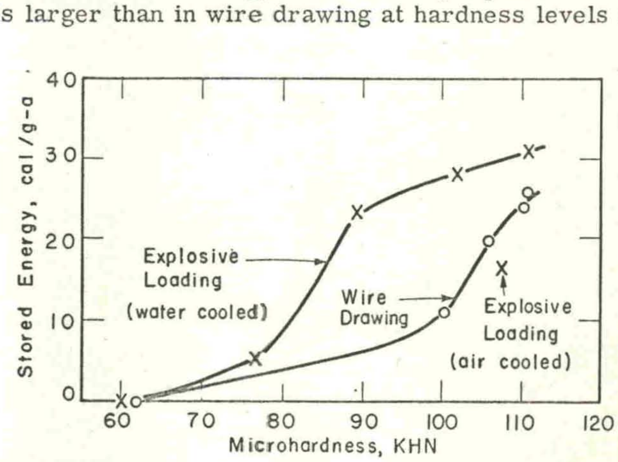

Fig. 4—Stored energy vs microhardness of specimens deformed by explosive loading and wire drawing.