

FIG 4.—*Top*, X-ray diffraction pattern of amalgam surface before application of pressure. Amalgam contained 5:5 mercury-to-alloy ratio, alloy was zinc free. *Bottom*, X-ray diffraction pattern of identical sample shows  $\gamma_2$  peaks missing six months after application of high pressures. Since surface of this specimen was ground off, pattern corresponds to internal structure; unlabeled peaks correspond to unreacted alloy ( $\text{Ag}_3\text{Sn}$ ) in sample.

ber of vacant lattice sites that results in a temporary increase in the diffusion rate.

If tin diffusion is activated by cold working and plastic deformation, then free tin would be available in amalgam to recombine with free silver, if present, to form  $\text{Ag}_3\text{Sn}$ . This process was not detected in the diffraction patterns, and it is unlikely that there is sufficient free silver available to form enough  $\text{Ag}_3\text{Sn}$  to be detected by X-ray diffraction. The temperature-induced phase transition from  $\gamma_1 \rightarrow \beta_1$ <sup>8</sup> also does not appear to be caused by high pressures. It is more likely that some of the tin atoms diffuse into  $\gamma_1$  crystals, forming the Ag-Sn-Hg phase described by Johnson.<sup>9</sup> Additional microprobe studies should aid in locating where

the remaining tin is diffusing in the specimens.

This proposed acceleration of the diffusion rate of tin in dental amalgam may have clinical importance, since amalgam restorations are subjected to large deforming forces during mastication and during rapid temperature changes. Since there is more tin present in amalgam than can diffuse into the surrounding hard tissues. Domagala, Van Thyne, and Lenke<sup>10</sup> and Jeolco, Inc.,<sup>11</sup> have demonstrated tin diffusion from amalgam restorations into hard tissues.

This evidence of tin diffusion into hard tissue may be associated with the phase disappearance detected in amalgam.  $\gamma_2$  ( $\text{HgSn}_{7-8}$ )

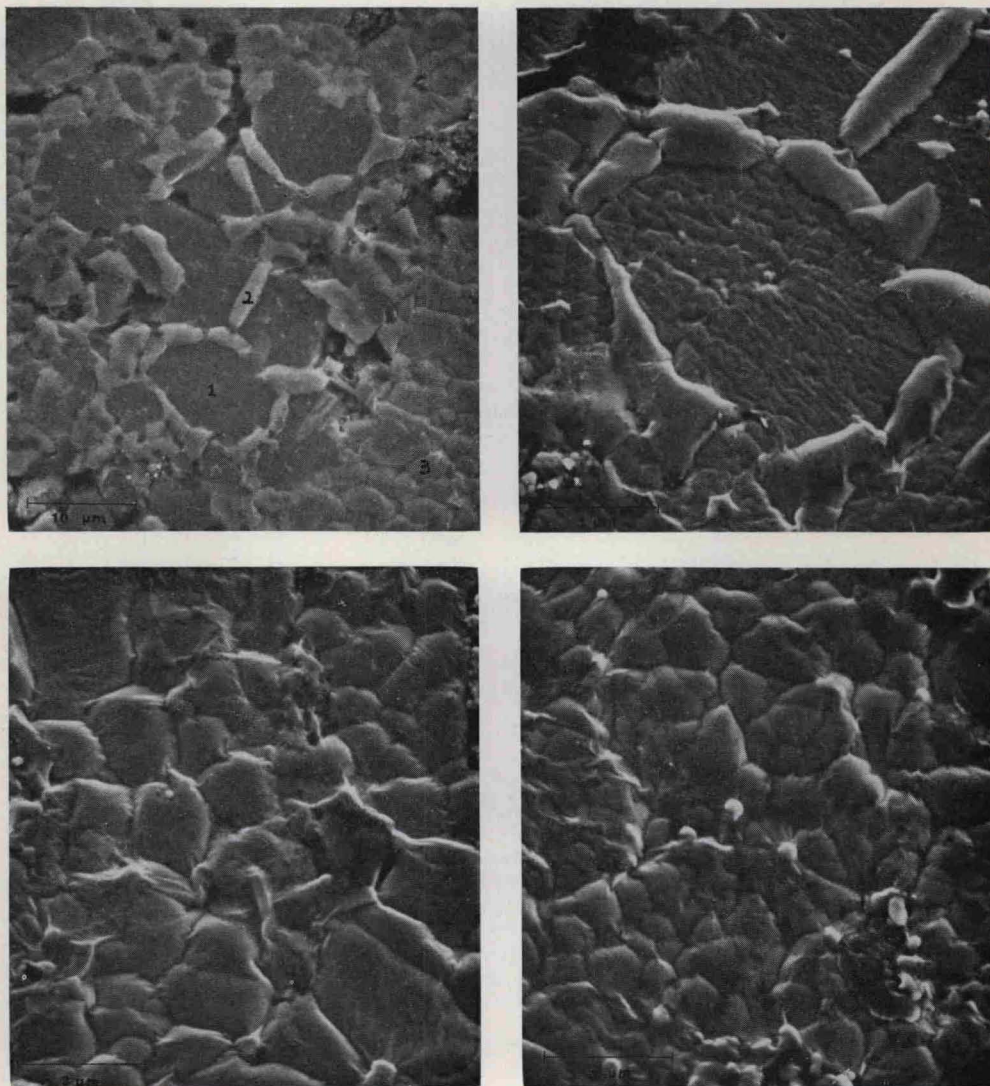


FIG 5.—*Top left*, Structure of dental amalgam before application of high pressure; sample has been polished and etched. Area photographed is  $45 \times 49 \mu\text{m}$ . 1, unreacted alloy ( $\text{Ag}_3\text{Sn}$ ) particle; 2,  $\gamma_2(\text{HgSn}_{7-8})$  crystal; 3, crystal of  $\gamma_1(\text{Ag}_2\text{Hg}_3)$  (orig mag  $\times 2,100$ ; reproduced at 41%).

*Top right*, Region containing 1 and 2 at higher magnification; area photographed is  $11 \times 13 \mu\text{m}$ . No  $\gamma_2$  crystals such as these were found in specimens six months after application of 50 kb (orig mag  $\times 8,000$ ; reproduced at 41%).

*Bottom left*, Grain structure of  $\gamma_1(\text{Ag}_2\text{Hg}_3)$  crystals before application of high pressure. Area photographed is  $11 \times 13 \mu\text{m}$ .

*Bottom right*, Area similar to that of Figure 5, *left*, shows effects of high pressures on  $\gamma_1$  crystals. Sample has been subjected to severe cold working and plastic deformation.

is the phase in amalgam with the lowest modulus of stiffness (Grenoble and Katz)<sup>12</sup> and is most susceptible to cold working and plastic deformation. In addition, Wing<sup>13</sup> has reported that  $\gamma_2$  crystallites tend to form along

the surfaces and in the neighborhood of the voids present in amalgam. Since voids tend to act as stress concentrators, i.e., concentrate the stress in the material between the voids, these  $\gamma_2$  crystallites are probably subjected to some