DECOMPRESSION CAPS

The function of decompression caps, which are disks of hardened steel inserted into the pressure transmitting medium, may be seen from the following, referring to Figs. 1 and 3. Consider the consequences of advancing a ram through the small distance δx. If there is no extrusion of the gaskets and the shear strength of the pressure transmitting material is small compared to the average pressures generated, there will be a pressure rise in the sample region $\delta P_1 \simeq B_1(\delta x)/(x+a)$ and a pressure rise in the gasket $\delta P_2 \simeq B_2(\delta t/t)$. B_1 and B_2 are values of the average bulk moduli of the sample region and the gasket, respectively; a is the axial half-length of the cylindrical hole in the die and t is the thickness of the gasket. If $\delta P_1 \gg \delta P_2$, the gasket will not contain the high pressure sample region but will be blown out or extruded at sufficiently high pressure and if the situation $\delta P_1 \ll \delta P_2$ obtains, the stresses on the components will be unnecessarily large and lead to their premature failure. Thus, the situation $\delta P_1 \simeq \delta P_2$ is the most desirable. Assume now that both the sample region and gasket have the same average bulk moduli. Letting $\delta P_1 = \delta P_2$, since $t = x \sin\theta, \delta t = \delta x \sin\theta$, we have $\delta x/(x+a) = \delta x/x$ which can be achieved only for the condition $a=0$, i.e., for a "folded" gasket simple Bridgman anvil. In practice, extrusion of the gasket improves the situation, reducing δP_2.The purpose of the decompression caps, which are relatively incompressible material such as steel, is to increase the average bulk modulus of the sample region relative to the gasket in order to increase δP_1 relative to δP_2. Their use reduces the press load required to reach the Bi I→II transition by about 25%. In addition, if one is using internal electrical heating, the caps distribute the the current over a larger ram area, reducing probability of local overheating and consequent fracture. We have used as decompression caps disks sliced off from a drill rod of appropriate diameter and heat-treated by quenching in a brine bath from red heat. The caps are invariably found to be cracked after a run, but they do not shatter or flow. The absence of nonmetallic thermal insulation between the high temperature zone and the ram ends does not appear to lead to early failure of the ram. We believe that the axial temperature gradient along the ram may even increase the ram lifetime by reducing the tendency of the material of the small highly loaded ram end to intrude into the main ram body, an effect believed by Bridgman[3,7] to cause the radial crack failure of his anvils.

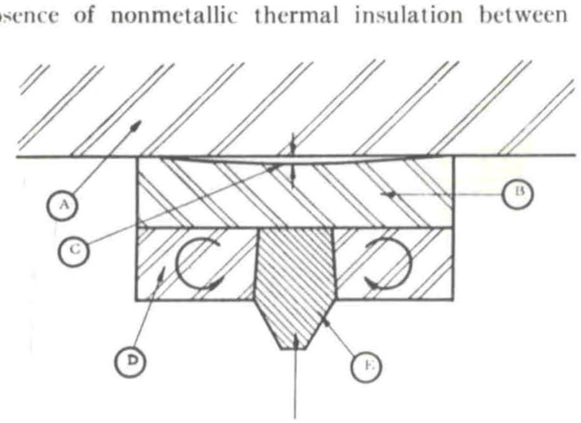

FIG. 4. Proposed variable support scheme for rams. (A) press platen, (B) "saucer backed" backup block, (C) initial gap, (D) ram support ring, and (E) tungsten carbide ram.

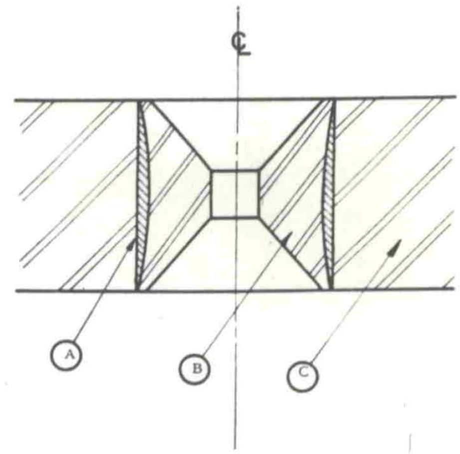

FIG. 5. Hyperboloidal prestressed shape of die. The radial dimensions are shown exaggerated. (A) 0.003-in. thick steel strip between die and binding rings, (B) die, and (C) binding ring set.

STRESSED CORE COMPONENTS

The "geometrical advantage" principle discussed by Hall[5] is seen to be operative for both the rams and the die. The rams have the highest stresses acting only on the center portions of the diameter. The shrunk-on hardened steel ring provides lateral support for the cylindrical part of the rams. The ram support rings shown in Fig. 1 provide insufficient support with 0.004 in. initial interference on the 1-in. diam. Ram failure occurs at about 130 000 atm at room temperature with the presently used rings, fracture occurring by the characteristic intrusion mechanism described by Bridgman.[3,7] We propose to try out an improved method of supporting the rams, by which an important part of the radial support will vary monotonically with the axial load applied. The method of accomplishing this is indicated in Fig. 4. The "saucer backed" backup block will deform as the ram load is increased, attempting to force the ring elements to rotate in the direction of the arrows. This rotation must be opposed by a shift of the radial stress S, increasing S near the region a, at the expense of the stress at b. This redistributed stress should reduce ram failure by inhibiting the intrusion of the ram end into the ram body or, one might say, by making the stresses in the critical region more nearly hydrostatic. A geometrical advantage is expected to be gained in the steel support ring since it would be called upon to provide maximum radial

[7] P. W. Bridgman, J. Appl. Phys. 12, 466 (1951).