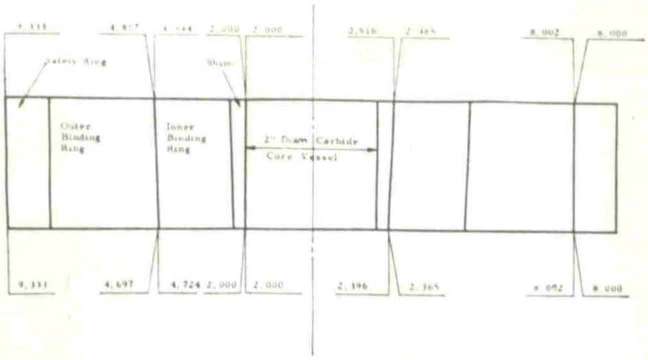

FIG. 6. Cross section of binding ring set giving diametral dimensions. The rings are assembled from the outside to inside. The 2.485-in./2.365-in. surface is finished after B-C-D are pressed in place. The shim ring is split axially into four pieces for ease of removal of broken dies. Small adjustments in the interference of the core in the rings may be made with thin steel shim stock wrapped around the core vessel.

support effectively only along a fraction of its axial length. "Pinch off" of the ram by excessive initial radial stress is avoided. The problem of sliding friction occurring in most variable support systems is not present because all changes in stress would be a result of elastic deformation of the components. Probably the advantage to be gained by this variable support approach will be more readily applied to the simple anvil devices which have a flatter conical portion than do our rams, or to multiple anvil devices.

An additional support to the ram is provided by the extrudable gasket which establishes some pressure gradient along the conical elements giving a "multistaging" effect and avoiding a sharp stress discontinuity.

In the case of the die, the geometrical advantage is gained by permitting only the central part of its axial length to be stressed by the internal pressure. This reduces the net splitting forces, but at the same time, sets up an additional stress system whose effects can be described as forcing elements parallel to the cylindrical external surface of the die into a barrel shaped configuration. This hypothesis is confirmed by the mode of failure of the dies. Cracks perpendicular to the axis of the die begin on the *outer circumference* near its middle and ultimately result in its failure. Axial clamping applied near the die circumference, although it reduces the tendency of this failure to occur, requires additional mechanical equipment. The clamping provided by the compressed gasket, in contrast, aggravates the barreling condition. Our approach to this problem has been to use noncylindrical radial support shown in much exaggerated form on Fig. 5. This could be accomplished by a precision grinding operation on the shim ring or by wrapping a smooth bevel-edged piece of thin steel stock around the middle of the die. We have chosen the latter approach. Note that the initial noncylindrical support stresses put a compressive stress along the external cylindrical elements, and a tensile stress along the internal elements which must result in a limit to the amount of noncylindrical support it is possible to use. The axial stresses due to the compressed gasket are now applied advantageously to the support of the die, opposing the axial tensions near the core.

In summary, this modification to the usual support has made the stresses in the critical core region more nearly hydrostatic when the system is at high pressure. The advantage of these simple modifications is that the cemented tungsten carbide structure need not be as massive as otherwise would be the case, giving correspondingly lower costs of constructing the high pressure equipment, an important advantage for small laboratory or production work. An additional advantage gained by this support modification is that for a given set of binding rings, one is allowed higher maximum radial support stresses on the center of the die than otherwise would be possible, i.e., the geometrical advantage principle is operating for the *binding rings* because they are forced to provide maximum supporting stress along only a short portion of their axial length.

BINDING RINGS

The dimensions of the binding rings used are shown in Fig. 6. The rings have been assembled from the outside in. The material of the rings is Nationalloy No. 7 gun steel[8] made up as pancake forgings and heat-treated to a hardness 48/52 Rockwell "C". The safety ring is left annealed. It is believed that the pancake forging leaves a desirable crystallite texture. The shim is made of Neor[9] hardened and drawn to 60/63 Rockwell "C" then "Electrolized"[10] on its external conical surface to reduce the frictional forces present during assembly. Finely ground molybdenum disulfide was used as a lubricant in all assembly operations. The 0.003-in. thick bevel-edged steel shim used to provide the deviations from cylindrical support, shown in Fig. 5, provides an interference in additional to those shown on Fig. 6. There have been no binding ring failures with the above conditions.

The apparatus is being used at present to study high pressure-high temperature reactions. Several mineral syntheses have been successfully completed at present, among them coesite, almandite, and diamond.

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[8] National Forge, Irvine, Pennsylvania.
[9] Darwin and Milner, Inc., Cleveland, Ohio.
[10] Electrolizing Corporation of America, 1650 Collamer Road, Cleveland 10, Ohio.