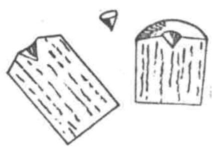

Fig. 3. *Sketch showing the characteristic failure of simple anvils made of 66HS, alumina or mullite*

The Rene' types deform rather than crack, whereas carbide cores crack, deform and splinter very badly when overloaded

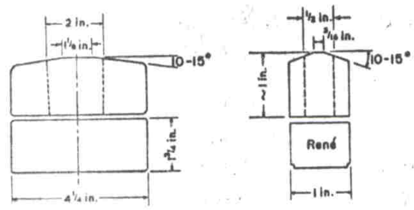

Fig. 4. *Modifications of ' two-stage ' anvils based on Bridgman's design*

The large anvil and flat assembly is the basic one for use in a 400-ton frame. Substitution of carbide cores with $\frac{9}{16}-\frac{5}{8}$ in. sample flats is done for work near 200 kb. The smaller assembly is used in 20 or 50-ton frames

based on extrudable gaskets such as the GE ' belt '. It is obvious that the compound anvils provide further opportunity to combine materials to the greatest advantage. The material of great hardness supports the direct thrust, while a tougher, less brittle material provides lateral support. What the substitution of a suitable polycrystalline diamond body for the carbide would produce is interesting to contemplate.

The use of red-heat tough steels or of high temperature–high strength alloys such as Stellite-25 and Rene' 41 permits work with the anvils at higher temperatures than are possible with the original Bridgman design. An effective two-stage anvil for work in the 100-kb region and 300—400° is made with $\frac{1}{2}$ in. cylindrical tungsten carbide plug force-fitted (1 % interference) into a 1 in. Rene' 41 collar, the end of the plug being finished to a $\frac{3}{16}$ in. circular flat. For use in the 400-ton frame, the safest and most useful all-steel anvil is made with a 2 in. plug of 66HS or similar steel at Rockwell-C hardness force-fitted into a 1° tapered hole in a TK steel holder at Rockwell-C 40—45. Each anvil is then backed with about a 2 in. thick flat of 66HS steel at Rockwell 66. The sample surface is a flat of $1\frac{1}{8}$ or 1 in.

Other materials may be used to work in specific ' P–T ' regions beyond those accessible with the anvils described above. Simple pistons of sintered polycrystalline alumina or mullite have been used by us in the range 1000—1200° and 7 kb in studies of the olivine–spinel transition of magnesium germanate. Silicon carbide anvils have been prepared by hot-pressing for use in the same region at higher pressures. Cemented titanium carbide is more resistant to oxidation than cemented tungsten carbide and is substituted for it (in a Rene' collar) for many studies a 600—750° and 35—20 kb. On the other hand, the Rene' alloy has been replaced by tungsten to give greater support to carbide inserts at the highest temperatures.

Size of samples and scale-up

A serious obstacle in laboratory high-pressure research is the restricted amount of sample which can be obtained. Thus in the 20—100 kb range in opposed-anvil apparatus, most of the significant synthesis work reported has been done with thin wafers amounting to 6—15 mg. of sample and a 20-ton ram.

In larger units based on 50, 100 and 400-ton rams, samples of silicates and similar oxides amount to about 40, 110 and 1000 mg. respectively. A typical large sample is $\frac{3}{4}$ in. diameter in a nickel ring $\frac{7}{8}$ in. o.d. and 0·04 in. thick. The significant increase in sample size is obtained at a modest cost of equipment when compared with increases in other types, so that, where studies may be carried out at temperatures up to 500—600°, the anvil apparatus is very convenient for subjecting a ' gram ' size sample to a known temperature, at pressures up to at least 100 kb, and higher with greater ram capacity.

Use of anvils in specialised applications

Shearing stress addition

The major mode of use of opposed anvils has been indicated in Fig. 1. Because of the temperature limitations on the anvils, all methods to increase reaction rates need study. The anvils