In all the experiments the quartz failed by sudden rupture as it does at lower confining pressures. An examination of thin sections of the deformed samples showed that the quartz had deformed by shear, or faulting, along rational crystallographic planes. One of the main objectives of the study is the examination of the mechanism by which this faulting takes place. The experiments were extended to a number of different orientations to provide a comparison of the strengths in different crystallographic directions and to determine which crystallographic planes are the fault-planes in specimens of different orientations.

EXPERIMENTAL METHODS AND PROCEDURE

Apparatus and Experimental Procedure.—The equipment used to deform the samples is a piston and cylinder device (Kennedy and LaMori, 1961) similar to those of Coes (1955), Hall (1958), and Boyd and England (1960a). It consists of a cylindrical tungsten carbide pressure vessel (G. E. Grade 883) supported by hardened steel (S.A.E. 4340) binding rings as shown in figure 1. The steel binding rings are pressed together with 1 percent interference on a taper with a 3° included angle. The ends of the carbide pressure vessel are supported by compression between large hydraulically-driven platens through which the carbide piston passes into the pressure vessel. The piston fits the cylinder within 0.0002 inch.

The principle employed in the experiments was as follows. At room temperature bismuth undergoes two polymorphic transitions between 25 and 30 kb, BiI ⇄ BiII at 25.4 kb and BiII ⇄ BiIII at 27.0 kb (Kennedy and LaMori, 1962). There is a considerable change of volume (approximately 8 percent) in the range of these transitions. Thus if the pressure vessel is filled with bismuth and then compressed, there is a large piston displacement with relatively slight change of pressure within the bismuth. The sample assembly in the experiments (fig. 1) was designed so that the deformation of the quartz would take place entirely within the pressure range of the transitions. The quartz cylinder and a tungsten carbide endpiece were sealed within a machined copper jacket which

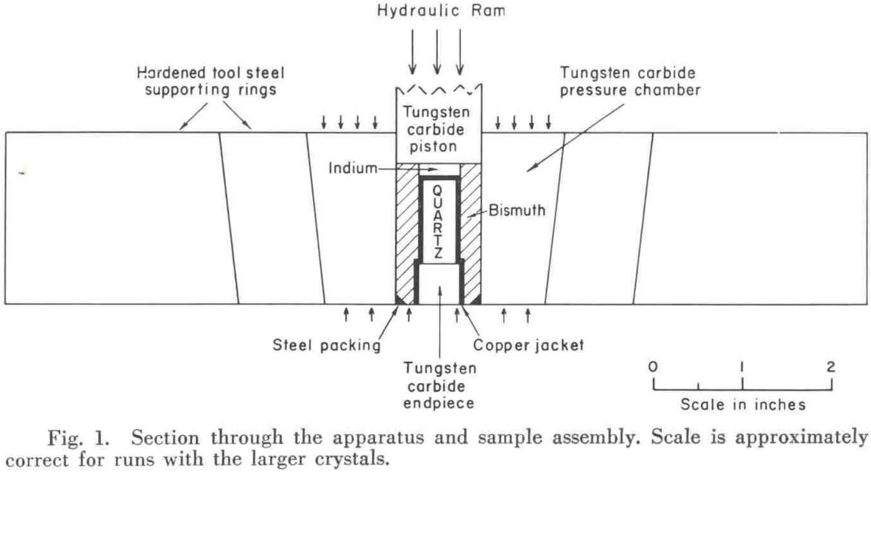

Fig. 1. Section through the apparatus and sample assembly. Scale is approximately correct for runs with the larger crystals.

was fitted into a hole machined in a previously-compacted slug of bismuth. The disc of indium between the quartz sample and the piston acts as a space-filler; indium was used because of its very low strength. It ensures that the quartz is compressed hydrostatically in the early stages of the experiment. During the experiment, as the loading piston is advanced, the indium is progressively squeezed aside along the piston face and between the bismuth and the copper jacket, until at a certain piston displacement, which depends on the geometry of the assembly, the compressibility of the bismuth and indium, and the elastic constants of the quartz, the quartz is in contact with the piston. The quartz is then compressed axially by the piston, at a confining pressure equal to that of the bismuth. The sample assembly was designed so that the piston would contact the quartz within the first transition (BiI ⇄ BiII) and the quartz fail before the completion of the second transition (BiII ⇄ BiIII).

In the first experiments quartz cylinders 1.0 cm in diameter and 2.5 cm long were deformed in a pressure vessel 2.5 cm in diameter. The records in these experiments showed that a large proportion of the cylinders failed after the second transition was complete. It is estimated that the confining pressure at the time of failure in these experiments was between 27 and 30 kb. It was impossible to calculate the strengths accurately for these experiments. The assembly was redesigned to ensure that the deformation would be complete (to failure) within the range of the second bismuth transition. This involved the use of smaller quartz samples (0.45 cm diameter, 1.3 cm long), thinner copper jackets, and a larger volume of bismuth, relative to the quartz. These were deformed in a cylinder of smaller diameter (1.27 cm). All the strength determinations reported below are for samples that failed during the second transition of the bismuth, when the confining pressure was 27 kb.

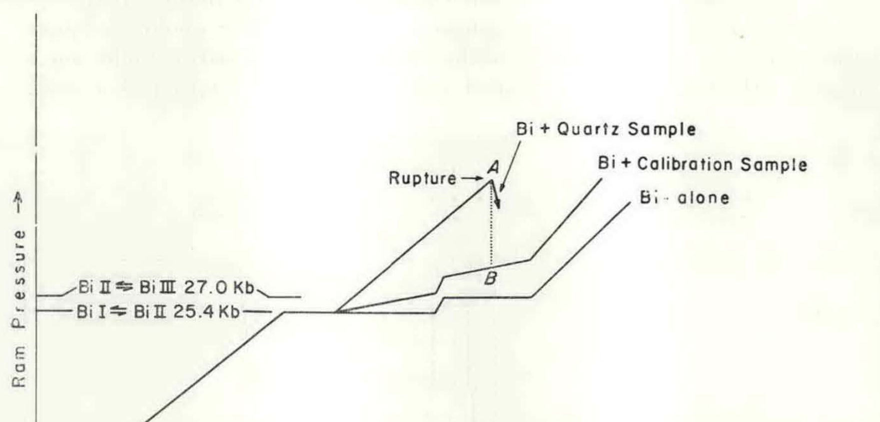

Fig. 2. Diagrammatic representation of records showing ram pressure and piston displacement.