pure, well-characterized and well-controlled single crystals are required. This must be coupled with the best micro-mechanical models available in order to determine the role played by various imperfections and atomic processes in dynamic failure under impact. When this is established, we may be in a position to predict dynamic failure in a material from ordinary laboratory measurements of yield stress, hardness, impurity content, etc. One thing that is needed rather badly is satisfactory reconciliation of shock experiments and ordinary thin bar experiments. The latter are used to measure failure stresses at strain rates up to about 10^3/sec. The former are essentially stress relaxation experiments. If data from both kinds of experiments are reduced to a common form, we may gain significantly in understanding of the underlying processes of dynamic failure.

The above remarks are directed primarily toward failure of ductile solids by the yield process. Fracture is much less understood, but concepts of fracture in ductile materials developed by conventional metallurgical techniques[61] and shock wave methods[62] are converging on what seems to be a reasonable understanding. The failure of brittle materials under shock conditions is not at all understood. Two questions are outstanding, and their investigation will lead to some insight into the total process. One concerns the transition from brittle to ductile behavior, which apparently occurs in some materials under pressure, and the role it plays in failure under impact. The other concerns the apparent total collapse of the stress deviator in some brittle materials, of which quartz and sapphire are notable examples.[63] Inasmuch as ceramic materials are coming to play an increasing role in our society, brittle failure will be of increasing future importance. If we understand it under the extreme conditions of impact, we may come to understand it otherwise.

Geometric aspects of fracture and failure in shock experiments have been largely neglected. It is reasonable during the formulation of concepts to concentrate on plane geometry, but an important test of concepts so developed lies in their extension to other geometries. It is not too early to start designing and planning experiments with other than uniaxial strain.

Insofar as phase transitions are concerned, we know essentially nothing about the kinetics of transition under shock conditions. Comprehensive and searching experiments on well-defined materials of various classes are needed before we can even state the problems clearly. A very critical question here, of deep meaning for physical theory, is whether or not this fast transition can be understood by application of quasi-equilibrium statistics. The only feasible alternative seems to be large scale machine simulation of particle dynamics.

It is unlikely that electron behavior is significantly influenced by the dynamics of shock compression. Electrons in solids move too rapidly for that. But we can't be sure without further experiments and interpretations of experiments. Anomalies exist, as indicated earlier, and until they are resolved we don't know whether electrical effects are understood or not. The anomalous thermoelectric effect reported by several workers[64] is a good example of a large effect beyond that expected from static experiments. It has been suggested that this is an essentially dynamic effect, but the argument is not conclusive. Alkali halides deserve more study under optimum conditions. Independent variations of temperature and pressure have been attempted, but more work along such lines is required.

Absorption spectroscopy is a powerful tool for studying the internal structure of solids under static conditions. Time resolved spectroscopy is possible in shock experiments, but it has been little used. Experimental problems are formidable, but not apparently insoluble.[51] Used in conjunction with resistivity or shock polarization experiments, it may tell us a great deal about the internal states of shocked materials.

Almost all insulating materials produce electrical signals on being shocked. This is commonly called "shock polarization" or "charge release," depending on the nature of the material. The effects are significant theoretically and practically. Practically, because these signals are often unwanted in experimental systems and they can obscure or confuse the nature of wanted signals. Their theoretical significance follows from the inference that they indicate the occurrence of dramatic changes in electrical structure of the solid in the vicinity of the shock front. These effects are well-documented[65] and have been characterized phenomenologically, but little progress has been made toward developing atomic models.

Problems of yield, flow and fracture are probably of greatest interest to the group assembled here this week. Such problems can usually be expressed in terms of behavior of stress deviators in the field. Because the amount of energy that can be stored in elastic deformation is limited, these deviators stop increasing at some point in the loading process and we call this failure. Failure of this kind is associated with fracture or flow of the material. But at least one other situation appears to exist which can produce collapse of the stress deviators, at least in uniaxial strain. If a first order phase transition occurs as a consequence of shock compression, it seems plausible that the new phase will form so as to reduce the energy of deformation as well as that of compression. Looked at macroscopically, one would say that the stress deviators had collapsed as a consequence of the transition. If the material had been on the verge of yield or fracture before