In a recent series of experiments on potassium chloride, D. B. Hayes has obtained results which tend to heighten the puzzle, rather than resolve it.[43] He has found that the kinetic behavior depends on crystal orientation. When the shock propagates along the <100> direction, the material transforms to a new and metastable phase or partially transforms to the CsCl structure in less than 10^{-8} seconds. He finds some evidence of slower decay from this intermediate state to some undefined state. When the shock propagates in the <111> direction, transition is slower, the transition time being 10 to 40 nanosec, depending on driving pressure, but the final state reached after this time is the well known CsCl state. There is no evidence of a transition state as found for the <100> orientation. The transition pressure determined from his experiments may be higher than the static pressure by about a kilobar, but this difference may be due to uncertainties in both static and shock experiments.

Effects of shock waves on magnetic materials has been of both practical and theoretical interest. Three processes have been identified as being responsible for producing demagnetization of magnetic materials by passage of shock waves. One is depression of the Curie temperature by compression. This occurs in iron-nickel alloys with nickel content greater than 30%. A second is transformation from a ferromagnetic to a non-magnetic state through a first-order phase transition. This is observed in iron when it changes from fcc to hcp at 130 kilobars. The third is anisotropic demagnetization, a kind of inverse magnetostriction resulting from rotation of the magnetic momentic vector when elastic strain is imposed on the lattice. This last effect occurs in nickel ferrite, yttrium-iron-garnet, manganese-zinc ferrite and other ceramic materials. It turned out to be rather complicated and has been resolved by elegant theoretical and experimental developments.[44-47]

Electrical measurements to determine the effects of shock compression on resistivity have been made for a number of materials.[28] The combination of geometric requirements, shock reflection problems and electronic response times make such measurements very difficult. Quite good measurements have been made in xenon, argon, carbon tetrachloride, germanium, iron, manganin and copper. Those in liquids were helpful in elucidating certain anomalies in the equations of state.[48] Measurements on germanium in the range of elastic compression were the basis for a detailed evaluation of band structure parameters, indicating that uniaxial compression is a valuable adjunct to hydrostatic compression for such studies.[49] Resistivity of iron shows some curious anomalies below 100 kilobars which have yet to be explained, and that of copper is anomalously high when compared with static compression measurements.[48,50] A

substantial number of resistivity measurements have been made on alkali halides for the purpose of studying the collapse of the electron energy band gap under compression. The results are ambiguous, but enough information is obtained to show that shock resistivity experiments can provide valuable information in this area.[28,51]

An isolated but striking result which has dramatic implications for future research is the production of x-ray diffraction patterns in the vicinity of or behind the shock front. This technique was developed with LiF as specimen material. Its recent application to boron nitride[52] suggests that it may become an effective tool for structural studies.

III. PROBLEMS FOR FUTURE STUDY

Much is to be done, of course, in digesting past work, making it available in a synthesized form for others, and developing its physical implications. This is particularly true in measurements of pressure-volume relations. There are at least two approaches to the problem of determining an equation of state from shock experiments. One is strictly thermodynamic. Shock experiments provide data on a single curve in p,V,E space. Supplemental experiments are then required to provide off-Hugoniot and thermal data. Various methods for doing this have been tried and have not been very successful.[53-56] The situation will be improved if bulk sound velocities and temperatures can be measured in the shocked state, but it is unlikely that a complete thermodynamic characterization of any material will be achieved without reference to physical models. A second approach, and the one most used to date, is to assume a rough physical model for the substance, derive the equation of state, including undetermined parameters, and use shock wave data to determine the parameters. This procedure can be improved upon by combining thermodynamics and model in such a way that all thermodynamic data can be used in determining parameters of the equation of state.[57] This procedure is useful but is, in a sense, a stopgap. At the present time what is required is precise model development for restricted classes of materials based on elementary principles. These can then be combined with Hugoniot and/or other thermodynamic data to produce equations of state in which one can have reasonable confidence. The success of this procedure for special materials has been demonstrated by Ross, Pastine and others.[58-60] It is a demanding process, but it yields valuable results.

Careful study of dynamic failure is just beginning. Measurements of elastic precursor decay and shock structure for simple,