transforming, no such failure is imminent after transition. It may then be possible for it to absorb additional deformation. An effect like this has been observed in CdS[66] and InSb,[33] so the speculation is not pointless. It is then reasonable to inquire what the material behavior is on being cycled through the transition and whether or not its ultimate strength is substantially modified. These are interesting questions because they may have significant applications in addition to their scientific implications.

IV. PROBLEMS OF APPLICATION

Most of the preceding remarks related to scientific questions having to do with shock waves. Many problems of application remain to be resolved. Technologists seem inclined to respect the principle that improved understanding of fundamental processes leads to better technology, but to ignore it in practice. This is done with good reason because technology has gone very far with little understanding and the road to better technology through better understanding is a long and tortuous one.

This seems to have been less true in shock wave problems than others, perhaps because of the precedent set in the Manhattan Project. Perhaps also because of the difficulty of a "cut and try" approach. So problems of application and science are not always far apart. There are, of course, continuing problems of major importance in weapons design and military defense, with which many of you are familiar. Progress is being slowly made in these areas and efforts along present lines will undoubtedly be continued.

There are other important applications. Explosive or impact welding is not understood, despite the fact that it is an important commercial enterprise. There is no continuum mechanical model which will predict the gross features of the bond. The first light of mechanical understanding may exist, but more is required.[67] Some of the qualitative metallurgical features can be rationalized, but there is, for example, no theory which tells us why apparent diffusion coefficients are so large. This feature is reminiscent of some early, rather poorly documented, observations which suggested that under some conditions carbon can be driven freely through an iron lattice. Is it possible for shock waves to differentially accelerate dissimilar atoms so that the usual barriers to diffusion are lowered?

Diamonds are being commercially produced by shock compression. They are not very large and the business may not be very profitable, but it exists and might be better if the transition process were understood. Some ideas exist,[68] but a great deal of work will be required to develop them. There may be other products sufficiently valuable for manufacture by shock methods, but the question has not been thoroughly explored.[70]

The hardening effects of shock waves on metals are still not understood, though they are frequently used. Understanding is intimately related to questions of dynamic failure and deformation, and therefore to the motion and creation of dislocations and other defects.[69] Commercial applications of these effects may provide additional motivation for understanding them.

Explosive or shock-actuated devices are frequently suggested and sometimes developed for engineering applications. They might include such items as one-shot electrical generators, timing devices and fast-acting valves. They may depend on changes in conductivity or interaction of waves with associated fracture and flow. Their development is usually very costly. Development of a quantitative engineering discipline soundly based on the known behavior of materials under shock conditions would accelerate such applications.

V. CLOSING REMARKS

Problems of shock wave propagation in solids involve continuum mechanics, thermodynamics and materials or solid state science, all interacting in a very intimate way. A great deal of progress has been made in sketching a framework of theoretical and experimental techniques within which it is possible to do meaningful, perhaps even revolutionary, experiments in solid state science. Within this framework many significant experiments have been done relating to mechanical, thermodynamic, electrical and magnetic properties of solids.

But in a deep sense the real science of shock waves in solids has hardly been touched. When nothing had been done, exploratory experiments were appropriate. Now what is needed is intensive study of problems chosen primarily for their scientific import, by specialists in materials and solid state science, using, where possible, established and reliable experimental procedures. When this becomes common, we shall begin to see the real significance of shock wave research.

ACKNOWLEDGMENT

This work was supported by the United States Air Force Office of Scientific Research Contract 71-2037A and National Science Foundation Grant Number GH 34650.