determined from within science. It is a venerable philosophic principle that the value of any universe of discourse must be judged from outside that universe of discourse. . . . The answer to the question: does this broad field of research have any scientific merit? cannot be answered from within the field." Weinberg proposes a criterion: "Other things being equal, that field has the most scientific merit which contributes most heavily to and illuminates most brightly neighboring scientific disciplines." Here is a principle with which many will take issue.

The technological factors are easier to deal with. One must assess the state of technology. Is it ripe for exploitation? Are the people in the area competent? Is the project likely to succeed? In this country we have considerable expertise in evaluating technological factors. The most difficult judgment is social merit. Social values are hard to define. They include national defense, health, national prestige, and food. Concensus on the relative weights to be assigned to various proposed projects is difficult to achieve. Nonetheless, Weinberg feels, some qualitative evaluations are possible.

In an effort to apply these criteria to the real world, Weinberg analyzes and compares five scientific and technical fields: molecular biology, high-energy physics, nuclear energy, manned space exploration, and the behavioral sciences. I will summarize his comments on two of these. High energy physics rates superbly on scientific merit. It has many interesting problems and the best people. Yet in its relationship to the development of technology it is mediocre, and on social merit its rating is poor. These two low grades would be acceptable if high energy physics were cheap. But it is not. However, if high energy phsics were to contribute to international cooperation, say, by a joint East-West accelerator, its overall rating could be greatly raised.

At an opposite extreme is molecular biology. Weinberg devotes an entire article to the support of his belief that "of all the sciences now supported by our society, biomedical science ought to stand first." Problems exist in abundance. They are being attacked by competent people, and are being solved. The prospects of social returns in the near future are excellent. The costs of biomedical science are spiraling as more and more sophisticated apparatus is developed. It is time for major investment in this area. The approach most likely to prove fruitful is that of the major research institute, in which interdisciplinary interaction is the rule rather than the exception. Weinberg approvingly quotes Professor Peter Rossi: "the social ecology of the university is not as well suited to a massive attack aimed at a single goal as is the ecology of the research institute" [Researchers, Scholars and Policy Makers: The Politics of Large Scale Research, *Daedalus*, LXLIII, 4, 1142 (1964)]. In a research institute the whole is much more than the sum of its parts, and a competent individual can exert far more influence than he can in an isolated environment. Molecular biology receives top marks for all of Weinberg's criteria.

The previous discussion has been devoted to the operation of science within the developed, industrialized countries. Far different problems exist in the underdeveloped nations. Several articles are devoted to the elucidation of the nature of these problems and to methods by which they might be alleviated. Of particular interest are a number of eminently practical suggestions proposed by Michael J. Moravcsic. He is concerned about the brain drain, the problem of admission of students from underdeveloped nations into graduate schools, and the maintenance of continuing productivity when communications are difficult. An international roving team of technicians is proposed as a means for keeping complex scientific gear operative. It is suggested that a team of interviewers travel through underdeveloped areas interviewing graduate school applicants in order to apply uniform standards and minimize the traditional problem that Eastern applicants arrive with superb letters of recommendation, regardless of their true competence. None of Moravcsic's proposals are expensive or impractical, and it is to be hoped that some of them will be put into practice.

Criteria for Scientific Development is rich in ideas. It is time that the dialog taking place in *Minerva* be brought to a wider audience. Publication of this reprint volume is a step in that direction. An index facilitates following concepts from one article to another and retrieving thoughts remembered only vaguely. The omission of biographical data on the authors is unfortunate, especially since many are British and their names are unfamiliar in this country.

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COMPREHENSIVE COMPOSITION ON COMPACTION

Title Vibratory Compacting—Principles and Methods

Editors H. H. Hausner, P. K. Johnson, and K. H. Roll

Publisher Plenum Press, 1967

Pages xi + 298

Price $17.50

Reviewer Harry M. Ferrari

Vibratory compaction has become an important commercial process for fabricating ceramic nuclear fuel and reactivity control elements. Although many articles have been written on this subject, the information is diffused over several hundred publications encompassing many diverse fields. This book, the first one entirely devoted to vibratory compaction, will serve as a useful depository of some of the more important information.

The book is basically a compilation of four loosely related studies by several contributors. Over two-thirds of the book is a translation of a detailed Russian study of the physiochemical principles of vibratory compaction. The remainder consists of two articles by American authors and one by British authors.

Although each of the individual contributions is good, the book suffers in that the articles are disjointed, the subject matter is not comprehensively covered in certain areas, and there is some unnecessary duplication in figures and data among the various articles. It would have been preferable if a comprehensive new book had been written on this subject, rather than a simple compilation of some of the better articles existing in the literature.

The Russian article presents interesting data and concepts previously unavailable in English language articles. The work covered is very broad, ranging from vibratory compaction of metal and ceramic powders to vibratory compaction of sandy soils and concrete mixtures. This study is unquestionably the most comprehensive existing publication on vibratory compaction principles.

The second article, by R. K. McGeary, is a reprint from a 1961 *Journal of the American Ceramic Society* on the mechanical packing of idealized spherical particles. When first published, McGeary's work was viewed as an excellent basic study of carefully characterized spherical particles which were ideal in behavior. With the advent of spherical nuclear fuel particles, McGeary's work now assumes significant commercial importance

The contribution by P. E. Evans and R. S. Millman discusses vibratory compaction of typical irregular particles. This article demonstrates the difference in packing behavior of typical non-ideal particles as contrasted to McGeary's idealized spherical particle work.

The final study by J. J. Hauth summarizes the extensive work performed by Pacific Northwest Laboratory on vibratory compaction of ceramic nuclear fuels. This article is especially useful to those working in the nuclear field.

The excellent bibliography greatly enhances the book's value. All important publications to date on vibratory compaction are referenced.

In summary, the book is probably the most comprehensive existing document devoted entirely to vibratory compaction and hence is of considerable value to those interested in that subject.

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BOLSHEVIK BUBBLES

Title Bubble Chambers

Authors Yu. A. Aleksandrov, G. S. Vornov, V. M. Gorbunkov, N. B. Delone, and Yu. I. Nechayev

Translation Scripta Technica; William R. Frisken, Translation Ed.

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Pages xii + 371

Price $17.50

Reviewer R. I. Louttit

Bubble chambers have been used effectively for about ten years in experiments in high-energy physics. Their high spatial resolution and reasonably high density interaction medium have made them ideal for the study of many characteristics of the "fundamental" particles of matter and their interactions with each other. A bubble chamber is a device which presents a transparent, superheated, liquid target (often liquid hydrogen) to a beam of high-energy protons or other particles from an accelerator, and in which the paths of charged particles are made visible by the growth of bubbles on the heat spikes left in their wake. A magnetic field is normally provided to permit momentum determination from the curvature of the tracks. These are recorded on film, and the "events" are deciphered later through measurements on curvatures, angles, density of bubbles along tracks, etc.

The fundamentals involved in accomplishing all this, including the theory underlying the formation, growth, and recondensation of bubbles in superheated liquids, are treated in great detail in this book. Its tone is that of a pedagogical text, written at roughly the level of a graduate engineering course.

There is a good introduction, which would make worthwhile reading for all engineers and technical specialists charged with responsibility for operation of bubble chambers. It will also provide the novice with a reasonable picture of what a bubble chamber is required to do. One very thorough chapter is devoted to the problem of illuminating and photographing vapor bubbles in liquids. Serious photographers will, however, note a glaring error in the result given for the relationship between intensity of image and field angle θ. This is stated as a $\cos^7\theta$ dependence, but, fortunately for wide-angle photography, it is actually only $\cos^4\theta$.

As long as the book sticks to the theoretical aspects of its subject, it does a commendable job, but in its illustrations of the technology, it shows its true age. Most chambers referred to as first-line experimental devices were actually retired years ago in favor of larger, more accurate second-generation chambers. These latter chambers, some of which have now been in operation for five years, are mentioned as though they were in preliminary design. As a result, the book fails to report on several recent important technological improvements. These include the use of neon-hydrogen mixtures in hydrogen chambers to produce a target medium of continuously variable density (1965); the use of "superinsulation" in cryogenic chambers to reduce radiation heat loads to near-negligible levels (1963); and the use of Scotchlite as a retrodirector of illuminating light (1963), which made feasible the design of very large chambers ($>10\ m^3$). The book contains no reference later than 1963.

The final part is devoted to methods for obtaining useful data from the pictures, and to various types of possible experiments. It