

New hope for science?

The following observations are based on reports that I had the privilege to listen to last June as a member of the Mathematical and Physical Sciences Advisory Committee of the National Science Foundation. These carefully prepared and well documented reports were given by four NSF staff members on the state of mathematics, astronomy, physics and chemistry. All four of them showed that the degree of unemployment among young PhD's in these fields has become quite alarming, especially so in mathematics and high-energy theoretical physics.

The majority of the individuals concerned are "squeezed out," not immediately as fresh PhD's, but 5-8 years afterwards, because of the lack of tenure positions. Thus to a person who has started out 13-18 years earlier on a scientific career, intending to reach a goal then considered of highest value, and has studied dedicatedly for many years, often making great sacrifices, this means a major tragedy. The reactions to this tragedy can take on different forms: Some realistically turn to other fields, for example, to industry, administration, medicine, and so on. This frequently requires additional years of study. Others, and by no means the least able, give way to self-doubt and despair, and postpone a decision until it is too late; still others seek the causes of their fate, justifiedly, in the faulty functioning of society, and try by various means to correct the state of affairs, which frequently produces additional upheaval.

The colleagues of the unfortunate individuals usually know for at least a year ahead what will happen, and they too react in various ways: Often beset by fear and panic concerning their own future, they may pretend that nothing has happened by treating the persons concerned as "lepers"; that is, by ignoring his or her existence; or they may be incensed and protest in various ways to the administration of their institution. All this does not contribute to a beneficial atmosphere for scientific endeavors. The undergraduates and even high-school students quickly draw their conclusions; thus the image of a scientific career has suffered considera-



bly in recent years. According to some sources a state of apathy towards education in general has set in at many high schools in the country, even among the more gifted students.

It is therefore of utmost importance that the superior intelligence, the talent, and the leadership qualities of the persons who, without any fault of their own, are not able to follow their chosen career, be made use of in a constructive way. They ought to be given an opportunity, by means of a fellowship to get acquainted with other choices that may prove to them eventually fulfilling and satisfying. (R. Peierls, Brookhaven National Laboratory, has pointed out in a communication that the quality of the people who are being squeezed out now and in the next few years is very probably considerably higher than the quality of the young scientists who will be available in about ten years from now. It therefore appears wise to encourage the institutions releasing scientists who are trying to enter new careers to promise to take them back, if needed, for at least two years after a trial period of one or two years.)

The most fruitful solution of the problem of these scientists would be employment in interdisciplinary projects. Some projects of this type lie entirely within the sphere of the division of physical sciences. For instance, the

spectroscopic analysis of stellar spectra, a very important, but tedious procedure, has not yet yielded to computerization. Collaboration of optical astronomers with applied mathematicians may lead to progress.

Other interdisciplinary projects transcend the realm of the division of physical sciences. One such project, which has been attacked on a broad front in recent years, is the study of the structure and function of membranes. In a somewhat less advanced stage is the problem of the developmental aspects and the mechanism of cell division, although great progress has been made on the structural components involved in this process. The etiology of various diseases, for example, of various types of cancer, may be advanced by more sophisticated statistical analysis. Further, the study of the evolution, structure, and function of the brain and the nervous system will, as it has already in the past, give rise to a series of interdisciplinary researches. Finally, the complex of feedback systems of which the nervous system and the endocrine glands form integral parts (neuroendocrinology) has just begun to yield to scientific analysis.

Still other projects may require the talents of physical and social scientists or even of physical, biological and social scientists combined.

There is further need for the talents of the "squeezed-out" scientists in education, in industry, in government; the problems of transportation and communication, of help for the poor, for the sick, for the relief of city blight, pollution, and, last but not least, the problem of how to insure international peace, require well trained and imaginative minds.

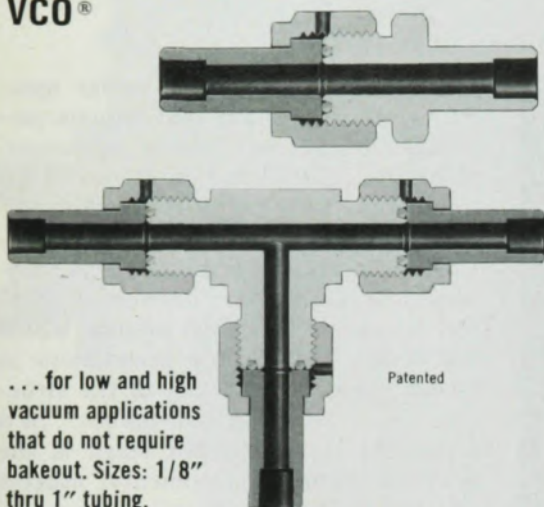
While we may consider the adjustment of the number of scientists produced to the number of scientists needed as a comparatively short-range problem, let us now concentrate on the longer-range problem: here the NSF is in an excellent position to provide a better climate for scientific research by coordinating education and public information constructively: 1) Science education has to be started at as early an age as possible. In the June issue

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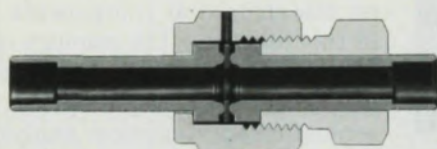
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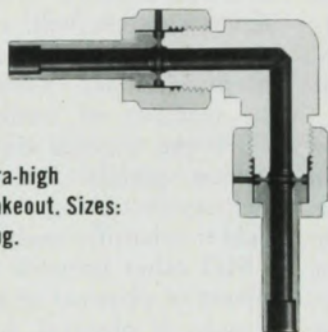
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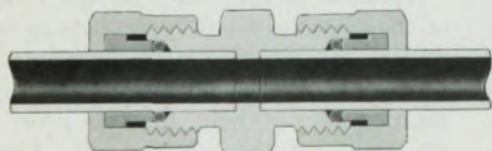


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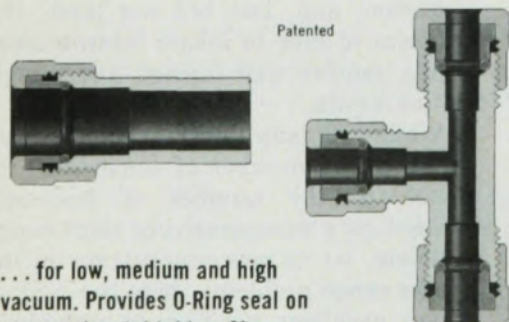
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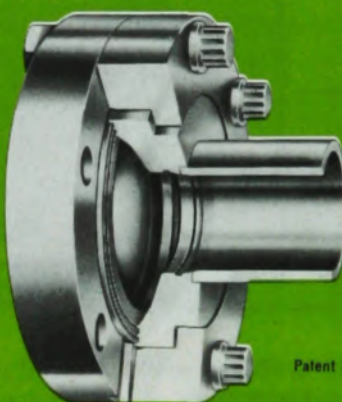
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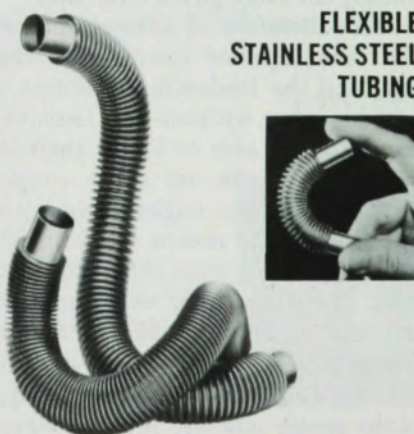


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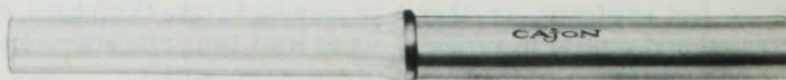
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letters

of PHYSICS TODAY, which is devoted to grade-school education of children in science, Robert Karplus has pointed out that when a student has reached the age of 15 it is too late to try to interest him or her in science. 2) The information of the public, too long neglected, can be brought about through many channels: adult education, the news media, science museums, and so on. (It is worth noting that New York has not had a true museum for the physical sciences for more than thirty years. On the other hand, there are two excellent new science museums at the West Coast: The Lawrence Hall of Science in Berkeley, and the Exploratorium, under the imaginative directorship of Frank Oppenheimer in San Francisco.) In particular the daily press could contribute a great deal in this respect by dispensing not only science news, but by presenting results that are well established, in attractive, easily digested articles, for instance, in daily columns, possibly in serial form. Such a column could report on the discovery and the properties of x rays (possibly starting out from a novel use of x rays), or on some phase of astronomy, on conversion of energy, and so on. The use of a moderate amount of mathematics in such articles could be made possible by exposing the readers occasionally to mathematical and scientific puzzles, in addition to verbal puzzles such as the ubiquitous crossword puzzle. This might prevent the receivers of high-school certificates to allow their generally quite appreciable knowledge of mathematics to atrophy within a short time, instead of making constructive use of it. Thus, slowly, the general public could learn to understand the beauty and power of science.

Some excellent recent examples of how to present past scientific developments in a dramatic and entertaining form are: *Worlds Within Worlds: The Story of Nuclear Energy* by Isaac Asimov, Volumes 1-3, published by the AEC (1972) and *Einstein—Creator and Rebel* by Banesh Hoffman, Viking, New York (1972).

GERTRUDE SCHARFF-GOLDHABER
Brookhaven National Laboratory
Upton, New York

Superconductors again

I disagree with William Little's argument about not developing high- T_c superconductors (November, 1972, page 13). The real economical limit of refrigeration is not from the consumption of hydrogen or helium but from the second law of thermodynamics. The limit of T_c to high-temperature superconductors is not that well established.

Empirically we have the limit set by B. T. Matthias and coworkers, who have searched thousands of superconducting alloys. Theoretically we have the rule of W. L. McMillan, who set the phonon limit of T_c for all superconductors. It appears that breaking the limits set by McMillan and Matthias is still easier than building a perpetual-motion machine.

L. Y. L. SHEN
Bell Laboratories
Murray Hill, New Jersey

THE AUTHOR COMMENTS: The most efficient cryogenic refrigerators available today for superconductor cooling have an efficiency between 10% and 20% of Carnot efficiency. Machines under development may raise this figure 30% for large-capacity systems. An improvement by a factor of at least three in this efficiency is possible, in principle, before one runs into the limit set by the second law. On the other hand, to obtain a similar improvement in system efficiency by the development of high-temperature superconductors would require values of T_c about a factor of three higher than those available today. I contend that the probability that a conventional phonon superconductor will be found with anything like this value of T_c is identically zero and, hence, refrigerator research is much more likely to yield an improvement in overall system efficiency than such superconductor research. Shen's letter appears to miss the point that existing refrigerators are so inefficient relative to the Carnot limit.

WILLIAM A. LITTLE
Stanford University
Stanford, California

Remedy for fear of physics

I am very disheartened when I hear of decreasing enrollments of liberal-arts students in the physics and astronomy courses. Four years ago, I began to investigate the problem and have come to interesting conclusions. I have implemented these thoughts, and, I believe, not in vain, since my modern-physics/astronomy course has increased in enrollment from 45 to 200.

What I essentially discovered was that liberal-arts students are intrinsically interested in physics and astronomy, but they are terribly afraid of not understanding it, especially when it comes to dealing with mathematics. Thus the main task is to make students comfortable and feel that some of the physics and astronomy phenomena are indeed very much in line with their own way of thinking and philosophy. Introducing mathematics as a mere tool and letting the students

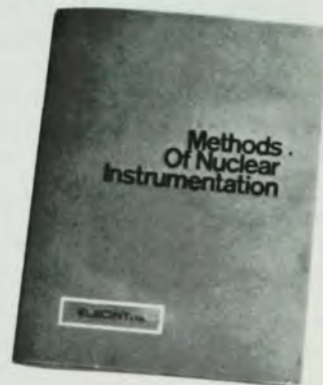
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