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Physics in the Communication Field

By A. H. White

FOR at least two generations the communications industry has interacted very closely with certain exciting areas of physics. The mutual benefits flowing to the technology and to the science, respectively, have been obvious to everyone involved. The central role of the electron tube in the instrumentation of physics and in the communication of information is well known. Solid-state devices are clearly destined for a similar role. This interaction has provoked extensive direct contributions to basic physics, especially in physical electronics, radio astronomy, and the solid state. Several of the contributors have received Nobel Prizes for their work.

In view of this record it may seem unnecessary to review the nature of physics research in the communications industry and the opportunities there for doctoral graduates who are well prepared. However, the purpose of this symposium is to review prospects for the future, rather than past accomplishments, with particular reference to the role and training of the physicist in industry. Probably the best way to deal with the future of physics research in the communications industry is to consider the philosophy which guides it. At this point I am compelled to discuss only one segment of the industry, that with which I am really familiar. However, I believe that I am expressing a point of view that is widely and increasingly representative of the industry.

With due apologies, then, I consider the physics research philosophy of the Bell System as representing a major fraction of the communications industry. This philosophy will be expressed in a series of statements each of which, I hope, is self-evident. I start with the fact that the Bell Telephone Laboratories is responsible to the Bell System for new communications technology. A great part of this responsibility involves work in applied science or development, for example on a novel communications system which embodies devices already invented, combined according to physical principles which are already known. Such work provides new communications technology for the near future, say within the next five or ten years. However, our laboratory is also responsible to our company for the more distant future of this technology, say ten to twenty years hence. An effort to look so far ahead yields only one certainty: the advance of basic research throughout the world will reveal new principles, new ideas, new materials, whose application will turn out to be vital to the industry. The problem is to assure our company and its customers their fair share of the benefits thus to be expected. It is, then, very important that the company be made promptly aware of these relevant advances in the world of science. Every scientist knows, however, that he cannot be *really* aware of what is going on in a field of science unless he is contributing to it. The conclusion is that, if the laboratory is to discharge its obligation to the company, it must among other things be undertaking basic research in a wide variety of fields which are relevant to the technology, or may become so. To be effective, this work must be conducted in an atmosphere very much like that of the best universities, an atmosphere designed to evoke all possible scientific initiative and imagination from the individuals involved. In general, the scientists will be motivated primarily by the intellectual excitement of their work. It is hoped that they will make leading contributions to their fields, thus almost automatically insuring their awareness of what is going on elsewhere. It is then often up to the research "managers" to see the connection between a scientific discovery and the technology, and to alert the appropriate applied research or development group to the possibilities. Meanwhile, the research scientists also contribute to the technology by their availability to the applied scientists for consultation.

This basic research will occasionally yield scientific results or inventions which are directly applicable to our company's technology. However, this technology cannot afford to rely on such events, which become relatively less probable as world-wide activity in the relevant science expands. What the company can do is to support leading contributions to the world of science, from which it always has drawn and always will draw so heavily for its technology.

This philosophy then specifies the nature of the basic physics research program of our laboratory, and of the opportunities thus provided for the individual contributor. What is needed is creative intellectual adventure of the highest order, leading at best in directions which only the contributor himself can choose. Areas of physics in which we are currently trying to make such contributions are principally the physics of solids, of surfaces, of microwaves, of plasmas, and physical electronics, chemical physics, and certain aspects of biophysics. We realize that even this broad effort may cover too limited a range to meet the laboratory's obligation to contribute in fields likely to become relevant to communications. The staff is therefore encouraged to take initiative in branching out into other aspects of physics. For example, we are actively searching for reasonable ways for our laboratory to make worth-while contributions to nuclear physics research.

This program obviously requires a staff of very able theoretical and experimental scientists trained in the most modern ideas and methods of physics research as practiced in our best universities. From this point of view it is difficult to see how these universities can improve their training procedures, unless by some magic they can increase the numbers without sacrificing quality. What can be improved is the understanding by senior academic physicists of the nature of programs such as that outlined above, and of the opportunities for free inquiry provided by them. The young physicist in training is entitled to an accurate view of the range of such opportunities.

Up to this point we have discussed the role of physics in providing for the distant future of the company's technology. As mentioned above, however, the laboratory carries a very heavy responsibility for the near future, which requires work in applied science and development. For many years this area was primarily the domain of electrical and mechanical engineers, although a goodly number of trained physicists also found it exciting and rewarding. With the advent of solid-state technology the recruiting of physicists for such work increased materially, since the training in the engineering schools was not generally designed for this discipline. Some part of this increased need for physicists may well be permanent. For example, masers in all their variety, and for that matter a number of other magnetic devices, are fundamentally quantum mechanical in nature. Development of such items requires men trained in quantum physics. Here again it is difficult to see why the universities should modify their present educational procedures, in view of the level of ability and sophistication required for such work. Industry should be able to rely on finding a number of physicists who enjoy seeing the direct impact of their work on society, as in the past.

It is true that great contributions have been made by the physicists who have applied their talents to less sophisticated aspects of the development of communications. The methods of classical physics are very powerful in such fields. However we do not believe that the university training of physicists should be modified to meet these needs. The primary purpose of the university physics department should be to foster the intellectual adventure into the complete unknown, the search for truth for truth's own sake, whose results are the pride and glory of our civilization. The training of suitable men for this purpose alone will fully engage the universities, in view of the probable growth of university research and of the expected wider adoption by industry of more basic research programs than in the past.

It is a fact that even from the best universities a considerable fraction of the physicists who complete their graduate training go on to careers in applied science; some by choice, some because they cannot find openings in basic research. It would be very desirable if during their training members of the latter group could be psychologically prepared for what might otherwise be considerable disappointment. However it is doubtful that the nature of the curriculum should be modified, for example by substituting classical for more modern physics, with this problem in mind. Surely a man who is well prepared in the methods of modern physics can quickly acquire those of classical physics as he needs them.

The primary responsibility for meeting the needs of modern technology for trained men should thus rest with the university departments of applied science and engineering. It is clear that in several fields this will require more emphasis on the methods of classical and modern physics than in the past. Indeed a number of forward-looking institutions are taking appropriate steps in this direction.

In summary, then, it is probably true that academic physicists often do not appreciate the degree to which the methods and goals of basic research in the communications (and probably other) industry resemble those of the university. There is in addition unlimited opportunity in industry for the physicist who is interested in applying his science, or who finds that the best available openings lie in this field. However, in my opinion, the university departments of physics should not modify their curricula to fill this industrial need, which is largely the responsibility of the applied science and engineering departments.