

COPFIC report on

TEACHING PHYSICS

The Problem

The demand for physicists exceeds the supply, universities are expanding their physics staffs both in teaching and research. Industrial and government laboratories have expanded to meet federal needs. Municipal and state colleges have grown to meet the growth in student population.

How can the four-year colleges keep a good physics faculty in the present competition?

An Obligation

Although their percentage contribution is decreasing, the liberal arts colleges still provide an undergraduate education to about one-fifth of the physics PhD's. Many students of other sciences and engineering and non-science students get their only contact with physics from the college physics faculty.

It is essential that these programs be maintained.

Some Solutions

The AAPT-AIP Committee on Physics Faculties in Colleges (COPFIC) proposes a number of programs that can be helpful in meeting this problem. The most important objective is to make college physics teaching attractive by providing adequate salaries, reasonable teaching loads, technical assistance and good facilities that make possible an opportunity for continuing scholarly development and research.

"Can Four-Year Colleges Prepare Physics Majors for Graduate Work in Physics?" In a paper bearing this title¹ George Pake discussed some of the problems faced by four-year colleges trying to prepare physics majors. Dr. Pake's article aroused a great deal of interest and concern. To a large extent it was the trigger for the formation of the Committee on Physics Faculties in Colleges, set up by the American Association of Physics Teachers and the American Institute of Physics, with the aid of a grant by the National Science Foundation.² The Committee (COPFIC) was asked to study the problems of physics in the colleges, particularly from the point of view of the conditions necessary to recruit able physics faculty members and to retain them there.

In the four-year college, physics is taught as a cultural subject and as part of the preparation for secondary-school teachers and for scientific and engineering professions. While graduates of the four-year college with a major in physics can obtain employment, the better students are encouraged to continue with graduate work. Although well-prepared physics teachers are needed for courses taken by students who are not planning to do professional work in physics, COPFIC has concentrated its attention initially on studying the problems that affect the preparation of college students for graduate work in physics.

The Committee has made a detailed study of the physics staffing situation of the college and smaller university. COPFIC members themselves visited twenty-six colleges to collect detailed information and to discuss these problems with college physicists and administrators. The Committee has studied available comments by other visiting physicists who have taken part in the Visiting Scientists Program in Physics during the last six years. The reports of national groups were reviewed to relate COPFIC findings to other available information. As a result of its study, the Committee believes

in the

FOUR-YEAR COLLEGES

... a summary of the results of a recent study carried out by the AAPT-AIP Committee on Physics Faculties in Colleges, otherwise known as COPFIC, with specific reference to problems affecting the preparation of students for graduate-level work in physics

that it is now in a position to put before the community of physicists and other interested persons what it believes is a serious national problem—how to staff the smaller colleges with physicists who are competent to provide vigorous programs in physics for their students.

The colleges and future PhD production

There are clear signs that the colleges are contributing a continually decreasing percentage of the graduate students in physics³ and that the students they do contribute tend to be less well educated in physics than undergraduates from the universities.⁴ The annual surveys made by the American Institute of Physics give information about the fraction of the bachelor majors of the colleges and universities who eventually secure a doctor's degree in physics. For the 130 universities, about one in four of the bachelor's-degree physics majors gets a PhD, while for the 608 colleges offering a major, about one in ten of the BA physics majors gets a PhD. Fewer than forty of the colleges have as good a ratio as the university average.

The situation of the colleges

The staffing problems of the colleges are far from simple, and there are marked differences among colleges. The Committee found some colleges that have excellent physicists on their faculties and that are doing an outstanding job of educating their students. Students can enroll in such institutions without concern about their eventual preparation for graduate study in physics, and young physicists can accept faculty positions there with the assurance of being a part of an intellectually vigorous community. It should be our national aim to increase the number of such institutions; the Committee's work is directed toward this end.

The existence of strong physics programs in

some colleges does not alter the fact, however, that—as a group—the four-year liberal arts institutions are in serious trouble in trying to staff their physics departments. Young physicists and their graduate advisers tend to view with skepticism the claims of the colleges to scientific stature, noting the lack of research, the failure of the physics faculty to keep up with physics, and the low level of vitality in their teaching. The teaching load in these institutions is appreciably higher than in PhD-granting institutions (on the average, roughly double the teaching load of universities). Administrators often seem unwilling to face the fact that scientists require considerably more time to keep up-to-date with their rapidly changing subjects than do scholars in many other fields. Although most of the current research problems in physics are too complex to discuss in depth at the undergraduate level, it is very important that these problems set the tone of undergraduate instruction.

Since the college physics teacher has less time for professional activity and more difficulty in staying professionally active within the physics community, he also has a harder time obtaining research and study grants.⁵ Many college physics teachers and administrators express interest in research and appreciate its importance in creating and maintaining a successful physics department. However, few college physicists are active in research as evidenced by publications in scientific journals and by such recognition of professional status as fellowships in learned societies and academies or the award of research grants.

Staff for the colleges

There are now substantial shortages in qualified faculty for college physics departments. In the next decade, college enrollments can be expected to increase from 3.6 to 7.0 million, requiring a proportionate increase in faculty. The problem of

adequately staffing our college physics departments will become correspondingly more difficult. The liberal arts college will, in most cases, be unable to meet the competitive offers of the universities, government, and industrial research laboratories. To be successful in attracting faculty, the liberal arts college must offer satisfactory salaries, assign reasonable teaching loads, and provide sufficient time and opportunity to engage in creative scholarship and research.

Some recommendations

To try to cope with some of the existing problems, COPFIC has made a number of recommendations:

- (a) That the highly successful AAPT-AIP Visiting Scientists Program in Physics, supported by the National Science Foundation, be increased in size and modified to permit a pilot program of continuing consultants to colleges. The advice and assistance of established physicists will be helpful to colleges that are seeking to improve their curriculum and the opportunities for faculty research.
- (b) That a pilot program be established that would provide for collaboration between a senior university physicist and a college faculty member. This cooperative program could develop between a beginning college teacher and the professor with whom he carried out his graduate research, or it could represent an interest that arises from the proximity of the college to a major institution with active research programs. Although providing research opportunities is not a solution for all of the current problems, the lack of research opportunities in colleges is perhaps the major deterrent to young physicists who are considering a college appointment.
- (c) That the criteria used by agencies and foundations in judging applications from colleges be somewhat different from those used in determining support for university research. The judging of a grant request from a college should give consideration not only to the acceptable quality of the research proposal, but also to the educational benefits of this activity and to its suitability within the facilities and time available to the college faculty member.
- (d) That, in addition to institutes such as are now supported by the National Science Foundation, there should be provision for flexible summer fellowships tenable at major universities and research institutions. The Committee commends the NSF programs that are aimed at upgrading the level of competence of science faculty mem-

bers in colleges and providing refresher education. Such NSF programs as those for science faculty fellowships and for institutes and conferences for college teachers are making a valuable contribution toward solving the problems with which COPFIC is concerned. At the same time it is greatly to be desired that the number of opportunities for self-improvement open to college physicists be increased by the expansion of present programs and the addition of a major program of summer fellowships.

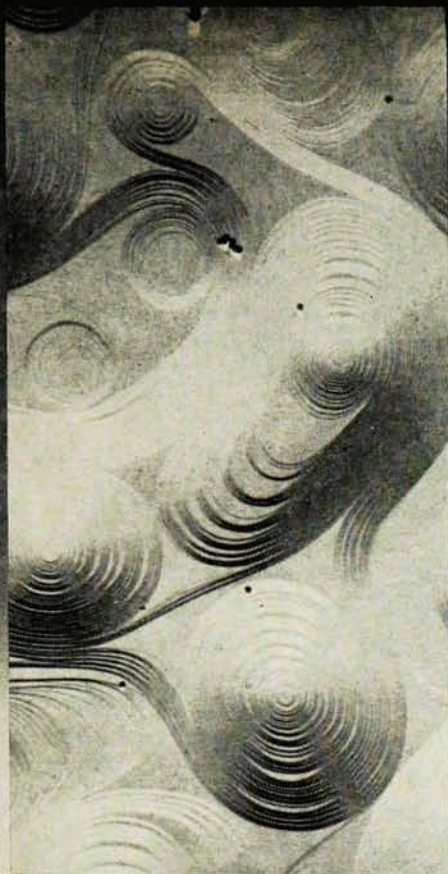
- (e) That the American Institute of Physics set up a clearing house for summer jobs (research and teaching) for college physics faculty members to provide them with additional opportunities for increasing professional competence and financial return.⁶

Toward implementation

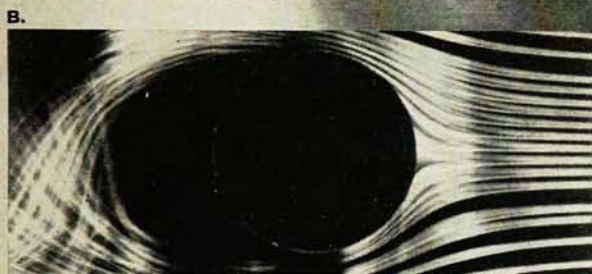
In the solution of the college physics problem, the college faculty members must take the initiative if any general improvement of the teaching of college physics is to occur. The recommendations that the Committee has made will only be valuable if the college faculties are eager to take advantage of any opportunities provided. One of the most obvious deterrents to the recruitment of college physics faculties are teaching loads such as 15 class hours per week and the lack of laboratory, technical and secretarial assistance. The faculty must reduce its teaching loads by curriculum revision that eliminates repeated sections for special groups. Some small colleges offer three kinds of beginning physics courses. In many cases advanced courses could be given in alternate years. Where there are other colleges in the community, cooperation with other institutions can be effective in reducing faculty teaching loads and, at the same time, giving improved opportunities to the students.

In those cases where the college is not able to meet the faculty's proposals for new appointments, technical assistance, and facilities, the question should be seriously considered as to the desirability of giving the full major program. The Committee believes that it is better to provide good elementary courses in physics than to attempt the full major instruction without a competent faculty and adequate facilities.

The Committee has not set up any standard curricula or conditions of faculty employment that are considered as meeting minimum requirements.⁷ In its study of a number of institutions it has found five private colleges, each of quite different



A.



B.



C.



D.



E.

Art for science's sake

That's what some of our research scientists got when they photographed what they were seeing close up in their labs: the etched surface of a cadmium sulfide crystal, an oxide film on a single crystal of iron, and many others.

The results were such striking examples of art in research that we collected the best for a small display at the General Motors Research Laboratories. And that was just the beginning.

Today, several sets of these photos in color are constantly on loan to universities, high schools, art schools, and museums. Even the GM Futurama exhibit at the World's Fair will feature some of our collection in two and three dimensions.

The art in research project is a dramatic example of the beauty and excitement experienced by the research scientist. Not only that, its success shows that the researcher's delight in the orderly world of science is something that can be shared with the student . . . the artist . . . or the ordinary man.

General Motors Research Laboratories Warren, Michigan

A. From our solid state physics lab (Oriented surface resulting from reduction of oxide scale on an iron single crystal) **B.** From our fluid dynamics lab (Air flow over a cylindrical body) **C.** From our semiconductor lab (Etch pit in a cadmium sulfide single crystal) **D.** From our solid state physics lab (Thermally etched single crystal iron surface) **E.** From our chemical separations lab (Crystalline organic nitrogen compound from vehicle exhaust gas)

character, that appear to have satisfactory opportunities for the faculty and the students. A pamphlet describing these schools and their programs has been prepared and distributed to physics departments.⁸

The problems of the many community, municipal, and state colleges are a serious matter which the Committee is continuing to study. These institutions will, in the next decade, be very seriously pressed by increased enrollments.

Money will not solve all the problems of the colleges, but it will be very helpful. Most of the suggestions that have been considered by the Committee—some of which are listed above—require some financial assistance for those able and willing to attack these difficult problems. Small grants by foundations can make possible the initial meetings of those who are interested in working on phases of the program and may enable them to develop plans for solving the problems. Larger sums will be needed to attack the problem at its roots.

The professional societies in physics are concerned about the place of physics in the curricula of colleges and the quality of physics teaching. The societies are very much aware that improvements in the general status of college physics teachers would make academic positions in colleges more attractive. While departments of physics appear to have more difficulty than those in other disciplines, chemists, mathematicians, and biologists do have similar problems, and their studies and programs for improvement are of continuing interest. The interest and support of the American Institute of Physics and the American Association of Physics Teachers have been very helpful to this Committee. The Optical Society of America has been very active in its program to develop colleges as a source of students and research scientists who are interested in optics. A

similar interest is developing in the field of acoustics, supported by the Acoustical Society of America. The professional societies can play a very important part in stimulating research activities suitable for the college teacher, in developing meetings and programs of papers where the college teachers can report and develop their research activity, in supporting a concerted attack on the problems of staffing the colleges, and in providing services that only national organizations can give.

Summary

There are not enough physicists to meet the educational requirements for our growing population of college and university students and, at the same time, staff the great developments in science and technology that are required by federal projects. With a limited supply of students prepared and able to go beyond the secondary schools to professional work in physics, we must make every effort not to lose any promising student who begins his studies in a four-year college. Some of the 608 colleges currently offering the bachelor's degree (but not the PhD) will probably be unable to continue to do so, but every effort should be made to help the colleges that try. It is hoped that the colleges will be assisted in their efforts so that not only will the immediate staff problems be met, but that the general environment of the colleges will improve to make teaching attractive and congenial for the physics scholars who seek the satisfaction of college teaching and also desire the opportunity to share their knowledge and to make contributions to the advancement of physics.

COPFIC is continuing its efforts to develop new ideas that will improve the college programs in physics and will be glad to receive suggestions and expressions of opinion from all interested persons.

References

1. G. E. Pake, *American Journal of Physics* **29**, 678 (1961).
2. The members of COPFIC are R. B. Brode, chairman; Fay Ajzenberg-Selove, executive secretary; H. H. Barschall; P. G. Bergmann; W. C. Elmore; C. A. Fowler; Ronald Geballe; George E. Pake; G. C. Phillips; Karl Strauch; W. W. Watson. The Committee also benefited greatly from close cooperation with Dr. W. C. Kelly of the American Institute of Physics.
3. Henry A. Barton, R. Bruce Lindsay, and Leonard O. Olsen, *Physics Today*, June 1962, p. 42 and Fred Boercker, Director of Manpower Studies, American Institute of Physics, private communication.
4. Philip M. Morse and G. F. Koster, *Physics Today*, August 1961, p. 20.
5. The present situation is that only 15% of the physics grants and 7% of the physics research funds of the National Science Foundation were given to college physicists in Fiscal Year 1963.
6. The Placement Service of the American Institute of Physics has put into operation a program to meet this recommendation.
7. However, the members of COPFIC feel that the critical size of a college physics department is about three full-time faculty members. COPFIC believes that teaching loads for college physicists should not be greater than 9 contact hours per week.
8. Copies of *Toward Excellence in Physics—Reports from Five Colleges* can be obtained upon request from the American Institute of Physics, 335 E. 45 Street, New York 17, New York.