

On physics and employment of physicists in 1970

H. William Koch

Why did the current job crisis come about so abruptly? What can we do to make sure it never happens again?

The American Institute of Physics has ended its fourth decade in a year of economic turmoil for science—one accompanied by an abruptly dismal job market for physics PhD's and by concern about unemployment and underemployment of physicists generally. Let us here review the contributions, education and employment of physicists during AIP's 40 years, so as to place the 1970 experiences in perspective and so understand them better. This perspective will allow us to look at the future of physics and physicists with the insight we need if we are to avoid a repetition of the current difficulties.

Contributions of physics

Physics is facing major changes, not so much in its role but in the orientation of its contributions to human welfare. The changes in orientation from production of knowledge to utilization of that knowledge and to service¹ indicate a maturing of physics that reflects the social revolution in process in the rest of society. The changes in physics are occurring simultaneously with other national changes; nearly all are having unprecedented, and often disruptive, effects throughout the physics community. Let us, therefore, examine the

contributions of physics and consider whether society will continue to depend on them.

In the past, the study of physics has contributed on two levels to the advance of science and to the application of science and engineering to our technology. At one level, physics has contributed a wide array of scientific tools and techniques on which our technological society is based. On another, deeper, level, it has led its sister fundamental sciences and the observational sciences in applying a balanced combination of measurement and analysis to the understanding and application of science.

Distinguishing features of physics, in comparison with its sister disciplines, are the degree to which theory is capable of experimental test; the degree to which it is possible to give experimental meaning and utility to mathematical expressions, and the degree to which, with its coupling to other sciences, those other sciences can really be useful.

For more than 50 years, the physics fraction of the doctoral degrees awarded in the natural sciences and engineering² has been more or less constant at 11%, except for war years, as shown by the five-year averages plotted in figure 1. This unusual degree of constancy suggests that the health and development of each of the other fundamental and observational sciences is coupled, in a subtle way, to the health and development of physics, especially to the extent that they make use of the body of physics tools and knowledge.

Attempting to predict what fraction the physics doctorates will be in the future is a difficult task. Nevertheless, it is reasonable to state that a healthy US economy in the decades ahead will require a substantial contribution of financial and manpower resources devoted to technology and its associated

professional and technical work force. Of that work force, physicists in the coming decade will undoubtedly comprise a fraction that is fairly close to the fraction in this 40th-anniversary year. If this is so, physicists must continue to be educated and employed, and at rates consistent with national technology and economy goals.

Why, then, did physicists experience the short-range employment disruptions of 1970? Are we training too many physicists? Alternatively, are the national funding investments in physics research and development at their present levels really warranted? In order to attempt partial, and perhaps inadequate, answers to these questions, let us examine the education and employment of physicists over the last 40 years before interpreting the 1970 crisis.

Education and employment

For most of the 40-year history of AIP, education and employment of physicists have received generous public support and encouragement. Education in physics was supported financially by increasing use of mechanisms such as fellowships, teaching assistantships, research assistantships and postdoctoral appointments.

The result has been the number of BS, MS and PhD degrees awarded per year³ as shown in figure 2. Summing these degrees and correcting approximately for deaths and retirements gives the cumulated degrees shown in figure 3. These latter data show two important features: First, the total number of PhD physicists in the 1960's has been increasing by about 8% per year; second, the number of PhD physicists employed in the US, as indicated by the National Register, and the total number of members of AIP societies increase from year to year as expected. There are no surprises in these data.

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The surprises occur in the relationships of these supply data with the demand (or employment) data. The employment data contained in various AIP reports⁴ show that there was a continuing demand for physicists until about 1967. Before 1967, the whole concept of supply and demand for physicists was poorly understood, and, furthermore, felt to be relatively unimportant. After all, the number of physicists produced per year at the PhD level is relatively small compared to the total technical work force, even at the all-time high of approximately 1500. That number should be easily absorbable in a prospering economy with its associated technology. Indeed, the free-enterprise system worked so well that questions about the relative numbers being educated and employed in the several subfields, for example high-energy physicists or solid-state physicists, were felt to be unimportant. The important factor was felt to be that of providing sufficient challenge to bright students so that they would be motivated to choose physics—any kind of physics.

The flexibility in the meaning of supply and demand, particularly important to physicists, was nicely explained by Allan M. Cartter⁵:

"... I must stress a peculiarity of the market for highly trained manpower. Short of a national depression—which is not a part of my picture of the future—it is unlikely that any substantial number of persons with the doctorate will be unemployed, despite the surplus conditions I foresee. If our universities turn out a sufficient number of PhD's to supply a 9% annual expansion in nonacademic employment of doctorates, then there will indeed be a 9% growth (give or take a small fraction). Doctorate holders will tend to "bump" those with lesser credentials in many types of positions. However, an increasing proportion of these specialists will not be employed in jobs for which they were trained, or to which they aspired..."

Even at a time when there was not such a focus on supply and demand, AIP consistently collected quantitative manpower data and reported it biennially in detailed reports made available to students and faculty.⁶ Annual and interim reports have been prepared and sent directly to department chairmen, who have been most cooperative in supplying the raw data.

Basing his remarks on employment surveys, Arnold Strassenburg, early in 1970, noted⁷ that "evidence has been gathering since 1967" that jobs were more difficult to obtain. Thus, while the employment crisis appeared to develop as far back as 1967, it was

necessary to analyze data for several successive years before a trend could be identified. Furthermore, the smallness of the numbers when dealing with physicists made analysis even more difficult. The data pointed to trends that resulted in department chairmen, during the last two or three years, instituting holding patterns at the graduate level as well as at the postdoctorate level to assist candidates while they found suitable employment.⁸

The severity of the employment problem in 1970 varied markedly from one discipline to another and from one subfield to another within physics itself. Even in the face of this complication, the data have suggested how to interpret the nature of the problem. Elementary-particle and nuclear physics were, and are, having difficulties, while the more applied subfields of acoustics and optics apparently had no employment problems in 1970. The latter situation is probably temporary. Similarly, some related disciplines, such as mathematics⁹ and geophysics,¹⁰ were without severe employment problems.

Once these data were available, several group meetings of department chairmen were held in 1970. Numerous invited and contributed papers, based largely on these AIP data, were presented at member-society meetings. In addition, a special newsletter¹¹ and a report¹² on manpower were distributed to all of the registrants at the spring 1970 meeting in Washington of The American Physical Society and the winter 1971 joint annual meeting in New York of the APS and the American Association of Physics Teachers. Copies of the special 1971 report on manpower were also mailed to most of the society members.

In the light of the data in these reports, how then do we interpret the abruptness and worsening of the employment conditions for physicists?

Interpretation

In general, 1970 was a catastrophic year in the employment history of physicists.¹³ Mechanisms that might

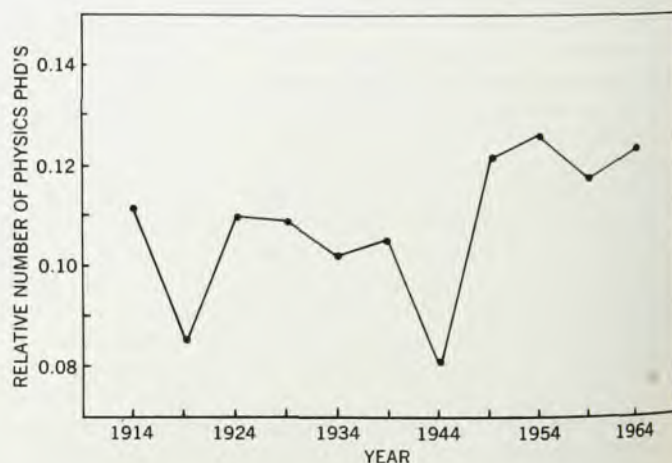
have been self-correcting under any normal course of events failed to function when forces converged to produce the simultaneous disappearance of opportunities in the three traditional job areas of teaching in academic institutions, research and development in federally-supported programs, and research, development, and production in industry. The result was a surplus of physicists of all ages and many types. Lee Grodzins¹³ emphasizes the difficulties encountered by the older physicists in the data he has collected; at AIP the statistics are concerned mainly with those entering the job market for the first time.

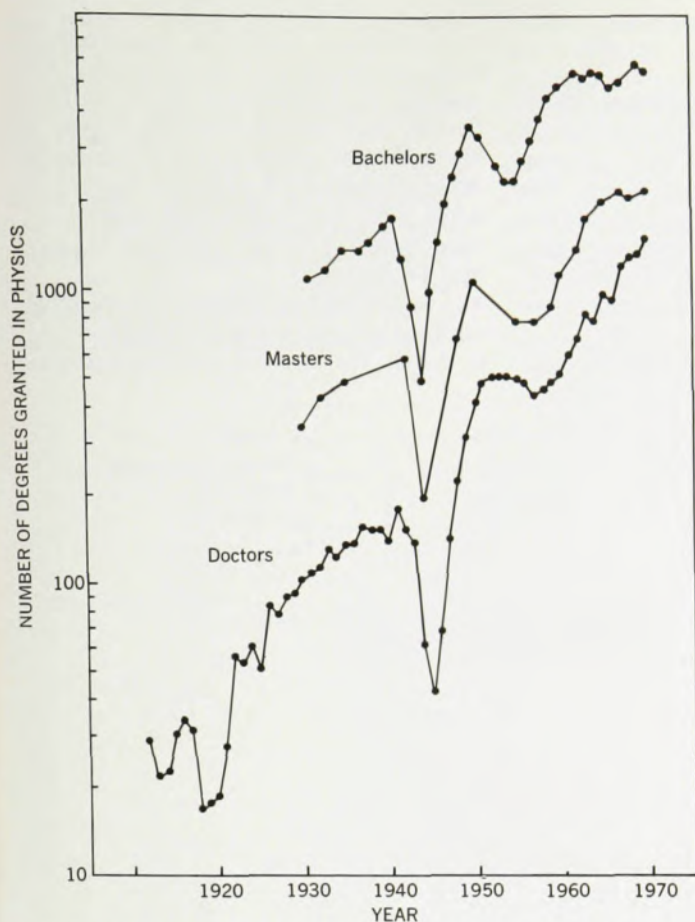
Quantitative data on the number and employment of physicists with BS and PhD degrees awarded in the summer of 1970 are given in figures 4 and 5. From them one realizes how dependent the statistics are on the point in time one uses for a base. Clearly, percentages for June 1970 graduates unemployed were greater in September 1970 than in February 1971. Clearly, too, the percentages have been intolerably large this past year. These figures appear in special annual reports prepared by Susanne Ellis, supervisor of the AIP manpower-statistics section.¹⁴

Grodzins estimated the unemployment figure for new PhD's to be 4% in January 1971. In his view, this large percentage represents a "disaster;" the prospective graduate has already been looking for a job for six months before receiving his degree.¹³

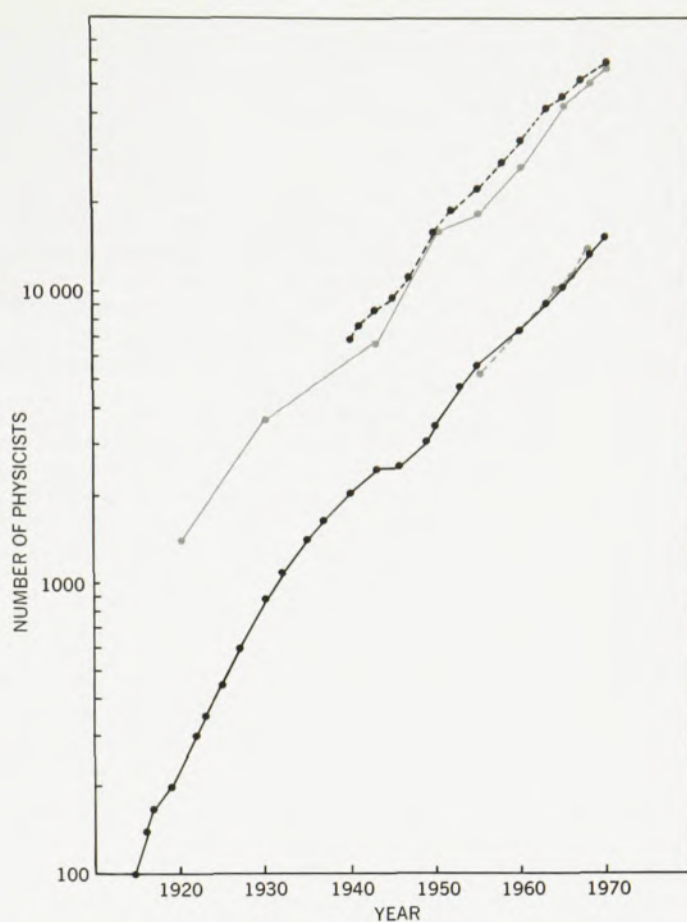
Some observers have oversimplified the causes of the problems for physicists and have overemphasized the applicability to physics of Cartter's predictions regarding faculty needs. As far back as 1964, Cartter pointed out^{15,16} that the teacher shortage in colleges and universities would be ended in 1969. His early predictions and his recent suggestions⁵ to cut back PhD production by 50% in the 1970's are being used by some as a generalized guide for all of the humanities, arts and sciences. However, the guide is not appropriate for a discipline such as physics.

Physics PhD's
awarded in the US
have remained at
about 11% of the
total doctorate de-
grees in the natural
sciences and engi-
neering. Data here
are five-year aver-
ages. Figure 1





Physics BS, MS and PhD degrees awarded in the US since 1912 show a steady growth, except for the war years, reflecting a continual increase in public support. Figure 2



Cumulated degrees. Solid black—PhD's; dashed black—BS's; solid gray—membership in AIP societies (duplicated); dashed gray—PhD's in National Register. Figure 3

The support and employment of PhD's vary markedly among the disciplines. The differences are illustrated by means of the data¹⁷ in Table 1, in which are grouped three sets of disciplines. Group A disciplines are those in which 85–91% of the new PhD's accepted employment in 1961 in colleges and universities; 84–94% had teaching as their primary work activity. It would, therefore, appear that the major factor controlling PhD demand is student enrollments. The corresponding percentages and major factor for Group B disciplines are 51–60%, 15–17%, and Federal R and D funding. For Group C disciplines, the percentages and factors are 20–38%, 14–17%, and industrial funding.

These data strongly suggest that PhD's in the Group A disciplines of history, English, and fine arts are very little affected by the state of the national economy, by industrial funding, or by Federal R and D funding. At the other end of the spectrum are the Group C disciplines of chemistry and chemical engineering in which the reverse is true: Employment demands are very dependent on industrial funding and very little affected by student enrollments. Accordingly one concludes that Carter's predictions, based as they are on student enrollments and academic openings, are of some interest to chem-

ists, but are not of the same importance to them as is the state of the economy.

The in-between disciplines of Group B (physics and astronomy, biophysics and biochemistry) are influenced by student enrollments and industrial funding, but, more importantly, by Federal R and D funding. Student enrollments and industrial funding are important to physicists, because jobs in teaching institutions and in industry

have permitted substantial lateral motion into other disciplines for employment. However, the factor of overriding importance to physicists is Federal R and D funding.

The influence of student enrollments on employment opportunities in academic institutions can be anticipated from the numbers of age-22 people in our population.¹⁸ The population wave has a small peak and a flattening in

Table 1. Short-term Factors Controlling Demand For New PhD's

Discipline	Postdoctoral employer— colleges and universities (1961–63 data)	Postdoctoral work activity in teaching (1962–63 data)	Major factor controlling demand
History English Fine Arts	A 85–91%	84–94%	Student enrollment
Physics & Astronomy Biochemistry Biophysics			
Chemistry Chem. Eng.			
	B 51–60%	15–17%	Federal R and D funding
	C 20–38%	14–17%	Industrial funding

Source: National Academy of Sciences publication no. 1489 (1967).

1969. This is not surprising, because 1969 is 1947 (the start of high birth rates) plus 18 years (the start of college) plus 4 more years (the end of college). As of 1969, the teaching profession has successfully mastered the handling of large student populations. Therefore, if Cartter's predictions are correct—and they would appear to be correct—the professions now must reduce teacher-production rates in Group A disciplines.

A set of figures more significant for physicists relate to Federal R and D funding patterns. As noted above, physicists are more dependent on Federal R and D support than are any other group of scientists. To be specific, the percentages of physicists in major work activities are: R and D, 55%; teaching, 22%; administration, 23%.

Not only are physicists more involved in R and D, but equally important, the funding for that R and D has come from the Federal Government. This latter is so for at least two reasons: The R and D activity in physics has a longer time to pay-off than in most other fields, and R and D requires larger capital investment than is so in most other fields. One result of the dependence of this funding on the Federal Government is the large effect that small budgetary changes from year to year can have on the availability of salary funds. Hence, it has been stated¹⁹ that the R and D system has operating on it a high leverage; that is, a small funding percentage change can mean a large percentage change in the employability of new PhD physicists.

A natural reaction to the surplus occurred in educational institutions. Reduced enrollments of new graduate students of about 20% were the result.⁸ Reports from some schools suggest that there may also be considerable attrition of existing students. What is to be hoped is that there will not be an overreaction in enrollments that would produce even greater percentage reductions over the next few years. Such an overreaction would adversely affect the progress of physics and science for a decade or more.

In summary, the supply of physicists being educated will be more consistent with the demand than it was in 1970 if the economy recovers simultaneously with a recovery of industrial and federal R and D funding. If the economy and funding do not recover, then there will, of course, continue to be a serious oversupply of physicists to be dealt with. If, in addition, the production rates of PhD's continue at the same levels as in 1970, and temporary support mechanisms such as postdoctoral fellowships are eliminated (as in the proposed NSF budget for fiscal year 1972), then unemployment problems for physicists will continue for the next few years.

Lessons for the future

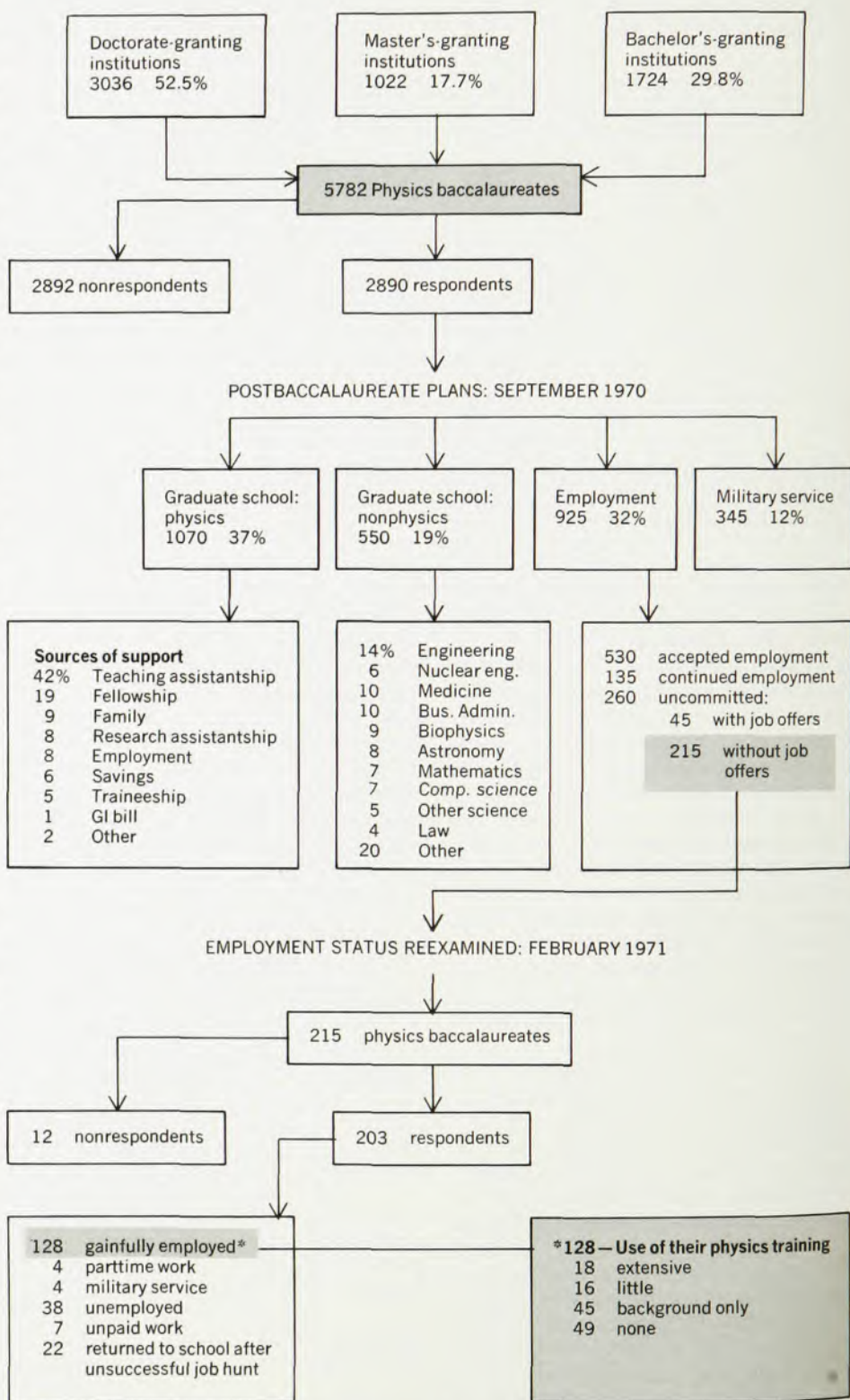
The severity and abruptness of the 1970 employment crisis could not be anticipated because of the unusual convergence and worsening in 1969 and 1970 of the three major factors affecting physics employment. How can one avoid crises in the future? There would appear to be at least four procedures:

► Collect, evaluate, and share signifi-

cant data on education and employment of physicists—for example, AIP assisted in development of an unprecedented national employment survey of over 300 000 scientists and engineers, accomplished by a postcard mailing in April 1971 by NSF under special arrangements with the Office of Science and Technology²⁰

► Use the data to improve the training, application, and use of physicists

► Assist the Federal funding agencies



Baccalaureate flow diagram. 5782 holders of bachelor's degrees awarded in 1969–70 were surveyed in September 1970 with a followup in February 1971. Figure 4

and policy makers to develop mechanisms for better science planning

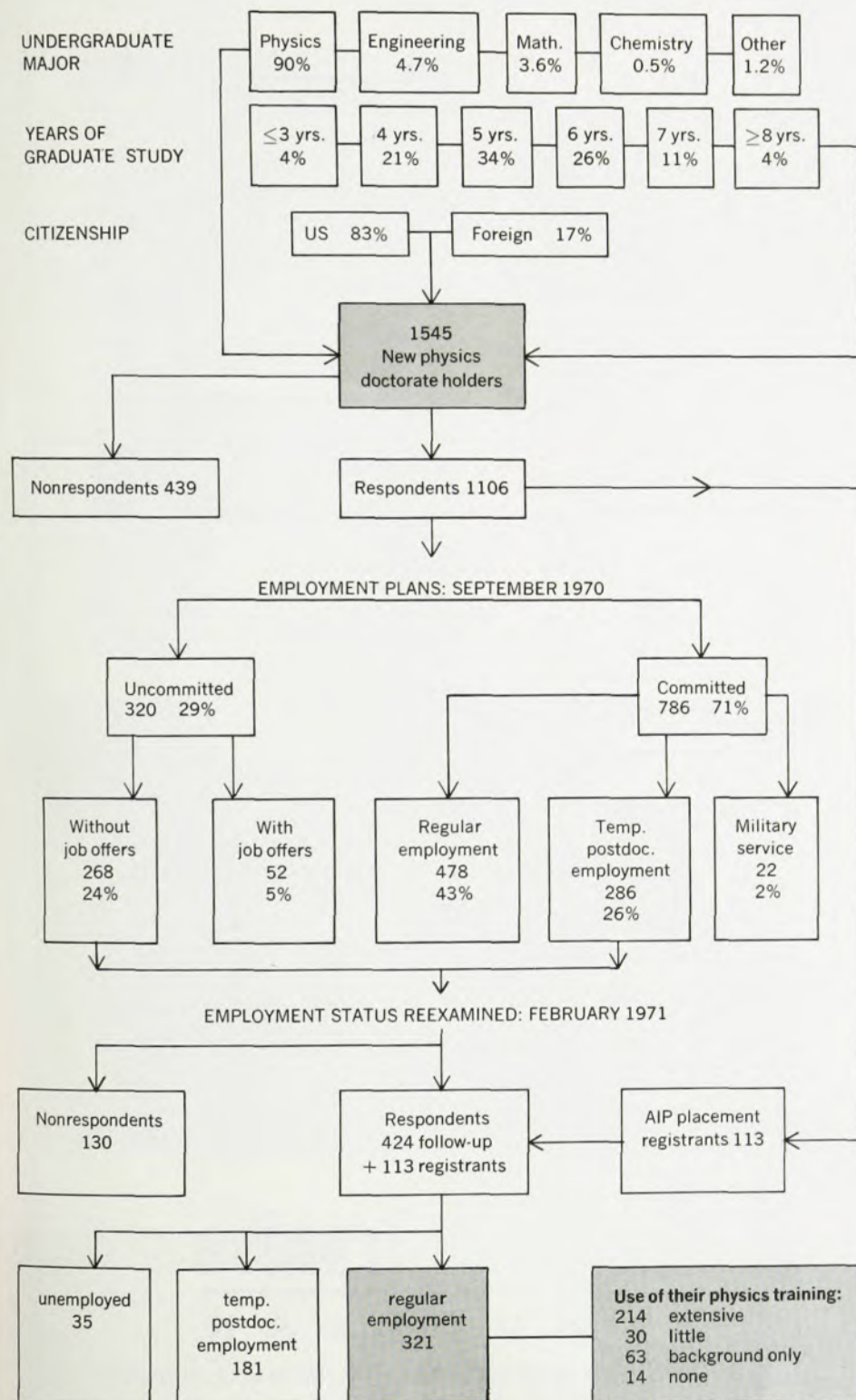
► Assist physicists in locating opportunities in existing and new employment areas.

AIP's role is an active one along these lines. However, AIP cannot pursue political lines because it is a membership organization dedicated to scientific aims. This limitation does not preclude political action by individuals. Physicists have a role to play as

citizens through all appropriate channels available to them for the purpose. Through efforts from all directions, we hope that effective planning for science at a national level can be encouraged and developed. With such planning, we are convinced, employment catastrophes of the type experienced by physicists in 1970 can be avoided in future years.

As AIP starts its fifth decade, it looks forward to a challenging future for

physicists if the economy recovers within the next year and US science and technology programs receive renewed financial support. That future, as already indicated, appears to be taking new directions as both faculties and students turn more and more toward direct application of their training in physics for the betterment of mankind. Such effort is all the more fitting, as AIP's purpose is the "advancement and diffusion of the knowledge of physics and its application to human welfare." The Institute stands ready to serve toward that end.



Doctorate flow diagram. 1545 holders of PhD's awarded in 1969-70 were surveyed in September 1970 with a followup survey in February 1971.

Figure 5

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