PHYSICS & SOCIETY

This article is the first in a new series to be devoted to topics concerning the impact of physics and society upon one another. —*The Editors*

SUPPLY AND DEMAND FOR PHYSICISTS

It's getting harder for new PhD's to fit into a declining job market. At the same time, industrial employers are complaining about their overspecialization and disdain for applied research.

Arnold A. Strassenburg

THE EMPLOYMENT SITUATION for physicists is at present in a state of imbalance, with supply exceeding demand, and there is no evidence for any rapid improvement. The facts, opinions and causes surrounding the employment problem have been and will continue to be explored by the Education and Manpower Division of the American Institute of Physics. Surveys of recently employed PhD's, employers and graduate and undergraduate students, plus data collected by the AIP Placement Service, gauge the current job market and foresee future difficulties.

The evidence has been gathering since 1967, and a 1969 employment survey confirms our earlier suspicions: More physicists are dissatisfied with their jobs now, and even those jobs were more difficult to obtain than before.

1969 statistics

This survey was the first attempt by AIP to monitor the job market for new PhD's. In December 1969, 2700 questionnaires were mailed to all PhD recipients during 1967–69. By February, 1500 responses were received from an expected 2000; of these 1500, 1145 were usable. Although we are now in the midst of analyzing these questionnaires, we do have results from two different samples. Some figures are based on a preliminary analysis from hand tabulations of 237 early returns and others on a more complete analysis from the later total of 1145. The final results will be ready by the end of this month and will be presented at the Washington meeting of the American Physical Society.

Part of our survey concentrated on present positions and job satisfaction. Table 1 summarizes how the 1967 and 1969 graduates responded to five different questions; 1968 responses are still inconclusive. Based on the three-year sample of 1145, there has been a striking increase of postdoctorate fellows, from 28% in 1967 to 47% in 1969. This increase supports our speculation, developed in earlier surveys, that many graduate departments are keeping their own PhD's, on an emergency basis, until they find suitable employment. This is the most plausible explanation because we are sure there was not an increase in regularly funded postdoctoral fellowships. The speculation is strengthened by the re-

sponses to the second question, where, in the small sample of 237, there was a 21% decrease in 1969 for those who considered their jobs even potentially permanent.

Responses to the remaining question in Table 1 reveal that fewer persons are satisfied with their present job. Based on 237 returns, the percentage that took the type of job they were seeking decreased from 78% in 1967 to 68% in 1969. This dissatisfaction with present employment is reflected in the number of PhD's who are looking for employment: Taking the larger sample of 1145, 29% of the 424 1967 graduates, 40% of the 125 1968 graduates and 35% of the 597 1969 graduates.

Unemployment was higher for 1969 graduates than for the other two groups. 17 of the 1145 reported unemployment and 14 of them were 1969 graduates. For the 237 sample, 9% were not employed as physicists, 8% had their education interrupted by military service and 3% have served in the armed services since graduation.

Additional questions uncovered the PhD's reaction to his employer and type of work activity from the two perspectives of his present position and of his desired position. Here the statistics are based on the limited sample of 237. For 1967 graduates, 76% wanted the type of employer they now have and 60% were satisfied with their work activity. For 1969 graduates the figures dropped to 67% and 42%, respectively.

Looking back to how the PhD's found their present employer, we asked the respondents to indicate how many offers they solicited and how many they received from different types of employers. The results, shown in Table 2, show that there were more offers than individuals in 1967, but by 1969 the situation was reversed. The first column in Table 2 compares the two groups of individuals who solicited ten or more offers. In 1967 the percentage varied between 30% and 35%, but by 1969 it was between 41% and 61%; yet each individual is receiving fewer offers, as shown in column two. The last column lists those who received no job offers. These were 25% or more in every category for 1967, but for 1969 the figures increased.

Table 1. Responses to 1969 Employment Questionnaire

QUESTIONS	AFFIRMATIVE REPLIES			
	1967 PhD's		*1969 PhD's*	
	percent	*sample*	*percent*	*sample*
Is your present position a temporary post-doctoral position?	28	424	47	597
Is your present position potentially permanent?	85	113	64	119
Is your present position the type you were seeking?	78	113	68	119
Are you satisfied with your present position?	72	424	74	597
Are you presently seeking employment?	29	424	35	597

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Employers' opinions

Why an unemployment problem? Important clues to the answers can be obtained by questioning industrial employers and by examining the level of federal support. The attitude of industry towards the hiring and training of physicists was tapped at the September 1969 meeting of 70 of the 141 AIP Corporate Associates. These associates represent the core of industrial employers that hire physicists. Their reactions indicate that the physics profession is suffering from overspecialization in graduate school, rapid obsolescence and competition from engineers who adapt more easily to applied research. We know this by examining responses to a series of statements posed to the representatives:

- "There has been no difficulty hiring all the physicists needed during the past five years." 55% agreed.
- "The training of physicists at the PhD level is strong but narrow." 93% agreed.
- "Graduate research supervisors instill attitudes in their students that result in low prestige for applied research among young physicists." 100% agreed.
- "Engineers now learn enough basic science and mathematics so that they can adequately fill positions once occupied only by physicists." 82% agreed.
- "Narrow training in highly specialized techniques, such as those used in subfields of physics that rely heavily on expensive machines and sophisticated instrumentation, is not adequate for the rapidly changing frontiers of applied research." 79% agreed.
- "Physicists should participate more strongly in interdisciplinary research." 100% agreed.
- "At present physics professors recommend research in industry only to their poorer students; the importance of some practical problems merits the best efforts." 93% agreed.

These opinions were corroborated by an AIP survey, published in 1969, of industrial organizations. The survey, labeled the "Work Complex Study," evaluated the relationship between physicists' education and job requirements. Its conclusions are the result of interviews with 161 scientific supervisors from 40 organizations, which were selected to represent the 1223 industrial organizations in the US that employ physicists.[1] Again, employers recommended that physicists broaden their education and become aware of practical problems.

Federal support

But perhaps the most important single influence on the job market is the level of federal support for physics research. The figure on page 27 shows the decrease in the federal-spending growth rate for research and development during 1962–68. Research support has now leveled off, and there is little evi-

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THE PLACEMENT SERVICE is being used by more PhD's but by fewer employers.

dence of immediate improvement.

The effect of these cutbacks on graduate education has been significant, but has not been as severe as some predicted. Two AIP surveys show that in the academic year 1968–69 the number of departments unaffected by funding cuts dropped to one in six from one in five the previous year; yet the number of physicists affected (1361) was larger than anticipated, and probably caused by the expenditure limitations placed on National Science Foundation grants. Other results revealed that faculties continued to grow in size but at a reduced rate. Simultaneously, the average number of regularly funded postdoctoral appointments decreased by one-half a man per department in 1968–69 after increases in the previous two years. The effect on graduate-student numbers was similar; the mean number of full-time students decreased per department by about one student after earlier increases.[2] Although federal cuts have not been as bad as feared, the pessimism is growing and may be as deleterious to physics as federal cuts themselves.

Earlier trends

This is, then, the status of the 1969 unemployment situation that has been developing since 1967. Our first warning appeared in the annual survey of graduate students during 1967–68;[3] a follow-up study later in 1968 strengthened the suspicion that physicists were finding it difficult to find jobs that matched their interest and skill.

This shortage of jobs, we discovered, was not matched by a reduction in the supply of new physicists. In 1967 the number of PhD's took a sharp upward jump and increased by 40% during 1966–68 (948 to 1325). The MS figure, 2077 in 1968, has remained constant over the past three years, and the BS figure, 5522, has recovered in absolute terms from a severe drop four years ago, although the percentage of all BS degrees awarded to physics majors continues to decline. These numbers can fluctuate because of the draft, research funds and other factors, but

Table 2. Job Offers For Recent Physics PhD's

Type of Employer	*Year of PhD*	*Number of candidates*	*Number who solicited 10 or more job offers*		*Average number of jobs per candidate*	*Number who received no job offers*	
			number	*percent*		*number*	*percent*
Four-year colleges	1967	43	15	35	1.2	14	33
	1969	38	23	61	0.7	21	55
University	1967	105	37	35	1.4	26	25
	1969	76	29	38	0.8	29	38
Industry	1967	76	23	30	1.3	29	38
	1969	69	28	41	0.7	39	57

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INDUSTRIAL employers are saying that the physics profession is suffering from overspecialization, obsolescence and competition from engineers who adapt to applied research.

there is no doubt that the supply at present is more than adequate and likely to remain so in the future.

What was not as firmly fixed was available employment. For the 1967–68 graduates, about 40% of the MS's and 30% of the PhD's did not receive any job offers by August 1968. The distribution of those who were working, shown in Table 3, had not significantly changed since 1965. The most noticeable change was the larger percentage of PhD's who began academic careers, from 56% in 1965 to 62% in 1968. 2000 MS's received degrees in 1968, but only one half sought immediate employment. Of these, only 46% had started working by August; for PhD's, 57% of the 1325.

Evaluating these figures was difficult because we were not sure how

EMPLOYMENT PROBLEM IN PERSPECTIVE

H. Richard Crane

The accompanying article gives a wealth of statistics on current problems of employment in physics. But statistics, no matter how well done, can tell only what has happened in the past. Somehow we must try to sense the future trends, and more importantly, to determine what responses should be made. Drawing conclusions as to where we are headed and what should be done is risky, but we must try.

I think it is unfortunate that published official figures on employment in physics, while entirely correct, do not reflect the true situation. There is, in the literal sense, very little unemployment of physicists. There probably never will be appreciable unemployment because physicists, being intelligent and highly educated, will succeed in finding stop-gap jobs, or jobs that do not use their special training. Indications are that about half of this year's crop of PhD's has done just that. Thus we have a situation in which a substantial resource is being lost, but in a way that does not come out clearly in the kind of simple numbers that impress the public. One of our tasks is to correct this kind of mistaken impression as to what is happening.

The ecology of physics over the past decade is both interesting and frightening. The basic trend is so clear that exact figures are not necessary. Over the past decade, physics support increased at something like 10% to 15% per year. Universities increased their physics faculties rapidly, to keep pace. The most recent figures indicate that there are between 15 000 and 16 000 working PhD physicists in the US. Over the decade the annual crop of new PhD's grew from about 700 to over 1400. Thus the figures suggest that the annual *expansion* was sufficient to absorb a large fraction of each year's crop of new PhD's. Now suddenly, the expansion (after allowing for inflation) has essentially halted. A replacement market, which would be important in any steady-state discipline, is not there to fill the gap, for the simple reason that most physicists are young. I have given these figures not to show the mechanism, which you already know, but to suggest why the physics-employment system has turned out to be so highly "leveraged", as management people say.

A way out that has occurred to many people is for physicists to widen their horizons, to train their students more broadly, and to mark out a larger domain of the world's work as that which is interesting and respectable for physicists. This can not be done very quickly, but there are signs that many individuals in the physics departments around the country are addressing themselves to it. In one area alone, that of environmental improvement, there surely will be opportunities. The opportunities suitable for physicists will come not in the clearing of streams or stopping of smoke, but in basic research problems whose solutions will be needed by those (engineers or others) working in the front lines. It will take time to identify these basic problems. Currently the attention is still on end results. Later the necessity for basic backup work will become evident, and it probably will be well supported by public money. Transportation and many other areas could be mentioned in a similar vein.

The broadening of interest will perhaps happen more quickly at the BS level than for the PhD. The lead time is

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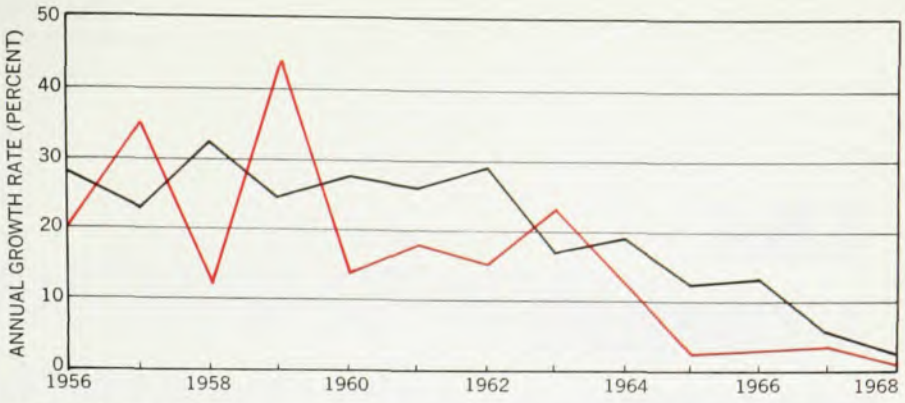
many were actually seeking employment and because we had no comparative data. Yet this much was apparent: The job market was narrowing and more conclusive figures were needed.

A follow-up study revealed that the 102 PhD's who were unemployed in August were all employed in the spring of 1969: 62% held potentially permanent positions in academic institutions, government or industry; 35% were postdoctorates, and 3% were in military service. As was later validated by the 1969 survey, the postdoctoral appointments were higher than normal. The follow up proved that many of the degree recipients who had been slow in accepting employment eventually accepted jobs they did not want or where they could not work in their speciality. This sample was selected from the 390 PhD's who reported no job offers in August, and we assume that the nonrespondents to the graduate survey did not bias the fraction. But only 102 answers were usable because some of the 390 did not participate in the first survey, and because further attrition occurred in the follow up. Also, 36 persons did not receive their degree before 1 July as they had hoped. This last group does not affect the total number of PhD's, but it does affect the 30% no-job figure. But at the maximum, the correction is not more than 10%.

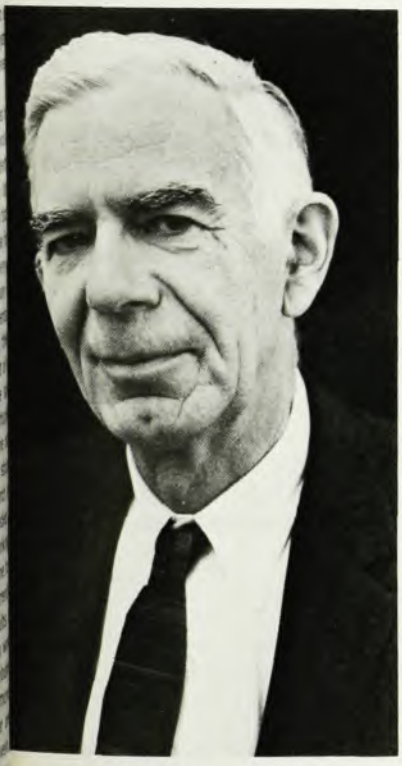
In comparison, the BS recipients are doing better in the job market. In 1968, 2200 of the 5000 or so BS's were looking for full-time employment. Only 16% of these had no job offers by August, which is considerably lower than for graduate students. Table 3 shows where the remaining 84% are working. The sharpest drop appeared in the number of BS's who were planning to enter graduate school: from 55% in 1967 to 44% in 1968. Those looking for full-time em-



ANNUAL GROWTH RATE in US support for research and development since 1956. Black line shows academic R&D; colored line shows total R&D. Since 1967 the growth rate has been less than 10% per year.

Table 3. Employment of Physics Graduates, 1967–68

Type of employer	*PhD*	*MS*	*BS*
College or University	62%	21%	4%
High School	—	5	13
Industry	20	56	58
Government	14	18	25
Other	4	—	—



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less, and there is more room for it. Students have the interest. At present, half of the physics major (BS) output goes to physics graduate school, and *all* are taught as if they were going there. It appears to me that this situation might now be reexamined in response to the interest of students who will wish to go directly into the practical applications of physics, especially those of social significance.

On the matter of broadening interests, it is an interesting commentary that what initiated the long honeymoon period for physicists was precisely their great versatility during World War II. They earned the reputation that physicists could do anything — even things in other people's domains such as engineering. Why did we lose that adaptability and the courage to tackle anything? In the 25 years since that time much narrowing, compartmentalization, and specialization have taken place; perhaps even more in terms of attitude than in terms of training. I believe we are faced now with the necessity, in fact opportunity, to regain our former breadth.

Crises do not last for ever. Some new equilibrium will be reached. Of the changes that will come to equilibrium with one another, three appear to stand out. The first is of course the reduction in Federal funding. There are many reasons to expect that a moderate annual increase will be resumed but that we will not see a return of the 10% to 15% increase. The second is the broadening of the area of interest of physicists, a trend that will increase their share of the job market. The third is a reduction (at least in the near future) of the number of graduate students who will go into physics, both because of the alarm about jobs and because of decreasing support money. All of these changes have different time constants and are interacting. Transient effects may be painful. A way in which AIP can contribute is by monitoring the changes and communicating the results to the profession. Hopefully, we can damp the transients and avoid disastrous overcompensation.

Let me urge anyone with ideas on the problems before us to communicate them to AIP. Arnold Strassenburg and I will be most grateful. The AIP Division of Education and Manpower is just now beginning another survey to determine current funding, manpower and graduate-enrollment trends in physics departments. This information will be used as broadly as possible, in making the problems of physics and physicists known within and outside the profession.

Table 4. Placement Register at APS–AAPT Annual Meeting

	1966	1967	1968	1969	1970
Number of registrants	677	895	984	1285	1347
Registrants present	491	641	671	866	775
Number of employers listing jobs	238	227	166	166	104
Number of employers present	257	272	192	167	101
Number of representatives present	405	421	282	258	148
Specific number of openings	369	617	254	234	121

ployment increased from 26% in 1967 to 49% in 1968. This drastic change is probably explained by the termination of deferments for graduate students; many BS recipients are now looking for draft-deferred jobs.

The draft will definitely have a significant influence on the supply of physicists in the future. Although our first draft survey, conducted in the fall of 1968, revealed that almost half of all the graduate students were eligible for the draft,[4] not many were actually inducted. Reduction in draft calls and the policy of allowing graduate students to finish the academic year, postponed the wholesale drafting of graduate students. But by the spring of 1969 a significant number had been called; 12.5% of the 3335 first- and second-year graduate students were drafted or had their induction postponed until the end of the academic year.[5]

Placement service

Another important indicator of the employment situation is the AIP Placement Service. This service operates a Placement Register for physicists looking for jobs and publishes a series of booklets that list the qualifications of recent graduates and that list academic openings. The data from these sources show that many PhD's who would have sought and found jobs in other ways are now using the Placement Service.[6] Conversely, many employers who formerly relied on the service now find it possible to fill their positions in other ways.[7]

For example, Table 4 shows comparative figures for 1966–70 from the Placement Service records at the annual APS and American Association of Physics Teachers meetings. There, the register arranges interviews between prospective employers and job seekers. The figures point to a worsening of the unemployment problem. At the 1970 winter meeting, the number of registrants increased by 4% from 1969, but the number of employers present decreased for the same period by 40%; the number of specific openings also decreased, by 48%. These recent figures fit the trend of the past three years. Between 1966 and 1969 the number of registrants increased 90%; the number of employers present decreased 35% and specific positions decreased 37%.

The booklets also support the apparent imbalance between the supply of physicists and the demand. Each PhD candidate submits forms that contain his qualifications and the type of job he wants; this information is later compiled into booklets and sold to employers. In 1966, 133 persons were included in the October issue, which was bought by 167 employers. In 1968 the number of persons listed jumped to 284, and this past October to 364. Simultaneously, fewer employers are using the information. Sales of the fall 1968 issue dropped to 84, and of the October 1969 issue only 70 copies have been sold.

Academic openings are also listed in separate booklets. Here the figures have also dropped: in 1966, 62 openings were listed, in 1968 there were 51, and in November of 1969 the listing had only 29 openings.

The future demand for physicists depends strongly on decisions that will be made by many individuals on the basis of factors presently unknown or unpredictable. A meaningful market analysis would be desirable but expensive, and would not be meaningful without the full cooperation of industry, academic institutions, other scientific societies and government agencies.

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