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ABSTRACT

This newsletter contains five papers which were delivered at a session of the Panel on the Preparation of Physics Teachers. The papers focus on the general topic of recruitment and preparation of high school physics teachers. Some of the important issues considered in the articles include poor teacher preparation, decline of student enrollment in physics, student value shift toward the social sciences, lack of relevancy in physics instruction, criticism of present college programs, prejudices toward teaching, and decline of employment in physics. Suggestions are included for teacher training programs and strategies. (RR)

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Commission on College Physics

University of Maryland
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newsletter

At the 1969 Summer Meeting of the AAPT, held this past June in St. Louis, Missouri, the Commission's Panel on the Preparation of Physics Teachers (PPPT) organized one morning session devoted entirely to invited papers and open discussion on the recruitment and preparation of high school physics teachers. The invited talks were:

- **Ben A. Green, Jr., MIT—*The Background***
- **Robert B. Bennett, CCP—*The Present: A Conference Report***
- **Melba Phillips, U. of Chicago—*Do We Really Need More Physics Teachers?***
- **Richard H. Sands, U. of Michigan—*Is there an Excitation Energy?***
- **E. Leonard Jossem, Ohio State U.—*Where Do We Go From Here?***

We were urged, by those attending this meeting, to use the relatively rapid and wide circulation of the CCP Newsletter to publish these five talks in the hopes of sustaining and expanding the considerable enthusiasm and genuine concern generated by this session.

The Commission on College Physics has long been concerned with secondary school physics problems and, since its establishment by the Commission in May 1966, the Panel on the Preparation of Physics Teachers (PPPT) has devoted its efforts toward translating this concern into programs for action within physics departments. In June of 1967, the PPPT sponsored a week-long workshop at the University of Minnesota which resulted in the publication of the Commission's widely distributed report, "Preparing High School Physics Teachers." Along with a review of pertinent statistical data, the report presented a design for implementing a teacher preparation program, outlined a three-leveled physics curriculum to meet the various backgrounds and career goals of prospective teachers, gave examples of some existing programs, and made suggestions for student recruitment. The report has proven to be instrumental in awakening members of the profession to their responsibility in assuring the existence of well trained high school physics teachers and several universities are considering or have already begun programs.

To further stimulate this advance, the PPPT sponsored a conference just prior to this year's AAPT Summer Meeting which brought together college and university representatives from institutions which have vigorous ongoing teacher preparation programs and others which have shown promise in the establishment of such programs. Robert Bennett's article reviews that conference.

For the future, the Commission plans to publish a revised version of its report, "Preparing High School Physics Teachers," which is now out of print. In advance of publication, we will gladly maintain a list of those persons desiring copies.

The Background

Ben A. Green, Jr.

First, let me say that there are many people here today whose qualifications to speak on the history of today's topic far exceed mine. While some of you have been working on the supply of well-prepared high school physics teachers for twenty years or more, my involvement with this problem began only two years ago when I was a staff member of the Commission on College Physics and John Fowler asked me to work with the Panel on the Preparation of Physics Teachers. At first, I did so out of a sense of duty. However, as the Panel taught me the magnitude and seriousness of the problem, I was enlisted whole-heartedly into their attack on it.

Appointed in May of 1966, the Commission's Panel on the Preparation of Physics Teachers began their inquiry into the problem by first collecting some background data. They asked Tom Joyner, who preceded me as staff liaison man, to make an informal survey of the universities in the United States to find out what preservice programs they were operating for physics teachers and how many such teachers they produced per year.

The replies to Tom's inquiries gave the Panel its first shock. We found that everybody had a problem, but that nobody produced any teachers. To be more precise, we could find only two institutions, out of the 1700 institutions of higher learning in this country, which produced more than ten physics teachers per year, and only ten schools which produced at least five physics teachers per year. We found that the largest, most respected physics departments typically produced only one physics teacher every five years.

We were depressed even further to read in the NSF report, "Secondary School Science and Mathematics Teachers, Characteristics and Service Loads,"[1] that, in effect, most people who teach physics in high school are not prepared to do so by their college training. To be specific, I will quote for you the fraction of physics classes taught by persons whose college transcripts show less than 18 semester hours preparation in physics. But first, consider the corresponding statistics for the other sciences. In biology, only 21% of classes are taught by such underprepared teachers. In chemistry, the fraction is 34%; in mathematics (high school only) the fraction is only 23%. In physics, the fraction is 66%.

This one statistic tells us several things. It tells us that we should not be surprised to find that, for the most part, high school physics is not well taught. It tells us not to expect that new curricula for high school physics will be, in themselves, dramatically effective in increasing the quality of the courses. It also helps us diagnose part of the difficulty; the trouble is not with the high school. While both poor salaries, which in the past have prevented competent people from teaching at all, and poor working conditions in the schools are obstacles to the person who wants to teach physics, they are just as much obstacles to the one who wants to teach chemistry. Yet the chemistry teacher is twice as likely to be prepared at the 18 semester hour level or better. The trouble is with physics.

As the Panel recovered from these blows and began to consider what to do about it, other facts became apparent. Consider the problem facing the high school principal who must hire a physics teacher. The percentage of high school students who take physics has been dropping for many years. Several years ago the fraction taking physics was about 25%. Now it is less than 20%, and the trend shows no sign of slowing down. Low enrollments mean that the principal cannot hire a person to teach only physics. Most people who teach physics must be primarily teachers of something else. According to the NSF survey, only 4% of the physics teachers taught only physics. The number who teach only one or two classes of physics is 81%.

Ben A. Green, Jr. is now at the MIT Education Research Center. After taking his Ph.D. at Johns Hopkins in 1936 he did applied physics for Bendix Radio and metal physics research for Union Carbide. In 1961 he joined Case Western Reserve University, where his interest in programmed instruction flourished alongside his work in low-temperature calorimetry. He served on the staff of the CCP during 1967-68 before joining the ERC.

[1] 1963 Report of a survey by the National Association of State Directors of Teacher Education and Certification and the American Association for the Advancement of Science for the National Science Foundation. Revised edition to be published in 1969.

I won't burden you with more gloomy statistics. The situation looks bad; the solution must be complex. Anything you pick out to work on is influenced by other factors. Enrollments are down because the courses are either too hard or too dull. The courses are poor because the teacher's heart is with his own subject, not physics. And the school cannot afford a physics specialist because the enrollment is so low.

The Panel chose to attack the problem at a sensitive point—the university physics department, for it is the department which wields influence as well as (and we believe it should) prepares teachers. The Panel recognized the conflict between concerns such as these and those of a department's research commitment, and the fact that quicker rewards may be had for the latter than the former. Yet enlightened self-interest dictates that something be done to improve the status of physics within society and the society's understanding of physics. The Panel believed that an appeal made on such terms would lead to some action. (This optimism was not entirely unfounded. Subsequent events have proved encouraging.)

The Panel ordered the preparation of a report which would set forth the facts about the problem and which would suggest things the departments can do. The report was to serve mainly as ammunition, or backing, for people who want to act but who must fight the uphill prestige battle to get departmental support. In order to put the report on firm ground, the Panel convened a workshop of people from physics departments, from science education departments, and from high schools to provide input for the report and to devise a plan by which departments could introduce programs for teacher preparation within their institutions and in cooperation with their allies in education departments and in other sciences. The workshop met at the University of Minnesota in June of 1967 and proposed the curricula which were published in the PPPT report.[2] The report recommended not only what physics courses the teacher should have, but it outlined seven boundary conditions which any teacher program should meet:

1. The program should prepare a teacher in at least one other field, usually chemistry or mathematics. This recommendation recognizes the fact that, for some time to come, the physics teacher will be forced to teach other subjects in most school systems.

2. It is not desirable to have teacher candidates simply take the courses of the research-oriented bachelor's program. There are two reasons for this. The teacher's needs are different (he doesn't need to be able to use Maxwell's equations or to make quantum mechanical calculations), requiring a wider background than those of the research man. Secondly, his interests are different. He is more interested in people than the research man is, and his tolerance for lengthy problem solutions is correspondingly less. In any event, the experience of departments who recommend their so-called R-curriculum is that those who graduate from it seldom enter the classroom.

3. The sequence of courses will affect recruitment and must accomodate the likely sources of students. Thus it must be possible to enter the program as late as one's junior year, and still get at least 18 semester hours in physics as a minor subject.

4. The content of the physics courses should reflect the needs of the physics teacher. This means more attention must be given to elementary electricity and magnetism, in practice as well as in theory, and to electronics experience. It means less emphasis on mechanics beyond the introductory level. It means emphasis on modern physics at the descriptive level. And it means giving some attention to engineering and technological applications of physical ideas and laws.

5. The style of the courses should reflect the fact that the teacher needs greater ability to explain physics in words, as well as mathematics, than does the research student.

6. A course in the history and philosophy of physics should be included.

7. The program should include courses offered at the convenience of teachers in service. This means summer courses, Saturday courses and evening courses.

The report gives space to the design of a possible program which has several entry points and three exits, a minor of 18 hours, a major of 24 hours and an advanced program of 32 hours which should satisfy the content requirement for a master of arts in teaching. Most of us felt that the advanced program would be closest to the hearts of the academic physicists, but that the minor program would have the greatest long range impact on our problems.

This report was issued in January 1968 and its publication has had some of the effects the Panel hoped it would. Shortly after its publication, the University of California at Berkeley adopted a program as have the University of Maryland, the University of Texas, the University of Massachusetts and the University of Georgia. More subtly, the report has come to the aid of some people who have been trying to activate an interest in the problem on the part of their colleagues. I was told at this meeting of two instances in which the fact of the report's existence has enabled programs to go forward in the face of previous resistance.

This progress represents a certain amount of momentum gained in a medium filled with friction. I hope that the subsequent actions of the Commission and, ultimately, of the leadership of the physics community will continue to strengthen this momentum through publicity of leading examples, through recognition of individuals who make contributions and through continued public statements of support for these activities.

[2] The PPPT report is currently out of print but a revised version is scheduled for publication. Requests to be placed on the mailing list will be honored.

The Present: A Conference Report

Robert B. Bennett

Many of the past difficulties which Ben has described as characteristic of the problem of recruiting high school physics teachers are still with us today. On the Saturday night and Sunday just prior to this meeting, the Commission's Panel on the Preparation of Physics Teachers (PPPT) sponsored a conference which brought together representatives from about fourteen large universities to share experiences from their teacher education programs. Some of these institutions have very active ongoing programs, some are in the process of organizing new programs and others have programs listed in their catalog but only occasionally process a candidate. We wanted to look at the experiences and difficulties and share our ideas on these programs and, as Ben said, "we also hoped that we could overcome some of the frictions and generate some momentum for more active programs."

To assure as broad a perspective as possible, we invited several practicing high school teachers and a representative from both the physics and science education departments of each university. As background information we circulated a summary of the responses we had received from state department of education representatives outlining the high school physics problem as they viewed it.

The opening talk was given by Fletcher Watson, professor of science education at Harvard University and a director of Project Physics, a group which has done a great deal of research into the problem of preparing high school physics teachers.

While time will not permit us to review all of his talk, I would like to briefly examine a few of the points that Dr. Watson raised for our consideration.

After taking his Ph.D. at the University of Oregon in 1958, Robert B. Bennett began his teaching career at Whitman College, where he served from 1957 to 1965, taking a leave of absence in 1962 as an NSF Science Faculty Fellow at the University of Washington. A UNESCO Expert from 1964 to 1967, Dr. Bennett served as Senior Lecturer in Physics at the University College of Rhodesia and Nyasaland in Rhodesia and at the University of Zambia. Currently Co-Director of PNACP and Associate Professor of Physics at Central Washington State College, he was on leave in 1968 to 1969 to the University of Maryland where he served as a staff physicist for the Commission on College Physics. Dr. Bennett's research activities have been in the field of collisions and aeronomy.

Split Loads

We have two kinds of teachers involved with physics, "the physics teacher and the teacher of physics." By far, the majority of the teachers is in the second category. These are teachers whose primary interest is in some other subject, but who, for administrative reasons, are teaching one or two sections of physics. As Ben Green has just reported, this is not new knowledge. However, in physics circles it has not been given appropriate emphasis. We must find a way (or ways) to face up to the fact that 80% of the teachers of physics do not consider themselves as "physics teachers."

Teacher "Development"

While some consideration was given to the question of what constitutes reasonable preparation for teaching physics, we did not try to construct a curriculum. There are some fine suggestions for two-year programs in the report which Ben described. However, we were reminded by Professor Watson that, "we should think in terms of the development of the physics teacher and the four years in the preservice program as just the beginning of the development. We need not try to give the students everything during the first four years." This development may or should take place in an integrated program having both preservice and inservice components.

Dissemination

A very difficult problem which has plagued PSSC, Project Physics, the new biology curricula and the other national curricula, is how to effectively disseminate both the content and teaching style of any new program. If it is difficult to disseminate a program at the high school level, it is at least an order of magnitude more difficult at the college level where we place very high priority on our academic independence and our right to structure our own courses. This, together with the limited time an individual can devote to pedagogical innovation, makes dissemination a high priority problem. While this conference, and what we are doing here right now, is aimed at just this problem, we need to find other avenues for disseminating ideas and experiences along these lines.

The Multiplicity of Goals

Another part of the problem is our tendency to lose sight of the purpose of the public school. Professor Watson presented a chart which traced the distillation which occurs as students progress through the educational system, all the way from the first grade to the PhD. The chart showed approximately three million students at the first grade level, and ended with an output of 8,000 Ph.D.'s in science (not just physics, but all science). It is clear that either our system is *very* inefficient or, as I think most of us believe, it serves a much broader purpose than to produce Ph.D.s.

Negative Bias

Professor Watson also reminded us that, as a professional group, we demonstrate a negative bias towards teaching which is felt by and transmitted to our students. In many departments, if a person decides to major in physics and go into teaching, he is not well received by the majority of the physics faculty members. As we commonly say, he becomes a "second class citizen." This negative bias is something that we need to try to eliminate if we are to improve our recruitment.

While Dr. Watson raised a number of additional points to our attention, it was decided to focus on these five problems in the group discussion and smaller working group sessions which composed the remainder of the conference.

Despite the varying backgrounds of the participants and the small working group structures adopted for this conference, there were a number of recurrent themes which served to organize our efforts. While the total impact of the conference discussions extends beyond these individual themes, summarizing them should at least reveal the tone of the conference—where it is pointing and what this implies for physicists and physics departments.

Of these several recurring themes, probably the most familiar to all of us is the need for the revision of the introductory course. While we certainly have heard this complaint raised before in the limited terms of course content, it is obvious that any real consideration of the problem must also include a thorough review of the mode and style of our teaching. This is a much more difficult thing to get hold of. Our style of teaching can affect the attitudes of our students toward our subject, as a teacher tends to teach as he was taught. The new programs which are being introduced from elementary through the senior high level tend to emphasize learning through experience and observation. Yet, in college our courses continue to be dominated by teacher presentation rather than student searching.

There is good evidence that we can provide students with more effective learning experiences than we have provided in the past. It will require a continuing effort on the part of a substantial segment of college teachers to accomplish a significant change in the pattern of instruction in physics. We need to bring into our college teaching some examples of instruction using the style of teaching which our students are expected to use when they themselves begin to teach. This is hard to do; none of us has experience in this kind of teaching and we, too, tend to teach in the way that we are taught. Yet, of all the people involved in physics education, we should feel the greatest responsibility for the preparation of the teachers of tomorrow.

There are three things we need to look at in our introductory course, both for our majors and non-majors, if we are going to see any real improvement: content, mode and style of teaching, and the attitudes and bias conveyed both intentionally and unintentionally.

A second general theme was the need for a departmental and a university commitment to teaching, to education, and to the process of education. Such a commitment would manifest itself by the presence of staff who are concerned with this kind of problem and by the presence of mechanisms for recognizing such a staff in terms of advancement and prestige. This is a very serious problem and a very difficult one for when a decision is to be made on who is going to be promoted or who receives tenure, especially when openings are limited, we have a strong tendency to lean toward the research personnel. Again, while this conference was looking at the problems specifically in the context of the large university, you will notice that these problems tend to be universal. An appropriate commitment of this kind will involve demands of money and space.

Ralph Lefler of Purdue gave us a very useful picture of what a committed department can do. Purdue has had an outstanding record of high school teacher production for many years. Lefler identified as the primary ingredient of success the strong support of the department and the chairman. The Purdue faculty has been willing over the years to teach the special courses for the high school teachers. There is university support also. Purdue has organized a Teacher Education Council, and the Dean of Teacher Education has a position, with influence at least, comparable to a Dean of the Graduate School. He chairs the Council, reports directly to the President of the University, and interacts strongly in the design of the statewide programs and standards.

Perhaps even stronger evidence of the commitment to the program is the existence of a teacher workshop—a room with periodicals for reading, with examples of teaching equipment, etc. But mainly it is a room which gives a focus, a home, to the prospective teacher or to the returning practitioner. Its continuing existence, in the face of need for research space, says what needs to be said about priorities.

It was the view of the participants that what is needed in a large department is an interacting and committed group, analogous to the research groups, which would form a critical mass of people in the physics department whose primary interest is the pedagogical problems associated with physics instruction. While they would work closely with the people in science education, it is important that this group be in the physics department where they will be interacting with the whole department. They would not take over the teaching of the

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Do We Really Need More Physics Teachers?

Melba Phillips

The number of bachelor's degrees granted per year in physics began to level off about 1962, while the number of advanced degrees continued to rise, although less rapidly than before. The demand for professional physicists, however, has begun to decline. According to the AIP Placement Service, the number of registrants for jobs at the Annual Meeting rose from 895 in 1967 to 1,285 in 1969, whereas the number of specific jobs listed went from a high of 617 to 234. We learn in the March (1969) issue of *Physics Today* that a survey of last June Ph.D.'s, conducted in the summer of 1968, showed that 29.5% of them had then received *no* job offers, and that another 32.6% had only one offer. Of the Master's degree recipients, nearly 40% had not been offered a job in the summer. It becomes quite apparent that physicists are no longer in very short supply.

While we know that physics majors, and hence physics Ph.D.'s, begin by studying physics in high school, there seems to be no demand for physics which would justify an all out campaign for more physics teachers.

The question is whether the chief role of physics teachers at the high school and college level is the production of professional physicists. We often act as if it were; a measure of teacher success is commonly the number of his students who become Ph.D.'s. We tend to teach as if that were our most important aim, even though not more than a handful of high school physics students will (or should) do graduate work in the subject.[1]

The awakening and encouragement of scientific talent will of course continue to be an important feature of teaching, and elementary physics leads to careers in other sciences, particularly engineering and chemistry. But there seems to be no very critical shortage of personnel in these allied sciences, either.

[1]A 1967 survey of physics teachers in Illinois revealed that approximately one third of them do not think physics is useful for general education!

Melba Phillips served as a commissioner on the Commission on College Physics from 1960 to 1968 and is currently a member of its Panel on the Preparation of Physics Teachers. After receiving her Ph.D. from the University of California, she taught at the University of California, Brooklyn College and the University of Minnesota before coming to her present position as Professor of Physics at the University of Chicago. She is co-author of the widely known text Classical Electricity and Magnetism *with W. K. H. Panofsky. She served as President of the AAPT in 1966 and received its Distinguished Service Citation in 1963.*

In what terms, then, is there a demand for well-qualified teachers from the schools themselves? The largest high school in Illinois, with an enrollment of 5,000, is said to have had thirty students in physics in 1967. Most schools cannot use a physics teacher to teach physics, as there is simply not enough physics teaching to keep him busy. It has been pointed out (probably with justification) that many schools prefer low-level preparation in physics teachers, partially because such teachers are less demanding of equipment. Certainly very few school administrations are willing to provide the time and money required for continued improvement, either in professional competence or in facilities and equipment.

So, then, are we attempting to recruit superior physics teachers to teach nonscientists more physics whether they want it or not? And we must admit that many students do not want it. By the time they reach the twelfth grade, they are already "turned off" science, especially physical science.

A good argument can be made to the effect that there are much more urgent needs than to know physics; the critical problems people face are social and economic rather than scientific, and the technological aspects of modern society have outrun progress in other areas. We live longer and faster, but without purpose, so that how to spend leisure time, and what to do with our extra years, have become the serious problems. Not that the benefits of technology are equably distributed; there is hunger in the midst of food surpluses, poverty in the midst of affluence. Technology has enabled us to increase production so as to make unnecessary much physical labor, even though a large fraction of this production is for military rather than civilian purposes. Technology has eroded our old-fashioned values—the sanctity of the family, hard work, courage in the face of adversity or the enduring of discomfort. It is no longer necessary or desirable to be brave under physical hardship, since the hardships are not necessary. There is of course the war, but that only proves the point: the most unpopular war in American history is made possible only by technology. Moreover, technology, based largely on physics, has made it possible to destroy all human life on Earth, many times over. And, it is argued, we as ordinary citizens have no control over these malignant fruits of science. Perhaps only the young tend to equate science so explicitly with the "military-industrial establishment," but oldsters also fail to see relevance in science for solving serious problems of society.

On the other hand, the existence of problems is clearly related to the quickening pace of science and technology. For example, a lifetime has become long in more ways than mere chronology: very few people in the future will be able to spend an entire working career with a single set of skills. Science has destroyed stability in almost every aspect of our lives.

Of course it may be argued that technology is the real culprit, and that pure science is above all that, to be studied for intellectual and cultural enjoyment—in the vernacular, for fun. But appreciation of the symmetries and asymmetries of physics is a taste acquired only with considerable effort, and for many it may not seem worth the price. As for science not being at all responsible for technology, that is a fiction quite impossible to defend.

In short, science and technology have created many problems, and problems continue to be created. Standard examples are pollution of the air, water and soil, insecticides, detergents, destruction of our protective ionosphere, all quite in addition to weaponry, with its vast overkill capability.

Why not, then, declare a moratorium, i.e., stop doing research, stop developing technology, and let society catch up?

This proposal, already familiar in the 30's, is raised by nonscientists with sufficient frequency to suggest that it is rather widely supported. Sometimes it is restricted to a moratorium on research which might have harmful applications. (As if one could always tell!) One thinks immediately of King Canute, but it must be admitted that science and technology are and have always been subject to more social control than the waves of the sea. This control has been haphazard, and characterized by lamentable lack of foresight. In many areas we have been witless, and, while not willfully evil, have let avarice play a significant role. Those who maintain that science and technology are used primarily for war and profits have something of a point. You may remember that Francis Bacon said science should be pursued "for the glory of God and the relief of man's estate." But the technological exploitation of knowledge and nature has not always contributed to the relief of man's estate, and we are told it should have been stopped long ago.

How long ago? Apart from a few elitist intellectuals who make capital of being antiscientific, most people will admit to the disadvantages of living in the Golden Ages of the past, whether Greek or Elizabethan or other, once they remember the plight of the average person in those ages. In fact, I have never succeeded in pinning down a date when the moratorium should have occurred except as "before the atom bomb."

In another sense, the moratorium on research and development is just as impossible as Canute's stopping the waves. The economic affluence generated by technology is hardly to be cut off by vote of those who have achieved it. Whether the coming generation will maintain this attitude belongs to the purview of the next speaker, but even those who despise affluence must admit that the technical possibility of alleviating painful poverty and hunger should be maintained. But why should everybody have to know any science for that?

So, apart from a few people who can help satisfy the avid curiosity of those who naturally love science and cannot be kept from working at it, why strive to recruit more physics teachers?

In my opinion, of course, we do need many more better-prepared physics teachers, and we should somehow increase the demand from high school students so that every one of them well be kept busy. There should be more kinds of physics courses, at different levels, so that more students will learn more physics and the life of a physics teacher will be more varied and interesting.

But I have not been dishonest. Science and technology have given rise to enormous problems, without offering many hints toward possible solutions, and physics has not been backward in contributing such problems. In this audience I hardly need argue the impossibility of a moratorium on science, but we must confess there is no guarantee more physics will result in a more rational and generally beneficial utilization of physics. Again, then, why campaign for more physics teachers?

My answers to this question, while fervent, are halting and incomplete, and I am sure the discussion period will supply others. But let me start. In addition to the very genuine contribution of high school and other elementary teaching to the subsequent achievements of professional scientists, there are growing responsibilities toward preparing future technical personnel. We are only beginning to take an interest in this field. Even more frustrating is the problem of trying to raise the scientific literacy of a now too completely nonscientific public. (Our past president, E. U. Condon, has in connection with his study of UFO's noted that more than 10,000 people in the United States make a living out of astrology, whereas the number of professional astronomers is about 2,000.) To a great extent, people are correct in saying they have no control over policies related to science and, it may be argued that a smattering of science would be of no use for judging whether a given policy is good or bad. But at present most people are simply apathetic, and this apathy would surely be dispelled if they knew something of the nature of scientific evidence, or the lack of it. And we must catch people young if we are to simultaneously convey this attitude and nourish their native curiosity and interest in the scientific aspects of things about us. It is, I think, essential that physics teachers should reach students well before the twelfth grade level, whether in courses explicitly called physics or not.

The inestimable value of physics teachers as a bridge between the frontiers of science and young people is one thing and we have, for a long time, talked of the

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Is There an Excitation Energy?

Richard H. Sands

Various scientific and governmental agencies here and abroad, including the AIP, have conducted surveys which attest to the serious decline in interest in the physical sciences among the present younger generation. Some of these collected statistics have been presented to you here. It is not the purpose of this paper to speak to the reasons for this overall decline, but rather to expound the prevalent attitudes of the younger generation as they pertain to their choice of careers in physics and physics teaching.

Their grievances—ranging from Vietnam and racism to adult hypocrisy—have been voiced loudly and clearly. Viewing both their surroundings and their future with a sense of frustration and, in many cases, despair, they see that *"our cities are in decay; our universities are in chaos; our poor are hungry. And yet our money and our energies are expended upon war and the perpetuation of war."*

Life magazine, in the June 20, 1969 issue, published excerpts from several baccalaureate addresses delivered by this year's valedictorians and elected student leaders which paraphrase and elucidate these frustrations and concerns in detail. To continue quoting from one such address by William M. Thompson of Yale University: *Most of us are plagued by the pain of an uncertain future and the prospect of fighting in a war which cannot be supported . . . The war must end now; and the fight for our cities, for our nation, for our people must begin.* A member of the fairer sex, Miss Stephanie Mills of Mills College said: *We have horribly disfigured this planet, ungrateful and shortsighted animals that we are. Our frontier spirit involves no reverence for any forms of life other than our own, and now we are even threatening ourselves with the ultimate disrespect of suicide.* Mr. Ira Magaziner of Brown University closed with these words: *We should lose sleep not out of fear of our economic security or our property because the Negroes are rioting again. But we should lose sleep because we are doing things that are wrong and we're allowing things that are wrong to go on in our society and we're accepting them.*

Richard Sands is a Professor of Physics at the University of Michigan. He received his Ph.D. from Washington University at St. Louis in 1954 and his B.S. in 1950 from the University of Redlin. Before joining the faculty at Michigan, he was an instructor at Stanford University. His research has been in atomic physics and biophysics. He is a member of the CCP's Panel on the Preparation of Physics Teachers.

What, you may ask, does all this have to do with physics and physics teaching? Just this: many of those students who think analytically are applying their minds to the social sciences, law, economics, medicine and the humanities rather than to the physical sciences. They have shifted their interest to these disciplines because they see them as needing their efforts. The problems of the poor and the crises in the cities are crying for solutions. Not only do our young find a challenge in these areas, but they see these problems as urgent and demanding of their attention. Physics and chemistry are viewed by many as being centered on the creation of destructive instruments which are the cause of their problems. To the more charitable, solutions for the problems of social concern have a much greater urgency than do solutions for the problems on the forefront of physical science.

These actions should not be interpreted as a "flight from science." The best thing that could happen would be for the scientist to tackle the problems of the cities. Those of us in the physical sciences have long contended that what the social sciences needed most was more "science." Well, as it would appear that this is what is about to happen, or can happen with our help, we should all rejoice. To be sure, this has deep implications; jobs for the physical scientist will be fewer and monies will be scarcer. But that is not the direct concern of this session, for we are speaking to the problems of secondary school physics courses and teachers. In that regard, in my mind, the outlook is brighter.

In assessing the future, let us bear in mind that our youth are asking solely for "relevancy" in their education and in their chosen careers. If it can be demonstrated that physics has much to offer toward the solutions of many of the problems of our society as we contend, then our enrollments will go up. Likewise, if the slight acquaintances which students find with physics as high schoolers can be placed in proper perspective for them in regards to their view of the world, and their understanding of that world, then again physics *will be* relevant and desirable. There is not the slightest doubt in my mind, or in yours, but that physics is at least as great a part of a liberal education today as it was in the late 1800's, when every school child took it.

There have been many articles appearing in our national magazines on this subject. I quote from one by Donald Cowan of the University of Dallas which appears in the March '68 issue of *The Physics Teacher*: *Physics has the job, probably more than any other discipline in our day, of providing the innovators for society, those people who will penetrate the barriers of the un-*

known and alter the paths of history. This task is the most important we have.

The problem, as I see it, is that we have been shirking our duties; we have been teaching stereotyped and sterile physics courses in high school and in college, speaking only to the prospective Ph.D. in physics, and ignoring completely the question of relevancy. We are being called down for it by the younger generation in no uncertain terms, and it is time we awakened to our responsibilities. We are being forced to prepare good teachers for the secondary schools and to provide good teaching in the universities, or suffer the consequences.

When asked to address a recent American Association for the Advancement of Science meeting in Dallas on this subject, Miss Katherine Swartz, a young student and the daughter of one of our colleagues, concluded as follows:

> Thus the problem facing the scientific community concerned about the "flight from science" by today's students is two-fold. They must make the teaching of science in the secondary schools more exciting and relevant to students interested in the humanities, so the students will have an understanding of science and its methods. And they must make basic research in the physical sciences more exciting and relevant to today's society while at the same time encouraging the use of the scientific approach in the social sciences. The solutions to these problems are not easy, but, as a member of the generation for whom the solutions are needed, I find the idea of solving these problems to be an exciting and challenging one.

One of the major characteristics of today's youth is this quest for a cause to champion. We must build upon this sense of dedication to a cause which pervades our youth and give them reason to believe that physics, and physics teaching, *are* relevant to the needs of our society.

In summary, you will notice that the younger generation is not telling us anything we didn't already know (nor do they presume to be), but they are relating it with a sense of urgency which cannot be ignored. We all applaud the "impatient young man," and he is, after all, nothing new. What is new is the fact that we find ourselves for perhaps the first time as an older generation *having* to respond to that sense of urgency, not because of anything the younger generation has done, but rather because of our situation: we *are* faced with the prospect of mass famine because of overpopulation, with the prospect of mass extinction by pollution of our environment, with the prospect of mass suicide by nuclear holocaust, with the prospect of mass rebellion, if not genocide, by our failure to understand and help our fellow man. We know better than anyone that the physical sciences can and must help in the solutions of many of these problems; we also know that the social sciences must be developed further if solutions to other of these problems are to be found.

Why, then, are we where we are? Why haven't we responded by teaching more relevant science courses? Why do we continue in our present state? From where is the required excitation energy to come? The answers to these and other questions must be supplied by us. If we do not know the source which must supply the excitation, then we are indeed in trouble.

By the exercise of a great deal of self discipline, I will refrain from stating my own answers to these questions for fear that they are only partial and will prejudice the discussion to follow. I don't believe that any of us knows all of the answers to this dilemma which we face, but some of these answers have been alluded to by a few of the speakers yesterday and today. The question which causes me the most concern is the one used for the title to my remarks: *Is* there an excitation energy?

I hope desperately that the answer is affirmative.

(Bennett, continued from page 5)

elementary courses or the introductory courses, although they likely will be deeply concerned with them. They would have teaching assignments as the other physicists do. However, their area of specialty might be in developing and testing course materials, for example, computer assisted instruction materials, or in some other phase of instructional research. They would be supported, rewarded, and advanced for their educational specialties.

Although many participants expressed agreement with the need for such groups, they also felt the need to generate professional support for such a group by, for instance, a statement by the profession through the governing boards of such national bodies as AAPT, CCP, or APS.

Recruitment of candidates is a very important part of any program and there is a good discussion of this in the panel report. Present in this report and reemphasized again in this conference was the importance of personal faculty contact with the prospective teachers. We will want to watch the Georgia experiment in this connection as they are now doing preliminary screening of the students by computer.

Another suggestion related to recruitment was that we provide students with early practice teaching experience, perhaps through participation in high school visitation or through some other activity associated with our course. Also connected with this problem of recruitment is the consideration of geographical factors. Perhaps our greatest efforts to recruit new teachers should be focused on students from those areas, rural ones in particular, which are experiencing teacher shortages, as, in all probability, it is these schools which will be hiring the future graduate of our teacher training programs.

The conference's consideration of preservice programs is the final item that I want to review here. One type of preservice program is the "one-shot" program which

(continued on page 11)

Where Do We Go From Here?

E. Leonard Jossem

The presentation of the problems of physics teaching and physics teachers by our speakers, and the discussion of these problems by our audience this morning, have been both wide-ranging and detailed. So I find it no easy task to try in a few minutes to sum up all that has been said.

It seems to me that in many ways the principal problems we have been discussing are related to those which are faced by society as a whole. As has already been noted, they are the problems of specialization and alienation. We seem to be telling ourselves that we are doing reasonably well in turning out professional physicists devoted to the work of extending the frontiers of our subject, but not very well otherwise. You have heard this problem set forth in many different ways. The statistics are jolting, as are the student points of view which were reported earlier.

There is not much that I can add here except, perhaps, to note that this is not exclusively an American phenomenon. It seems to be international in scope. Some of you may have seen the article by John R. Baker on American Physics Curriculum Projects which appeared in *Contemporary Physics* last year [Vol. 9, pp. 399–418, 1968]. He discusses there some of the enrollment statistics which we have heard this morning and goes on to say: *It is interesting to note that we have a similar position in this country* [*i. e., the United Kingdom*]. *Much has been written and spoken recently on the decreasing percentage of six-formers taking physics and on the shortfall of students in physics undergraduate departments.*

After having reviewed the American scene and discussing some of the inferences he draws from it, Baker concludes by saying: *Many of the actions suggested above as a result of a consideration of the American scene would appear to be consistent with the recommendations of the 'Dainton Report'.* In particular we may note:

1. **There should be a broad span of studies in the sixth form of schools, and irreversible decisions for or against science, engineering, and technology should be postponed as late as possible.**
3. **Breadth, humanity and up-to-dateness must be infused into the science curriculum and its teaching.**
4. **Schools and Local Education Authorities should take steps to insure that within the next five years the majority of pupils in secondary education should come into early contact with good science teaching.**
6. **The participation of teachers in in-service courses should be encouraged; financial incentives should be provided and flexible arrangements for replacement should be developed; the need is especially great in science and technology.**
9. **. . . advances in educational technology should be fully exploited in the teaching of science and mathematics . . .**[1]

E. Leonard Jossem is Professor and Chairman of the Department of Physics at The Ohio State University. A Cornell Ph.D., his research work and interests are in the field of x-ray spectroscopy and solid state physics. He has been Chairman of the Commission on College Physics since 1966, and is a member of the National Advisory Council on Education Professions Development, the A.I.P. Advisory Council on Education and Manpower, and the Council of the A.A.S.

You will easily recognize the counterparts of these suggestions in the discussion we have had here. In many respects, then, we share our problems with colleagues in other countries.

A mathematician friend of mine is fond of saying that the easiest way to solve a complex mathematical problem is to guess the solution and then show that it is correct. In very complex situations this may indeed be nearly the only way to arrive at a solution, but it does require great insight. Finding solutions to our problems, it seems to me, also calls for deep insight into their nature and causes. Why don't more students take more physics? What turns them off? We have heard many partial answers to these questions, and I would like only to remind you that the situation is very complex. It involves, among other factors, the nature of the instructional materials we use and how we present them; the views we have of our students—what they are interested in and what their capabilities are; our own views of what physics is all about and what its relation is to the world and to our fellow men. To these we must add the actual overall shortage of good teachers and the geographic imbalance in their distribution—the problems about which we have been mainly speaking today.

We have been reminded as well that there is more to being a good teacher than just knowing the subject matter well, though clearly that is a primary requirement; that we need at all levels to provide more kinds of instruction for more kinds of students, and that the social system of which we are a part has many strong feedback loops—what happens in one segment may influence the whole. The attitudes that the teacher of

[1]*Inquiry into the Flow of Candidates in Science and Technology into Higher Education,* **Cmd. 3541, HMSO, 1968.**

physics takes towards his subject influence the attitudes of his students toward it—those students who later become members of school boards and legislatures, as well as those who become the new teachers in elementary and secondary schools and in colleges and universities. Again, we are reminded that this is a problem for the entire physics community; that each of us, whatever role we may play, is necessarily involved and has a vital interest in the continuing improvement of physics instruction.

This being the case, I believe that no one of us can afford to "leave it to George to do". There is something that each of us can and should do to help. Our great diversity, which is partly a problem, but also, in my view, a large part of our strength, would indicate that the answer to the question, "Where do we go from here?," probably depends on who "we" happen to be. Probably we each need to do somewhat different things. But we all need to work in cooperation and in a common general direction, and we all need to find or invent ways to facilitate our doing so. In this connection I would mention the work that has been done in setting up Regional Physics Associations. There are a few such now in existence and, as you know, a discussion of their activities is programmed for later in this meeting. I believe that their experiences hold valuable lessons for us. I would call your attention also to the work being done in setting up Instructional Resources Centers and to some of the new National Science Foundation programs. The NSF Cooperative College-School Science Programs, for example, provides another interesting attack on our problems of getting good teachers.

Finally, you have heard, and I will not repeat, many suggestions of things that college and university departments of physics and of education might do. Suggestions for new teacher training curricula, for more active recruitment, for better pre-service and in-service programs. Again, the requirements of diversity mean that we need to remain open minded and flexible in our approaches, to be willing to plan, to try, to discard, and to try again. But mostly to keep at it. In some respects the problem we face is a bit like housekeeping in that it is a continuing one. Much of the work is not at all glamorous, but it needs to be done. We have to prepare the intellectual food in an appetizing form, and we have to keep our intellectual houses clean and attractive *every* day. If we get lazy or careless about what we do, no one will want to consume what we offer and they will move out of the house of science.

It has been some hundred and fifty years since William Blake said: *He who would do good to another must do it in Minute Particulars.* So perhaps one answer to the question of where we go from here may be to go back home and cooperatively attend to the many Minute Particulars we must take care of to put our collective house in better order.

Materials For a Radar Ranging Experiment

We call your attention to the offer made in the article "Materials for a Radar Ranging Experiment," J. M. Fowler, Amer. J. Phys. 37, 712 (July 1969). The CCP is offering at cost a stereo tape of data for a measurement of the Earth-Moon distance. The experiment was performed for us by J. V. Evans of the Lincoln Laboratory. A train of 23 cm radar pulses was reflected from the moon and the echoes recorded. The stereo tape has a pulse on one track which is synchronized with the outgoing pulse and the echo pulse is recorded on another track. The tape and slides are offered at a cost which will depend on the number of orders, but will be in the neighborhood of $3.00. See the AJP article noted above for further details.

(Bennett, continued from page 9)

is aimed at stimulation. We have had these in the past, and should continue them in the future as a means to treat a special topic and to build up the teacher's enthusiasm.

Another type of program, the "retread" type of inservice program, has also been in existence for a while now. These are generally institutes for the person who did not start as a physics teacher, who is now teaching in physics with little or no physics background, and who wants more physics so he can handle his classes better. These "retread" programs have also been a major mechanism in the dissemination of new curricular materials and are appropriate for mature teachers who took their training prior to the development of the new curriculum. Unfortunately, it is rather common that new graduates must immediately take a "retread" program because the colleges are not introducing these new curricular materials into their teacher training programs. This point was mentioned earlier, when it was noted that the style of our teachng should be compatible with the kind of teaching we would like to see our students do.

What we need, however, is another kind of inservice program, which is not so random in its clientele. If we are to serve as the second half of the teacher development program described by Dr. Watson, we need an integrated preservice-inservice program which encourages the teacher to continue systematic developments in both subject matter and teaching skills during the initial years of his teaching career. Certainly, such a "teacher development" program will require a physics course which is designed and taught in a manner appropriate to the school teacher. Our traditional courses and teaching will not do.

The development of really new courses and new teaching patterns is hard and time-consuming work. Individually, we are not likely to affect the status quo. However, if a number of departments can be encouraged to establish "critical mass" groups as described above, maybe we will get something started.

(Phillips, continued from page 7)
"scholar-teacher" as the ideal. We should add, I believe, something that connotes awareness of the social context, the relation of science and technology to our lives at various levels. We can hardly become experts in the sociology of science (in fact, there are very few such experts), but we must more explicitly admit the existence of the kind of problems I have mentioned. Our failure to take into account the ill as well as the good resulting from the applications of science is one (of course not the only) reason for the lack of interest in school science. To increase that interest is our chief goal; not so that people should indiscriminately urge their congressman to allocate more federal money for research, but that they should, with some confidence, share social responsibility for improved national (and local) policy in science and technology. Chiefly for this reason, it seems to me, we must increase and improve the study of physics at every level. And for this we really do need many more physics teachers!

COMMISSION COMINGS ...

... AND GOINGS

As in the past, the beginning of a new academic year brings changes in the Commission staff. Staff Physicist *Dr. Robert B. Bennett* has returned to Central Washington State College where he will both teach and co-direct the Pacific Northwest Association for College Physics (PNACP). Staff Physicist *Dr. Philip DiLavore* has left to take on the duties of Associate Chairman of the Physics Department at the University of Maryland. *Dr. Gregory Edwards* has left his position as Associate Staff Physicist to join the College Science Curriculum Improvement Program in the Division of Undergraduate Education in Science at the NSF. We wish them well and take this opportunity to publicly thank them for their many contributions to the CCP.

Commission on College Physics

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