June 16, 1966

Annual Report of the Department of Physics

TO: Richard M. Millard, Dean CLA
Richard S. Bear, Dean GRS
Faculty, Department of Physics

FROM: Robert S. Cohen, Chairman

This report serves, as last year, as a record of Department activities, and as evaluations by the separate members of the Physics faculty of departmental matters. It contains a complete bibliography of faculty and student publications, a detailed report and critical study of the Machine Shop (as Appendix), and a substantial portion of my response of April 20th to Dean Millard's request concerning long-range university planning.

The year saw several grave disturbances. Professors O'Neill and Sachs resigned; and Professor Roman nearly did so. The physical plant grossly deteriorated, partly due to the severe strain of construction in front, partly due to insufficient housekeeping and originally poor standard materials (such as black-boards). Admission of graduate students has gravely suffered from our low and non-competitive stipends for teaching and research assistants as well as from the serious competition of the large number of Federal fellowships available at all the graduate departments. The number and quality of undergraduate concentrators has also continued to be relatively poor, with several outstanding exceptions. The physics library is unusually inadequate by every standard: physically cramped for shelf space and for work space, staffed by amateur and part-time help, and funded at a level which is almost disastrously far below that of an adequate collection for a graduate research department.

Nevertheless the current research and teaching have been managed with general efficiency and with notable achievements in both aspects of our work. Furthermore, physicists have entered strongly into the administrative and advisory activities of CLA, GRS and the University. We have about 60 publications to record this year, and the Harvard department records precisely the same number; and while numbers games can be played in many ways, at least we have reached the stage of being a player. Our faculty have been actively engaged outside of the University too: Professors Franzen, Sachs, Zimmerman, Hoy, Siegel, Willis, Stachel, Papagiannis, Hawkins, Booth, Edmonds, and Cohen have engaged in scientific activities outside of the United States, to indicate one measure. Faculty activities within the country are listed individually below. University support of research has improved noticeably through the GRS allocation of funds, mainly to Professors Hoy, Franzen, and Zimmerman, but the total amount is still small. University support of faculty salaries has, in the main, increased substantially in this department; but it is still unclear whether the increase does more than attempt to match the national standards in physics. The colloquia of the department, together with the several relevant colloquia of the Boston Colloquium for the Philosophy of Science, have been of high quality, and they will be listed in this report.

Annual Report of the Department of Physics

CONTENTS

Introduction

I. General Statement

As part of my annual report, which is intended for my colleagues as much as for the Deans, I am copying certain paragraphs from my letter to Dean Millard of April 20 which was mainly concerned with questions of long-range planning in the University.

Present Status of the Department of Physics

Strengths and Weaknesses.

As a general appraisal, one might say that we are a very good 3rd rank department, on the margin of becoming 2nd rank (where first rank would be Harvard and Columbia, and 2nd rank would be Brown and Rutgers). The faculty quality is our greatest strength, and indeed in my experience it is superb. But most of the faculty members are too young to have their ability and knowledge tested or otherwise matured and known; only several of us are so known (Franzen, Roman, Siegel, Hawkins, Corinaldesi) while several others seem to me to be on the edge of vital national reputation (Willis, Zimmerman, Booth) and still others have similar potential but not sufficient achievement to be sure (surely Chasan and Stachel, probably Hoy and Hellman and Edmonds). These remarks apply to calibre as scientists.

As a teaching faculty, we have also some strength which would be easily as good as any, anywhere, but for our poor facilities. As things stand now, we have no adequate classrooms for lecturing in theoretical subjects, no lecture halls adequate for scientific demonstrations, marginal facilities for preparation, storage, and repair of research and teaching equipment, and marginal staff to assist the faculty in these matters. Almost every high school in metropolitan Boston has a better lecture hall with preparation rooms and staff for use by their physics students and teachers.

Hence, while some of our faculty are outstanding teachers (particularly Roman, Stipe, Stachel, Chasan, Edmonds), a great deal of their energy is wasted in overcoming material obstacles.

It has been easy to say that we developed our department first at the graduate level, and moreover that we stressed theoretical rather than experimental competence. But this statement is no longer true when as a description of our current situation. Half of our faculty, and more than half of our graduate students are engaged in experimental physics, and our intentions are to increase the relative portion of our effort in this direction. Our experimentalists are (excepting Booth and Franzen) less experienced than our theorists, and their investigations will generally not bear fruit on a national level for another few years. But they are supported by outside grants to the same extent as our theorists, with similar rates of publication, and in my considered judgment they are of similar high quality of mind and insight. They are naturally more limited by financial factors, especially including our poor range of staff support in the way of equipment curators, machinists, and so forth. But altogether I regard the experimentalists in the physics department as now to be considered a strength, and not a weakness.

Recruitment of graduate students is not as successful as we should like. The competition is severe; our reputation is good only in selected places and in a few fields; thus we can more easily attract post-doctoral fellows and faculty than graduate students. Here we are also limited by the stipends of teaching fellows which have been substantially less than those offered at competing universities, and even less than those at many of the more famous ones. So we are weak in that our graduate students are often not sufficiently prepared (and hence our senior 300-level courses are populated largely by first-year graduate students), or even marginal in their promise. But we have had some unusually good students come through this arrangement, some through part-time working at local industries or other laboratories or teaching, some from doubtful undergraduate schools, some from overseas, and a few through an orthodox admission to full-time study from a very good college. The graduate program is, overall, a remarkable success, considering the weaknesses of finance, facilities, lack of tradition or reputation, lack of university efforts at major publicity or recruiting for physics, and even the lack of any specific decision at any time on the part of the university to make any special and substantial effort to buld up the physics department to a national level of research and graduate education. Here it is important to recognize that the department budget is great as compared with that of ten years ago; and that the present building (however crumbling) was an enormous advance over what preceded it for pure physics--although it does not compare to what was devoted to applied physics before 1958; and so the trend of university support for physics has been upward, especially the record of support for faculty appointments, and for an expanded, and now quite satisfactory, graduate degree curriculum.

Recruitment of undergraduate physics majors has lagged and has been almost without effort, so far as I know. With one or two exceptions in the way of pamphlet literature, there has been no effort by the admissions office or its recruiting officers to bring science students from the high schools here for physics education. The department once had high school teachers' days, but these brought only a few dozen teachers; and in view of our poor facilities, such teachers' days may have done harm. Our faculty participate in many events of the American Association of Physics Teachers, but these probably do little for our recruitment of college students. Hence our majors come from the general admissions policy results, a kind of statistical probability that some undecided students will try physics. Of the 40 or so physics majors in the current freshman classes, only a dozen or so will reach senior status as physics or astronomy majors. The rate is upward but I feel this admissions policy is a weakness; and moreover I am not sure where the responsibility for changing it will lie.

The evening physics program was instituted in the early 1950's as a service of the then-existing optics facility; it was continued after 1958, and I believe that it was thereafter a principal source of strength to the development of our department. The faculty was increased in numbers in response to the great use of evening graduate courses by working scientists and engineers in the Boston area; and we recruited some of our best graduate students from these originally part-time students. To a much lesser extent we have had success with undergraduate physics in the evening, repeatedly being impressed that the lack of an evening bachelor's degree program was a factor. In addition, there have been competing evening programs, mainly at Northeastern, for the undergraduate courses, whereas our graduate evening

courses have had little competition of the same quality. This graduate evening program could have been a strength far beyond the physics department's benefit since it showed how new doctoral level scientists could be educated from the large numbers of B.S. and M.S. scientists and engineers in an area like this. We are a number of years late in devoting large university efforts to such recruitment and publicity, but it still could be done. As yet it seems to me unlikely that the enthusiasm for Metropolitan College within the administration will include science as a principal factor (and hence I believe that Northeastern will continue to benefit from the enormous science and engineering appetite of the Boston area far more than B.U.).

Our strengths in serving non-physics programs within the University are well-known. The principal factor is the service to non-CLA students: SAR, SED (here only elementary ed and special ed), ENG. The engineers now recieve a physics program which is up to national standards of curricular content, which was not true in the past. We do not reach any substantial portion of non-science CLA students with our physics courses (although a great many, perhaps 700 each year currently take elementary astronomy). In CLA, there is strong non-science faculty sentiment supporting student wishes and fears, and hence physics and the physical science course, are avoided in satisfying the science distribution requirement in favor of more specialized subjects, which are also somewhat more descriptive. On the whole, however, the service functions of physics and astronomy to the non-specialists throughout the university are of major magnitude, involving about 1600 students.

Manpower needs

A. Faculty: Rise to about 20 in physics and 5 in astronomy by 1970.
No retirements in prospect.
Probably several resignations in normal course of affairs.
Strengthening of present research fields, particularly solid state and low temperature experimental physics.
Hence I anticipate no faculty changes except as justified by general rise in number of students to be taught, and then within fields of special competence as fitted to our present interests (thus, no major new fields need to be anticipated, certainly not in experimental facilities).

B. Staff:
(1) We need several supporting personnel for the greatly expanded instructional obligations, in the first instance for preparation of demonstration apparatus; plus for research equipment and its care; plus an administrative officer or associate for the chairman.

(2) Urgently need additional secretarial assistance beyond that supported by grants.

(3) Educationally, we need undergraduate assistantships in the GRS.

C. Other: Faculty salaries are now not comparable with those at competing institutions (except in the initial years of appointment perhaps), and must be raised by about 40% to reach the competitive level of 1965, and hence perhaps by 80% or more by 1975.

The scope of our general courses may be indicated by a table of registration figures.

Fall 1965

Course No.		Students Registered	Completing
ASTRONOMY			
AS101	(Sect. A)	224	219
	(Sect. B)	234	215
	(Sect. C)	219	190
AS201		20	19
PHYSICS			
PY101		267	237
PY105		198	174
PY111		45	42
PY121		40	37
PY151		164	159
PY201		7	6

Spring 1966

ASTRONOMY			
AS102	(Sect. A)	230	218
	(Sect. B)	173	167
	(Sect. C)	113	103
AS202		12	12
PHYSICS			
PY102		235	187
PY106		178	169
PY112		34	34
PY122		36	36
PY152		133	130
PY202		13	11

Colloquia 1965-66

September 29, 1965: J. L. Snider (Harvard University), "The Gravitational Red Shift".

October 13, 1965: Franz Metzger (The Bartol Foundation), "Resonance Fluorescence in Nuclei".

October 27, 1965: Forrest Boley (Dartmouth College, Wilder Laboratory), "Large and Small Amplitude Hydromagnetic Waves".

November 10, 1965: Jonas Alster (Northeastern University), "Nuclear Structure Studies by Inelastic α-Particle Scattering".

November 29, 1965: Peter Havas (Temple University), "Relativity and Causality".

December 8, 1965: Robert K. Adair (Yale University), "Search for Elementary Particles--Fundamental Triplets".

January 31, 1966: C. Kavaloski (University of Washington), "Nuclear Reactions with Emphasis on Studies of the Shew Model".

February 1, 1966: James Vignos (Argonne National Laboratory), "Attenuation in Liquid Helium 4".

February 2, 1966: Max Lipsicas (Brookhaven National Laboratory), "Nuclear Spin Relaxation in Hydrogen Atoms".

February 9, 1966: George Ruff:(Princeton--Palmer Physical Labs), "Spin Exchange Optical Pumping and Light Modulation".

February 16, 1966: Leonard Meyers (Brandeis University, and National Magnet Labs), "Flux Quantization Experiments".

March 2, 1966: H. Saloman (Columbia University), "Relaxation in Optically Oriented Atoms".

March 7, 1966: O. Fleischman (Syracuse University), "Nonrelativistic Internal and External Symmetries of Particles".

March 14, 1966: H. Lee Watson (Institute for Advanced Studies, Princeton), "Bootstrap Physics".

March 16, 1966: R. Bell and R. Hodges (Boston University), "Coincidence Moessbauer Experiment" and "Photons and Nuclei", respectively.

April 6, 1966: Sidney Chapman (University of Alaska), "The Aurora Polaris".

May 26, 1966: Jean Pierre Vigier (Institut Henri Poincare), "The Geometrical Connection Between External and Internal Noncompact Symmetries of Elementary Particles".

Space Science Seminars 1965-1966

Sept. 20: M. D. Papagiannis (Boston University), "The Objectives of Scientific Observations in Space".

Sept. 27: R. J. Hayes (NASA Electronics Research Center), "The Research Program of NASA in the Greater Boston Area".

Oct. 4: Isaac Asimov (Boston University), "The Existence of Life Beyond the Earth".

Oct. 11: G. G. Fazio (Smithsonian Astrophysical Observatory), "Observations of X-Rays and γ-Rays in Space".

Oct. 18: G. de Santillana (Massachusetts Institute of Technology), "Space Science in Antiquity".

Oct. 25: Thornton Page (Wesleyan University), "Galactic Structure and Evolution of Galaxies".

Nov. 1: E. J. Burtt, Jr. (Boston University), "Economics of the Space Related Industries".

Nov. 8: E. T. Angelakos (Boston University), "Physiological Effects of Zero Gravity".

Nov. 15: W. Schwartz (Boston University), "Legal Aspects of Space Exploration".

Nov. 22: W. M. Irvine (Harvard and Smithsonian Observatories), "Planetary Atmospheres".

Nov. 29: Jules Aarons (Air Force Cambridge Research Laboratories), "Space and Radio Astornomical Research at AFCRL".

Dec. 6: M. Z. Hoffman (Boston University), "The Earth's Primordial Atmosphere and the Origin of Life".

Dec. 13: G. R. Huguenin (Harvard University), "Solar and Galactic Radio Radiation".

Jan. 31: Robert D. Stuart (Northeastern University), "The Earth's Upper Atmosphere".

Feb. 7: Francis M. Stienon (Smith College), "Solar Activity".

Feb. 14: Morton S. Roberts (National Radio Astornomical Observatory), "The Study of Galaxies by Radio Techniques".

Feb. 21: Carl E. Sagan (Harvard University), "The Planet Venus".

Feb. 28: Alexander Rich (Massachusetts Institute of Technology), "Information Theory and the Origin of Living Systems".

Mar. 7: J. S. Goldstein (Brandeis University), "Dwarf Stars and the Physics of Dense Matter".

Mar. 14: A. E. Lilley (Harvard University), "Spectral Line Radio Astronomy".

Mar. 28: Joseph Weber (University of Maryland), "Modern Gravitational Theories".

Apr. 4: Philip Morrison (Massachusetts Institute of Technology), "Supernovae".

Apr. 11: Sidney Chapman (University of Alaska), "Solar Wind and Aurora".

Apr. 18: William Henze (University of Colorado), "Rocket Observations of the Solar Spectrum".

Apr. 25: Louis H. Orzack (Boston University), "Pressures on Scientists".

May 2: E. O. Wilson (Harvard University), "Biocommunication".

May 9: M. D. Papagiannis (Boston University), "Radio Galaxies and Quasars".

Undergraduate Affairs (prepared by Professor Chasan)

The two year introductory program is too young for evaluation, but some problems should be mentioned. Some students in other sciences take just the first year, and thus lose coverage of electricity, light, etc. The "transfer function" for math, chemistry, etc. majors was not good.

Another more serious problem is the great diversity of preparation, motivation, etc. of students entering PY151. We impose no high school physics prerequisite, but the spread would be there anyway. While many good students are from the College of Engineering, it is only fair to point out that most of the poorest students are from that school. It should be mentioned that the ENG program stresses managerial and systems engineering, and a basic interest in physical sciences is simply lacking in many ENG students. The use of two texts (Resnick and Halliday and Feynman) was a great aid in dealing with this diversity, and the honors section may help further.

There was a substantial body of interested and able students in PY151, drawn from all groups taking the course. Among these are about seven very promising physics majors and about four or five other physics and physics-astronomy concentrators. Some of the more promising group will be juniors next year, and will double up on sophomore-junior courses. This doubling up, if successful, will soften the difficulty of entering the physics major program later than the freshman year; a major difficulty in the two-year program.

Physics Majors, Numbers and Quality: This year's graduating class (June plus August) there are five (5). Of these, three are rather weak. Of the other two, William Sarill's abilities are well recognized. For next year the numbers are:

sophomores (includes juniors taking sophomore course and some junior work)	12
juniors-seniors-special	10

These numbers include physics-astronomy.

Comments on the Graduate Committee (Prepared by Professor Franzen)

(a) Graduate Students with outside fellowships 1965-66:

John Brownson (NSF Cooperative Fellow)
Michael Horne (NSF Trainee)
Richard Bell (NSF Trainee)
John Hegarty (NASA Fellow)
Bruce Newell (American Optical Company Fellow)
Wijit Senghaphan (Government of Thailand Fellow)
Frank Kearly (New York State Regents Scholar)

(b) Impromptu (no-credit) seminars that were conducted during the year:

1. Seminar on Relativity Theory (both semesters), J. Stachel.
2. Seminar on Nuclear Structure (Sem. I), E. C. Booth and W. Alston.
3. Seminar on Particle Polarization by Resonance Scattering (Sem. I), W. Franzen.
4. Seminar on Moessbauer Studies (both semesters), G. Hoy.

(c) Graduate Degrees Awarded 1965-66:

1. Ph.D. Degrees:

Ira Kohlberg: "Series Solution for the Propogator of the Linear Boltzmann Equation" (A. Siegel, first reader).
Final Oral: July 6, 1965.
Passed Qualifying Oral: August 5, 1963.
Passed Comprehensives: May, 1962.

A. S. M. Mahbub'ul Alam: "Moessbauer Studies of Spin Relaxation of Fe^{3+} in TiO_2" (W. Franzen, first reader).
Final Oral: May 3, 1966.
Passed Qualifying Oral: September 18, 1962.
Passed Comprehensives: May, 1962 (second try--first try in May, 1961).

Jacob Aghassi: "Higher Symmetries in Elementary Particle and Field Theory" (P. Roman, first reader).
Final Oral: May 3, 1966.
Passed Qualifying Oral: June 23, 1964.
Passed Comprehensives: May, 1964.

2. M.A. Degrees:

Comprehensives Option:

Charles Norwood (August, 1965)
John V. O'Brien
Sven Roosild
Arthur Snider
Timothy Swanson
Harriet Tamulonis
Emmanuel Bliamptis

M.A. Thesis Option:

John Kuppenheimer: "Optical Constants of Silicon" (W. Franzen, first reader), August, 1965.

(d) Other Comments:

In May 1965 the Department adopted on a trial basis a new system of oral qualifying examinations. Under the old system, students who had passed the Written

Comprehensives with Distinction were asked to pass an oral examination in three advanced areas of physics (based on three 700-level courses) in order to qualify as Ph.D. candidates. The argument against this system was three-fold: In the first place, the oral tended to duplicate information already available from course grades; secondly, it did not provide a very good basis for deciding whether a given student would be capable of carrying a Ph.D. thesis through to completion; and finally, it tended to delay the student's progress unnecessarily.

Under the new system, the student must form a trial association with a faculty member for one semester, in the course of which an advanced topic of experimental or theoretical physics is studied with concentration. Ideally, the topic would be related to a possible subject of thesis investigation. At the end of the semester, the student presents himself for an oral examination given by a committee of three faculty members, one of whom is the supervisor of the directed study mentioned above. The student must deliver a 45 minute talk on the subject of his study at the beginning of the examination.

A further requirement later voted by the Department is that a Ph.D. canaddidate must pass successfully at least 15 semester credits of 700 level courses after attainment of the M.A. degree.

So far three students have successfully passed orals under this system (Ramesh Chandra, John Ward, and K. P. Singh), two of whom are making good progress toward a thesis topic. I believe the system is good and should be adopted officially in the near future.

A second piece of business for the Graduate Studies Committee was the adoption (for transmission to the Graduate School, which has in the meanwhile also approved) of a new Graduate Program in Physics and Astronomy. (This question I am sure will be discussed at some length by the astronomers in the Department.)

In general, I feel the graduate program is in excellent shape, except for somewhat inadequate library and experimental facilities that should not be brought up at this point, and for a serious problem in admissions. The remarkable fact is that we had an unusual number of good applicants for admissions this year, but on the other hand, an unusually high rate of rejections of offered admission, fellowships, and teaching fellowships. This is undoubtedly a reflection of the increasing competition for first-rate graduate students.

On thinking over this situation, it struck me that of the good students who finally accepted offers of admission, almost every one had visited us (largely on their own initiatives): Nartonis, Li, Farago, Corones.

Suggestions to improve acceptance ratio in the future:

a. Act rapidly on all good candidates--not later than the first week of March. Send them complimentary telegrams immediately, and then follow up with letters inviting them for a visit, even if we have to pay travel expenses. After all, many of these students are prospective teaching fellows, and we should see them, just as we see prospective faculty members. If the average cost of transportation is, say, $80.00, and we invite, say, 20 students, of whom 12 actually accept the invitation, this procedure would cost about $1000.00 per year, a small amount compared to the $50,000.00 per year teaching fellow budget. Apparently we make a good impression on students who actually visit us.

b. Increase teaching fellow stipends still further (to at least 2400 per academic year). Our present stipends still is uncompetitively low, despite the small raise to 2200 per year this year.

Faculty Affairs

1. Resignations.

To my profound regret, Edward L. O'Neill and Mendel Sachs have resigned from the Department of Physics.

Professor O'Neill has accepted a position as initial holder of a chair in theoretical optics in the Department of Physics of the Worcester Polytechnic Institute, sponsored by the American Optical Company. He has been at Boston University since the early fifties, when he began graduate studies here after receiving his undergraduate degree at Boston College and his M.A. at Tufts University.

Professor Sachs will join the Department of Physics of the State University of New York at Buffalo. He came to us after previous work in California and Canada; and after completing a distinguished series of research studies in theoretical solid state physics, he turned to his well-known investigation of a new and fully deterministic formulation of the foundations of physics.

2. Appointments.

Ernesto Corinaldesi will join us as Professor of Physics, coming from the Westinghouse Research Laboratories in Pittsburgh. Cordinaldesi was Visiting Professor at Boston University during Spring 1964. He works mainly in the theory of atomic and elementary particle physics.

Owen Fleischman will join us as Assistant Professor, working in elementary particle physics. He comes to us from a research associateship at Syracuse University and an assistant professorship at Brooklyn Polytechnic Institute.

Leonard Meyers will join us as Assistant Professor, working in experimental low temperature physics. He comes to us from Brandeis University, and he will continue his work as research associate in the National Magnet Laboratory.

3. Leaves.

Professors Armand Siegel and Charles Willis have been on sabbatical leave during 1965-66, Siegel at the French research center in Saclay, near Paris, and Willis at the Institute of Theoretical Physics in Utrecht, Holland.

4. Visitors.

Dr. Wlodzimierz Tulczyjew has been at this department since February 1966 as National Science Foundation Distinguished Visiting Professor. He comes to

Faculty Affairs Continued:

us from the Institute for Theoretical Physics of the Polish Academy of Sciences in Warsaw, and his appointment will continue through the Fall of 1966.

A short visit was paid to us by the eminent geophysicist and theoretical physicist Sidney Chapman during April 1966. He gave two colloquia, and consulted with Professor Papagiannis's research group.

Excerpts from faculty appraisal of the department and its problems.

Alston: "In a small department a faculty member must be more versatile and imaginative (perhaps even brighter) than in the 'big' schools. Not only must he struggle to function well as an employee (high teaching standards, committees) but in addition possibly harbor big-time research ambitions, often directly competing with full-time research efforts at the larger institutions.

One of the handicaps of the B.U. Nuclear Experimental Group is the lack of an accelerator facility that would point the way to a continuing exploration of nuclear structure. The present program at M.I.T. possibly will be exhausted within a year.

It is an ambition of the Nuclear Group to expand its efforts to higher energies, learning and using different techniques either with an accelerator of our own or at external facilities (M.I.T.'s new LINAC, N.B.S. LINCA, etc) with independent support. Involvement in such measurements will call for an increase of the order of 100% in the number of graduate students and staff members (including a senior faculty member) doing this sort of physics.

More to the point, it may require that a major portion of one's time be devoted to research. A maximum teaching load for a faculty member engaged in such research realistically could be one course a semester with minimal committee obligations. Obviously Boston University would not be expected to finance such projects, but would share some of the research burden by assignment of appropriate faculty loads.

Conceivably in less than a year we will be faced with the decision to commit a large part of our energies to a concrete and complex research program. One hopes that when that time comes the University will encourage us to go ahead and compete."

Booth: "The research position is satisfactory at the moment. We are apparently going to do the things we proposed doing with the low energy machine at M.I.T. The future is less clear. The possibility of a regional Van de Graaff facility is still unrealized, and is apparently unlikely. I have no hope for an in-house 'bench-top' program unless it operates in conjunction with a machine oriented program here or elsewhere. With reference to our microtron project, there is little progress toward a concrete proposal. I believe that such progress would be greatly expedited if one of us could devote vull research time to the study of machine design, but this seems unlikely. I am moreover, discouraged by the great and widely publicised scarcity of funds for this type of research. The war, emphasis on broad based support for education, and heavy support for high energy research make the project somewhat of a long shot.

Finally, the responsibility would be primarily mine, and I feel uncomfortable about accepting it, since I would have to handle much administration as well as do a large share of the actual work. Everyone I talk to says it's a terrible burden to assume. On the other hand, why do so many try to assume such responsibilities? Perhaps to be group leaders.

A compromise seems to be the M.I.T. facility, the linear accelerator now beginning construction. A B.U. group of competent faculty and students are welcome there. The research is a change from low to medium energy physics, but I hope that one could manage well enough. Research support would be more likely than for our own machine, and would probably be comparable in magnitude, perhaps $100,00 per year. Considerable overhead would be due M.I.T. We should acquire one more faculty member interested in this type of research and hope to find also a post-doctoral fellow in our grant support. We should not be involved except as an independent, internally supported group. We have been asked to participate in a series of seminars exploring possible experiments beginning this summer (the seminars, that is) and lasting indefinitely. Chasan, Edmonds, Alston, and I have agreed to attend and contribute to these seminars. All this represents the opportunity to participate in big time, nuclear physics, and I hope we are good enough to take advantage of the opportunity."

Chasan: I would like to see this department develop a whole set of 'hyphenated' majors with other departments, physics-mathematics, physics-chemistry, physics-biology, physics-philosophy, etc. (For that matter, a real physics-astronomy combination) The precedent for this already exists in the philosophy-sociology, philosophy-psychology, etc., majors listed in the CLA catalogue under Philosophy."

Edmonds: "No comments, except maybe cheers."

Hawkins: "The most serious problem in Astronomy is space of the mundane kind. The chairman's office contains display material, exam pick-up, the Dept. secretary, research and Dept. files, etc. It is a whirling galaxy of students, faculty and assistants. It is impossible to conduct interviews, discussions and conferences on this basis. There are similar problems in other faculty offices, in the research labs and graduate student areas.

The space problem can be eliminated by moving to the certain portions of the Chenery Library area as outlined in the memorandum of February 18, 1966."

Feldman: "The personnel in the department are great, so is the chairman. Like others, I would like more money, better building, etc. However, this must be the best possible of all worlds."

Roy: "Even though I'm only a junior faculty member, I can't help being concerned about the direction of the University. I wonder to what extent Boston University is committed to fundamental research as a necessary function of a university. It seems there is some lack of commitment or at least an uncertainty in this area. For example, our library funds and computing facilities are very meager. The problem of obtaining funds for research is a difficult one and, for all I know, this could be the answer. If everyone realizes the need for pure research, and it is just a question of finances, then the problem if there is one, is not serious. However, the recent talk of stressing 'applied research' is disturbing.

With regard to the physics department, I think it might be helpful if recommendations as to specific texts and specific topics for each course were made by our faculty or a committee selected for this purpose. This is a very touchy area, but this procedure would tend to produce a more integrated and well defined program. Thus, if an experimentalist taught a course usually taught by a theorist, he could follow the recommended text covering the same material albeit with a different flavor.

It seems to me we need more interaction between the theorists and experimentalists, and also between graduate students and faculty. As our facilities improve these problems will vanish. As our offices become conducive to deep thought we will all be in the physics building more often. With the acquisition of more space we will be able to have informal discussions with each other and/or students.

I have one recommendation of a specific sort. I believe it would be helpful if we offered some solid state physics before PY 715, perhaps in Modern Physcs, or maybe we could squeeze it in somewhere else.

Since this has been my first year in the department, I would like to express my appreciation to my colleagues for their generous cooperation. In spite of some hectic moments, this has been an enjoyable year for me."

Roman: "The department developed healthily during the year, and reached a size which is big enough for efficient work, at least as far as research is concerned. Further increase should be made only by the motivation of strengthening existing research groups, and by considering teaching personnel for subsidiary physics courses (service courses).

There is an obvious lack of appreciation of research on the part of the administration. The viewpoint that research be supported almost entirely by government and other contracts and grants can no longer be

upheld. As a start, the University should contribute a greater amount to publications and preprint costs, travel expenses, and secretarial support.

In spite of some improvement, student quality on the Ph.D. level is still not good. (The outstanding ones are almost always part-time students.) Admission standards must be raised further, and good students be attracted by more intensive propaganda directed to U.S. (not overseas) schools.

Although it is probably useless to reiterate once more the numerous complaints made during the year, re: facilities, one should again emphasize the intolerable 'outhouse character' of the whole department. With the abominable construction in front of our labs and offices, this becomes more and more a serious obstacle to scholarly and high-level work.

I did not have the gratifying reassurance to observe that there is any improvement on the Administration's part to pay more attention to the academic character of the University. Actually, the reiteration of 'Community Service' and 'Applied Research' aspects and policies is more than alarming. If these are to become directives, the University will not only be unable to attract new scholarly personnel, but will actually lose its best teachers and researchers. This applies certainly for the natural sciences, and will apply more and more for the social sciences as well. The word 'University' is an obligation, and any confusion with 'Metropolitan Study Center', 'Professional Training Institution', 'Community Oriented School' is most dangerous and suicidal indeed!

Comments on colleagues: It is necessary to express once again my high appreciation of the outstanding efforts of our chairman, for his continued efficient work in both building and keeping together this department. The fact that the Physics Department has now both national and international reputation is greatly his merit. However, in order to be able to cope efficiently with the increasing needs and more and more intricate problems, he will need in the future considerably more support from the Administration. I do not mean simply cooperation, but actual facility-wise support, such as the employment of a full time Department Administrator.

The regisnation of Professor E. O'Neill is a great loss, and I owe a lot to Ed in many respects and it is with sadness that I wish him good luck elsewhere."

Siegel: "I am immensely grateful for the University's policy and concrete help which made this year of sabbatical possible. It was a year of genuine re-creation in many ways.

It is important to mention that the two of my three children who stayed in Paris with us went to French schools and became bilingual as well as, to some extent, 'bicultural'. Thus the University's sabbatical leave program is to some extent a fulfilment of its acknowledged responsibility to further the education of its faculty members' children wherever possible."

Steckel: "I think there was some slippage of marale this year: ups and downs over new building; tizzy over Paul and concessions to keep him; state of this building; loss of O'Neill and Sachs, etc. But I am hoping return of Willis and Siegel and advent of Cordinaldesi and other new blood will put us back on evener keel. (Some of my feelings should probably be disregarded on subjective grounds, slump in my morale for a while due to personal losses, but not all I think, from talks with other in the Department.)"

Stipe: (Much of this Annual Report derives from Professor Stipe's assistance. But his 1965 summary about current problems is given here --RSC)

"And we still need a large lecture room (300-400) and a small lecture room (75-100) both adjoining a demonstration preparation room that isn't used by anyone but the physics and astronomy staff, and we still need more space for teaching laboratories, and we need more and better teaching fellows, with better selection of them and better morale for the teaching fellows and the staff that teaches the big basic courses and uses the teaching fellows, and we need desk space for the teaching fellows, and we need more seed money for getting new ideas in experimental research started, and every year we seem to give out of ditto paper and stencils in February, with the money all gone..."

Willis: "I have no publishable reflections other than sabbaticals are a necessity."

Zimmerman: "After struggling for three years, I finally received a grant for three years to come. What a relief!!!

Now that I cannot complain about money, I will complain (a little) about ..." (the remainder censored --RSC)

Faculty Record.

William J. Alston

Academic Obligations:

Elementary Physics (PY 105E, 106E)
Principles of Physics I & II (PY 151E, 152E)
Principles of Physics I (PY 151) second semester
Graduate Student Supervision: Richard Hodges, Research Assistant.

My teaching load over the past two years has dealt primarily with introductory courses of a remedial nature, reversed sequence courses and evening courses for beginning Physics majors under Metropolitan College. The quality of the students was consistently low, particularly in PY 151E and PY 152E, opening up the question about the realism of a Physics Major for part-time students. Out of the 31 part-time students beginning Mechanics during the past two years only one could be considered competent.

The PY 151 course was offered twice to accomodate the Department of Engineering. Ostensibly it was to serve the newly entering freshman (9) and to give the engineering students failing it the first time (10) a second chance (on the theory they "Needed time to catch hold"). In the latter group one improved sufficiently to pass with a mark above D. The majority of the entering freshmen were transfers, students, only two of whom displayed competence.

Committees:

In charge of Research Stockroom.
In charge of Nuclear Seminar (second semester); Speakers: two B.U. faculty members, two graduate students, two guest speakers from Yale University.

Research:

Nuclear Spectroscopy continued during the summer of 1965 and the past academic year, using the 4 MeV Van de Graaff accelerator at M.I.T.'s High Voltage Laboratory. The group consisted of two faculty members (Booth and Alston) and five graduate students (H. Wilson, R. Hodges, D. Ostrowsky, J. Brownson and W. Mathews). Research was sponsored by grants received from the Army and the National Science Foundation.

Travel:

Attended Conference, October 11, 1965 at National Bureau of Standards; Preliminary Users Meeting for New Linear Electron Accelerator; discussed possibility of Boston University Nuclear Group's participation. Attended APS annual meeting in N.Y.C. in January 1966; presented two papers with Booth and Hodges.

Community Service:

Director of Summer Choir, Waban, Mass.

Edward C. Booth

Academic Obligations:

Electricity and Magnetism (PY 201)
Modern Physics (PY 301E,302E)
Nuclear Seminar, informal
Research Students: Henry Wilson, John Brownson; also directed research assistants, Wallace Mathews and Daniel Ostrowsky. Directed Hugh Churchill, undergraduate, in Van de Graaff project.

Committees:

Academic Standards Committee: This is a mission-oriented committee which works very efficiently. It takes about two days of dog-work at the end of each term in addition to a number of policy meetings. It would be an act of charity to offer the use of one of our many secretaries to assist me at such times, provided they are not busy of course.

Department of Physics Experimentalist Committee, Graduate Committee, Health Safety Committee.

I have taken on John Brownson as the most promising graduate student to date interested in nuclear physics. I hope to have him complete his Ph.D. dissertation by next August, if my eardrums hold out. We lost two students from the Nuclear Group this year, Mathews and Ostrowsky. I can think of various reasons, but see no immediate cure.

Travel:

Sabbatical leave: travelled to numerous facilities for nuclear research, London, Darmstadt, Munich, Lubljana, Braunschweig, Oslo, Malmø, Hamburg with lectures given at underlined places. In residence at Niels Bohr Institute, Copenhagen for several months; participated in widely advertised preliminary experiments in proton scattering from analogue states in heavy nuclei. Attended photonuclear conference (Gordon), August 8-14; gave colloquis at Northeastern University and the University of Illinois; attended conference at Bureau of Standards, Washington to explore B.U. participation. Attended similar conference at M.I.T. for participation in use of linear accelerator.

Bernard Chasan

Academic Obligations:

Principles of Physics I & II (PY 151,152)
Current Topics in Physics (PY 701,702)
Senior Seminar (PY 398) with J. Stachel

In addition, I conducted (for half a semester) an informal reading course for three sophomores on Bohm's Relativity.

Concerning PY 151, more comments later. But I wish to mention the excellent work done by the teaching fellows in the course, Hamill, Kearly, and Zimnoch.

Chasan continued:

Graduate education: Mr. Ramesh Chandra is currently engaged in thesis research in nuclear angular correlations. He has made solid progress. Mr. John Brownson was associated with the angular correlation effort in pre-thesis research, and is currently doing thesis work with E. C. Booth.

Committees:

Chairman, Departmental Undergraduate Affairs Committee
Member, CLA Preston Lecture Committee, CLA Library Committee, Graduate School Academic Programs Committee.

The Committees are a good thing; or a least a necessary evil. Anyone interested in education per se, or at least in how a university runs, should serve time on committees.

Outside Work:

I spent four Fridays commuting down to New London to teach recitations in Professor Stipe's Polaris University course.

Robert S. Cohen

Academic Obligations:

Physical Science (PY 102) (the first semester was taught by Professor Joseph Agassi of the Department of Philosophy.
Philosophical Foundations of Physics (PY 807). Mainly the students were from the Philosophy Department. The course was attended by Professor Stachel and Tulczyjew. It was devoted to problems of space and time.

In addition, several graduate students, in physics or philosophy, have taken directed study leading to M.A. or Ph.D. thesis topics; and I have three such students at other universities.

B.U. Committees:

Member, Graduate School Board (selected from CLA)
Member, Faculty Board of Metropolitan College (elected from CLA)
Member, Science Building and Development Committee (ex-officio as Chairman, Department of Physics).

Organizational memberships outside of B.U.:

(1) Professional

Chairman, Boston Colloquium for the Philosophy of Science
Member, Executive Committee, New England Section, American Physical Society
Staff member, Harvard Project Physics (summer 1965)
Member, United States National Committee for the International Union of the History and Philosophy of Science (appointed from the Philosophy of Science Association by the U. S. National Academy of Science)

Cohen continued:

Chairman, American Institute of Marxist Studies

(2) Community

Secretary, Boston Area Faculty Group on Public Issues
Member, Executive Committee, Emergency Civil Liberties Committee
Member, Board of Directors, Bill of Rights Foundation

Travel and lectures at other institutions:

St. Joseph's College, West Hartford, Conn. (lecture), Oct. 17, 1965.
John R. Mott Colloquy, Cornell University (participant), Dec. 12-16, 1965.
New York Academy of Science, Colloquium on Time (discussant), Jan. 17-20, 1966.
Community Church (debate with Dr. James Luther Adams), Feb. 16, 1966.
Leibniz tercentenary, Brooklyn Polytechnic Institute, March 12, 1966.
Providence College (lecture), March 28, 1966.
Wesleyan University (lecture), Apr. 11, 1966.
U. S. National Committee for the Christian Peace Conference, Washington, D.C. April 24, 1966.
Marxism and the Western World, University of Notre Dame Colloquium (lecture), April 25-29, 1966.
Bowdoin College, (lecture), May 1, 1966.
Thiel College (for Visiting Scientists Program of American Institute of Physics), May 12-13, 1966.
International Conference on Logic, Physical Reality and History, University of Denver (lecture), May 16-20, 1966.
N.S.F. Institute on History and Philosophy of Science, American University, (lecturer), June 20-24, 1966.
Cambridge School (Weston, Mass.)
Putney School,(Putney, Vermont)

Dean S. Edmonds, Jr.

No publications this year. My electronics book, "Introduction to Electronics for Scientists" is almost finished (one chapter out of twelve left to go). I have recently arranged to do some consulting with Hickok Teaching Systems for the purpose of developing a kit that they will produce for doing my series of experiments, and an instructors' manual will also come out in this connection.

Last summer I taught PY 209ES, the Atomic and Nuclear course, which is attracting a more and more heterogeneous group of students. We have everything from evening students that come in from jobs all over metropolitan Boston to certain members of the 6-year CLA-MED program who have enjoyed (and gotten good grades in) Gordon Stipe's PY 121 and 122 and want some more physics. PY 209 is now an approved elective for members of this group who have demonstrated the necessary abilities in physics and math.

D. S. Edmonds continued:

In the fall my courses were PY 205, Physical Electronics, and PY 111, the first semester of the new one-year general physics course with calculus. PY 205 attracts a registration of around ten students total, of which two thirds are CLA and one third DCE. As you know, we have a very complete line of experiments for this course, and I would dearly love to see it occupy a full year, as I fell the students get rather short-changed for lack of time. Part of the reason for this is that I have to start at a very elementary level. Originally I had to begin right at the beginning with basic DC circuit theory, and even now when I omit this (and the accompanying experiment) I find students who are insufficiently prepared. Presumably the combinatinn of our stepped-up general physics courses and a tightening of the adherence to stated prerequisites will fix this, but I still have to teach AC circuits in some detail since almost no one comes to PY 205 with any real knowledge on this subject. In fact I find a good fraction of them have never met ecomplex numbers before. How anyone can be a science major or work in the various technological industries of the greater Boston area without encountering this material, which I think they should have gotten in high school, is beyond me, but such is apparently the case, and I doubt if our general physics program is going to do much about it. AC circuit theory seems to be one of the things people come to PY 205 to get.

In view of all this, I would like to recommend making PY 205 into a full year's course by dropping it in its present form and instituting a full year of 300-level electronics. I know such a thing existed at one time and was dropped for lack of registration, but I wonder if that would be true now with the rather nice series of lab experiments we have available. I don't think the present registration would fall off any as a result of such a change, and it might even increase when the word got out that by using a full year we could cover more interesting and advanced material and could reduce the concentrated rush imposed by trying to pack a reasonable amount of so large a field as electronics into a single short semester. I realize that in this argument I may be a voice crying in the wilderness, and so let me state a back-up recommendation which I urge very strongly: If PY 205 cannot be replaced by a full year's 300-level course, let it at least follow PY 206 (Electricity and Magnetism) rather than precede it. I find the general absence of acquaintance with Maxwell's equations very hampering, nor does it seem to me logical that people should get their physical electronics before an appreciable exposure to electromagnetic theory.

PY 111 was taught for the first time last fall and also, along with PY 121, represented the first use of Gordon Stipe's new book. The student body (numbering some 50 at the start of PY 111 and falling off to just under 40 by the end of PY 112) consisted of chemists, biologists, mathematicians, and the more scientifically advanced premedical students. Their reaction to both the book and the course was mixed, some criticising the text for indulging in too much history of science, others liking it for that very reason, and some objecting to the course on the grounds that it gave them a lot of boring, grimy details, but failed to present the Big Picture of

D. S. Edmonds, Jr. continued:

Science. I defend both the book and the course, the former because I like the history part but don't want to have to lecture on it, (I can thus make my lectures and the book complement each other rather well) and the latter on the grounds that grimy details, otherwise known as basic physics, is what you're supposed to get in a general physics course. Incidentally, I was interested to note that about 75% of the students were girls and that the best students were to be found among them. While statistically it is perhaps not surprising that the best students should be found in a group consisting of 75% of the class, it is at least interesting to note that it wasn't the other way.. I'm not sure I'm willing to state that the worst students were in the male 25%, for there were both girls and boys who really didn't have the foggiest, but we can perhaps conclude that the world of tommorrow is going to be assailed by a large number of reasonably competent female scientists.

In the spring semester I had PY 112, a continuation of PY 111, and PY 202, the fourth semester in our new general physics sequence for majors. Registration was fortunately small (about a dozen), fortunately because it allowed more of an opportunity for setting up the new laboratory experiments with the equipment purchased for this course under the matching N.S.F. grant for the undergraduate laboratories. We now have a series of very nice experiments in optics and modern physics ready to go (equipment assembled and working and writeups prepared) and are thus in pretty good shape to receive the much larger registration expected next year. A great improvement in the course which will then occur is that the instructions will be available to the students further in advance of the day they actually go into the laboratory to do a given experiment. Perhaps we can also guide them a little more specifically with regard to what is wanted in the way of a laboratory report. I'm sure some of my PY 202 students felt a little lost in this regard. The same could be said of PY 111 and PY 112.

6-year CLA-MED program: I served as a counsellor in this program again for the academic year 1965-66 and again had a group of five of the incoming freshmen as counsellees. We met for dinner once every two weeks, mostly at the faculty club, sometimes at my house, and sometimes outside, especially when a theatre program was the order of the evening. I don't know how much good this counselling program does, but it certainly can't do any harm, possibly contributes something to the students' overall development, and at least lets them know where and how to find a faculty member who will take it upon himself to do something about any special problems his counsellees may have.

Seminars: Last fall, at the urging of Professor Asher Zlotnik of SFAA, I gave a series of four lectures on the physics of music in a course he teaches. These included anumber of demonstrations, electronic and otherwise, of wave phenomena and were apparently well received despite the insertion of some rather thoroughly watered-down mathematics.

D. S. Edmonds, Jr. continued:

Research students: Rosalyn Greenberger has finally decided to do a master's thesis with me. The subject will be theoretical calculations and experimental testing thereof for a small mass spectrometer using synchronous RF acceleration rather than magnetic deflection to obtain mass separation. A computer program is being prepared to compute the ion acceleration obtained with various masses, frequencies, and entering phases, and we hope to verify the results on an actual instrument. The spectrometer structure itself (a small tube) is available commercially from Raytheon-Machlett, and I hope to be able to talk them into presenting us with an example.

Peter Wintersteiner continues to work with me on the microtron. Last semester he ran a number of computer programs directed towards calculating the critical electron orbits following injection, but since we used a non-relativistic approximation the results are not very useful. They did, however, give us some insight into the problem and some practice with machine computation. We are now preparing to do the full relativistic calculation, which is much more complicated because the differential equation must itself be solved by the computer, whereas in the non-relativistic case the differential equation was solvable in closed form, the computer being merely required to plug numbers into the messy algebraic and trigonometric result. We should soon be able to come up with a sufficiently advanced design to allow the writing of another proposal.

Committees: Premedical advisory committee; my only comment is to salute Professor Mason, the retiring chairman and welcome Professor Estes, the incoming chairman. Chairman, Machine Shop Committee.

Vice president of Nuclide Corporation (State College, Pa., and Medford, Mass.) and a member of the APS, AAPT, IEEE, and AAUP. In addition, I'm a (paid up) member of the Boston Chapter of the Society of the Sigma Xi. Finally I'm a member of an organization called the International Academy of Law and Science which purports to worry about the relationships between the legal and scientific professions, especially the influence each has upon the other.

Community Service: H. Chandler Stevens, representative of Middlesex County in the state legislature, has set up various local citizens' advisory committees. I am a member of his citizens' advisory committee on education. Also judge at the Mass. State Science Fair at M.I.T., April 30, 1966.

Last summer I went to London for a meeting of the International Academy of Law and Science mentioned above and thereafter visited E. C. Booth in Copenhagen. He showed me the Institut für Teoretisk Fysik and the nuclear lab at Risø, and together we went to see the microtron at the University of Lund, Sweden.

On March 19 before the meeting of the New England Section of the AAPT at Storrs, Connecticut, I delivered a paper entitled "An Inexpensive Vacuum Tube Electrometer".

FRANZEN

Academic Obligations

1. Teaching

A. First reader of J. K. Kuppenheimer's M.A. Thesis, completed Aug. 1965. Thesis title: "The Optical Constants of Silicon".

B. First reader of A. S. M. Mahbub'ul Alam's Ph.D. Thesis, completed May 1966. Thesis title: "Moessbauer Studies of Spin Relaxation of Fe^{3+} in $Ti\,O_2$".

C. Guiding Ph.D. Thesis project of Rojandra Gupta dealing with the production of polarized electron beams by resonance scattering from rare gas atoms. This project is well under way.

D. During the year, I have been guiding directed study projects carried out by two Ph.D. candidates, Phillips Heeper and Bruce Newell.

E. I organized and directed an impromptu seminar on particle polarization by resonance scattering in the full semester.

F. I was responsible for a regulur graduate seminar (PY 814: Seminar on Optical and Magnetic Resonance Phenomena) during the second semester.

G. I was in charge of the Advanced Laboratory (PY 313-314) during the entire year. The laboratory has been improved further by new instructions for a number of experiements, and by completion of two new experiments, an x-ray diffraction experiment, and an experiment, using an infrared spectrometer, on the spectrum of black-body radiation.

H. I was in charge of two sections of PY 151 during the first semester, and one section in the second semester.

2. Committees

A. Member, Honors Committee, CIA.
B. Member, Committee on Faculty and Committee Membership, Graduate School.
C. Member, Ad Hoc Committee on the Lines of Academic Authority in the Graduate School.
D. Chairman, Committee on Graduate Studies, Dept. of Physics. (See separate comments).
E. Member, Graduate Admissions Committee, Dept. of Physics.

3. Outside Activities

A. Member, Regional Selection Committee, Woodrow Wilson Fellowships Foundation.

B. Consultant to Arthur D. Little, Inc.

C. Member, Board of Editors, Zeitschrift für Angewandte Mathematik und Physik (Swiss Journal of Applied Mathematics and Physics).

D. Member, Board of Reviewers, Mathematical Reviews.

E. Referee for the Physical Review.

F. Referee for the National Science Foundation and the Army Research Office.

Franzen, continued

4. Honors

A. Elected Vice President of B.U. Chapter of Sigma Xi for 1966-67.

B. Grantee (Principal Investigator) of Research Grant awarded by the National Science Foundation.

5. Travel and Lectures at Other Institutions.

A. Delivered colloquium talk entitled "Spin Polarization of Slow Electrons by Elastic Resonance Scattering" at the Physics Department of the University of New Hampshire, Dec. 2, 1965.

B. Delivered colloquium talk entitled "Polarized Electrons by Resonance Scattering" at the Physics Department of Syracuse University, March 10, 1966.

C. Delivered Colloquium talk entitled "Polarized Electrons" at the Electron Physics Division of the National Bureau of Standards in Washington on March 16, 1966.

D. Delivered paper entitled "Polarization of Slow Electrons by Resonance Scattering from Rare Gas Atoms" at the Annual Meeting of the American Physical Society, Jan. 1966.

HAWKINS

Academic Obligations

Research Students, AS 101-102, AS 201-202

Stephen Saslow
William Zack
David Whalen
Alan Katz
Maharana Batra
John Hegarty

Committees

B.U. Grad. Journal, Editorial Board.
Interim Advisory Committee for Ph.D. Programs in Geological Sciences
Committee on Admissions
NASA Traineeship Committee (Chairman)
Boston University Press, Editorial Board
Chairman, Symposium Committee Smithsonian Astrophysical Observatory for "Meteor Orbits and Interplanetary Dust".

Consultantships, etc.

Prof. Hawkins has continued to administrate the NASA Meteor Program at the Smithsonian Astrophysical Observatory. It has been organized especially so as to take no more than 1/3 of his time. In 1965 he was appointed coordinator of the project.

Honors Received

Arthur S. Fleming Award, Junior Chamber of Commerce, Washington, D.C.

Special Award, Smithsonian Institution.

Hawkins, continued

Community Service

Astronomy lectures in the Wellesley Grade Schools System.

Radio Report on the t wo fireballs of April 1966 on WBZ, WEEI, and other local stations.

Travel, lectures

Towson State College, "Stonehenge", Baltimore, Maryland, Sept. 1965.

Smithsonian Institution, "The Mystery of Stonehenge", Washington, D.C., Nov., 1965.

Royal Canadian Institute, Toronto, "Recent studies concerning the archaeology of Britain in the 2ns millenium B.C." , Nov., 1965.

Faculty Forum, "Astro-Archaeology at Stonehenge", Feb., 1966.

WBUR Interview, "Astro-Archaeology", March, 1966.

Epsilon Alumni, Panel: "Exploration of the Moon", June, 1966.

Armed Forces Management Association, "Managed Research in England", June, 1966.

Conferences attended

Symposium on Meteor Orbits and Interplanetary Dust, Smithsonian Institution, Aug. 9 to 12, 1965 (Symposium Director G. S. Hawkins).

Second Symposium on Radio Astronomical and Satellite Studies of the Atmosphere, Oct. 19-22, 1965.

Science Careers, Museum of Science, Co-host , Nov., 1965.

Centennial Academic Symposia, Dean Jr. College, "A Decade of Decision," "(panelist), March, 1966.

Rayleigh Day, March, 1966, Hanscom Field, Bedford, Mass.

HELLMAN

1. Academic Obligations

Teaching: Mathematical Physics (PY 303-304), Electromagnetic Theory (PY 310), Principals of Physics IV (PY 202).

2. Research Students

Bernstein

3. Committees

Department Committee on the Written Comprehensive Examinations.

HOY

1. Academic Obligations

Graduate Course in Solid State Physics (PY 715-716)
Assisted Gordon Stipe in Physics course for six-year CLA-MED program (PY 121H-122H)
Three graduate students, S. Chandra, R. Bell, and K. P. Singh, took Research in Physics, (PY 923-924), under my direction.
PY 923-924 developed into a seminar dealing with Moessbauer Physics which met formally on Fridays at 3:30 p.m.

Hoy, continued

Students

The students with whom I've come in contact fall into two categories: graduate students, and students in the six year CLA-MED program. The latter group of students are very quick and intelligent. It is regrettable we don't have sufficient time to cover physics in some depth with this group.

The above-mentioned graduate students, who are mostly my own students, have impressed me with their hunger to do physics. I have found them to be competent and interested in attempting to do physics research. We will see a significant improvement in the efficiency with which our graduate students do research, as well as an intensification of their interest, as our graduate research facilities are upgraded.

2. Research

The effort to establish research in the area of "Moessbauer Studies of Solid State Phenomena" has made good progress. This is the result of several factors, among them, the funds contributed to this project by the Graduate School, and helpful cooperation of colleagues.

In april a grant from the U.S. Army Research Office - Durham was awarded for my proposal "Delayed Coincidence-Moessbauer Studies of Solid State Phenomena". This award put our research on a firm foundation for the next two years.

The graduate students working in the Moessbauer laboratory are doing very well. Mr. M. Alam has finished his Ph.D. thesis entitled "Moessbauer Studies of Spin Relaxation of Fe^{3+} in Ti O_2". Mr. S. Chandra is styding ferrous salts that exhibit both hyperfine and quadropole dcoupling of the iron nucleus to its environment and has recently started styding the Jahn-Teller effect. Mr. R. Bell is applying Moessbauer techniques to the study of ferroelectricity. Each of the above students has obtained experimental results and gave a paper at the Washington meeting of the American Physical Society in April. Mr. K. P. Singh passed his Ph.D. oral qualifying examination in March and has started doing research into "POssible Moessbauer Spectral Changes due to Optical Excitation". Mr. D. Hamill recently passed the written comprehensive examination. He has begun building equipment we need and preparing for the oral examination.

3. Community Service

During the academic year I gave a lecture on sound to fifth grade students in the Heath Elementary school in Brookline. G. Stipe, D. Edmonds, and J. DeSousa were very helpful in rounding up equipment that could be borrowed from our department and also in giving advice about possible topics.

4. Honors

I was awarded a stipend from the National Science Foundation through the University of Florida to attend the Winter Institute in Quantum Chemistry, Solid State Physics, and Quantum Biology in December.

Edward O'Neill

Academic Obligations:

Vibrations and Waves (PY 204)
Thermal Physics (PY 212)
Classical Mechanics (PY 305)
Electromagnetic Theory (PY 309)

Research students: John O'Brien, William Kennedy, Ernest Lacour, Max Michelson, and John Ward.

Committees:

Graduate Research Policy Committee
Department Graduate Studies Committee

Michael D. Papagiannis: (Astronomy)

Academic obligations: Several new courses were introduced for students interested in the fields of Space Physics and Radio Astronomy: AS731, Physics of the Ionosphere, AS702, Topics in Astrophysics and Radio Astronomy, AS801-802, Space Science Seminar. The latter course was given in both semesters with a very encouraging attendance. The enrollment of the first semester (14) was approximately twice of the previous year. The enrollment of the second semester (20) was even better. Research papers submitted by the students in partial fulfillment of the course requirements were on the average of very good quality. Students and faculty from neighboring universities attended several of the lectures (5 to 15 visitors were usually present) and two graduate students, one of Boston College (J. M. Deveney) and one from Northeastern (N. W. Hall) took the course for credit which was then transferred to their own schools.

Committees: Committee on Graduate Studies, Committee on Graduate Degrees in Physics and Astronomy, Library Committee, Dept. of Physics.

Research: Experimental results from a high altitude rocket probe with a single-axis magnetometer were presented in the April 1966 annual meeting of the American Geophysical Union in Washington, D. C. Developed a new theory to explain the return of Z-mode echoes from the F-layer of the ionosphere. Prof. G. R. A. Ellis of the University of Tasmania, Australia, who had developed the previously accepted mechanism for the Z-mode echoes wrote to Prof. Papagiannis recently saying: "I read with great interest your paper on Z-mode echoes in Jour. Atm. Terr. Phys. 27, 1014, 1965.....horizontal gradients of the type you suggest certainly occur.....it is possible therefore that both mechanisms operate from time to time....."

Continued theoretical and experimental work in the field of space radio astronomy as a co-investigator in the Space Radio Project of the Harvard College Observatory.

Supervised the Ph.D. thesis work of Alan Katz in the area of extra low frequencies. Measurements are made in the 2-16 Hz frequency range and efforts are made to develop a theoretical model capable of explaining the radio signal patterns observed. Propagation of radio waves along field aligned electron density irregularities in the earth's magnetosphere is one of the models currently under investigation.

Supervised the work on radio scintillations carried out by David Miller. Three month radio data from the Early Bird satellite (a synchronous satellite fixed over the Atlantic) have been obtained in cooperation with the Air Force Cambridge Research Laboratories and have been analyzed for ionospheric radio scintillations.

Many of the above projects are supported by a research contract with the AFCRL. The 1965-66 contract surpassed the 1964-65 by more than 100% and was further increased in April to reach a total budget which is nearly 3 times higher than last year's. The expanded research contract provided the financial means to invite Prof. Sydney Chapman for a one-month visit to our department. Prof. Chapman is one of the most eminent scientists in the field of geophysics and his visit will be remembered for a long time by both students and faculty.

Papagiannis, cont'd

Library: In the summer of 1965 Prof. Papagiannis initiated an effort to build a research library in the field of Astronomy and Space Science. After less than a year the library now possesses 180 book catalogued in a new filing system and arranged in 8 different groups according to the book's subject (e.g., Astrophysics, Radio Astronomy, Celestial Mechanics, etc.) We have been acquiring books during the past year at the rate of approximately a new book every other day and this has made our library a valuable aid to our research. Our new collection has also been of great help to the students of the Space Science Seminar and was of particular value in the preparation of their research papers for the course.

Honors and External Appointments: Lecturer in the Department of Astronomy of Harvard University since July 1965; Research Fellow of Harvard College Observatory since July 1965; Member of U.R.S.I. (International Union of Radio Scientists) since April 1966.

Calendar of Lectures and Conferences:

June, 1965: "Observations of Extraterrestrial Radio Emission from Space Vehicles", Colloquium, Dept. of Physics, Boston University.

July 12-13, 1965: "The Formation and Structure of the Ionosphere"; "Radio Wave Propagation in the Ionosphere"; "Antennas and Radio Telescopes"; "Cosmic Radio Radiation at Long Wavelengths", a series of 4 lectures in the summer school on Planetary and Space Sciences of the University of Miami, Coral Gables, Florida.

Sept. 20, 1965: "The Objectives of Scientific Observations in Space", Space Science Seminar, Boston University.

Oct. 21, 1965: "Atmospheric and Man-Made Noise Observed at 4 and 7 mc. from a Series of Low Altitude Satellites", paper presented (with G. R. Huguenin) in the Second Symposium on Radio Astronomical and Satellite Studies of the Atmosphere, Boston, Mass.

March 29-31, 1965: Annual meeting of the American Astronomical Society, Hampton, Virginia.

April 22, 1965: "Measuring the Earth's Total Magnetic Field with a Single Axis Magnetometer on a Spinning Spacecraft", paper presented in the annual meeting of the Americal Geophysical Union, Washington, D. C.

PAUL ROMAN

Academic Obligations: Courses taught during the first semester were PY703 (Advanced Mathematical Physics), PY711 (Advanced Quantum Theory), PY815 (Seminar in Theoretical Physics), PY909 (Directed Research), PY933 (Directed Study). During the second semester, PY712 (Advanced Quantum Theory), PY726 (Theory of Elementary Particles), PY816 (Seminar in Theoretical Physics), PY910 (Directed Research), PY934 (Directed Study) were given. During the summer term of 1965, one course was offered, PY 724 (Dispersion Relations) in addition to the Directed Research. The names of research students working with Prof. Roman are J. J. Aghassi (received Ph.D. degree in June 1966), B. M. Aghassi, C. J. Koh, S. K. Yun, F. Feldman, and U. Oseguera.

ROMAN (cont'd)

Committees: Language Examination Committee, Graduate Studies Committee, Ad hoc Committee on the development of the Physics Department (chaired it).

Remarks on students: J. J. Aghassi was the best and most productive student I ever had in my life. C. J. Koh underwent a remarkable development, both in scientific competence and in maturity in general. He is the most promising of all. S. K. Yun is solid, mature, and a successful hard worker. Students in classes were of rather mediocre quality, with a few exceptions. The best one was W. Sarill, in spite of the fact that he is only an undergraduate! It was a great frustration that the number of students in 711, 712, 726 and 724 was extremely low.

Outside Activities: Reviewer of books and articles for the "Mathematical Reviews"; consultant for the book publishing firm, Addison-Wesley.

Honors: Three of Roman's papers have been reprinted by the Physical Society of Japan in their series "Selected Papers in Physics". They are "Correlation Theory of Stationary Electromagnetic Fields, Part I" (with E. Wolf), "Correlation Theory of Stationary Electromagnetic Fields, Part II (with E. Wolf), and "On the Matrix Formulation of the Theory of Partial Polarization in Terms of Observables (with G. Parrent).

Roman was invited to serve as an outside observer and participant on the panel of "Potential Users of the Stanford Linear Accelerator".

Travel and Lectures:

1. Invited paper given at the "Gravity Research Foundation 1965 Symposium", New Boston, New Hampshire, August 1965.
2. Attended, by invitation, the "MIT-USAF Second Conference on the Mathematical Theory of Elementary Particles", Dedham, Mass., September 1965.
3. Attended, by invitation, the "SLAC Users First Conference", Stanford, California, October 1965.
4. Seminar at Duke University, Durham, North Carolina, November 1965.
5. Colloquium at the University of New Hampshire, Durham, New Hampshire, November 1965.
6. Attended, by invitation, the "Fourth Eastern U. S. Theoretical Physics Conference" at N. Y. State University, Stony Brook, New York, November 1965.
7. Attended, by invitation, the "Fourth Annual Conference of the Belfer Graduate School of Science", New York, November 1965.
8. Colloquium and seminar at Syracuse University, Syracuse, New York, December 1965.
9. Colloquium at the University of Wisconsin, Milwaukee, Wisconsin, February 1966.
10. Presented two papers at the "Spring Meeting of the American Physical Society, Washington, D. C., April 1966.
11. Presented invited paper at the "Conference on Noncompact Groups in Particle Physics" at the University of Wisconsin, Milwaukee, May 1966.
12. Colloquium and seminar at Oak Ridge National Laboratory, Oak Ridge, Tennessee, May 1966.
13. Short lecture course on Quantum Field Theory in the Advanced Study Series of Bolt, Beranek and Newman at Cambridge, Los Angeles, New York and Washington.
14. Attended, by invitation, the 10-day "Conference on Elementary Particles" at the University of Colorado, Boulder, Colorado, June 1966.

MENDEL SACHS

Research Students: S. G. Hamilton has been progressing with his thesis work under my supervision. I anticipate that within the next few months he could reach a point in his research problem (on charged particle scattering) where it could be written up for presentation.

Committees: Member of the Graduate Admissions Committee.

Travel and Lectures:
1. Invited to attend the Aspen Institute for Humanistic Studies, Physics Division, June 15 to July 31, 1965.
2. Lecture given at the University of California, Berkeley, August 4, 1965, entitled "Recent Developments in a Unified Field Theory of Elementary Interactions."
3. Lecture given at the State University of New York, Buffalo, April 1966, entitled "Investigations of a Unified Approach to Elementary Interactions".
4. Presented paper at the Washington American Physical Society Meeting in April, 1966, entitled "A Derivation of the Positive-Definiteness of Inertial Mass from the Generally Covariant Dirac Theory". (Abstract of this paper was published in the Bulletin of the Durham meeting, accidentally.)
5. Attending the International Centre for Theoretical Physics, Trieste, Italy, June 20 to August 15, 1966.

JOHN J. STACHEL

Conferences Attended: The Stevens Institute Conferences on General Relativity (six meetings during the year).

Travel and Lectures: Comments on paper by Prof. Peter Havas on "Relativity and Causality", at the Boston Colloquium for the Philosophy of Science; to be published in the next volume of Boston Studies in the Philosophy of Science. Spent June 1965 at Temple University working with Prof. Peter Havas and will spend June 1966 similarly working on research in general relativity. Invited to spend July and August 1966 as guest of the Centro de Investigacion y de Estudios avanzados del Instituto politechico nacional, Mexico City, where Prof. J. Plebanksi heads a group working in relativity.

Teaching Activities: Taught PY311 (Thermodynamics) during the summer term, 1965. In addition to the regular teaching assignment of PY307,308 (Quantum Mechanics), PY311 (Thermodynamics) and PY206 (Electricity and Magnetism), initiated a regular seminar in general relativity and related topics, which was transformed into a regular course, PY816B, during the second semester; participated with Prof. Cohen in a Seminar on the Philosophy of Space and Time, PY807; and with Prof. Chasan started an undergraduate Senior Seminar, PY398, during the second semester. Also supervised a student starting thesis research in general relativity (Laurence Rothman, PY931,932) and an undergraduate student doing honors work in general relativity (William Sarill).

Committees: Continued to serve on the Undergraduate Committee and the Comprehensive Examination Committee; second reader for J. J. Aghassi's Ph.D. thesis; served on Oral Examination Committee for K. P. Singh.

J. GORDON STIPE, JR.

Teaching Activities: Taught PY105,106 (Elementary Physics) and PY121,122H the Physics course for the 6-year medical students

Committees: Graduate School representative to the Senate Council; Secretary-Treasurer of the New England Section of the American Association of Physics Teachers. This (latter) work involves a close association with many college and secondary school physics teachers throughout the six-state area.

Additional Activities: A preliminary edition of a textbook, The Development of Physical Theories, has been published in a limited quantity and was used in two courses, PY111,112 and PY121H,122H. Minor revisions, based on the experience of using this text, are being incorporated in a new typescript for the publisher. McGraw-Hill Book Company has this book scheduled for publication in the spring of 1967.

A series of thirty taped television physics lectures was presented on Tuesday evenings, October 5, 1965 through May 24, 1966, on Channel 2, for University Extension. (So far as I know, none of my colleagues in the Physics Department or anyone else at Boston University saw these, although they were seen and commented on by colleagues in other institutions.)

CHARLES R. WILLIS

Lectures: "Models of Interacting Radiation and Matter" in Puerto Rico, 1965; "Quantum Theory of Lasers" at the University of Utrecht, The Netherlands.

(Note: Prof. Willis is on leave of absence for the academic year 1965-66.)

GEORGE O. ZIMMERMAN

Teaching Activities: Taught PY105,106E (Elementary Physics); this course is probably given too late in the evening. People can't build up too much enthusiasm between 6:30 and 8:00 p.m. after a day's work. Some bright kids were enrolled and on the whole the girls did better than the men. Almost had one convert to physics. Also taught PY719 (Low Temperature Physics) and was surprised at the large number who signed up for the course (10). I have had several inquiries as to when the course will be given again; I enjoyed teaching it and learned quite a bit in the process. The third course I taught was PY312, Statistical Physics, and as usual there was not enough time to go into the subject as thoroughly as I would have liked. I learned a lot and hope that the students did also. To my surprise they did not display complete ignorance of the subject on the final examination.

ZIMMERMAN (cont'd)

Graduate Students and Research: Roy Yee is quite eager, quick and alert. He is currently in the throes of getting data for his thesis and I suspect that he will be able to have enough data by the end of the summer (1966). Philip Zeldes is progressing at his usually slow pace, but progressing. Wijit Senghaphan (the boy wonder) should be ready to start taking data for his thesis. I am quite excited about his experiment. David Abeshouse is a good experimentalist. He is just starting to work on the adiabatic demagnetization setup at the National Magnet Laboratory.

My own research on the critical point of He^3 experiment at the Magnet Lab is becoming fancier and more accurate each day. On the whole, research is progressing quite satisfactorily except for the fact that one cannot be everywhere at the same time and one has to leave some of the responsibility to the common sense of the students which, as it sometimes turns out with the brightest of them, might be a mistake.

Other Activities: Was nominated for Director at Large of the Boston University Chapter of Phi Beta Kappa. Now both I and A. Stevenson can say that we did not seek the office and did not get it either.

William J. Alston (with R. P. Hodges) "High-Resolution Resonance Fluorescence Measurements with a Germanium Detector", Bull. Am. Phys. Soc. II. 11, No. 1 (1966), 70.

(with E. C. Booth) "Photoexcited States of In^{113}", Bull. Am. Phys. Soc. II, 11, No. 1 (1966), 119.

(with R. H. Hilberg, and J. E. Draper) "Construction and Operation of Thin Parallel Plate Proportional Counters", Nuclear Instr. and Meth. (to be published).

Edward C. Booth (with W. J. Alston) "Photoexcited States of In^{113}", Bull. Am. Phys. Soc. II, 11, No. 1 (1966), 119.

Robert S. Cohen, "Marxism and Democracy" in Marxism and Democracy, ed. Herbert Aptheker (New York:Humanities Press) 1965.

"Introduction" to What is Relativity? by Landau and Rumer (New York: Fawcett Publications) 1966.

"Otto Neurath" in Encyclopedia of Philosophy, ed. Paul Edwards (New York: Collier-MacMillan) 1966.

(co-editor with M. W. Wartofsky) Boston Studies in the Philosophy of Science, Volume II (New York:Humanities Press) 1965.

(co-editor with D. J. Struik) "Consideration About the Certainty of Knowledge" by Arnost Kolman (New York: A.I.M.S. Occasional Papers) 1965.

Wolfgang Franzen,(with R. Gupta) "Spin Polarization of Slow Electrons by Elastic Resonance Scattering from Neon", Phys. Rev. Letters,15, 819 (1965).

(with R. Gupta) "Polarization of Slow Electrons by Resonance Scattering from Rare Gas Atoms", Bull. Am. Phys. Soc.,II, 11, No. 1 (1966), 70.

Book reviews: J. W. Matthews and R. L. Walker, "Mathematical Methods of Physics", Math. Rev 31, 1635 (1965).

M. Kline and I. W. Kay, "Electromagnetic Theory and Geometrical Optics", Math. Rev. 31, 4330 (1966).

R. R. Birss, "Symmetry and Magnetism", Math. Rev. 31, 4543 (1966).

Gilbert R. Hoy (with S. DeBenedetti and F. de S. Barros) "Chemical Structural Effects on Nuclear Radiations", Annual Review of Nuclear Science, vol. 16, edited by E. Segre (1966).

Gilbert R. Hoy (with F. de S. Barros) "Mössbauer Studies of Inequivalent Ferrous Ion Sites in Ferrous Formate", Phys. Rev. 139, A929 (1965).

(with M. Alam and S. Chandra) "Hyperfine-Field Fluctuations in Fe^{+++}-Doped TiO_2 Using the Mössbauer Effect", Bull. Am. Phys. Soc. II, 11, No. 3 (1966) 3[illegible]

(with S. Chandra) "Mössbauer Measurements of the Quadrupole and Hyperfine Interactions in $FeCl_2 \cdot 2H_2O$", Bull. Am. Phys. Soc. II, 11, No. 3 (1966), 37[illegible]

Introduction by G. R. Hoy, R. O. Bell "Mössbauer Absorption in Ferroelectric Pb_2NbFeO_6", Bull. Am. Phys. Soc. II, 11, No. 3 (1966), 387.

Gerald S. Hawkins (with John B. White) Stonehenge Decoded (New York:Doubleday)

"The Secret of Stonehenge", Smithsonian Report for 1964, pp. 307-313.

"Sun, Moon, Men and Stones", American Scientist 53, No. 4, Dec. 1965.

(with other authors) Earth Science and Space Science (Boston:D. C. Heath) 1966.

The Life of a Star (New York:Rinehart and Winston) 1966.

"Stonehenge Physics", Physics Today 19, No. 4 (1966).

Catalogue of Lunar Craters Cross Section I, Craters with Peaks, (with William Zack and Stephen Saslow) Research Report No. 16, September 1965, NASA G246-62.

William S. Hellman (with P. Roman) "Goldstone Behavior in Some Model Theories" Phys. Rev. 134, 1247 (1966).

Michael Papagiannis, "The Theory of Z-mode Echoes", Jour. Atm. Terr. Phys. 27, 1019 (1965).

"Measuring the Earth's Total Magnetic Field with a Single Axis Magnetometer on a Spinning Spacecraft" submitted to the Journal of Geophys. Res., May, 1966.

Paul Roman, Advanced Quantum Theory (Reading, Mass.:Addison-Wesley) 1965.

(with J. J. Aghassi) "D/F Ratios and Baryon Magnetic Moments in the SV_{12} Scheme", Nuovo Cimento 38, 1092 (1965).

(with E. Corinaldesi) "Operator Gauge Transformations", Amer. Jour. of Phys. 33, 939 (1965).

(with C. J. Koh) "A Sharpening of O'Raifeartaigh's Theorem", Nuovo Cimento 39, 1015 (1965).

(with W. S. Hellman) "Goldstone Behavior in Some Model Theories", Phys. Rev. 134, 1247 (1966).

Paul Roman (with J. J. Aghassi) "On the Energy Spectrum in de Sitter World Theories", Nuovo Cimento 42A, 193 (1966).

"Problems of Physical Interpretation Connection with Noncompact Groups in Particle Physics" in "Proc. of the Conference on Noncompact Groups in Particle Physics", University of Milwaukee, May 1966.

(with S. K. Yun) "A New Theory of Nonleptonic Decays", Bull. Amer. Phys. Soc. 11, 397 (1966).

(with C. J. Koh) "Physical Statevector-space Representations of Noncompact Groups", Nuovo Cimento, June 1966.

(with J. J. Aghassi) "Classical Field Theory and Gravitation in a de Sitter World", Jour. Math. Phys., in press.

(with S. K. Yun) "A Novel Approach to Nonleptonic Weak Hyperon Decays", Nuovo Cimento, in press.

(with S. K. Yun) "Two-pion Decays of Kaons in a Novel Approach to nonleptonic Weak Processes", Nuovo Cimento, in press.

(with J. Rosen) "Some Observations on Enveloping Algebras of Noncompact Groups", Jour. Math. Phys., in press.

Joseph Rosen, "Embedding of the Schwarzschild and Reissner-Weyl Solutions", Nuovo Cimento 38, 631 (1965).

"A Survey on the Origin of Internal Symmetries of Particles", submitted for publication.

Mendel Sachs "The Mass of a Neutrino from Spinor Connection in a Riemannian Space", Nuovo Cimento 37, 888 (1965).

"Black Body Radiation from a Self-Consistent Field Theory of Quantum Electrodynamics", Nuovo Cimento 37, 977 (1965).

"Comments on a Paper by R. A. Berg on General Spin Equations", Nuovo Cimento, in press.

"A Derivation of Positive-Definiteness of Inertial Mass from the Generally Covariant Dirac Theory", Bull. Am. Phys. Soc. II, 11, No. 2 (1966).

Armand Siegel (with H. Akama) "Parameter of Discontinuity and Differential-Operator Expansion of the Linear Boltzmann or Master Operator, Physics of Fluids 8, 1218 (1965).

(with H. Akama) "Small-parameter Expsnsions of Linear Boltzmann Collision Operators", Physica 31, 1493 (1965).

"On Chronically Unsolved Basic Problems in Physical Theories" in Boston Studies in the Philosophy of Science eds. R. S. Cohen and M. W. Wartofsky (New York: Humanities Press) 1965.

Armand Siegel (with W. C. Meecham and T. Imamura) "Wiener-Hermite Expansion in Model Turbulence in the Late Decay State", Jour. Math. Phys. 6, 707 (1965).

(with W. C. Meecham and T. Imamura) "Symbolic Calculus of the Wiener Process and Wiener-Hermite Functionals", Jour. Math. Phys. 6, 695 (1964).

John Stachel, "Cylindrical Gravitational Waves", Jour. Math. Phys. 7 (June, 1966), in press.

Charles R. Willis (with R. H. Picard) "Coherence in a Model of Interacting Radiation and Matter", Phys. Rev. 139, A10 (1965).

"A Model of Interacting Radiation and Matter. II", J. Math. Phys. 6, 1984 (1965).

"A Model of Interacting Radiation and Matter. III", J. Math. Phys. 7, 404 (1966).

"Models of Interacting Radiation and Matter for Gas Lasers" in Physics of Quantum Electronics, eds. P. L. Kelley, B. Lax, and P. E. Tannewald (New York:McGraw-Hill) 1965.

"Quantum Theory of a Laser Model", Phys. Rev., in press.

"Quantum Theory of a Gas Laser", Physics Letters, in press.

George O. Zimmerman (with C. E. Chase) "Dielectric Constant of He^3 in the Critical Region", Phys. Rev. Letters 15, 483 (1965).

(with R. Yee) "Low Temperature Magnetic Susceptibility and Specific Heat of Constantan", J. Applied Phys., in press.

Appendix (Prepared by Professor D. S. Edmonds, Jr.)

Report on Research Machine Shop

In the fiscal year 1965-66 the department's research machine shop under the care of Mr. R. Allen O'Neill did a total of 2000 hours of work divided among the Graduate School departments requiring such services as follows:

Biology	145 hours
Chemistry	370
Geology	30
Psychology	190
Physics	1270
Total	2005 hours

This is almost entirely time actually spent by Mr. O'Neill in machining or laying out jobs, although some consulting time is included in an effort to make billings and hence hopefully collections come up to GRS expectations. A resume of these billings and collections is given in the following table: Note that the rate at which Mr. O'Neill's time charged is $4.85 per hour.

Billing	Hours	Materials Charge	Hours Charge	Total Charge	Received	Outstanding
Carried over from 1964-65	315	--	1527.76	1527.76	979.71	548.05
August	111	--	537.14	537.14	537.14	--
September	623	--	3021.49	3021.49	1518.01	1503.48
March	467	146.75	2266.11	2412.86	2019.15	393.71
May	489	82.50	2371.61	2454.11	889.45	1564.66
Totals 1965-66	2005	229.25	9724.11	9953.36	5943.46	4009.90

The department research machine shop has made great strides in recent years due notably to the acquisition of Mr. O'Neill as the man in charge, and also to the increase in capital equipment made possible by two GRS grants. No longer do experimenters feel that only by going outside can they get a reasonable job done on their various projects requiring machine work, although they still find that getting things done in the shop here takes an inordinate amount of time (due to Mr. O'Neill's being along) and costs an excessive amount (due to the very unfortunate financial arrangements). A comparison with the set-up at Brandeis might prove helpful in pinpointing some of our areas of weakness.

Personnel: Brandeis University employs in their research machine shop a superintendent who does no actual machine work himself but merely assists in the design and scheduling of projects and administers the shop, three instrument makers,

and one helper. The total payroll is $40,000 per year. Such a set-up certainly puts to shame our operation in which Mr. O'Neill has to do everything and often finds himself so taken up with paper work, student instruction, and helping faculty with projects requiring machine work that little time is left for actually producing the equipment. This is what lies behind complaints that an unreasonable amount of time is required to get anything through the shop. In this connection we should refer to Mr. O'Neill's memo to you of July 27, 1965, projecting his needs in the shop over a five-year period starting with 1966 and assuming a 50% increase in work load every year. While this assumption may be optimistic in that it calls for expansion at this rather high rate to be maintained unabated for five years, the continuing trend towards enlarged departments and with the enlargement a greater number of grants and demands for laboratory course equipment indicates that such an expansion may be fully justified provided we do not drive people to look for outside help by making unworkable machine shop arrangements within the University. Mr. O'Neill's memo calls for the addition of a helper at $4000 per annum in 1966, and this is as yet not forthcoming. I observe that the need for someone at this level who can run a machine that Mr. O'Neill has set up (watch a cut, for example, so as to stop the feed when the pass has been completed) while Mr. O'Neill talks to someone or sets up another job, clean up machines and benches, and handle a lot of the paper work is extremely pressing right now. I know Mr. O'Neill feels quite frustrated because of the lack of any help at all and the consequent impairment of his efficiency.

Capital equipment: The Brandeis shop has about $50,000 invested in basic machinery including a large miller, two smaller millers, a large lathe, three medium-sized lathes, and miscellaneous other equipment such as power saws and drills. By comparison, our main machine shop has an old miller, an new Bridgeport miller, a new medium-sized lathe, two old lathes, one of which is almost unusable, a good metal-cutting saw, an old bandsaw, and a bench-mounted drill press. The two newer machines (lathe and Bridgeport miller) were bought with a GRS grant (GRS-036-PY) in January, 1965, and a second GRS grant made possible the purchase of various essential accessories such as colletts for the lathe and a dividing head for the miller last fall. Much remains to be done in the direction of adding capital equipment, the next item on the list being a surface grinder, but presumably these things can be handled with GRS grants, following up the excellent start that has been made. However, the figure from Brandeis should be regarded as the sort of investment the University should feel committed to make for capital equipment in its research machine shop. Furthermore, it should not consider the investment made prior to the purchase of the lathe and miller mentioned above as being of any value whatever, since most of the items concerned, such as the old lathes, will have to be replaced soon.

Small tools and measuring instruments: There is a continual shortage of these which got some relief from the grant last fall but will require more. The Brandeis shop has about $15,000 invested in such items whereas, if we do not include Al O'Neill's personal tools, we have probably less than a fifth of this amount.

Expendable budget: The Brandeis shop is given an annual budget of $5000 which the superintendent can spend as he sees fit and which is nominally divided into $2000 for material (thereby relieving the shop people of having to engage in a lot of paper work everytime a scrap of aluminum or brass is taken from the bin) and $3000 for small tools (thereby covering breakage, disappearance, and the desire to add some items in this category every year). In comparison, we have an $1800 budget which both Al and I are scared to use, the fear of death having been put into us if this money is spent and not replaced from billings. The difficulty in ordering materials without being able to immediately charge them out to grants is reflected in the

figures tabulated in this report which seem to indicate that nearly 10,000 dollars' worth of work was done on 230 dollars' worth of stock. This means that the great majority of the stock used in the projects carried out in the machine shop was either charged directly to grants or actually ordered by the the project director on Mr. O'Neill's instructions. Such a procedure is extremely inefficient. The set-up at Brandeis in which stock may be ordered at the foreman's discretion is far superior. While it is true that they charge for materials at the flat rate of $3.00 per pound for quantities under five pounds and $1.75 per pound for larger amounts, the $2000 annual materials budget is considered really expendable and not just an advance or "progress payment" intended only to "tide the shop over" until the next billing.

Space: The Brandeis shop is considerably larger than ours, as well it might be, given the greater number of machines and people involved, but our own space seems adequate in size for our present needs if the "surplus equipment" (i.e., junk) in the welding shop room can be got rid of. Note that this will require a certain rigging expenditure as some of the said junk is exceedingly heavy. However, if this is done, we should be pretty well fixed. You will observe from O'Neill's memo that he does not envision a need for additional space before 1969. This does not mean that the present space does not need some fixing up. Some of the items involved here were brought up in the recent safety inspection, and Mr. O'Neill is currently drawing up a plan which I hope we can get Buildings and Grounds to execute.

Charges: The greatest complaint about the shop in recent months has been the size of the bills. As already noted, billing has been at the rate of $4.65 per hour for Al's time with materials charges billed separately at cost. This is to be compared with the Brandeis system which charges machining time at $5.75 per hour and materials at the flat rate given in the last paragraph. Those who complain about our rate should take note of this, but at the same time and in all fairness to the complainers, Mr. O'Neill has been told to charge for consultation time whereas the billed time at Brandeis includes only the instrument maker's time expended on actually doing the job. I imagine somebody with an equipment design problem can talk to the foreman as long as he wants for free. We could do this too if the foreman and the instrument maker were not one and the same person. In addition, because the graduate school requires that we make up half of Mr. O'Neill's salary of $7200 and replace any of the 1800-dollar supposed budget that we use, we cannot afford to be generous with Mr. O'Neill's time. The tabulated figures indicate that we have carried out Dean Bear's wishes pretty well this year, but the cost has been great. One of the problems is that the financial burden falls most heavily on those who have secured sizeable grants and/or are conscientious about bill-paying. People who have either spent all their money or consider that they have better uses for what they have left than to pay a bill whose collection cannot be enforced simply don't pay. I don't really blame them, and I certainly am not willing to instruct the shop not to accept work from delinquent accounts. After all this is a university research facility and not a business we're talking about. Nevertheless the present system does produce an unequal distribution of the load and in particular forces the fat grants to assume a share that should be covered by university overhead. Furthermore this business of unpaid bills is always an unsavory one(note in the table that something under one half of our total billing remains unpaid, although this is perhaps an exaggerated picture inasmuch as the returns from the May billing are by no means complete at this writing) and tends to discourage faculty and students from using what they should regard as their own facility. My strongest recommendation in the matter of the shop is therefore that the financial arrangements be changed in basic form and a new system be instituted that will relieve Al of the hampering effects of detailed accounting and at the same time encourage rather than discourage use of the shop by B.U. experimentalists.

Conclusions: First and foremost we should thank our lucky stars that we have Al O'Neill in charge of the shop. He brings the high order of technical ability characteristic of a first class instrument maker together with a sense of management in a combination much to be desired in any research machine shop but obtained in very few. By the same token, he must be properly supported if he is to be kept happy and if we are to profit by our good fortune in having him with us. In the past year he has been badly frustrated specifically by a lack of help and the difficulties surrounding every effort on his part to accomplish anything and in general by the apparent absence of any sort of accepted or even proposed plan for the development of the shop. In addition I think it is probably time for a further raise in his pay. He has received only one since coming here, and that was not very large.

With regard to the help, the extra man as described earlier in this report is urgently needed, and the university should move at once to make twelve to fifteen thousand dollars a year available for shop personnel salaries. Mr. O'Neill's present salary is $7200 and if indeed a proper sort of helper could be obtained for $4000, this would mean a total payroll of $11,200. Such an amount is, however, an undesirably low minimum making no provision for either a raise for Mr. O'Neill or for the fact that at the present time in this area $4000 may not be sufficient to secure qualified help.

As to additions to capital equipment, I have been delighted with the graduate committee's positive response to our requests for funds with which to purchase machines and propose to submit additional applications in the near future. Mr. O'Neill's memo indicates that an expenditure of $6200.00 would be desirable in 1966, whereas the total amount spent in this category so far this year is about $800. I propose to submit very shortly a proposal for a surface grinder costing approximately $2000, and a further proposal for approximately this amount should be forthcoming before the end of the year. In short, the university should expect to invest, if not $6000, at least $4000 in permanent machine shop equipment every year until holdings totalling some $40,000 have been built up.

Finally, and most important of all, the shop's financial plan of operation must be changed. At present Mr. O'Neill's salary is $7200 of which the graduate school expects to pay half, the other half to be covered by billings. In addition $1800 was made available to spend for small tools and materials, but all such expenditures are to be recovered by appropriate charges to shop users. This means that Mr. O'Neill is effectively prevented from spending anything on small tools, shop improvements, or supplies because of the difficulty involved in billing such items to particular customers. He has thus not been encouraged to draw up detailed plans for developing the shop inasmuch as he does not see any prospect of support for them. I can hardly blame him when I note that the above indicates the university's total regular annual committment to the shop to be $3600. I therefore recommend that the University underwrite research machine shop salaries in the amount of $13,000 as noted above effective immediately with the understanding that further increases will be requested as additional presonnel become necessary. Moreover an annual budget of at least $3000 for small tools, materials, supplies, and shop improvements should be made available against which Mr. O'Neill can order things he needs, write open orders, and draw a petty cash fund without feeling that he has to figure out how every penny so spent can be billed. He should, in fact, not have to consider replacing these funds at all. This is not to say that the shop should no longer bill for its services. The Brandeis system of a stright, simple billing for ordinary materials (there's no problem about billing individual users for special materials ordered for their individual projects) plus an hourly charge for machinery time seems perfectly

REA

reasonable. I don't know where our $4.85 per hour rate comes from, but it doesn't look so bad when compared with the Brandeis figure. I think the users could live with it if they did not feel a time clock started the instant they set foot in the shop door. If the University would only realize that a research machine shop cannot and is not supposed to be a profit-making institution and would thus relieve us of the necessity of paying our own way and give us a fixed annual amount to work with, we could easily arrange the billing so that users would not complain of being overcharged and at the same time develop and implement a plan for making more and better shop service available to our growing community of experimentalists.

I, 1965 Proposal (Proposed by Mr. A. O'Neill)

Machine shop increases:

Work load: 50% increase per year, 250% increase per 5 years.

Added Labor Each Year

1966	Helper	$4,000.00
1967	Instrument man	6,000.00
1968	Helper	4,000.00
1969	Instrument man	6,000.00
1970	Helper	4,000.00

Machine Shop Areas	Main Machine and Welding Shops	Student Shop
Present	1500 square feet	315 square feet
1966-68	1500 square feet	315 square feet
1969-70	4000 square feet	600 square feet

Suggested Increases in Expenditures on Equipment and Tools

	Main Shop	Student Shop	Small Tools and Supplies	Total
Capital Equipment:				
1966	$3,500.00	$1,500.00	$1,200.00	$6,200.00
1967-68	5,500.00	500.00	400.00	6,400.00
1969-70	15,000.00	1,500.00	2,000.00	18,500.00
Materials and Hardware				
For Inventory	1,000.00	500.00		1,500.00

The method for ordering tools, supplies and materials is so cumbersome I have done everything possible not to order. The same applies to custodial help, and the answer should be in an entirely new approach, which I would like to discuss.