

a Decennial Look at

NSF's Research Grants Program in Physics

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The National Science Foundation was established by an Act of Congress in May 1950, making 1960 an anniversary year. This article gives a brief review of one of its programs with emphasis on the direction in which it is moving. The author is program director for physics at the National Science Foundation and has been with the program since 1952.

THAT a theme or motif can be heard, when a list of Foundation grant titles are read, is due in part to the anniversary character of the year. This is the tenth anniversary of the National Science Foundation's establishment. Over the last ten years the physics grants program in the NSF derived much of its strength from its panels of advisers and proposal reviewers. If one looks carefully at the ensemble of grants made under their guidance one observes a program purpose and program direction that was not always apparent when the grants were handled individually.

With the establishment of the NSF in 1950 the nation's research effort underwent an enlargement, which in physics meant an enlargement in breadth rather than further enhancement of existing peaks of postwar research activities. The broadening took the form of a gain in the number of physics departments engaging in research, a gain in the number of physicists doing research, and a widening of the scope of subjects deemed eligible for assistance. With no mission spelled out

in terms of research fields, the Foundation's research grants program backed a large variety of research topics, even though they were not linked to technology, weapons, or atomic energy. Extensive as this coverage was it never grew to include basic research in industry, government, or nonprofit laboratories, so the program can be described almost entirely in terms of university research.

Highlights of The Program

INSPIRED to look for decennial highlights, one notes first of all the help the Foundation's program has given to young PhD's—in particular to those starting research as assistant professors in emerging physics departments. Grants to younger men, still in their first post-PhD decade, have accounted for about half of all those made. Many of the newer-developing departments receiving assistance are found in the nation's less technologically minded states, creating a network of research nuclei which pretty well covers the country. The mean free path between knowledgeable research physicists, as viewed geographically, has shrunk perceptibly during the last decade, creating per square mile an impressive measure of research know-how. The sowing of these late-to-develop areas with young assistant professors was accomplished with the products of a very large number of our country's physics departments of long heritage.

Driven at first to concentrate on small individual projects, the NSF program was forced into a pattern which proved to be an asset rather than a liability, and enabled the Foundation's program to become the champion for those starting new research problems. Each year a majority of the Foundation's grants have gone to new applicants to the Foundation, making the Foundation the leading source of support for new uni-

versity projects in physics. In recent years the total number of new projects sponsored by the NSF frequently exceeded those of all the other agencies combined.

Lest it be thought that all NSF grants went to those still-to-be-proven younger physicists, mention should be made of some of the grants awarded to well-established leaders in physics, such as the support for Bruno Rossi's project using a two-square-mile scintillator array where the directional source of 10^{19} -Bev cosmic-ray particles is being studied. A five-year grant to John Daunt has, among many other things, enabled him to carry out a very difficult and theoretically important measurement of the melting curve for helium-three. Others holding grants are C. Kittel at the University of California, E. J. Konopinski at Indiana University, R. S. Mulliken at the University of Chicago, Robert Oppenheimer at the Institute for Advanced Study, and N. F. Ramsey at Harvard, just to mention a few.

With all the diverse demands for funds placed on the Foundation's Research Grants Program, it may be surprising to learn that as many as 25 percent of all the grants (by number) have gone to non-PhD-granting departments, some of which have physics staffs of not more than two persons. A most compelling reason for the program's support of research in these schools, in addition to that of the research per se, has been the salutary effect it appears to have had on the flow of undergraduates out of these small colleges and universities into the nation's graduate school system. As early as 1953 the Foundation's physics program undertook to segregate the grant requests coming from small-school research-environments, setting aside special funds for this group and arranging the procedures so that those applicants competed with their peers. These grants, especially those to liberal arts colleges, are believed to have been instrumental in moving young PhD's to seek careers in those small institutions in which teaching traditionally has commanded the major attention. How successful this program has been will probably never be known, as its accomplishments are of the kind that slip through questionnaire nets.

The impact which the Foundation's research grants program has had during the last ten years is, like all long-range basic research investments, difficult to demonstrate with a spread of charts and figures. Each bi-monthly issue of *The Physical Review* contains from two to five articles acknowledging NSF help. About one paper per month in the *Journal of Chemical Physics* and one every three months in the internationally oriented *Nuovo cimento* shows NSF as a source of support. A proliferation of papers was not expected under the program since much of the Foundation's help has gone into long-term investments in young men on the threshold of their research careers, whose productivity cannot as yet compete with those turning out papers with almost an assembly-line efficiency acquired gradually over the years.

Perhaps the most effective method for measuring the impact of the program on physics research is to call

attention to the fact that there are about 300 active grants and that on the average about one-fifth of all the Federal support for basic research in university physics departments and their closely associated institutes now comes from the Foundation's research grants program. All but one of the PhD-granting physics departments have had NSF research grants.

With regard to major facilities, the program has remained within modest limits. In accelerator dimensions it has not risen above a 10-Mev Tandem Van de Graaff, and this million-dollar-grant accomplishment just squeezed under the wire during the last month of the last fiscal year. But it is heartening to note that there has been an ascendancy in the size of accelerators being sponsored by the Foundation, the 10-Mev award being preceded by grants for a two- and a three-Mev machine. While held to a low score on accelerator awards, the Foundation has participated in a satisfying way on the development of accelerator ideas. MURA, under NSF grants, developed the spiral-ridged FFAG machine and made appreciable progress exploiting the clashing beam idea for a super BeV accelerator. To this list of achievements should be added the bubble chamber, which was brought along under an NSF grant to Donald Glaser in 1954.

Trends and the Future

ANNIVERSARIES, in addition to being occasions for epitomizing the past, are likewise moments for looking ahead. Of the topics subjected to comment in this prognosis, the fiscal one is perhaps the easiest to illustrate. The funds available for research grants for the last six years are shown below with the fiscal year 1961 being an estimate.

Fiscal Year	Grants Awarded out of Physics Grants Program (millions of dollars)	Grant Re- quests to Physics Program (millions of dollars)	Grants Awarded out of Physical Sciences Program (millions of dollars)
1956	\$1.11	\$ 4.13	\$ 4.50
1957	1.37	3.92	8.3
1958	2.11	11.8	9.4
1959	5.51	11.3	23.5
1960	6.38	12.8	31.9
1961	(")	(—)	(37.0)

The growth of the program reached a maximum in fiscal year 1959, the first fiscal year after the first Sputnik, and then declined to the current fiscal year for which it is estimated there will be no increase. The average annual growth, leaving out the big year of 1959, runs around 20 percent—small compared to increases being requested by physicists submitting proposals for renewed support, small if the Foundation is to keep up with the demands of each year's new crop of research-minded PhD's entering our expanding educational system, and very small if the Foundation's physics research grants program is to fulfill the recom-

mentations of its advisers that it become the central government agency supporting the big new ideas in physics.

The table also shows how the demand for grants has been progressing. The dollars requested through the formal submission of proposals leveled off for the last three years which, in turn, is reflected in the amounts of money made available for the physics grants program. In order to have an additional reference line, the table includes the Foundation's budget for all research grant funds going into the physical sciences, including mathematics and the engineering sciences.

At this junction between the past and coming decades, tempting forks appear in the road ahead. One bears a direction marker labeled "support of research in foreign countries". Strong interests exist for establishing research grants for foreign scientists outside the United States, even though the research task might not be unique with respect to either its geographical location or its associated experimental facilities. This support of foreign research has not materialized. However, the program continues to make grants dealing with research which can only be carried out in laboratories outside our own country and in one way or another it has been instrumental in accelerating the visits of physicists for year-long stays, coming and going, across our national boundary. The practice of importing young research associates by holders of Foundation research grants has given to the program an international ingredient that is more than just one of flavor.

It will be interesting to see what the next decade brings with regard to the support of research in non-profit and industrial laboratories. Requests for support from these sources have come up for consideration at intervals during the last decade, but grants to these two types of research organizations have so far not materialized. Other offices in the Foundation have had more success with requests from the nonprofit laboratories and a number of grants have been awarded, especially in those of the engineering sciences, earth sciences, and atmospheric sciences. A small number of research grants and research contracts to the industrial laboratories have also been made by the Foundation in the physical sciences, but these fell outside the physics program.

An unmistakable trend observed at this inter-decade time is an increased interest in grants to groups of cooperating physicists, rather than to physicists as individual project workers. The recent grants to John C. Slater at the Massachusetts Institute of Technology were of this type, where a group attack (involving sixteen professionals and fourteen graduate students) is being made on solid and molecular structures. However successful group grants prove to be, they are not expected to replace the individual project system, a system that has proven to be very versatile and accessible to physicists with new ideas. Clearly, the conditions mandatory for successful group efforts are strong scientific leadership and the presence of strong reinforcing interactions among the group members. Conversely, the group grant system will not flourish if the programs are

built solely around administrative leadership or have their origins in organization charts.

Trends have appeared recently in the granting program that may eventually have a profound effect on the character of its administration. The movement favoring group support and the inclination of the universities to request that the grants pay for a larger portion of the staff member's salary, suggest a revision of grant-monitoring methods. Whatever system is invented, it is bound to involve more accounting and less science, thus displacing the plane of government-university communication from one of science to one of business. This shift in focus away from the researcher, with the corresponding incentive to make substitutions for the scientist-to-scientist contacts, would be less alarming if the situation were not aggravated by the difficulty the research grants program office has had in keeping well staffed with university physicists. Many university physicists do not fully realize how essential it is for their colleagues' socio-economic welfare that they serve a tour of duty on the grants program. Failure of university physicists to take seriously invitations to temporary duty in Washington aggravated the monitoring problem, a problem which may well correct itself by weaving a fool-proof web of automatic but disturbingly inflexible administrative substitutes for science administrators.

Since one purpose of this report is to present the Foundation's physics research grants program in its national setting, a comparison between the Atomic Energy Commission, National Aeronautics and Space Administration, Department of Defense, and the NSF becomes inevitable. When budgets for research in university physics departments are used as a gauge, a comparison of the agencies shows the Foundation's program in third place, a position which remained unaltered by the Sputnik-inspired increases in the government's funds for science. Ranking third as a supporter of basic research in university science departments is not true for all Foundation-supported fields. Strong national leadership in cooperation with the Foundation has enabled some fields to achieve first and second place positions.

Physicists have expressed the hope that the Foundation could support all kinds of new research ideas—not just the inexpensive ones—and perhaps become the major federal source of research support. New, exciting ideas in physics are as a rule expensive to explore, demanding as they do the use of apparatus that is scheduled to perform in a way hitherto considered to be impossible. One of the administrative problems of the first decade of the Foundation's physics research grants program was the proper balance between costly frontier projects and less expensive small projects, it being known full well that a program of small grants could easily be nullified by careless handling. In the next decade it is hoped that this will no longer be a problem and that the program's growth will be adequate to meet the rising tide of stimulating research opportunities which physics is currently generating at an inspiring rate.