FEDERAL SPONSORSHIP OF UNIVERSITY RESEARCH

by

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Federal sponsorship of university research is currently the fastest growing item of university finance. It now accounts for $1 out of every $5 spent by the 2100 higher educational institutions in the United States. In some institutions federal funds for on-campus research exceed one-half of total university cash flow. Three-fourths of all university research is sponsored by federal agencies.

The federal government is clearly committed to a dominant role in supporting scientific progress in this country. The present system of selective placement of federal grants and contracts in universities is an outgrowth of the large scale mobilization of university resources to accomplish military ends in World War II; it has now become a permanent part of the peacetime organization of the leading universities and technological institutes.

The search for viable policies governing research relationships between federal sponsoring agencies and institutions engaging in federally sponsored research has led slowly but inevitably to a greater concern for the total impact of federal sponsorship on the institutional well-being of the colleges and universities. This search has been conditioned at every step by the universities' insistence that research serve educational objectives. In the past ten years it has been quickened by the explosive growth of federal sponsorship of university research and by profound changes in the composition of federal sponsorship among sponsoring agencies. Federal research funds remain concentrated largely in three fields--physical sciences, life sciences, and engineering.

Whereas federal sponsorship was focused primarily on the acquisition of research results in the immediate postwar years, the present basis of sponsorship increasingly embraces research and education as mutually desirable ends and as joint products. Some aspects of federal sponsorship have lagged this development, notably the cost reimbursement policies of federal agencies.

The federal government's acceptance of the educational values served by university research has been prompted largely by the pressing national need for more adequately trained scientists and engineers. Some agencies have lagged behind others in viewing research as a means of expanding this output and improving its quality. Universities have contributed a share to the uneven integration of research and education by their own rate of acceptance of the educational values served by research; only about 400 engage in federally sponsored research, 90 per cent of which is concentrated in 100 institutions which support strong centers of graduate education.

Within the colleges and universities the conversion of education to a research based process has proceeded steadily at the graduate level, where federal sponsorship is concentrated, and only nominally at the undergraduate level.

This study has explored the benefits and problems of the present system of federal sponsorship with the aim of identifying opportunities for the application of economic analysis. As universities are called upon to play a strategic role in promoting economic growth, these opportunities are multiplied. It is hoped that students of economics will turn more attention to this subject in the future than they have in the past.

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In 1959-60 the writer collaborated with General James McCormack, Vice President, Massachusetts Institute of Technology in a study of federal sponsorship of university research under the auspices of The American Assembly, Columbia University. This earlier study was published as Chapter 3 in The Federal Government and Higher Education, Prentice Hall, 1960 (Douglas M. Knight, editor) pages 76 - 139.

The writer wishes to express deep appreciation to General McCormack for permission to draw freely upon the 1959-60 study and for his early encouragement that the subject be presented as a graduate thesis; to the American Assembly for its support of the earlier study; and to Professor Richard S. Eckaus, without whose interest this thesis would not have been undertaken.

The writer has been helped generously by M.I.T. associates, to whom a large debt is owed, especially the staff of the Division of Sponsored Research. Their individual comments and suggestions have not been identified purposely to minimize the referencing problem and to avoid the impression that this study is based solely on M.I.T.'s experience--whereas in fact the writer has attempted to reflect as adequately as published information permitted the experience of the educational community generally.

Not the least contributors to this study were the writer's administrative associates at the Institute, upon whom an added workload fell during the period when this paper was written. None of the foregoing should be held responsible for the facts or opinions expressed in the following pages.

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CHAPTER I

INTRODUCTION AND PURPOSE

It is useful to begin a study of federal sponsorship of university research with a few observations about the nature of American colleges and universities and the larger arena of education in which they operate. Our growing dependence as a nation upon education, and especially higher education, gives this subject an importance that goes far beyond the particular institutions, numbers of people, and dollars directly involved.

In their basic functions American universities are modeled after those of Western Europe. By contrast, however, American universities, both public and private, maintain a strong tradition of service to the general community, a tradition distinctly American in origin. In this country the formulation of university goals has been conditioned to a large degree by rapid national development and practical dependence upon scientific progress to promote economic growth.(1) This link with the mainstream of everyday events in turn has had important consequences for the structure of American universities and for their relations with the federal government.

(1) For an historical treatment of this subject see Dupree, A. H. Science and the Federal Government. Harvard University Press, Cambridge, Massachusetts, 1957.

In the United States the pursuit of learning beyond the level of secondary school is by no means limited to the 2100 institutions of higher education listed officially by the U. S. Office of Education. At the same time their performance sets the standard for no less than 70 million students enrolled in all forms of education in the nation,[(2)] a group comparable in size to the current U. S. labor force.

Although less than two per cent of the national income is spent in and by the institutions of higher learning,[(3)] the national movement in education is much broader than this, and it embraces a variety of social, economic and political institutions--not all of which have as their central mission the education of students. Hospitals, museums, business corporations, labor unions, trade associations, government organizations, and the military services are some of the agencies who maintain their own specialized educational and training programs. Thus, for example, a recent study at the University of Chicago estimates some 25 million adults--roughly 20 per cent of our adult population--are enrolled in formal adult education programs throughout the country, not including the

(2) Over 40 million in elementary and secondary schools, 4 million in colleges, and 25 million in adult education programs.

(3) U. S. Office of Education, <u>Biennial Survey of Education in the U.S., 1955-56</u>; Chapter 4, Sec. II, page 59. The figure quoted for 1955-56 was 1.14 per cent.

4.2 million students enrolled in our colleges and universities.[4] Private industry spends considerably more on training and education of employees in a single year than the total spent in and by the nation's colleges.

The magnitude of the educational task in the United States staggers the imagination. Despite the overriding cultural value of education, the bulk of it beyond high school (including a significant share of women's education) is still undertaken largely to serve practical ends; but there is growing evidence that education for its own sake is becoming an accepted pattern of individual and group behavior in which the learning process is fostered, rewarded and applauded as a basic social aim. This theme is recurrent in the various panel studies conducted under the auspices of the President's Commission on National Goals, in the published reports of the President's Science Advisory Committee, in the explosion of literature dealing with academic excellence and, indeed, in the small but growing body of writings by economists who have begun to concern themselves with the economics of education and with the larger impact of research and development upon economi growth. Bowen, Eckaus, Eckstein, Harris, Kaysen, Machlup, Musgrave, Mushkin, Shultz, and Solow are some of the

(4) "Twenty-five Million U.S. Adults in Schools". Boston Globe. May 21, 1963, page 29.

economists who have devoted special attention to the economics of education and its role in the economy.[5] Gailbraith, among economists, has probably gone farthest to argue that public acceptance of education in the United States has proceeded to a stage where, next to survival, investment in education has become the basic index of social progress.[6]

While the national problem of school dropouts suggests that our educational development may not actually have proceeded much beyond the limit of compulsory attendance, the persistent rising demand for education by all age groups in the population is a fact that commands our highest attention. Its meaning for higher education and for the colleges and universities is clear: Never in their history have they sought to serve a more education-minded society. Never have they been entrusted with the leadership of a national movement towards education of comparable size and importance. In the language of economics, never have their services been commanded in such a tight sellers market. Never have their opportunities and needs been as great.

(5) References included in the bibliography and in this study. See especially Harris, Seymour E. (ed.), Higher Education in the United States. Cambridge, Massachusetts, Harvard University Press, 1960, and U.S. Office of Education. Economics of Higher Education. Selma J. Mushkin (ed.), Bulletin No. 5, Washington, 1962.

(6) Gailbraith, J. K. The Affluent Society. Houghton Mifflin Company, Boston, page 345.

The college-age group in the United States is expected to increase from 9.6 million in 1960 to about 14.6 in 1970.(7) The percentage of college-age youth entering college has risen from about 4 per cent in 1900 to 15 per cent in 1940 to 38 per cent in 1960, and it is still rising. These figures are behind the current rough estimates of a doubling of the 1960 college enrollment by 1970. There is admittedly some conjecture in the doubling estimate, since it assumes a continued upward rise in demand for higher education by this age group and an ability to accommodate the increased enrollment by the educational institutions. College enrollment has already doubled in the last decade. Even if the percentage of college-age youth attending college were to remain constant between now and 1970, there would still be an estimated 6 million students seeking enrollment at that time, or an increase of more than 75 per cent over the enrollment in 1960.

It is a matter of elementary economics that profound changes in the demand for limited resources raise crucial questions of allocation. This applies no less to the resources available for higher education than it does to the supply and demand for other scarce goods and services in our economic system. A great deal of the interest in federal sponsorship of university research is the natural result of this concern for optimum allocation of our educational effort.

(7) U.S. Bureau of the Census, Current Population Reports, Series P-25.

Although there has been no general agreement about what it is that we seek to optimize, there is widespread recognition that the economic returns from education as a whole are significant and measurable. For example, leading economists ascribe 40 per cent of the postwar growth in GNP to increases in the general level of education in the labor force. It is clear that our ability to deploy our educational resources effectively will have a determining influence upon the rate and character of our economic development in the period ahead.

The great and growing demand for higher education forms only part of the picture, of course. On the supply side are a host of problems posed by increasing costs. It is sufficient to note here a fundamental desire on the part of the universities to find financial solutions which will strengthen rather than dilute their basic goals.

From what has been said above, the writer's occupational bias in favor of viewing federal sponsorship of university research in terms of its effect on university operations should be clear. Throughout this study the choice of data, their method of presentation, and the conclusions drawn will all reflect a fundamental bias towards introspection in the matter of assessing the effects of federal sponsorship. Students of university organization will find little in these pages that is new or startling.

To be sure, there are far-reaching aspects to this subject, but they can hardly be dealt with adequately in the limitations of time available. Without going into the matter deeply we shall simply note that federal sponsorship of university research falls logically into two areas of growing interest in the field of economics--namely (1) the economics of research and development, and (2) the economics of education, both of which are relevant to the broader subject of economic growth.

Purpose of This Study

Our purpose in studying federal sponsorship of university research takes its lead from two areas in economics mentioned above. First, we hope to shed further light on the subject because of its importance to the economics of research and development. Universities are major performers of research in the United States; they perform over half of all basic research sponsored by the federal government. Second, we hope to develop an economic basis for analyzing government-university relationships in research as a contribution to the economics of education.

The latter field is new and until recently, most economists viewed the problems of education as outside their sphere of interest and competence. This situation is changing. In 1962 the U.S. Office of Education published a pilot study that should go far to stimulate greater professional interest in the economics of education.(8) In the words of one of the

(8) U.S. Office of Education. Economics of Higher Education. Selma J. Mushkin (ed.), Bulletin No. 5, Washington, 1962.

contributors, Alice M. Rivlin:

> "Within the last few years the economics of education has become a respectable, even a fashionable field in which to write a doctoral dissertation or direct a research project. A president of the American Economic Association has even devoted a presidential address to the subject. Economists have begun to investigate the return on investment in education, the demand for and supply of persons with specific types of training, the economic advantages and disadvantages of alternative means of financing education, the comparative costs of different ways of organizing an educational system and so forth. Those who make decisions affecting education have also begun to realize that this type of research may be useful to them and to call for more of it." (9)

(9) Ibid., page 357.

CHAPTER II

STRUCTURE OF HIGHER EDUCATION

Colleges and universities are the principal institutions of higher learning. We have noted earlier that they do not stand alone in the task of educating the nation beyond high school; but they stand at the apex of our educational system and they are interlocked with the whole, in which 70 million students are enrolled.

Within their organization they provide an environment in which man seeks to understand himself and his universe. They are essentially communities of scholars organized around three goals--the dissemination, creation and preservation of knowledge. These goals interlock and reinforce each other in the educational process. Translated into operational terms, they take the form of teaching, research, and public service--all of which are traditional in the makeup of American colleges and universities.

In 1962, there were 2075 colleges and universities in the United States. While there has been a significant growth in the number of junior colleges in the past five years, the formal community of higher educational institutions is essentially fixed, at least in the short run. Among four-year institutions there has been no significant change in the number of institutions during the past ten years.

Institutionally, there is a high premium on age, stability, continuity, and excellence through proven performance. Each of these institutions is unique in terms of its history and educational status. All share in the common purpose of providing the implements and values of higher education; all measure their success primarily by the quality of their graduates. But each has pursued its goals on an individual basis. Geography, prevalent educational philosophy, age, motivation, finances, national and local events, and chance have produced a variety of institutions.(10)

The great multiplicy of institutions staggers the imagination. There are schools which range in size from under 20 to over 100,000 students against a national average of some 1500 students at all institutions. They range in age from 327 years to new schools established in 1963. There are public and private institutions and schools which combine both elements, either in terms of their sources of support or in terms of their organizational makeup; all are, of course, public in the context of their broader purpose.

Colleges and universities vary widely in the relative emphasis they place on the operational elements of higher education--teaching, research and public service. But all emphasize teaching as their central

(10) For a sociological study of American Colleges see David Riesman, Constraint and Variety in American Education, University of Nebraska Press, 1956.

function, for it is this primary mission that differentiates these institutions from all others. Some conduct no research while others utilize research extensively in their educational programs. All are engaged in public service in varying degrees, according to their resources and historical commitments. There are civilian and military institutions, secular and nonsecular, primarily undergraduate versus specialized graduate schools, along with a variety of undergraduate-graduate combinations. Plainly, there are more differences than similarities among colleges and universities. There is no typical institution; at best there are institutions which typify particular classes of schools.

Depending upon the purpose to be served, there are a number of ways to classify colleges and universities. The most meaningful breakdown for a study of federal sponsorship of university research is according to the level of degrees awarded. Federal funds for research have been applied almost exclusively to colleges and universities which emphasize research in their graduate educational programs, more specifically doctoral degree programs.

Table I gives an indication of how few institutions support advanced education within the community of colleges and universities. Only one-third support graduate teaching and research. Just 11 per cent offer the Ph. D. degree. Excluding the junior colleges, the fraction awarding the doctoral degree is still only 15 per cent of those institutions

(TABLE 1)

STRUCTURE OF HIGHER EDUCATION IN THE U.S., 1963

2, 075 Institutions

		Percent of Total
223	Institutions offer the Ph.D. degree or equivalent.	11
681	Institutions offer graduate degrees.	32
1, 447	Institutions offer bachelors degrees or first professional degree.	70
628	Institutions are junior colleges.	30
2, 075	Institutions in the total.*	100

Source: U.S. Office of Education. Education Directory, Part 3, OE50000-63, Washington, 1963, page 15.

* Does not include 25 institutions who do not award degrees but whose level of education is classified as postdoctoral, e. g., the Institute for Advanced Study at Princeton, New Jersey.

which award the bachelors and higher level degrees.

Another useful classification is according to type of control. There has been no distinction between private and public institutions in federal sponsorship of university research, but there are enough important differences in the financial operations of the public and private sector to warrant another grouping. The bulk of federal funds designated for research are now and have been applied in the major private and state universities and in land-grant institutions. In 1957-58 there were 308 institutions participating in research programs sponsored by the federal government, or about 15 per cent of the colleges and universities in the country at that time. In sharp contrast, virtually all of the 2075 institutions of higher education have some involvement in a variety of federally financed educational programs. Those institutions which report no federal income are, for the most part, junior colleges, proprietory schools, small undergraduate colleges, or theological schools.

W. Homer Turner has suggested the following classification as a useful way to analyze colleges and universities in terms of their dependence upon public and private purses.[11]

(11) W. Homer Turner. "The Prospects for Private-Sector Support of Higher Education" in Financing Higher Education, 1960-70; Dexter M. Keezer, Editor, McGraw-Hill Book Company, Inc., New York, 1959.

1. Major private and state universities and land-grant institutions
2. Public and private teachers colleges
3. Private mens colleges, four-year
4. Private womens colleges, four-year
5. Private coeducational colleges, four-year
6. Private professional or technological institutions
7. Municipal colleges and universities
8. Public and private junior colleges
9. Public and private institutes for advanced study
10. Jointly operated educational facilities, public and private

This breakdown is useful for purposes of studying federal sponsorship of university research for it largely groups (1) and (6) that are participating in this type of educational program, with groups (7) and (10) involved to a limited extent.

Private institutions have played a special role in higher education. Institutionally, they are more numerous than public institutions of higher learning. They dominated the early population of schools in this country and established basic patterns of scholarship and teaching precepts at the college level. From the founding of Harvard College in 1636 until the establishment of the University of North Carolina in 1793, all American colleges and universities were private; by 1853 there were only seventeen state universities.[(12)]

Today, private institutions are viewed as important catalysts of our mixed educational system: They number 1319 or almost two-thirds

(12) For an historical survey of higher education see Rogers, Francis Millet, Higher Education in the United States, A Summary View. Cambridge, Massachusetts, Harvard University Press, 1952.

of the total colleges and universities. Their enrollments are at an all time high. At the same time their share of the student population is steadily declining. Table 2 sets forth the comparison between public and private enrollments for the period since 1950.

The difficulty of establishing new institutions and the inadequacy of private sources of support has thrust the heaviest burden of expansion upon publicly supported schools. For many of the private institutions this has required a reaffirmation of purpose and difficult decisions related to the acceptance of support from public sources in order to accommodate enlarged enrollments. The financial crisis they face is best described as the inability of private support to develop as fast as the over-all needs of the private colleges and universities, despite record-breaking gifts, the record-breaking capital fund campaigns they have successfully conducted in the last decade, and the growth of new sources of support in the private sector, notably U. S. corporations.

(TABLE 2)

TOTAL ENROLLMENT IN U. S. COLLEGES AND UNIVERSITIES

1950 - 1962

Year	Total	Public	Private	Percentage Public	Percentage Private
1950	2,296,592	1,154,456	1,142,136	50	50
1951	2,116,440	1,051,990	1,064,450	50	50
1952	2,148,284	1,113,700	1,034,584	52	48
1953	2,250,701	1,203,558	1,047,143	53	47
1954	2,468,596	1,372,937	1,095,659	56	44
1955	2,678,623	1,498,510	1,180,113	56	44
1956	2,946,985	1,681,671	1,265,314	57	43
1957	3,068,417	1,780,280	1,288,137	58	42
1958	3,258,556	1,912,232	1,346,324	59	41
1959	3,402,297	2,002,868	1,399,429	59	41
1960	3,610,007	2,135,690	1,474,317	59	41
1961	3,891,230	2,351,719	1,539,511	60	40
1962	4,206,672	2,596,904	1,609,768	62	38
Growth Since 1952	100%	136%	60%		

Source: A Fact Book on Higher Education, Office of Statistical Information and Research, American Council on Higher Education, Washington, 1963, Tables 10 and 12.

CHAPTER III

THE GROWTH OF FEDERAL SPONSORSHIP

The practical role of American colleges and universities in promoting economic progress and in developing an enlightened body of citizens is as old as the institutions themselves. Within the last twenty years they have been asked to play a new and critical role in national affairs. The success of the Office of Scientific Research and Development (OSRD) in mobilizing their resources to promote national security ranked in importance with industry's phenomenal demonstration of its ability to expand production during World War II.[(13)] What was conceived as a wartime mobilization of colleges and universities has now become a permanent part of the life of many of these institutions.

As the functions of government, both civilian and military, come to depend increasingly upon complex scientific information, the use of university resources has grown steadily. Some prominent examples are in the provision of technical assistance to less-developed countries, the extensive use of university personnel in government advisory

(13) Vannevar Bush has pointed out that World War II was "the first war in human history to be affected decisively by weapons unknown at the outbreak of hostilities." Quotation from Irvin Stewart, Organizing Scientific Research for War, Little Brown and Company, 1948, page 9.

committees, research and development sponsored by federal agencies, the cultural exchange programs of the Department of State, and the education of government military and civilian personnel.

The most rapid growth in government-university collaboration has been in federal grants and contracts to underwrite research. In 1940, for example, the federal government provided $15 million in grants and contracts to colleges and universities for research and development, or about one-tenth of total university research expenditures. Almost all of this was for agricultural experiment stations of the land grant institutions. By 1962, federal expenditures for "on-campus" research reached $613 million, not including $98.5 million made available for campus research facilities and equipment.(14) This $700 million was about three-fourths of all university research expenditures. In the meanwhile, total federal expenditures for research and development have risen from $74 million in 1940 to over $10 billion in fiscal 1962, and they are expected to reach $15 billion by the end of fiscal 1964.(15)

In going beyond its own laboratories to seek large-scale

(14) The colleges and universities also acquired government surplus property valued at more than its purchase price under the federal government's surplus property program. An estimated $65 million in such savings went to all educational institutions, including the colleges and universities and other schools as well.

(15) Source: Wall Street Journal, June 6, 1963.

assistance from colleges and universities in World War II, the federal government's interest was focused mainly on military applications of nuclear energy, communications, control systems, and improvements in propulsion. Industrial resources for these fields were not as available then as today. Research and development contracting was not widely engaged in by industrial laboratories in 1940. The universities were successful in bringing science and engineering to bear upon problems of military technology; they were willing and eager to contribute to the war effort. Their achievements have in turn greatly influenced their relationship with government in the postwar period.

Accurate data on the extent of university participation in the war effort are not available. But some insight into the magnitude of the dollar volume can be gained from an examination of the war records of the various institutions involved. At M.I.T., for example, a total of $93,031,000 was expended on research and development contracts for OSRD, other government sponsors and private industry during World War II. Writing in the M.I.T. President's Report, 1945, President Karl T. Compton reported the following war-related work at the Institute:

161	Army, Navy and other agency contracts
89	OSRD contracts
150	Industrial contracts (not including 275 orders for Wind Tunnel work)
400	Total war-related contracts at M.I.T., 1940-1945

In addition to the $93, 031, 000 expended on these contracts, $5, 217, 500 was spent to provide special training for military and other personnel during the five-year period, 1940-45, making a grand total of $98, 248, 500 in war-related research and training at the Institute (op. cit., page 8).

That all of this was possible without sacrificing the freedom and control of the universities was due in no small measure to the adoption of wise policies on the part of the Federal Government in its relations with higher education.

President Harlan Hatcher of the University of Michigan recently contrasted the experience resulting from the First and Second World Wars in a manner which reflects credit upon the Government's treatment of universities in the latter period and which points up the partnership forged under a national emergency. After a reference to the wiser policies adopted by the military authorities, he went on to say that "the Second World War did not bring about the wholesale dislocation and disruptions caused by the First World War."

"Instead, military training programs and research contracts came to the University in orderly and efficient fashion. Special programs included the Judge Advocate Generals School, the Military Intelligence Language School, Reserve Officers Naval Architecture Group, Civil Affairs Training School, Medical and Dental programs, Navy V-12, and others. In this War, too, the research facilities of the University were an essential factor in the Nation's war effort, contributing to such important developments as radar, the proximity fuse, RDX explosives and the atomic bomb."[16]

The postwar emergence of the United States as a world leader brought enormous responsibilities in international affairs. In seeking resources to meet this challenge, the federal government again appealed for assistance from the colleges and universities--in trained manpower, advice, and prosecution of research. The cold war and Soviet achievements in space technology have further accelerated this dependence.

Definitions

In order to measure the significance of federal sponsorship of university research, a few definitions will be needed. The practical problem of measuring university research did not arise until the center of gravity of research sponsorship moved out of the universities to outside sponsors. University research was a small part of the total educational enterprise and it was largely a matter of internal management with no pressing need to identify all of the relevant items of expense. Now that it has become a major factor in university finances, a great deal of attention has been focused on the subject of costs.

(16) Address to The Newcomen Society, New York City, January 9, 1958 page 23.

During the postwar period, there has been a certain amount of confusion about federal sponsorship because of the inherent difficulty of measuring and accounting for research in the universities. All of the challenges that industrial research laboratories offer to accountants are present in university research, plus the imponderable fact that university research is interlaced in varying degrees with teaching and with other university functions. There have been added difficulties introduced by statutory limitations and by the variety of policies and procedures followed by agencies of the federal government, but we shall turn our attention first to the universities and ask the question: Is the volume of university research measurable?

The answer is yes, sometimes, but only if we are willing to be quite arbitrary about separating research and teaching from other university functions and from each other. One can hardly grant the premise that university goals are interlocked, and that they reinforce each other, and then proceed to segregate university activities into discrete functions without admitting to a certain latitude for miscalculation and without recourse to difficult accounting conventions. The crucial point we are making here is that, while not all university output is jointly produced, most of it is. When research is properly related to teaching, the two elements are merged functionally; the educational result is not equal to the sum of the two parts.

Add to this imponderable characteristic of university organization the inherent problem of imposing an overlay of accounting requirements on academic life for the sake of obtaining reliable cost accounting estimates. Also add substantial differences in the cost structure of universities according to the type of education offered, an astonishing variety of methods by which colleges and universities do their accounting, and a general lack of experience with cost accounting principles on the part of many college and university administrators.

In the end, the most baffling problem of all is the irreducible fact that university research, if it is properly related to teaching, is organically part of a single, interacting process by which students are educated. Both may be involved in the educational process: which part research, which part teaching? We shall see later that, in some areas of education, notably but not exclusively in the advanced fields of science and engineering, the word "education" has, _of necessity_, come to require the integration of classroom instruction and an internship in research.

We shall conclude this commentary on the difficulty of measuring university research with an inventory of concepts that will help the reader to interpret the meaning of published data on the magnitude and effect of federal sponsorship. The categories shown below are listed in order of descending size:

1. University Research - On Campus

As described above, this term includes all research conducted in universities, sponsored or unsponsored, formally or informally organized, basic and applied, graduate and undergraduate. It excludes only research and development performed in contract research centers operated by the universities for the various agencies of the federal government. The dollar volume of activity in these contract research centers (e.g., Jet Propulsion Laboratory, Argonne National Laboratory, Lincoln Laboratory) was $468 million in fiscal 1962, or about 45 per cent of the total $1.1 billion expended by federal agencies for university research performed under grants and contracts.

2. University Research - On Campus Separately Budgeted

This term refers to that portion of on-campus university research which is explicitly or separately budgeted by the universities, always involving a formal sponsor. The words, "separately budgeted," are misleading to the extent they may suggest that separately budgeted research is somehow isolated from "regular" or "normal" educational activity. Separately budgeted research is performed by the various departments and campus laboratories which comprise universities. Sponsorship may come from individuals, foundations, industry and government agencies--local, state and federal.

It is important to note that this particular category of university research does not encompass all of the research a university might perform on its campus with funds underwritten from a particular source--say, government. There are methods other than separate budgeting for research by which universities receive funds that are earmarked for research, may be, or are used for university research. Examples are training grants to institutions in particular areas of interest to government agencies, institutional grants from these agencies, fellowships, and direct grants to teachers. Thus, in 1962, there was at least $100 million spent by universities for research from such funds provided by the federal government but not separately budgeted by the schools.

It is also important to note that published data on the volume of federal sponsorship of separately budgeted research do not take into account the full coverage of costs associated with this component of university research. The history of university research, and especially the federal government's participation in it during the period since World War II, encompasses a continuing debate in the matter of identifying and recovering costs properly related to university research performed under grants and contracts. In addition, the universities themselves follow a variety of practices in charging direct and indirect costs to separately budgeted research (government sponsored and others as well) so that the net result is underrecovery of their costs on separately budgeted research. A great deal of progress has been made in this regard, both by the universities in rationalizing their accounting methods and in their relations with government; indeed, the area of research accounting is an illustrious chapter in university-government relations, and the work is continuing.

We introduce the expression "underrecovery of their costs" at this point, merely to observe that the published data available on separately budgeted university research understate its volume and importance to the universities as well as to research sponsors.

3. University Research - On Campus
   Separately Budgeted
   Actual Recovery of Direct and Indirect Costs

This term is the quantity regularly reported by colleges and universities as their on-campus sponsored research volume. It expresses the actual operating result of charges made by universities and accepted by sponsors of university research. In research programs involving private sponsors, the charging of expenses by the universities and their acceptance by private sponsors are identical, except for an occasional over- or underspending under budgets established for such work. In those programs involving federal sponsors under cost reimbursement contracts, the charging and acceptance come together retroactively in the annual process of negotiation regarding indirect and other expenses. The process of determining final costs on federally sponsored research involves the day-to-day application of accounting formulas to research related expenses. Those expenses which are finally accepted by government representatives become research costs and enter into the total of separately budgeted university research. Those expenses which are not accepted are absorbed in departmental accounts or in general university expenses and do not enter the total of separately budgeted university research. There are many technicalities involved in the negotiation process, requiring special skills on the part of university business officers and government representatives alike.

It will suffice for our present purpose to indicate that published data on the volume of federal sponsorship of university research is the result of practical experience gained under the application of accounting formulas and procedures, and continuing negotiation between university and government personnel on items of expense that are negotiable. Thus, the 1962 figure of $613 million in "on-campus" university research mentioned earlier has been derived, in large part, through this procedure.

What is meant by federal sponsorship of university research? To answer this query, one should recall the process by which the $613 million figure mentioned above has been explained. It refers only to separately budgeted, on-campus research financed from federal sources, not all federally financed campus research. To repeat, there was at least an additional $100 million of university research performed on-campus with federal funds during 1962 under other arrangements. To repeat further, it does not include $462 million in federal funds expended to support "off-campus" work in contract research centers managed by the universities. It does not include government grants earmarked for on-campus research facilities and equipment--which amounted to almost $100 million in fiscal 1962, and it does not include the underrecovery of expenses related to on-campus research sponsored by the federal government. It is clear that federal funds spent for on-campus research <u>and</u> facilities exceeded $800 million in fiscal 1962, not including the underrecovery factor.

With this brief introduction, the growth of federal sponsorship of university research can be presented concisely in Table 3. The data shown in the first column are consistent with Item (3) explained above. For lack of better estimates we will use these officially published data throughout this study, except when otherwise noted.

(TABLE 3)

FEDERAL SPONSORSHIP OF UNIVERSITY RESEARCH

1953-1963

Funds obligated for the Performance of University Research under Grants and Contracts. (Figures in Millions of Dollars.)

	On-Campus	Contract Research Centers	Total
1953-54	$141	$130	$271
1954-55	140	135	275
1955-56	172	138	310
1956-57	219	158	377
1957-58	282	196	478
1958-59	356	261	617
1959-60	449	333	782
1960-61	540	421	961
1961-62 (est.)	732	551	1,283
1962-63 (est.)	906	668	1,574

Source: National Science Foundation, Federal Funds for Science, Nos. V-XI, Washington, G.P.O. Data for 1950-51, 1951-52, and 1952-53 are not available on a comparable basis. Published figures for these years include federal funds for R & D plant expenditures in higher educational institutions. Data for the years shown above are exclusive of R & D plant outlays.

CHAPTER IV

CONTRACT RESEARCH CENTERS

Before going on to consider on-campus research in the universities, it is worth stopping to say a word about contract research centers, even though these university managed laboratories are not the focus of this study. It was the wartime creation of a few such major laboratories to mobilize scientific effort in the universities that marked the beginning of a new pattern of university research organization.

This successful innovation was made by the Office of Scientific Research and Development when it proposed the creation of university research centers. The universities undertook to supply management for the assembling of scientists and engineers for concerted attack on areas of major technical importance with specific end purposes in view. The Applied Physics Laboratory of Johns Hopkins University, which developed the proximity fuse, was one such endeavor. A second was the Jet Propulsion Laboratory, for rocket development, by the California Institute of Technology. A third was the Metallurgical Laboratory at the University of Chicago, which developed the basic uranium and plutonium technology. A fourth was the Radiation Laboratory at M.I.T., which was the U. S. center for the development of radar.(17)

The practice was followed by the Manhattan Project, with the Los Alamos Laboratory operated by the University of California. The pattern was continued and extended after the war by the Atomic Energy Commission and the armed services, resulting examples being the Lincoln Laboratory for air defense research, a descendant at M.I.T. of the wartime Radiation Laboratory, and the atomic weapons laboratory at Livermore, operated by the University of California. A variant is the Brookhaven National Laboratory for work in atomic science supported by the AEC and operated by an association of universities, the management of which has since undertaken also to build and operate a radio astronomy center for the National Science Foundation.

These are examples of the larger ones. There are a score of others, generally smaller. Some have disappeared or folded into successor organizations. In 1962 the National Science Foundation listed

(17) The Radiation Laboratory was the principal activity responsible for the wartime expansion of sponsored research at M.I.T. Whereas the Institute's pre-war volume of sponsored research was $1.15 million, it reached a high of $39.97 million in 1945 and declined to $9.2 million following the demobilization of the Radiation Laboratory. The Laboratory accounted for over one-fourth of the total expenditures of OSRD and employed at its peak 3897 persons, including roughly one-fifth of the nation's physicists. For an interesting account of its activities, see Five Years at The Radiation Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1946.

thirty-four "Federal Contract Research Centers" managed by educational institutions. Research and development obligations through these centers amounted to an estimated $668 million in fiscal 1963.[18]

The motivation in each case has been a national need that, in the government's opinion, could be adequately met best by the universities. Although the full course of this organizational development may not yet have been run, it would seem, under present circumstances, that the trend would be in other directions. The dollar volume of university-managed centers is about half of the total in such centers. Whereas the universities managed twenty-one of the twenty-four contract research centers that existed in 1952, they managed only thirty-four of the sixty-two centers that were in operation in 1962.[19] The existence now of well-rounded research and development capabilities in industry and in nonprofit organizations not directly university managed offers the government other resources adaptable to such missions. Some of these

(18) Federal Funds for Science, XI, NSF, 62-11, Washington, 1963. In 1962-63, in addition to the thirty-four university-managed centers, there were thirteen managed by other nonprofit organizations with a volume of $125 million. Private industry managed fifteen additional centers for the government with a volume of $435 million. The grand total of all such centers was $1,228 million, or just half of the total "in house" obligations for R & D in the government's own laboratories.

(19) National Science Foundation. Federal Funds for Science, Nos. I and X, Washington.

latter organizations have been initiated by universities, although as corporately separate entities, such as Cornell Aeronautical Laboratory and Stanford Research Institute. Two, at least, were created specifically to take responsibility for the more industrially oriented parts of the operation of a university managed center: The Sandia Corporation, relieving the Los Alamos Laboratory, and The Mitre Corporation relieving the Lincoln Laboratory.

Obviously, we have been witnessing an important evolution. The university solution was the initial catalyst, and has generally worked well. It has caused philosophical and administrative difficulties, both for the government and for the participating universities, but the satisfactions of national service have generally outweighed the troubles.

These centers are large and require extensive facilities. The work in some of them is dangerous. So they are generally located off-campus. Their missions require that they have considerable authority to deal directly with their sponsors in setting and carrying out their programs. Secrecy enters also as a segregating factor, for some of their work is classified. These and other considerations have led typically to a substantial degree of autonomy in both administrative and technical affairs.

As a consequence, then, of a degree of separateness, the programs of the centers are not related to education in the close sense used in this study, which deals with on-campus relationships. It should be noted, however, that wherever possible the managing universities promote intellectual relationships between their faculties and the professional staff of the centers. Depending on the activity in the center and its distance from the campus, this effort succeeds in varying degree. In some places it is quite successful.

The importance of these centers, as they have evolved in some instances from their original quite specific purposes, is that they serve as "institutes" for the concentration of a wide range of talents toward broad, yet concerted objectives. An example is the work of the Lincoln Laboratory which developed the SAGE system of continental air defense and whose fundamental studies laid the groundwork for the definition of the DEW and BMEWS lines. In this concentration the contract research centers perform a service beyond that which campuses can supply. They also entail certain risks for the universities.

Because of their size, their financial operations are large compared with other university activities. Because they must compete in the market place for staff, lacking some of the university's attractions, their salary scales are above campus levels. Other costs tend to run higher also, from operating closer to the industrial world. The result, with large cash flow and higher "unit costs," is an inflationary influence in university finances. Perversely, the closer the relationship of the university with the research center (for the advantages to the center of technical support and competent managerial supervision) the more effectively the inflationary influence can operate. And in any case, where the center's budget is large compared with the university's other operations, a management mistake that permitted a sizable fraction of center costs to fall back on the university could be serious indeed.

There is a challenge also to the university in that the contract research center, with a position of eminence and a degree of intellectual monopoly in its field, is subject to forces of complacency. If as a consequence its quality deteriorates, the potential embarrassment to the university is obvious. The insurance of quality is in the main achieved through the environmental infusion of the university's own uncompromising standard of intellectual excellence. Yet the necessarily large measure of autonomy granted to the center for the conduct of its technical affairs conditions the university's ability to guarantee the result.

Whither the Centers?

The principal advantages accruing to a university from its managerial role in one of these enterprises stem from the fact that the work of the center is genuinely important (else the university has no business being there). So, first is the satisfaction of public service, which is not negligible.

Second, and somewhat more tangible, is the association afforded to schools of science and engineering with some of the dominant technologies of our times. Despite the sometimes casual attitudes displayed by faculties and students in this regard, there can be no real question as to the values of association with work of major technical importance.[20]

Third, and most tangible, the center provides a source of qualified specialists for teaching, particularly in advanced subjects: for part-time and term assignments, for lectures, for conducting seminars--sometimes for permanent transfer to the faculty, when the individual is qualified and so moved. The center, in turn, can offer stimulating off-period work for faculty members, occasional support for on-campus research, and job opportunities for students and new graduates.

As regards interchange of faculty and center staff, there are of course some inhibitions. It must police the time and compensation of faculty members participating in the center's work to insure that no special privileges are enjoyed. And, in the reverse direction,

(20) Three recent examples of collaboration between Lincoln Laboratory staff members and M.I.T. faculty members point up the interaction of off-campus and academic research interests--(1) the emergence of the National Magnet Laboratory for work in solid state physics and high magnetic field research; (2) Project Mac for a pioneering program in computer time sharing; and (3) the establishment of a New England regional center for work in computer technology development for biological and medical purposes.

salary differentials introduce difficulties into the employment of center staff as teachers.

However, on the whole, with careful and intelligent direction, these inhibitions are modulated and, provided the separation in distance or nature of the work is not too great, the interaction can bring positive benefits to both sides. Indeed, such must be the case in the long term. When duty has been done, the university has no cause to continue in the management of such operations, unless it can enhance quality and, at the same time, strengthen educational processes.

CHAPTER V

THE ROLE OF UNIVERSITY RESEARCH

Given a high level of quality, university research represents the most powerful stimulus available to higher education.[21] If it is properly related to teaching, its benefits will be realized in a variety of educational forms, invigorating the very heart of the learning process. A catalogue of these benefits would include:

1. Stimulation of students. Research motivates students to learn through their personal participation, either as interns at the post graduate level, or as thesis students, research assistants, or undergraduates. There are no deeper learning experiences than the personal discoveries students can make for themselves through research.

2. Definition of fruitful areas of inquiry, both for students and faculty members.

3. Increased opportunities for professional interaction between faculty members and students outside the classroom and, most important, on a highly individualized basis.

4. Professional development of faculty members. At the graduate level especially, but at the undergraduate level too, the stimulation to teaching

(21) See J. A. Stratton, "Research and the University." Chemical and Engineering News, 31, June 22, 1953, page 2581.

that comes from personal involvement in research by faculty members cannot be exaggerated. In fields that are changing rapidly, it may be an absolute necessity, in order to teach effectively. Faculty obsolescence is an insidious threat to effective teaching in these fields.

5. Inspiration of students. In advanced areas of learning there is no known substitute for an acknowledged leader in his field. A second choice is a teacher who is personally making significant contributions to the advancement of knowledge in the field. A third choice is a skilled lecturer who teaches at some distance from the frontier in a given field.

6. Redesign of Curricula. The choice of what shall be taught is at least as important as how it shall be taught. In advanced fields the choice of subject matter dominates the teaching methodology. Here the price paid for teaching the solved problems of the past is the potential misuse of educational resources. In fields that are changing rapidly, research is the prime mover of curriculum design. The explosion of scientific knowledge makes it imperative that the choice of what shall be taught be made by those who are themselves deeply involved in the changes occurring in their field of specialization. Faculty involvement in research is thus a necessary (although not sufficient) form of institutional insurance against curriculum obsolescence.

7. Environmental influences, campus-wide. Research is a well spring

of excitement to those who participate personally as well as to those who do not. It charges the atmosphere of learning with importance and urgency that goes beyond the campus. It pervades the classroom, dormitory, faculty club, gymnasium, and university organization.

8. Communication with the real world. Campus research provides an avenue through which advances in research in non-educational laboratories can most easily be brought to bear on the educational process. This is becoming increasingly important as the volume of basic research outside the universities grows.

9. Financial support of education. When it is sponsored by external sources, university research can help to underwrite educational expenses by providing financial support for the participants in the process--students, faculty, and staff. If they are diligent, and if the terms and conditions of sponsorship permit, the educational institutions can minimize the inherent financial risks.

It bears repeating that during the past twenty years university research has been marked, both by changes in degree and by changes in kind. Explosive growth and outside sponsorship have been the dominant changes on the demand side. Interdisciplinary organization and the emphasis of team effort have been the most notable developments within the universities.[22] At the same time, university research is not a new phenomenon. In its various guises research has always been a part of higher education. Teachers, with a more-than-average grasp of current knowledge, have naturally displayed a more-than-average interest in expanding that knowledge; and the arts and substance of teaching have invariably benefited.

Without suggesting that classic principles are overturned daily through campus research, it is clear that the growth of our understanding of things and happenings in nature sheds new light on those principles (and occasionally does overturn one). And the quicker the rate of change, the deeper the importance of close relationships between research and advanced teaching.

Of course not every teacher is or should be a research scholar, nor is every scholar a teacher. The two bents are by no means identical. They may run parallel, but not all people are doubly gifted, or interested. It suffices for education that individuals have the opportunity to exercise their talents in both, and that we encourage good research for the value to science of the results and for the stimulation of education in advanced fields.

From the national point of view, such indeed is the joint interest

(22) See, for example, A. R. Von Hippel, "Universities in Transition." Technology Review. April 1959.

of universities and the federal government in university research. However, one can go too far in building on this obvious truth. The university, no matter how genuine its interest in seeing its research serve the needs of society, must in dedication to its primary responsibility give greatest emphasis to its teaching function.

Under the present system of sponsorship, the federal government, while recognizing its responsibility for education, shapes its sponsorship largely to give emphasis to national needs for research results--in atomic power, in military weapons, in weather prediction, in space exploration, and so on. The emergence from university research of a new idea for improving electronic switching, for example, can be important to the government if it serves no other purpose. But the university can be fully satisfied only if the result also serves the educational process--if it improves the value of a teacher, stimulates a student, adds to knowledge.

Thus, the joint interest, however natural in the usual case, does receive somewhat different emphasis from the two parties. It is when this gap opens too wide that fears are most urgently expressed regarding the compatibility of sponsored research with the objectives of academic institutions. Actually, the central incompatibilities are not severe and can, with understanding management, be turned into strengths.

CHAPTER VI

TYPES OF GOVERNMENT SPONSORSHIP - GRANTS AND CONTRACTS

It can be misleading to generalize about administrative practices that range from the management of a large off-campus laboratory to the coordination of a typical small project in a teaching department. To give some preliminary focus to the more detailed discussion to follow, therefore, we present a brief outline of the principal means of supervising and financing federal sponsorship of university research on the campus. Let us first consider the government side.

Probably closest to the prevailing image of federal sponsorship is the system of grants employed by the National Science Foundation, mainly in the physical sciences, and by the National Institutes of Health in the life sciences. The basic idea is to strengthen the fundamentals of science generally while emphasizing certain areas in accordance with technical significance and financial need. Within available funds, grants support worthy endeavor where competent individuals are ready to take responsibility for its supervision. The result is a broad spread of funds, institutionally and geographically within the limits imposed by research competence--broad in comparison with the concentrated "mission-oriented" research, connected, for example, with certain military programs.

Grants are made on the basis of proposals from individuals and groups, supported by their institutions. The size of the grant is determined through estimated direct costs of time, materials, and services, frequently supplemented by funds to pay for part or all of needed special equipment. To the total is then added a percentage, generally fixed by law or regulation,[23] of direct costs to be applied toward the institution's indirect costs: e.g., building maintenance and repair, utilities, and other items of general administrative expense.

The use of grants, as distinguished from contracts, has come into greater prominence as certain agencies, namely the National Institutes of Health and the National Science Foundation have greatly enlarged their dollar volume of sponsorship. These agencies have as one of their principal tasks the provision of broad support to underwrite scientific progress in fields under their surveillance, and they have employed the grant form of sponsorship as a matter of historical practice. However, even in the mission-oriented agencies the employment of the grant form of sponsorship has now come into use as a result of 1962 legislation which specifically allows the Defense Department

(23) At least, such as been the case. The National Science Foundation is now urging within government the application to grants, where practical, of negotiated charges for indirect costs as is done with research contracts. This will be discussed in some detail later.

agencies the freedom to use their discretion in the choice between grants and contracts when basic research is involved.

The National Science Foundation, in a study published in March 1962, estimated that federal sponsorship of university research through grants was $198 million in fiscal 1960 on an expenditures basis. By fiscal 1962 the total for grants was supposed to reach $380 million.[24] The growth in dollar volume of grants can be compared with the growth of total federal obligations for university research, on-campus, which amounted to $449 million and $732 million in fiscal 1960 and 1962 respectively. Thus, the volume of grants increased by 92 per cent while the total volume of federally sponsored research on-campus grew by 63 per cent in the two-year period. We shall see later that this large and growing component of federal sponsorship has aggravated the problem of cost reimbursement for the universities because of the generally lower indirect cost recovery permitted by federal statutes under the grant form of sponsorship. The important point to note here is the broadening use of grants as the philosophy underlying federal sponsorship of university research shifts markedly from the "purchase-of-service"

(24) National Science Foundation. Reviews of Data on Research and Development. March 1962, Number 32, page 5.

concept to research "support."[25]

A second system for financing government sponsored university research is represented by the contracts commonly used by the "operating" agencies of government, of which the Department of Defense, the Atomic Energy Commission, and the National Aeronautics and Space Administration supply the most familiar examples.

It is possible to philosophize on the difference in spirit between grants and contract payments for financing research, but in truth the fundamental difference is not so great. Present law permits a number of government agencies to make grants as an alternative to contracts, and the decision between the two methods tends to be in large part a matter of agency practice or management detail, for example, affecting the ownership of special equipment. A grant by definition permits operating flexibility, but so also can a contract when the contracting agency so desires. Two examples of wide latitude for freedom under research contracts are the Department of Agriculture support provided to agricultural experiment stations and the Office of Naval Research sponsorship of basic research in physics over the years.

Further back in the government organization and fiscal cycle,

(25) We are even witnessing the beginning of a more profound shift in federal philosophy in the provision of "educational support" through the establishment of training and institutional grant programs. But more on this subject later.

as annual budgets are being approved, there is close scrutiny of the research to be sponsored by the various agencies; and a mission-oriented department, such as Defense, must justify its sponsorship of a given scientific area in relation to its missions: in weapon development, oceanography, intelligence, materials engineering, or whatever. The resulting programs, conducted mainly under contract, are properly weighted toward applications rather than toward basic research. But properly also, a large amount of basic research in relevant scientific area is sponsored by the military establishment (see Table 4), and where it parallels research supported by grants from the National Science Foundation, for example, there is little difference to a university if both programs are intelligently administered. By the nature of research, a contract can hardly call for a more specific result than would come in the same case from a grant, nor can the contract instrument in any magical way fix the course of the research or the date on which preordained results will emerge.

The amount of the contract is based, as in the case of the grant, on an estimate of the direct cost of the project. Additional allowances, however, are negotiated, unlike the common present procedures for grants. Typically, the government and the university agree on a guide-line rate at the beginning of the fiscal year to cover the pertinent parts of the university's operations during the year. Then, at the end of the year, when actual costs can be presented, the figure is renegotiated to a precise amount.

(TABLE 4)

AGENCY SPONSORSHIP OF BASIC RESEARCH IN THE UNIVERSITIES, 1961-62

(Dollars in Millions)

Agency	Amount(1)	Percent of total Federal Sponsorship of Basic Research in Universities
NASA	$143	25%
HEW	124	22
AEC	121	21
DOD	94	16
NSF	86	15
All other agencies	11	2
	$578	100%

Source: Federal Funds for Science, XI, page 36, (obligations basis)

(1) Includes basic research in contract research centers as well as basic research on-campus. For contrast, total federal sponsorship of university research was $1, 283 million in the same fiscal year. Totals do not add precisely because of rounding.

So much, for the time being, for the variants in government procedure. We shall turn now to a brief description of the principal methods by which universities accept these funds and the responsibilities they entail.

First, we shall mention the relatively small and personalized project in which a principal investigator, with one or a few associates and minimum administrative support, undertakes a line or research, estimating its duration and specifying the funds required. Typically, his assistants will include graduate students who may be working to supplement their income or to acquire background for a thesis or other technical paper. Typically, also, the project proceeds from the earlier work or interests of the investigator and uses equipment and supplies--even perhaps some money--left over from such work. The operating funds allocated by the government may be augmented from other sources available to the university. The group may include persons from more than one department, but the project is generally identified with a particular department and with a major sponsor. The reports coming from such work are given as wide distribution as circumstances permit and their importance merits. In short, the arrangements are businesslike but not tightly formalized.

Projects of broader scope, especially with two or more departments involved, may be supervised by a higher administrative echelon of the university, but the next large step is likely to be found where work of a more continuing nature and requiring substantial financing seems to require a laboratory of indefinite tenure. Here, the university is gambling on continuing support from outside and therefore gives close attention to the size and scope of the endeavor as it implies commitments beyond the period of assured project funding.

It is also one of the objectives of government as well as a primary objective of the universities that the programs of these laboratories shall provide maximum opportunity for participation by students working for advanced degrees. Such laboratories may be departmental or interdepartmental. They may be significantly supported from other than government funds. They may, as in the past with agriculture at some places, form the nucleus of a school. Such, indeed, may be the future course of recently emergent areas of interest, as for example in the interacting physical, electrical, and chemical properties of materials. At least, the possibilities are of great interest to education, both broadly and, as regards each institution, in the context of its own position and prospects.

The financial aspects of these laboratories are of long-range interest also to the government administrator. Where competence is organized on a continuing basis, especially where it encompasses related disciplines, the commitment for continued support rests not with the university alone but with all who have pertinent responsibility for strengthening research and for amplifying and implementing its results. Thus, the government administrator sees his future funds subject to an increasing and most persuasive call, which, however beneficent in other respects, will certainly pass to universities and laboratories some fraction of his present authority for detailed selection among individual projects and for shifting support from one individual or institution to another.

One must add to the variants we have outlined, concerning mainly the mechanics of administration, others of personality and imaginativeness in this highly individualistic business of research cum teaching. There is ample room within the framework of standard operating procedure for the individual tastes of government research administrators to make important differences that affect academic freedom of action.

There is no really standard form. The university or government administrator who feels uncomfortable among such complexities is well advised to turn his attention to other fields.

Problems of Data Collection

At this junction a word should be said about the difficulty of obtaining consistent data on federal sponsorship of university research. The National Science Foundation publishes annual estimates in Federal

Funds for Science, which has become the principal reference source for information dealing with research and development expenditures by the federal government. The Foundation's approach to this annual survey is undergoing continuing refinement and there are significant revaluations in the figures for such items as basic research, R & D plant outlays, and funds obligated for scientific and technical information activity (dissemination) as contrasted with funds obligated for the performance of research and development itself. In the early years of publication, NSF reported R & D plant outlays separate from R & D performance in some but not all of its statistical series. For example, it did not separate R & D plant outlays from R & D performance in the universities.

Beginning with No. V of Federal Funds for Science, fiscal year 1953-54, the Foundation made this separation, as federally sponsored R & D plant outlays began to be a significant variable in the universities.

A similar pattern has developed in the matter of reporting funds obligated for scientific and technical information activities which have to do with dissemination of research results as contrasted with the performance of R & D. Beginning with No. IX of Federal Funds for Science (fiscal year 1959), scientific and technical information activity funds have begun to be reported separately. The result is that estimates of federal spending on components of R & D are changing but not uniformly as the various agencies which make data available to NSF adapt uniform distinctions and definitions of various research spending categories.

The separation of R & D plant outlays from R & D performance is somewhat easier to accomplish, and it is especially useful from the standpoint of economics, since one is a capital account and the other is a current or operating account. But the separation of scientific and technical information activities from R & D performance poses complex problems of measurement. Both are largely current items. However, the separation of one from the other poses the same kind of problem as that posed by the attempt to separate research and teaching functions in the universities.

There are added difficulties in the present system of reporting federal research sponsorship because of the multiple check points at which federal spending for R & D in the universities may be metered. The following catalogue of possibilities gives some idea of the statistical differences that can enter federal reporting depending on whether funds involved for any period are:

1. budget estimates by the agencies
2. budget appropriations by congress
3. agency obligations (contractual basis)
4. agency expenditures (cash basis)
5. university receipts (to perform research)
6. university expenditures (to perform research)

These multiple checkpoints would not matter much if R & D data were changing only moderately from year to year. But such is not the case. For example, for the fiscal year 1961-62, the National Science Foundation estimates the on-campus research volume sponsored by the federal government at $732 million, on an obligations basis.[26] A study released on June 28, 1963 by the House Committee on Labor and Education shows detailed breakdowns of federal sponsorship for the same period on an expenditures basis.[27] But the House Committee study reports, not $732 million for the period but $613 million, on an expenditures basis--a difference of over $100 million.

The problem of obtaining adequate information about R & D spending in the universities is further aggravated by long delays in publication of special studies. Long before meaningful measures of R & D activity can be obtained, the quantities involved have grown so much as to render much of the data of limited usefulness. For example, the fiscal year, 1953-54, was the first period covered by the Foundation in an exhaustive study of Scientific Research and Development in the Colleges and Universities--Expenditures and Manpower. This 173-page

(26) Federal Funds for Science, XI, (June, 1963)

(27) U. S. House of Representatives. Committee on Education and Labor. Federal Government and Education. 88th Congress, 1st Session, Washington, June, 1963, page 48.

study was published in 1959. A succeeding study of the fiscal year 1957-58 has appeared in published form in 1963. Yet federal sponsorship of university research has more than doubled in the interval since 1957-58.

The same problem exists in the matter of detailed statistical studies regarding higher education. The most comprehensive survey, the Biennial Survey of Education, issued by the Office of Education, provides splendid information on finances, enrollments, degrees, faculty, students, etc. But the Survey for 1957-58 was published in 1962. Thus, the facts upon which federal legislation affecting higher education may be based may be as old as four or five years before they become available, despite the public nature of education data, and one should add--its importance to the nation.

CHAPTER VII

THE ROLE OF FEDERAL SPONSORSHIP IN UNIVERSITY OPERATIONS

The importance of federal sponsorship of university research in the financing of university operations can be summarized in a short sentence: It is large and growing. However, it would be misleading to generalize on this subject because of the limited involvement of the community of higher educational institutions in research, and more specifically in government sponsored programs. But we must start from somewhere to reach a degree of understanding about its importance to particular institutions that are primarily involved. So let us look first at the total picture on the revenue side.

In the following table it can be seen that in 1957-58 (before the post-Sputnik explosion of federal sponsorship), on-campus university research funded by the federal government amounted to $534 million out of a total of $3.8 billion in current operating revenues of all institutions. Thus, federal research revenues accounted for 14 per cent of total current operating income in all institutions, with significant differences in the public and private sectors. Comparable data are not available for later years, but we know that the government component of separately budgeted research (on-campus) grew to $613 million by 1921-62. It seems reasonable to guess that separately budgeted research on-campus is currently about 15 per cent of total operating income in the public institutions and about 25 per cent in the private institutions.

(TABLE 5)

(TABLE 5) CURRENT INCOME OF INSTITUTIONS OF HIGHER EDUCATION, BY CONTROL AND SOURCE OF INCOME: 1957-58(1)

(Amounts in Thousands)

Source	Public and Private		Public		Private	
	Amount	Percent of Total	Amount	Percent of Total	Amount	Percent of Total
Educational and general income	3,762,532	100.0	2,174,074	100.0	1,588,458	100.0
Tuition and fees from students	939,111	25.0	274,181	12.6	664,929	41.9
Federal Government	712,431	18.9	392,521	18.1	319,910	20.1
Veterans' tuition and fees(2)	5,056	0.1	1,336	0.1	3,720	0.2
Land-grant institutions (regular appropriations)	83,937	2.2	82,295	3.8	1,642	0.1
Research	534,389	14.2	232,775	10.7	301,613	19.0
Other Purposes	89,049	2.4	76,114	3.5	12,935	0.8
State governments	1,156,537	30.7	1,128,895	51.9	27,643	1.7
Local governments	129,389	3.4	125,843	5.8	3,546	0.2
Endowment earnings	181,638	4.8	15,881	0.7	165,758	10.4
Private gifts and grants	324,971	8.6	68,774	3.2	256,197	16.1
Related activities	199,303	5.3	108,400	5.0	90,902	5.7
Sales and services	47,448	1.3	30,864	1.4	16,584	1.0
Other sources	71,705	1.9	28,716	1.3	42,989	2.7

Note: Totals do not add precisely because of rounding.

(1) Data are for aggregate United States - 50 States and the outlying parts.

(2) Includes tuition and fees for World War II and disabled veterans only. Excludes tuition and fees for Korean veterans enrolled under Public Law 550.

Source: U. S. Office of Education. Economics of Higher Education. Selma J. Mushkin (ed.), Bulletin No. 5, Washington, 1962, page 255.

Herbert H. Rosenberg has estimated the over-all growth in university research (including contract research centers) as a per cent of over-all educational and general expenditures as follows:

(TABLE 6)

GROWTH OF FEDERAL RESEARCH FUNDS
AS A PERCENTAGE OF OVER-ALL EDUCATIONAL
AND GENERAL EXPENDITURES, 1930 - 1960

YEAR	PERCENT
1930	4.8
1940	5.4
1950	13.2
1952	16.4
1954	16.4
1956	18.1
1958	20.2
1960 (est.)	24.4

Source: Herbert H. Rosenberg. "Research and the Financing of Higher Education." Economics of Education. U. S. Office of Education, Washington, 1962, page 306.

There have been a number of estimates, like the preceding, that have led to the general statement that university research had grown to one-fourth of total university operations by 1960, and the reader will notice that my estimates for 1961-62 are substantially lower. My estimates do not include off-campus contract research centers. Whether one includes them or not, the important point is that university research is the fastest growing item of university finance, and it has now grown larger than many of the traditional categories of university revenue such as endowment earnings and private gifts and grants for operating purposes. There are, of course, crucial differences in the character of these various revenue streams that mask their relative effectiveness in university financing. But some feeling for the relative over-all magnitudes is important as a starter.

When one comes to grips with the role of university research in particular institutions where it is performed, its importance begins to stand out in bold relief. Data are available from the biennial surveys of education to permit a first approximation.

The data in Table 7 are only a first approximation because they include university research expenditures in contract research centers. But the sharp rise in the relevant percentages is apparent as soon as one focuses on the 141 universities and 45 technological institutes, which account consistently for over 95 per cent of total research outlays by institutions of higher learning.

(TABLE 7)

RESEARCH EXPENDITURES IN THE MAJOR UNIVERSITY RESEARCH CENTERS, 1954-56-58

Type of Institution	Organized Research as a Percentage of Educational and General Expenses		
	1953-54	1955-56	1957-58
Universities (81 public and 60 private)	22.3	24.5	27.0
Technological Schools (24 public and 21 private)	33.0	37.4	41.3
All other	2.0	1.8	2.2

Source: Biennial surveys of education. U.S. Office of Education.

Now let us examine the available figures for a sample of institutions. Data are available from a recent study for the year 1959-60 by the Carnegie Corporation and the American Council of Education. The tables following present comparisons for a group of 22 institutions representing a range of involvement in federally sponsored university research. These institutions collaborated in a series of self studies in 1961 and reported data on their research operations to the Carnegie Corporation for inclusion in a final report which was issued in the spring of 1963.[28] Institutions were included in the sample because they were thought to be representative of a range of factors relevant to the study. Beyond this there was no special significance attached to their inclusion or exclusion in the sample. Students of research administration will notice, for example, that several institutions, public and private, which are prominent in research were not included.

The Carnegie Corporation study focused upon on-campus research supported by the federal government (separately budgeted and other forms of government support for research). Hence, it is especially useful for our purposes in emphasizing the role of federally sponsored research in university finances. I presenting these data, however, a word of caution should precede. The data shown in column (2) should not be equated with

(28) "Twenty-Six Campuses and the Federal Government." Educational Record, 44, April, 1963, pages 95-136.

(TABLE 8)

RELATIONSHIP OF FEDERAL SPONSORSHIP OF UNIVERSITY RESEARCH TO TOTAL EXPENDITURES FOR EDUCATIONAL AND GENERAL PURPOSES AT SELECTED INSTITUTIONS, 1959-60

Institution	Total Expenditures for Educational and General Purposes (Total Campus Operation Including Research)	Total Federal Support of On-Campus Research	Total Federal Sponsorship of Separately Budgeted On-Campus Research	Percent of Column (1) Represented by Column (3)
University of Michigan	$69, 367, 019	$20, 540, 740	$20, 043, 304	29. 0
Massachusetts Institute of Technology	37, 232, 000	16, 164, 694	15, 814, 444	42. 5
Stanford University	30, 169, 704	14, 433, 730	13, 535, 157	44. 9
Harvard University	53, 393, 589	12, 590, 048	11, 860, 796	22. 2
University of Chicago	44, 812, 237	10, 819, 389	10, 775, 939	24. 0
University of California, Berkeley	45, 954, 257	8, 678, 751	8, 357, 381	18. 2
University of Texas	----------	----------	7, 172, 300	----
University of California, Los Angeles	42, 007, 983	7, 614, 457	6, 507, 150	15. 5
Cornell University	37, 763, 060	7, 405, 408	6, 288, 550	16. 7
Princeton University	14, 162, 000	5, 888, 193	5, 445, 193	38. 4
University of California, San Diego	7, 530, 145	5, 731, 310	5, 097, 727	67. 7
California Institute of Technology	11, 685, 090	5, 592, 193	5, 035, 107	43. 1
Pennsylvania State University	39, 794, 843	3, 681, 018	2, 655, 739	6. 7
Indiana University	32, 854, 957	2, 396, 555	2, 378, 255	7. 2
Syracuse University	17, 938, 855	2, 355, 006	2, 145, 512	12. 0
Tulane University	12, 785, 212	1, 779, 673	1, 766, 715	13. 8
Iowa State University	21, 506, 079	2, 517, 013	1, 744, 763	8. 1
University of California, Davis	13, 902, 718	2, 015, 354	1, 577, 918	11. 3
University of Louisville	6, 490, 773	915, 840	868, 340	13. 4
University of Notre Dame	7, 824, 400	1, 287, 172	681, 436	8. 7
Union University	----------	----------	433, 382	----
University of Wyoming	5, 471, 178	565, 216	141, 044	2. 6
Newark College	----------	----------	24, 309	----
Catawba College	----------	----------	2, 300	----

Source: "Twenty-Six Campuses and the Federal Government." Educational Record, 44, April, 1963, pages 95-136.

the total on-campus research volume in these institutions--which includes privately sponsored research as well as other forms of private research support. All that these data represent is the total of federally supported on-campus research--as recorded in the accounts of these institutions. The non-federally supported component (private sources and the institutions themselves) is typically estimated as one-fourth of all university research.

Student and Faculty Involvement

In the preceding pages we have attempted to trace the dollar volumes involved in total educational income, university research, and separately budgeted research on the campus--with emphasis on federal sponsorship in institutions that are primarily involved. Another measure of the role of federal sponsorship of university research in the operations of higher education is the extent of educational opportunity it provides in terms of student, faculty, and staff participation. Here again, we shall have to contend with measurement problems and specialized definitions, but if we are careful, a rough estimate can be made of educational involvement in terms of people.

In a recent study, the House Committee on Education and Labor noted that 19,350 graduate students received "major support" from federally sponsored research in the universities in 1961-62. This represents a significant part of the total volume of federal funds flowing to students through a variety of federal programs which go beyond sponsorship of research to aid students directly. The following table sets forth a summary of these data:

(TABLE 9)

FEDERAL SUPPORT OF STUDENTS, 1961-62

	Number of Students
I. Graduate Research Assistants on Federally Sponsored Research Projects	19,350
II. Direct Federal Grants For Support of Students:	
a) Graduate Fellowships and Traineeships	35,404
b) Undergraduate Scholarships	1,960
c) Part-time Undergraduate Support	10,197
Total	66,911 Students

Source: U. S. House of Representatives. Committee on Education and Labor. Federal Government and Education. 88th Congress, 1st Session, Washington, June, 1963, page 14.

There were other major federal programs of direct assistance to students in 1961-62, involving NDEA loans, assistance to Korean War veterans, and payments for the education of military personnel but these need not occupy us in this study. The important point we should note in the preceding table is the significant number of graduate students who now receive income in connection with federally sponsored research programs compared with those who receive funds through fellowships and training grants. The whole area of student support is highly specialized and involves a separate set of questions that we shall not have the time to examine. But the record is clear on sponsored research programs. They represent major support for 35 per cent of the graduate students in the United States who are supported by federal funds. The 54,754 federally supported graduate students included in the preceding table in turn represented one-fourth the total graduate student enrollment in the U. S. in 1961-62.

Without the educational opportunities provided to graduate students in a number of fields through federally sponsored research programs, the nation's graduate programs in science and engineering could not be maintained at their present size, barring a tremendous increase in direct fellowship and training grants from private or governmental sources. In those institutions which foster advanced education, the role of sponsored research in underwriting student expenses is even more pronounced. At M.I.T., for example, the regular graduate student enrollment in the fall of 1961 was 2,462 students.[29] Of these, 656, or over one-fourth, were participating financially as well as professionally in sponsored research

(29) M.I.T. President's Report, 1962, page 303.

programs.[30] An additional, indeterminant number of graduate and undergraduate students were intimately associated with sponsored research programs at M.I.T. but these students were supported from sources other than project funds--private, governmental, and institutional.

The resultant patchwork of funding operates to the distinct advantage of sponsored projects, which may and often do have the benefit of association with faculty and students not being supported from project funds but working in adjacent areas or on facets of the same problem. But this is, in effect, what the sponsor properly expects--the placement of projects and programs in an environment of scientific inquiry that brings resources to the work in question from outside the immediate area of sponsorship. This is particularly true in the placement of sponsored research with faculty members whose professional distinction and personal influence are significant among their colleagues and among students. It is explicit in the broad funding provided to formally organized laboratories, both departmental and interdepartmental.

The universities, in turn, share in these special benefits that arise from interaction between sponsored and non-sponsored work. Often, the sponsored project provides the critical mass necessary to make the

(30) "Twenty-Six Campuses and the Federal Government." Educational Record, 44, April, 1963, page 107. The 656 students did not include undergraduates employed in sub professional work in sponsored research programs, which accounts for a significant fraction of student employment on the campus.

reaction go. And the result is that both areas are strengthened. Indeed, it would be difficult to segregate six graduate students, all writing their doctoral theses under a single faculty member, according to the sources from which they have drawn their support.

Dean Harold L. Hazen of the Graduate School at M.I.T. has put the matter succinctly: "Today, as throughout the history of graduate work in this country, the graduate student comes to his graduate study without resources and expects them to be provided in one way or another."(31) The chronology of how a given student may finance his graduate education may run the gamut of fellowships, project support, teaching, federal training grants, loans, income derived from employment of one's spouse in the case of married students and deferred payment of tuition. When sponsored research funds are available, and the student is interested, education is a principal beneficiary along with government.

All of this presupposes that federally sponsored research originates in a climate of concern for educational opportunities it can provide for students, not only at the graduate level but at the undergraduate level as well. If the university is doing its job well, this concern will find expression at all levels of decision in research administration but, most importantly, at the level of the individual faculty member whose idea it was in the first place to pursue a given line of inquiry.

(31) M.I.T. President's Report, 1962, page 297.

Faculty Participation

This brings us to the question of the extent of faculty participation in federally sponsored research on the campus. Unfortunately, current data are not available on this specific subject but one can infer from data on university research the trend of faculty participation in research activity sponsored by the federal government.

Two checkpoints are available nationally on the number of faculty members participating in research and development programs, separately budgeted and otherwise supported. The 1953-54 and 1957-58 studies by the National Science Foundation of research and development in colleges and universities are the primary source of this information.(32) For more recent information one must turn to the data on individual institutions. At least two trends are discernible in the 1954-58 and 1958-62 periods.

In the period 1954 to 1958 the colleges and universities met the expansion of university research by greatly increasing the numbers of non-faculty scientists and engineers engaged in research, i.e., graduate students and full time research staff, with emphasis on the latter. They also increased the allocation of faculty time devoted to research and

(32) National Science Foundation. Scientific Research and Development in Colleges and Universities, Expenditures and Manpower 1953-54. Washington, 1958. Scientific Research and Development in Colleges and Universities, Expenditures and Manpower 1957-58. Washington, 1962.

development among those faculty members who were participating.

In 1954, the colleges and universities had 44,000 scientists and engineers engaged in research and development, 75 per cent of whom were faculty members. In 1958, they employed 70,000 scientists and engineers engaged in research and development, 46 per cent of whom were faculty members. The total faculty engaged in R & D, thus, rose only 3 per cent--from 31,450 in 1954 to 32,400 in 1958.(33) At the same time, the number of faculty engaged full time in research and development rose from 7,000 in 1954 to 10,400 in 1958, or a 50 per cent increase. Incidentally, these data on full time research faculty should not be confused with full time faculty equivalents. Some institutions, as a matter of policy, appoint full time faculty members to research posts which carry no teaching obligations.

By 1958 then, the extent of faculty participation in university research can be compared with Table 10 on the total number of science and engineering faculty members employed in the colleges and universities.

The period 1958 to 1962 presents an interesting contrast with the period 1954 to 1958 in that the more recent expansion of university research appears to have been met largely by increased faculty and graduate student participation, rather than by the employment of additional full time research

(33) National Science Foundation. Scientific Research and Development in Colleges and Universities, Expenditures and Manpower 1957-58. Washington, 1962, pages 4 and 5. (Not including Contract Research Centers.)

(TABLE 10)

FACULTY PARTICIPATION IN UNIVERSITY RESEARCH, 1958

1. Total Science and Engineering Faculty Employed in 1916 Institutions. (Life, Physical, Engineering and Social Sciences)	100, 100
2. Total Science and Engineering Faculty Employed in 377 Institutions Reporting Separately Budgeted Research. These institutions accounted for 99 per cent of the Science and Engineering Faculty in the U. S. and 99 per cent of all Scientists and Engineers in U. S. colleges and universities.	74, 400
3. Total Science and Engineering Faculty Engaged in R & D in 377 Institutions.	32, 800
4. Per cent Science and Engineering Faculty Engaged in R & D in 377 Institutions.	44%

Source: National Science Foundation. Scientific Research and Development in Colleges and Universities, Expenditures and Manpower 1957-58. Washington, 1962, page 44.

staff. Quantative data at the national level are not available but some under-lying factors can be identified to explain this shift of emphasis towards research that simultaneously serves an educational purpose--i.e., involves teachers and students.

1. increased reliance on the part of sponsoring agencies upon basic research to accomplish their purposes.

2. increased recognition on the part of sponsoring agencies that educational involvement increases the long run returns from university research and the ability of educational institutions to participate.

3. the national need for more adequately trained manpower in science and engineering.

4. a slower rate of growth of contract research centers managed by the universities, in sharp contrast to the growth of on-campus research.

5. the renewed determination of the educational institutions themselves, as expressed in their sponsored research policies, to see to it that sponsored research is properly related to teaching as its volume continues to grow.

6. the continuing accumulation of experience by the universities in utilizing research for educational purposes, especially in combating obsolescense among faculties in science and engineering.

We shall see later that there has been a steady change in the character and composition of federal sponsorship of university research, which is in turn a reflection of the factors identified above. We shall see, too, that there are institutional barriers to the growth of university research that have confined its educational development largely to existing centers of research competence, despite the marked shift in the basis of sponsorship from the "purchase-of-service" to research "support" concept.

The contrast mentioned earlier between the 1954-58 and 1958-62 periods can be seen in the data for particular institutions which have traditionally emphasized research as an integral part of their educational program. To these institutions the growing availability of federal funds for research in the natural sciences and in engineering, under increasingly favorable educational terms, has made possible a substantial increase in faculty and student participation. At M.I.T., for example, the number of faculty members (professors, associate professors, and assistant professors) engaged in separately budgeted research on the campus grew from 238 in 1958 to 358 in 1962, or an increase of 50 per cent in four years. There was an equivalent growth in the participation of graduate students in this research, expressed as full time equivalents.

That there might be room for further growth along these lines can be seen in Table 11 which indicates that only one-half of the total M.I.T. faculty and one-third of the graduate students were participating in sponsored research programs in 1962--a degree of participation that has increased steadily with the growing availability of funds and with a conscious effort to minimize the growth of full time research staff employed to conduct on-campus research. (34)

(34) For a full account of M.I.T.'s emphasis of educational values in sponsored research, see the study by J. A. Stratton in the <u>M.I.T. President's Report</u> for 1961, pages 12-22.

(TABLE 11)

PARTICIPATION BY M.I.T. STAFF AND STUDENTS IN SEPARATELY BUDGETED RESEARCH, 1958 and 1962

A.

PARTICIPATION BY M.I.T. ACADEMIC AND RESEARCH STAFF IN SEPARATELY BUDGETED RESEARCH (DSR) 1958-1962.

(Full Time Equivalents)

	1958	1962	Percent Increase
M.I.T. Academic Staff Participating	622	992	59%
Full Time DSR Research Staff (on-campus)	312	367	17%
Full Time DSR Research Staff (off-campus)	1,127	1,087	(4%)
Total Professional Staff Participating	2,061	2,446	18%

Source: Division of Sponsored Research, Visiting Committee Reports.

B.

PARTICIPATION BY M.I.T. FACULTY ONLY IN SEPARATELY BUDGETED RESEARCH (DSR) ON-CAMPUS 1958-1962

	1958	1962	Percent Increase
Total M.I.T. Faculty (Professors only)	591	728	21%
Total Engaged in DSR Research	238	358	50%
Per Cent Engaged in DSR Research	40% (1)	49%	9%
Total M.I.T. Faculty (Full Time Equivalents)	591	728	21%
Full Time Equivalents Engaged in DSR Research	101	146	45%
Per Cent Full Time Equivalents Engaged in DSR Research	17%	20%	3%

Source: DSR Visiting Committee Reports and Registrar's Reports on number of Faculty Members.

(1) This percentage is lower than the 44% of faculty engaged in R & D in 377 institutions mentioned in the NSF 1958 study. Doubtless the M.I.T. figure for faculty participation would be higher than the national average if all M.I.T. faculty research and development activity were tabulated.

(TABLE 11)
continued
C.

PARTICIPATION BY M.I.T. STUDENTS IN SEPARATELY BUDGETED RESEARCH (DSR) ON-CAMPUS, 1958-1962

	1958	1962	Percent Increase
Total Regular Graduate Students	1,970(1)	2,462(2)	25%
Total Graduate Students Engaged as Assistants	555	817	29%
Per Cent Graduate Students Engaged as Assistants	28%	34%	6%
Total Regular Graduate Students	1,970	2,462	25%
Equivalent Full Time Graduate Students in DSR Research	405	633	56%
Per Cent Full Time Graduate Students in DSR Research	21%	26%	5%

Source: DSR Visiting Committee Reports
Annual Reports of the Dean of the Graduate School.

(1) Spring 1958
(2) Fall 1961

The opportunities for further growth of faculty participation would seem to depend upon the growth of sponsorship of research in a number of "new" areas both within the fields that are now receiving support and, to a greater extent, in the fields that are now not well supported. Later on, we shall touch upon this paradox of poverty among plenty, and the special problems it creates in the "science rich" institutions which are the locus of heavy federal spending for research in selected areas. The problem is not confined to the social sciences and humanities. There are fundamental areas within the natural sciences and in engineering that are grossly underfinanced, e.g., earth sciences, fiber research, chemical engineering, nuclear engineering, high temperature chemistry, structural engineering, biochemical engineering, and many more. In these areas and in others faculty members would like to be more extensively engaged in basic research but inadequate funds hold their research programs in check.

Undergraduate Involvement

Another direction in which increased faculty participation is sure to come is through the increased involvement of undergraduate students in university research. Nationally, a significant move in this direction could also be the means towards a greater involvement of institutions. The reader will recall that 681 institutions offer graduate degrees while another 766 institutions offer only the bachelors degree. Within the 681 institutions which offer both graduate and undergraduate degrees, one might expect the first gains to be realized at the undergraduate level. It is well known that strong undergraduate programs are best maintained in the stimulating environment of strong graduate schools, and the best among these are those institutions in which graduate and undergraduate teaching is interlocked through a common faculty.

At M.I.T. the role of the undergraduate in sponsored research has received increasing attention in the postwar growth of research at the Institute. Commenting on the establishment of the Research Laboratory of Electronics and the Laboratory for Nuclear Science in 1946, President Karl T. Compton said prophetically, "While we call them 'Centers of Research' because research is their predominant role, they are nevertheless destined to play a very important role in our educational program, especially at the senior and graduate student thesis levels."[35] In his 1961 study of sponsored research at the Institute, President Julius A. Stratton emphasized the growing involvement of undergraduates in M.I.T. research activities[36] and later, in an Alumni Day address on June 12, 1963 he pointed up the role of undergraduate research as a major direction of future development.

(35) M.I.T. President's Report 1945-46, pages 22 and 23. Students at M.I.T. are required to submit a senior thesis for the bachelor's degree. (My underlining.)

(36) Op. cit. pages 22-30.

Educational Criteria

So far we have said that research is an invigorating, and in some areas necessary, element in the educational process. The basis for this statement is simply that good students make good teachers, i.e., the process of teaching (the transmission of knowledge) is enriched and enlarged by an intimate association with the generation of new knowledge.

There are, of course, colleges and universities which do not encourage research to any extent. Indeed, at institutions where it plays a prominent role, a sizeable fraction of faculty members do not participate. The fact remains that such institutions and faculty still benefit from the search for new knowledge conducted elsewhere or by others. The price paid for teaching in isolation from research may involve a retreat from the cutting edge of knowledge and a higher rate of obsolescence in curricula dealing with areas of science and engineering that are changing rapidly, or where significant advances are occurring in research conducted outside the university. But many faculty and institutions are willing to pay the price.

When research is sponsored, it expresses a mutuality of purpose between sponsor and recipient. An abstract view of the university might lead one to conclude that any influence by the sponsor upon the direction or selection of study is an *a priori* interference with academic freedom. This view is closely linked with an antiseptic concept of university life and presupposes a predominantly passive character in the make-up of institutions of higher learning. History indicates otherwise. Great universities have always concerned themselves with the urgent problems of their time.

Speaking from Harvard's experience with the federal government, President Nathan A. Pusey recently summarized the universities' involvement in a variety of federally financed programs in a September 1961 report as follows:

> "At the same time the university is led to a new relationship with Government by more than a need for money; if only that were involved, it might be desirable to renounce Federal grants in order to avoid any risk to academic freedom. But science and technology have done more than make academic research and teaching expensive; they have made them a necessary ingredient in national policy and in the advancement of human welfare. The university no longer expects to avoid involvement in public affairs, for it is by now all too clear that free universities and free political institutions are interdependent and their future intertwined."(37)

Sponsored research, then, is a desirable aspect of university life, not because it is free of conflicts, but because the area of mutual interest between sponsors and universities far overshadows the area of conflict. It is the search for a common ground between institutional objectives and those of the sponsor which concerns us here.

In this, a central question revolves around the criteria by which the university will accept or reject a research program. Two main considerations should be satisfied. First, the university must be free

(37) Harvard University. Harvard and the Federal Government. Cambridge, Massachusetts, 1961, page 27.

to determine independently whether a research proposal contributes to or detracts from the role it sees for itself. This principle of self-determination is not only essential to the prosecution of a research program, but also vital to the preservation of the institution itself.

Second, if research is to be productive in an educational sense, it should be motivated by educational objectives and not narrowly by a specific end-use of the knowledge sought. Whatever it does, the university will not want to depart from its primary function as an educational institution. Using this standard, the choice of research at a university is bound to be influenced by the character of education there, as well as by the nature of the disciplines represented. Institutions which emphasize the teaching of fundamentals are more apt to favor basic research over those whose objectives are primarily vocational. Institutions which accept responsibility for leadership in developing specialized fields or in promoting new educational concepts are more apt to favor research that directly involves professors and students as participants over those institutions which are primarily followers.

This is not to say that university research is inseparable from teaching, nor that research conducted in the universities is disabled if it is insulated from education. In many places it is separated by design, as in the case of contract research centers and to a lesser extent in the questionable practice of appointing faculty members to full time research positions which carry no teaching responsibilities. Far from it. Universities provide an excellent environment for research, whether or not it is linked with teaching. Their faculties encompass an incomparable reservoir of scientific talent.

But that is not what concerns us here. In suggesting an educational criterion for university research we are expressing a fundamental preference for evaluating research in terms of its effect upon education not the reverse of this order.

One can differentiate between full and less-than-full employment conditions in applying the second criterion described above. In an area where educational capacity exists (faculty, space, funds, etc.) but is not being utilized fully, the connection between research and teaching can be less demanding. For example, a given research program may serve desirable educational ends, even though no students are directly participating, if it serves the professional development of faculty alone. Obviously, the closer an institution is to the maximum use of its resources, the more concerned it will be, must be, about the integration of research in the educational process. But even under the most crowded conditions existing in the universities today, there is a wide range of utilization of resources. Variations in student enrollment, the tenure system, curriculum rigidities, discontinuities in space allocation and a host of operational factors that are part of everyday university life coalesce to produce a range of economic constraints operating at a given place at a given time, so far as research proposals are concerned. Thus, it is difficult to apply a simple, single-valued standard in evaluating research proposals. Instead, the practice has grown up, administratively, of asking a series of questions, not all of which may be satisfied in a given proposal. Examples are:

1. Does the research in question "belong" in a particular department or in an institution in the first place?

2. Is a faculty member interested and willing to supervise the research?

3. Is the research suitable for student participation?

4. Are the available space, personnel, and funds adequate to the task?

One can hypothesize that it might be desirable to develop measures of the interrelationships between research and teaching. Under full employment of university resources, it might be especially helpful to develop standards at all levels of decision (Department, School, Institution). These standards would seek to make explicit a part of what is now accomplished implicitly in the process of administrative review. For example, one could start with the basic idea that teaching requires two parties: the teacher and the student. From this, one could develop a measure of the educational opportunity afforded by a given research proposal.

If a unit could be defined that would adequately express this combination of teacher and student, one might have a basis for determining the relative educational opportunity of two research proposals, or for comparing a given proposal with existing standards in the department from which the proposal originated. The reader should note carefully that the writer has used the expression "educational opportunity" and not "educational merit." We shall return to this subject in the next chapter in an attempt to introduce opportunity cost analysis in the research project selection process.

Basic Versus Applied Research in the Universities

In the aggregate, the division of university research between basic and applied is weighted on the basic side, although applied research and development are by no means excluded. For example, the National Science Foundation has estimated a 64-36 split between basic and applied research on the nation's campuses in fiscal 1954.[38] By fiscal 1958 the Foundation reported a 74-26 split between basic and applied research.[39] On the basis of a substantial enlargement of basic research in the universities in the post-Sputnik period, it seems safe to guess that the relevant percentages are now probably 80-20.

The use of categorical definitions to segregate research which universities should or should not perform generated a great deal of discussion in the early 1950's. At that time the debate over research definitions became encased in the discussions between university business officers and government representatives over the charging of university expenses properly allocable to grants and contracts for research sponsored by the federal agencies. In retrospect, the debate produced more heat than light, but

(38) National Science Foundation. Scientific Research and Development in Colleges and Universities, Expenditures and Manpower 1953-54. Washington, 1958.

(39) National Science Foundation. Scientific Research and Development in Colleges and Universities, Expenditures and Manpower 1957-58. Washington, 1962. These percentages are based on the institutions' own evaluation of the character of the work they perform on their campuses. There may be some tendency towards exaggerating the basic research component, but this seems less likely today than a decade ago.

it did result in a firm statement by the American Council of Education which clarified the position of the universities. The Committee on Institutional Research Policy commented on the division of university research between basic and applied studies as follows:

> In our society educational institutions are the principal sponsors of basic research and uncommitted scholarship. They therefore have heavy responsibility to encourage the free exercise of intellectual curiosity as their special share of the nation's research activities of all kinds. At the same time they should not be limited by any narrow or doctrinaire definition of what is appropriate research. We believe that fine distinctions between basic research and applied research are difficult to draw. Investigators should be free to pursue that kind of research which contributes best to their educational objectives and to the fields of investigation they embrace.(40)

During the mid-1950's, the growing volume of federal sponsorship raised serious questions about the effect of continued heavy federal spending

(40) Sponsored Research Policy of Colleges and Universities, A Report of the Committee on Institutional Research Policy. American Council on Education, Washington, 1954, page 5. Interestingly, the Committee urged that at no time should a university permit basic research to be less than 50% of its research volume.

on the character of university research. In a celebrated 1958 study, Basic Research, A National Resource, the National Science Foundation laid great stress upon the importance of support basic research for its own sake, as well as for the future vitality and strength of the nation. The following year a rash of conferences were held on this subject throughout the country, and the nation's concern for basic research and for education was expressed at the highest level of leadership. Speaking at the Symposium on Basic Research in New York City, May 14, 1959, President Eisenhower said in part:

> The dignity of man is enhanced by the dignity and freedom of learning. How well the learning is accomplished depends upon the competence and devotion of those to whom the training is entrusted: the teachers and educators at all levels, everywhere, throughout our land. So let us cultivate more respect for learning, for intellectual achievement, for appreciation of the arts and humanities. Let us assign true education a top place among our national goals. This means that we must be willing to match our increasing investments in materia resources with increasing investments in men.[41]

(41) Symposium on Basic Research. Washington, American Association for the Advancement of Science, 1959, page 141.

The practical difficulty of applying workable definitions of basic and applied research has led educators to de-emphasize the semantics in favor of such educational criteria as those mentioned earlier. Does the proposed research contribute to the professional development of the principal investigator? Is it suitable as a possible thesis topic for interested students? In practice, almost all universities engaging in sponsored research are equipped to do applied research, and many do so either from a sense of public duty, or because of faculty preferences, or in consideration of sponsors' interests. This is not to say that universities live in an ideal world. Most of them would prefer to place more emphasis upon basic studies if financial support were available in the amounts and areas needed.

The evaluation of sponsored research in an academic setting is usually stated in terms of praise and criticism of present systems of sponsorship. These arguments have been stated more often in form than in content. Objections to "projectitis," lack of control by university administrations, amount of time required by faculty members to do research at the expense of time spent with students--these and allied questions are not in opposition to the basic concept of research on the university campus. Such criticisms are sometimes aired by those who place only a nominal value on the regenerative effect of sponsored research and are more impressed with the shortcomings of the present system than its substantive advantages. In theory and practice the concept of federally sponsored research is workable. It is, in fact, a key to future growth and attainment in American institutions of higher learning.

CHAPTER VIII

PROJECT SELECTION AND TERMINATION

In most educational institutions, research project proposals originate with faculty members. They are reviewed internally before formal submission and leave the institution as officially executed documents which become binding upon the institution when the proposal is accepted by the sponsor.

Beyond this general statement of procedure there are no general studies from which data can be drawn on the machinery of project selection in the universities. Even if such data were available at the national level, it is doubtful whether they would have much significance in illuminating the procedures by which projects originate, are developed as formal proposals and are finally accepted. For meaningful insights one must turn instead to the experience of individual institutions and accept the limitation that the data may be so embedded in institutional characteristics that generalizations are risky if not unwarranted.

In this section the writer has examined the procedures for processing sponsored research proposals at three institutions which participated in the 1961 self studies conducted under the auspices of the Carnegie Corporation--Harvard, Princeton and M.I.T. Each institution maintains an administrative department which is responsible for the business administration aspects of separately budgeted research sponsored under grants and contracts. Each maintains a professional staff whose full time responsibility it is to administer this research in accordance with the established policies of the institutions they represent. The respective groups are the Office for Research Contracts at Harvard, the Office of Research Administration at Princeton, and the Division of Sponsored Research at M.I.T. A brief description of the formal organization of research administration at these three institutions will illustrate the variety of arrangements that now exist.

Harvard

The Office for Research Contracts administers the details of research grants and contracts, which were formerly handled by the Treasurer's Office. The Office reports to the Administrative Vice President of the University who has special responsibility for all federally sponsored programs in any department of the University, although his responsibility in the Medical School is shared with the Associate Dean. The Office for Research Contracts deals with all federally sponsored grants and contracts, with the exception of grants from the U. S. Public Health Service. For these, the Administrative Vice President or, as appropriate, the Associate Dean of the Medical School signs grant applications. The reasons for this division of labor are largely historical.

The coordinating instruments at Harvard are the Committee of Deans and the Committee on Research and Development, with the President of the University serving as chairman of both.

Princeton

The Office of Research Administration reports to the University Research Board. This Board is a faculty committee composed of four faculty members appointed by the President, two faculty members elected at large by the faculty, a Chairman appointed by the President of the University, the Treasurer of the University, and the Director of of the Office of Research Administration, who serves as Executive Officer of the Research Board. Each of the four main divisions of the University (Humanities, Social Sciences. Natural Sciences, and Engineering) is represented by at least one faculty member on the Board.

The Research Board is responsible directly to the President and is concerned with policy formulation and supervision. Grants or contracts over $10, 000 must also be approved by the Board, or the Chairman of the Board acting for the membership. The Office for Research Administration is the administrative arm of the Board. Prior to the establishment of this organization many of the present research administration functions currently carried out by the Board and by the ORA were performed by a group called the Committee on Project Research and Inventions, which was established in 1946 and disbanded in 1959. The transition from the Committee to the more broadly based Research Board was accomplished in part to reflect the belief that a sizable research program at Princeton inevitably affects the University as a whole.

Massachusetts Institute of Technology

The Division of Sponsored Research reports to the Vice President for Research Administration, who serves as Chairman of the Committee on Sponsored Research. The members of this Committee are the Dean of Engineering, the Dean of Science, the Director of the Division of Sponsored Research, the Comptroller and the Vice President for Research Administration. The Committee serves as a board which formulates and supervises research policies approved by the Executive Committee of the Corporation, of which the President of the Institute serves as Chairman. Grants and contracts whose budgets are over $35,000 must also be approved by the Committee on Sponsored Research or the Chairman, acting for the membership of the Committee.

The Division of Sponsored Research has the immediate responsibility for all research contract and grant administration at the Institute. All contracts and grants are prepared by the Division. But the Executive Committee of the Corporation has designated the Comptroller of the Institute as the legal signator for M.I.T. The Comptroller, in turn, reports to the Treasurer of the Institute.

M.I.T. has two additional committees concerned with patent affairs: the Faculty Committee on Inventions and Copyrights, and the Committee on Patent Management. These two committees are concerned with patent policy and patent administration respectively. The Vice President for Research Administration serves as Chairman of both.

The Faculty Committee on Inventions and Copyrights is appointed by the President. It deals with patent problems arising from activities of both staff and students, including inventorship, equities between co-inventors or between inventors and the Institute, inventor participation in financial returns, and the disposition of patent equities which the Institute does not wish to exercise.

The Committee on Patent Management is also appointed by the President. It is charged with administrative affairs such as advice to faculty members and sponsors on contractual arrangements involving patents, to determine the character of inventions on which patent applications are to be filed, and in general to represent the Institute in all matters of patent policy affecting M.I.T.'s relations with the federal government, industry and the public.

Whereas the Faculty Committee on Inventions and Copyrights is composed of Faculty members, the Committee on Patent Management is comprised largely of administrative officers, including the Director of the Division of Sponsored Research, to whom the M.I.T. Patent

Office reports.

Some interesting contrasts can be noted among the three institutions in terms of their organization for research administration:

a) a less centralized administrative control at Harvard.

b) personal participation by the university presidents in special research policy committees at Harvard and Princeton, whereas research policy at M.I.T. is ultimately an Executive Committee matter.

c) different patterns of reporting at each of the three institutions involving vice presidents for administration, treasurer, and research administration.

d) different thresholds of approval requiring higher levels of authority.

e) varying degrees of faculty participation in research administration committees.

Procedure for Establishing Grants and Contracts for Sponsored Research at M.I.T.

The following statement taken from the M.I.T. pamphlet Policies and Procedures, August 1961[(42)] describes the formal approval procedure at M.I.T.:

(42) Op. cit., page 22. At the August 1961 printing of Policies and Procedures, research grants-in-aid from private sources were not centralized in the Division of Sponsored Research. They were administered by the various academic departments. At this writing, all but a small fraction of these grants have been brought under the supervision of the Division of Sponsored Research. Thus, the statement above now applies to all grants as well as contracts for research at M.I.T.

"1. Preliminary negotiations may be carried on between a faculty member and a sponsor, but no proposals or commitments should be made.

2. A proposal by a faculty member for D. S. R. contract research with either government or industry must first be approved by the head of the department concerned, who should satisfy himself that (a) the project is appropriate for the department to undertake as a part of its educational and research program; (b) senior staff are available and willing to supervise the research; and (c) adequate space and facilities are available. Proposals should include a budget based on advice from the D. S. R. office.

3. After departmental approval, the proposal should be submitted to the appropriate dean for endorsement. The dean will also determine the appropriateness of the project in relation to the entire Institute program of research.

If the proposal has an annual budget exceeding $35, 000, the dean's approval is guided by the decision of the Committee on Sponsored Research acting within policies determined by the Executive Committee of the Corporation. The Committee on Sponsored Research may also be asked to approve projects affecting interests outside of the school in which the proposal originates.

Project supervisors must plan in advance in order to allow sufficient time for administrative review of all proposals.

4. After administrative approval, as outlined under Item 3, the proposal is sent to the D. S. R. office. All contracts are prepared by the D. S. R. and signed by an official of the Institute approved by the Executive Committee of the Corporation. When negotiations have been completed, the D. S. R. office will notify the dean, department head, and the project supervisor.

5. Contract renewals or extensions involving additional funds also must be approved by the procedure outlined above.

6. Any correspondence proposing modification of the terms or conditions of a research contract, including changes in the scope of the work or the period of performance or an increase or decrease in the total estimated costs, should be forwarded by the D. S. R. office."

The reader may wish to compare a statement of criteria which has been drawn up to guide sponsored research selection at Princeton.

It is similar although somewhat more detailed than the M.I.T. statement presented above.

At one of its early meetings, the University Research Board at Princeton decided that it would be advisable to have a written statement of criteria to be used in judging whether the University should undertake any given research project. After considerable discussion, the following statement was agreed upon by the Board, approved by President Goheen, and circulated to all department chairmen:

"It will be the policy of the University, the University Research Board, the departments and members of the faculty involved to consider the merits of any proposal for sponsored research based upon the following criteria:

1. The research should fit within the framework of the four primary and essential objectives of the University.....(1) The education of undergraduate, graduate, and postdoctoral students; (2) The advancement of knowledge through research and scholarship; (3) The preservation and dissemination of knowledge; (4) The advancement and protection of the public interest and public welfare.

2. The research should be soundly based and give promise of a significant contribution to knowledge, and the personnel involved should be qualified and enthusiastic.

3. The research should be proposed and carried out within a regular department of the University or through the cooperation of several departments, and be led by a member of the faculty.

4. The research should not extend the activities of the department or departments involved too much, increasing the quantity of research at the cost of quality or to the detriment of undergraduate or graduate education.

5. Adequate facilities should be available or provisions should be made for funds to make them available.

6. There should be a good prospect of employing any additional professional or non-professional personnel required within the limits of existing salary scales and personnel policy.

7. The budget should be adequate for the work proposed, including allowance for contingencies and possible salary increases.

8. Provision should be made for any University funds required, whether in the form of direct costs or indirect expenses computed in accordance with usual University practice.

9. If the research is to involve Governmental security regulations and classification, it should conform with the 'Report and Faculty Resolutions With Regard to Security and Classification in Government Sponsored Research' approved by the Faculty on May 4, 1953.

10. The terms of any contract, grant or gift to cover the research should, insofar as possible, permit flexible operation under regular University policies and procedures, permit free publication of results (except where the requirements of national security dictate otherwise), reimburse the indirect expenses as well as the direct costs of the research, conform to the principles of the University Patent Policy, and in general permit the University to exercise administrative control and responsibility for the work."(43)

How the Present System Works

So much for the formal description of research organization at Harvard, Princeton and M.I.T. How does the system of approvals actually work? Are any generalizations possible?

At the outset it is important to observe that an educational

(43) Bowen, W. G. The Federal Government and Princeton University. Princeton, 1962, pages 10 and 11.

institution is a highly decentralized enterprise. In contrast to the more authoritative forms of research organization in all but a few governmental and industrial laboratories, the university is at the lessez faire end of the spectrum with regard to decision making in research. This is so because of the broad sanction to advance knowledge for its own sake and for its educational value under which university research is conducted, in contrast to the profit or product orientation around which most industrial and governmental laboratories are organized.

Decisions bearing upon academic life are made at all levels of faculty and administration, and the crucial decisions as to the subject matter of research proposals are made by faculty members acting largely, although not always as individuals. This is not to suggest that there is no exercise of institutional authority, but simply that in an intellectual community professional decisions are initiated on an individualistic basis. In contrast to administrative decisions, professional decisions in research rarely go beyond the level of the department chairman. Students themselves participate in this decentralized order by their choice of academic subjects and of topics for thesis investigation. They are n turn conditioned by the values held by their parents and by their intellectual environment.(44) Alumni, trustees, and

(44) See, for example, the study by David Riesman. "Influence of Student Culture and Faculty Values in the American College." Chapter Two in Year Book of Education. New York, World Book Company, 1959.

visiting committees bring further significant influences to bear in all phases of university operation. The organizational make-up of the university thus involves a complicated interplay between faculty, students, parents, committees, department heads, deans, other university officials, and trustees who may serve on a part-time basis.

To fulfill their essential functions, institutions of higher learning require freedom in both their administrative and academic pursuits. In the selection of research projects this means that individuals can best contribute when they are free to determine whether a subject is worthy of investigation. Even if faculty members were willing, it would be foolhardy for an administration to pose as authority on problems that should be studied. Institutions properly emphasize fields of scholarship by the choice of disciplines they support but their ability to discriminate among research problems is inherently limited. The identification of a problem is an integral part of the research itself and is best done by the individual or group proposing the investigation. In university research, no less than in industry and governmental settings, there is no substitute for the individual's knowledge and judgment.

When research is sponsored by a federal agency, there are three parties to the selection of a project: the faculty member or group proposing the project; the interested agency; and a university organization which must provide a setting for the conduct of the research. The final selection requires that each play a role in determining the desirability of a particular project at a particular institution at a given time. The individual can contribute his specialized knowledge in the formulation of plans and objectives. The government agency is interested in sponsoring research to cover the development of a field related to its responsibility. The university must insure that the project fits its criteria, that it is worthy, that it is consistent with the educational pattern of the institution, that it can be accommodated by the physical and administrative facilities.

With funds for support, the government agency can wield positive influence in pointing up the relevance of a research proposal to the national need and in revealing plans for similar undertakings at other institutions. The agency frequently has information about research activities in a general field which may be of value in determining whether research of a particular type can best be conducted at a given institution.

The institution itself must provide a balance among alternative research possibilities on its campus. Once in possession of a proposal by a member of its faculty, the university must decide whether the research makes sense in terms of its capabilities and chosen lines of development before placing it formally with the sponsoring agency. Usually, the machinery for arriving at this decision will include the faculty member himself. Beyond the satisfaction of institutional criteria the individual is free to pursue his research as he sees fit.

There is much variation in the procedures by which research proposals reach the attention of the offices responsible for administering sponsored research at Harvard, Princeton and M.I.T.--more so than the variety of organizational arrangements described earlier. In general, all research proposals require the signed approval of department chairmen. At Harvard and at M.I.T. the appropriate dean must also affix his signature before proposals are submitted to the sponsored research office for further processing. But there are almost as many patterns of departmental organization for research proposal review as there are departments at the three institutions.

Some department heads play a passive role and wait for research proposals to be submitted to them by individual faculty members. Others may encourage the submission of research proposals to stimulate research in the department or to fill a budgetary gap in an area that lacks support. Some departmental chairmen encourage formal review procedures ranging from a few close colleagues to a few senior faculty to full committee review by the entire department. Some rely on faculty members who serve as executive officers in their department to handle research administration; others do it personally. There is no standard form. At all three institutions individual departments are free to frame their own procedures, and they have exercised this freedom generously.

The most significant point to be made about individual freedom in the choice of research problems is that the three institutions rely on means other than the project-by-project approval or disapproval of research proposals to shape their over-all research program. Project proposals are, in fact, rarely rejected in a formal sense. Long before the internal machinery of formal presentation has begun to operate the faculty member has ascertained whether the research he wishes to undertake can make a significant contribution to his field of interest, whether it is likely to be judged appropriate to institutional criteria, and whether there is a reasonable promise of sponsorship.

The individual will be self-disciplined in advance through previous exposure to the scrutiny and accomplishments of colleagues both within the institution and in the larger scientific community. His professional advancement is directly involved. Thus, the project review procedure does not operate in a vacuum nor without institutional and professional constraints operating on the faculty member. It begins with responsible members of the academic community and is conditioned by the values and standards implicit in academic life.

The "other" means by which institutions seek to achieve quality control, balance, and direction in their research programs include the traditional tools of academic administration--recruitment of talented faculty members in fields of institutional interest, the use of the tenure system to encourage or discourage a particular field or individual, an unremitting emphasis of excellence in academic pursuits, space and budgetary controls applied at the level of departments, quotas on departmental enrollments at the graduate level, and most important perhaps of all, the deployment of uncommitted funds to underwrite the achievement of institutional goals. One of the least understood essentials of educational finance in the presence of large research undertakings is the magnitude of unrestricted funds needed to maintain balance and direction of the over-all research program when the separate elements have wide lattitude of freedom.[45]

The reader should not conclude that the elaborate machinery for project proposal review described earlier serves merely as a rubber stamp on the research aspirations of individual faculty members or particular laboratories. The means to exercise project-by-project control over the scientific direction of research resides in the system, even though the center of gravity for professional judgments rests, as

(45) Private sources of support can wield an enormous leverage when an institution's sponsored research volume is large, in terms of providing the free funds that enable an institution to balance its over-all program at a high (rather than lower) rate of expenditure.

it should, with the individual investigator. Formal project review can theoretically involve the highest institutional authority (and sometimes does when questions of institutional policy are at issue). This in itself is an important element of self-discipline in the system. But it would be a mistake to infer that professional anarchy accompanies the limited exercise of this authority from above.

Those who question the effectiveness of this permissive system of management have exhibited a consistent tendency to regard sponsored research as an appendage rather than as an integral part of the educational process today. Their evaluation of project selection procedures correspondingly assumes that these procedures somehow stand alone in the screening process. Clearly, they do not. They are interdependent with academic administration and its myriad forms of institutional control operating at all levels of decision in the university.

Despite the added safeguards of academic administration an institution's portfolio will inevitably contain at any given time projects less desirable than others, and, indeed, projects that become marginal before they are completed. Faculty judgments are not infallible, nor are the controls uniformly effective. Any selection system that claims an automatic or impersonal ability to discriminate among research proposals in an academic setting runs a risk of stifling individual initiative, which is the least attractive alternative to university management.

Marginal research is not by definition a waste if it serves to develop faculty and to educate students. "Unproductive" lines of inquiry frequently provide as sound a basis for new directions of study as those projects which result in significant findings. The inefficiencies of university project selection can thus take two forms: the freedom of the individual to choose research methods or topics which lead to poor results, and another which is purely administrative--a small but certain number of marginal projects from time to time.

The reader may properly ask: Are formal research proposals <u>ever</u> rejected within the university? The answer is, yes, but the formal rejections typicaly involve projects or programs which originate outside the university from potential sponsors and not those which originate from within. There are no general studies of the selection process that would indicate how many unsolicited requests are received by the university community and what share of these eventually become university research projects. The requests come to a number of locations within the university and may or may not result in further action. In the aggregate, they represent an insignificant percentage of the total research proposals considered formally by the universities--probably well under 5 per cent of the total.

What is more likely to happen is that potential sponsors will indicate their interest in receiving proposals from the university regarding sponsored research in a general area of investigation. Or faculty members will solicit or be aware of the research interests of sponsoring agencies through previous contracts, personally or through colleagues. Thus, sponsor interests are registered in a more or less continuous way with faculty members and with the administrative offices responsible for sponsored research in the universities.

To what extent faculty interests or sponsor interests ultimately shape research proposals is hard to determine. This question involves a number of hypothetical considerations as to the choices faculty members would make if they were entirely free to shape research plans on their own. But there has not been a great deal of concern expressed over undue influence from sponsors in fields that are eligible for support. Most of the concern is about the lack of support in fields that are not sponsored and the effect of this uneven sponsorship on the shape of the over-all university research program. We have noted earlier the steady increase in the share of university research that is regarded by the educational institutions as basic research. One might conclude that the universities were gaining ground in the continuing effort to relate sponsor interests to their own preference for fundamental studies. This is probably true but it would be incorrect to equate basic research with university interests alone, for government sponsors have also been in the position of questioning whether basic research funds at their disposal should be used to support faculty research proposals on applied problems. For example, the acceptance of an ever-widening field of support by the National Science Foundation in its first ten years of operation has involved a steady pull from the universities towards such fields as engineering and the social sciences which are, by their nature, more concerned with applied subject matter than are the physical sciences and mathematics--which were the original focus of NSF interest.

Shifts of sponsor interests from one period of funding to another are of special concern to the universities because of the short-term nature of present research sponsorship. It is in the context of grant or contract extensions and modifications that the interplay of faculty and sponsor interests come into sharpest focus. Here the university has made a past commitment of personnel, space, and facilities and the changes that may be required to accommodate modifications of sponsor interests are generally less attractive to the university than the commitment of university resources to new research projects faculty members may wish to undertake. While federally sponsored research in the universities is growing rapidly, it is important to remember that its growth is only one aspect of the selection process. Of equal importance is the problem of maintaining the direction, quality and continuity of existing programs. Here the welfare of sponsors and universities have a deeper interdependence because both parties have vested interests in the quality and direction of work under way.

It might be instructive to the reader to have an example from M.I.T.'s experience in the matter of proposals originating externally to modify on-going work. One faculty member in the Department of Electrical Engineering has kindly made available an exchange of letters between M.I.T. personnel and a sponsoring agency to illustrate the nature of shifts in sponsor interests and the problems they pose for university research programs. In deference to privacy, we shall refer to the faculty member simply as Professor Friend.

The example has a number of elements in it that dramatize the responsible position taken by individual faculty members in seeking outside support. The sponsor had been the sole source of support for a research group supervised by the faculty member for eight years. The sponsor's mission was primarily hardware development but it had supported basic research at M.I.T. under Professor Friend because the agency believed his work to be important to its long-term interests. At the same time there was no unanimity within the agency about Professor Friend's basic research program, and there were at least two schools of thought about the desirability of spending the agency's funds in this manner. The Department of Electrical

Engineering had a sizable investment in the area of study, including a formal laboratory organization, regularly published reports emanating from the laboratory, and there were a number of graduate and undergraduate students writing theses on various aspects of the research. Professor Friend's laboratory was an educationally productive center in the Department, indeed, one of its major laboratories. Professor Friend and the contracting officer for the sponsor were thoroughly acquainted through years of personal association in this sponsored research program. They liked and respected each other. The contracting officer had defended the agency's support of Professor Friend's laboratory over the years. It was contract renewal time, and over $100,000 was involved in the budget for the coming year.

The exchange of correspondence reproduced in the following pages concerned a desire on the part of the sponsor to reduce the ongoing work in the laboratory by 20 per cent in order to accommodate a new investigation under the contract to be renewed. Professor Friend's thoughtful refusal and his advice given to the sponsor illustrate the responsibility for professional decisions residing with individual faculty members, as described earlier. It also illustrates a major benefit accruing to federal sponsors of university research, namely, advice and guidance on the prosecution of government research programs whether or not they are eventually placed in the universities.

Professor Friend's determination to maintain the current allocation of research effort under the contract included saying "no" to a personal appeal written by the contracting officer, all of this occurring against the backdrop of a crucial period of contract renewal.

COPY

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Division of Sponsored Research
Cambridge 39, Mass.

Office of the Director

March 12, 1959

MEMORANDUM

TO: Professor Friend

FROM: Assistant Director

We have received a telephone call from ________________ in respect to the addition of a new area of investigation under Contract ________________. This will be provided by Attachment A to the present scope and is identified as Microwave Power Rectification. They are now asking that you review this additional work and we are to advise ____________________ as promptly as possible if you can reduce the rate of effort on other areas of investigation and apply approximately 20% of your over-all effort to the work under this new Attachment A.

I understand that Mr. _______________ is now the Technical Monitor for this program and is in a position to discuss any questions you have in respect to this request.

They are also interested whether this will involve any change of manpower or equipment requirements.

COPY

March 17, 1959

TO: Assistant Director

FROM: Professors Friend and Prince

In reference to your memo of March 12, 1959, regarding the request by ________________________ to add Attachment A entitled Microwave Power Rectification to the extension of Contract __________ for the period beginning April 1, 1959, it is, in our opinion, not in the best interest of this research program. The Magnetohydrodynamics (MHD) Research, as contained in our proposal dated February 10, 1959, calls for an integrated effort and the faculty and research staff which are available to work in this area are motivated by interest and experience to follow the program as outlined.

Attachment A which covers work in Microwave Power Rectification requires technical competence which is outside the scope of the present MHD work. It is also our opinion that study of the problems of energy transmission by microwave radiation is a large scale effort which should be studied in an integrated fashion by a single research activity or at least closely correlated between research activities. While a part of this program similar to Attachment A can be undertaken it is our opinion that it should be defined in relation to the total program; and further, when this is done, the magnitude of each individual task will probably be a large scale effort. To underestimate the complexity of the problems in microwave radiation and utilization of said energy would be a serious error at this time. We have specifically discussed Attachment A with Professor __________ who is in charge of the Microwave Tube Laboratory in the Research Laboratory of Electronics at the Massachusetts Institute of Technology and he feels that $20,000 used by experienced people in the microwave tube area could provide an adequate definition of a research program in this area. He further indicated that at this time the problem was not of interest to him. Since Professor ____________ was not interested in this problem and no one associated with the energy conversion activity is active in the microwave tube area we feel that any attempt of our group to undertake Attachment A would be an unwise use of funds. If the (Agency) can interest a research activity where a strong competence in microwave tube and techniques exists, we strongly advise them to do so. We would also like to inject the thought that the problems of microwave transmission of power for energy conversion processes is fraught with immense difficulties other than rectification. Since we have had no personal contact with the background research in this area where feasibility has apparently been proven our suggestion of further study of the whole idea may be unnecessary. If, however, feasibility has not been established we urge caution in entering a program of this sort. In light of the above and considering our interest in maintaining an effective research group in magnetohydrodynamics we respectfully request that Attachment A not be included in the extension to Contract ______________.

COPY

March 17, 1959

Massachusetts Institute of Technology
Department of Electrical Engineering
ATTENTION: Professor Friend
77 Massachusetts Avenue
Cambridge 39, Massachusetts

Dear Tom:

I am writing this unofficially to solicit your cooperation in extending your efforts under Contract . ________ to include preliminary work in microwave power rectification. It is my understanding that the current contract negotiations for extension of the program are proceeding on the basis of the recently mutually agreed to work statement which did not include the microwave rectification.

I realize that you cannot, at this late date, handle the preliminary investigations on microwave rectification on the basis of a doctorate thesis or give it the attention you normally give any specific segment of the energy conversion program. We do have an immediate need for an exploratory effort to determine possible methods of converting S-band radiant energy to useful power. I cannot divulge at this time the intended applications nor do I know of any specific applications. For the lack of this information, I cannot give you any feeling for the size of the conversion systems. It is possible, however, that if such energy conversion can be made practical, applications in the order of several hundred horsepower are foreseeable in the ultimate future.

We have purposely maintained a flexible work statement so as to provide for a quick reaction time if and when we see the immediate need for a change in program or need for the specific exploitation for a new energy conversion process. Accordingly, I see no contractual restrictions to your entering into this additional program. It is hoped that the talents of your department or other departments at M.I.T. could be exploited to help guide us in planning a long range program in this energy conversion field. Will you please reconsider our request and if you are not able to complete the proposed program per the work statement which has been forwarded you, will you advise what you could arrange to have completed on what will, by necessity, be a low rate of effort exercise but one which, in say three months, could provide the direction for a full fledged exploitation of the energy conversion processes which appear feasible.

As stated above, we are continuing our current contract negotiations with the buyer. This contact is strictly informal in that I am asking you a personal favor. If you are receptive, proper contract coverage can then be made.

Sincerely,

Contracting Officer

Author's Note:

Professor Friend subsequently repeated his rejection of the agency's proposed modification of the contract work statement. The contract was ultimately renewed on the basis of the original work statement.

It should be apparent to the reader that the ability of a university selection system to choose wisely among research alternatives rests primarily in the hands of those who are responsible for the performance of the research itself. The major impact of the machinery for proposal review has been on administrative questions regarding the terms of sponsorship rather than on the substantive content of campus research. There is no evidence collected on either side that the machinery itself has either encouraged or discouraged more or less sponsored research in the aggregate. The direct actions taken by university organizations which participate in the formal review process appear to be oriented largely towards making financial modifications or changes in contract language. Indirectly, they serve as a warning system by their existence and they exert moral suasion by raising questions about research proposals rather than by formal rejection. They rely heavily upon academic administration rather than project-by-project review to insure quality and direction in university research.

Project Termination

The expeditious movement of projects out of a university research portfolio plays a crucial role in determining the character and scope of its research program at any given time. Yet project termination in the universities has received far less attention than its counterpart on the incoming side. When it is treated as a subject, project termination is typically discussed as an integral part of contract administration, and it is generally not viewed as an element in the selection process. The natural assumption is that the administrative actions involved in closing out research operations follow along in due course after the professional decisions to terminate or shift the emphasis of research have been reached.

It stands to reason that educational institutions may find it appropriate to elevate project termination procedures from the tactical, rear guard actions they have traditionally entailed to a more prominent place in institutional research strategy, the larger campus research becomes as a fraction of total educational activity, and the more closely it is related to teaching. In certain areas where full employment of university research resources may prevail, the egress of research projects matches the new arrivals in importance. Here, the opportunity costs of delayed termination can be significant.

The dynamic, ever changing character of modern research would seem to place a premium on the speedy exit of research programs that have passed the peak of their promise in the universities. In applied research and development especially, but also in areas of basic research in which professional interest is waning, the ability to disengage faculty, students, space, and facilities from one line of inquiry or another can make the crucial difference whether students are being drilled with the solved problems of the past. Here again, there is no substitute for the professional decisions that inevitably rest in the hands of individual faculty members and an unremitting emphasis of institutional standards at all higher levels of administrative decision--department, school and institution.

Sponsored research may terminate for a variety of reasons, as indicated below:

1. The terms of the grant or contract have been satisfied.
2. The investigation has been completed.
3. Financial support has been terminated by the sponsor or the budget has been exhausted.
4. The sponsor or institution may cancel the contract.
5. Interests of faculty members have changed.
6. Interested students are not available to continue work on the project.
7. Faculty members have shifted to other departments or to other institutions.
8. The general area of study has largely moved out of the university into industrial practice.
9. An institution has disbanded or reconstituted a department or laboratory.

An adequate treatment of this whole subject could serve as the basis for detailed studies ranging from high(and low) finance to campus politics. Without pretending to cover the intricacies of project termination, it may be helpful to the reader to have an inventory of constraints acting upon the educational institutions in this area of research administration. For convenience, these constraints can be grouped according to the source from which they originate: (1) the character of university research, (2) academic organization, and (3) sponsorship arrangements under the present system of federal funding.

1. First, university research is rooted in a continuum of knowledge, at whose base there are no discrete intervals. The emphasis of basic research in the universities leads naturally from one problem to the next and from one project to the next. The work is never done, despite the tidy administrative arrangements that support creative activity in the university. A discovery in one area opens a host of new research opportunities in another, and so on.[(46)] The net result is that there are strong forces inherent in the research process itself that involve long periods of build-up and momentum. Moreover, the uncertainty that any particular basic research project will produce the desired result raises deep philosophical questions about when it "should" be terminated.

Modern research has tended increasingly to emphasize team effort and interdisciplinary organization. The increased scale of operation that accompanies this trend brings with it vested interests in perpetuating a given line of inquiry if for no other reason than there are more people involved whose professional agreement or dissent is essential to the work in question, peo le who may have a substantial professional investment in the effort.

(46) See, for example, the stud by Vannevar Bush, Science: The Endless Frontier. Washington, National Science Foundation, July, 1945, pages 18 and 19.

The cost structure of modern research is another characteristic that tends to restrain project termination decisions professionally as well as administratively. We shall have more to say about rising capital thresholds required for entry into new fields later on. The employment of expensive facilities and equipment, many of which are highly specialized or physically fixed in place, may require large investments of university funds and research staff. Anechoic chambers, wind tunnels, oceanographic vessels, nuclear reactors, electron microscopes, mass spectrometers, particle accelerators, clinical facilities, computers, towing tanks, and radars are commonplace items in the leading university research centers. The result has been a steady rise in fixed costs of doing research and reduced flexibility in project termination decisions.

2. Second, intellectual freedom is a basic condition of academic organization. Project termination decisions involve a central incompatibility with intellectual freedom if they originate from sources other than the principal investigator himself. Even where administrative contradictions must prevail (health or property hazards, security problems, use of students as subjects, disbandonment of a laboratory, etc.) the individual whose project is affected is not likely to accept such decisions with equanimity. At their best, universities provide the scientific worker with a strong sense of solidarity and security in an

atmosphere that is relatively free from the adverse pressure of convention, prejudice, or economic necessity. Project termination decisions are, therefore, typically meddlesome and unpopular.

Tenure systems that emphasize research achievement bring special pressures to the life cycle of university research. Faced with the prospect of "publish or perish" investigators may see significant personal advantages in continuing a line of inquiry beyond the peak of its promise in order to wring a few additional publications from the work. Specialized facilities or laboratory setups may invite the research worker to persist on a project when the alternative is to spend critical time acquiring outside funds and approvals for new studies.

Among its important attributes, academic organization emphasizes the stability and permanence of disciplines. These disciplines may compliment each other in attacking research problems on an interdisciplinary basis; they often share common facilities. But they also compete for students, faculty appointments, space and dollars. The competition is keenest within the academic departments but intradepartmental competition for scarce resources is not unknown to the universities, nor are intradepartmental contests for prestige and influence in academic affairs. Departmental boundaries rest on the same continuum of knowledge as do research undertakings. The exact division of labor among departments is subject to departmental leadership, strength of individual faculty members, the ebb and flow of students, historical accident, and a host of other considerations.

The permanence of university disciplines is not easy to reconcile with the time varying pattern of demand for education in any given area. No responsible department head relishes the prospect of contracted operations for the sake of short-term fluctuations in demand. Thus, research as an integral part of education, may be used in the short run to stabilize the employment of departmental resources (including faculty, space and dollars) as a secondary aim to attracting outstanding students and giving expression to faculty interests in conducting research. Pressures to terminate particular projects will rise and fall as a function of total demand for the educational capacity of a department--including both teaching and research resources.

3. The sponsorship arrangements under the present system of federal funding adds further constraints on project termination decisions. The uncertainty of research funding from one year to the next imposes _ad hoc_ planning at the level of individual projects and leaves higher levels of administrative authority with limited knowledge on which to base allocation decisions for the future. The funding cycle of individual projects is usually not harmonized with the budgeting cycle of the university at large or with individual departments. The result often is a

complicated juggling procedure to stabilize departmental operations, and as sometimes happens, a tendency to keep projects going for the sake of the short-term support they may provide.

The initiative required of individual faculty members in the matter of securing project funds is another factor in project termination decisions. Responsibility and control go together in professional decisions but there is a natural carry-over to administrative decisions. It is hard to disassociate pressure to terminate research projects from a rejection of the individual himself. From his vantage point, he is convinced that the funds involved would never have come to the university had he not secured them in the first place, and it is natural that he should feel a proprietary interest about deciding when to terminate them. To a large extent, the possessive influences introduced by the project-by-project method of sponsorship are being alleviated by broad program grants to support research in a general area, as in the case of the larger laboratories, or in the case of research proposals which are secured by several faculty members acting as a group. Project termination decisions are no less complicated under these circumstances but they do have the advantage of coming from professional peers who have participated in the securing of funds and not from higher levels of institutional authority.

Property accounting and disposal procedures under federally sponsored research contracts represent another restraining influence on project termination decisions. Whereas federal grants generally leave the institution in legal possession of equipment purchased as part of a research project, contracts vary in the matter of property ownership they permit according to the agency and dollar amounts involved. Restrictions on the sale of government property or on its use in university research for purposes other than those specifically authorized under the terms of the contract can immobilize valuable space and facilities beyond their useful life in a research program, to the disadvantage of educational institutions. For example, over one year was required to dispose of the Whirlwind I computer at M.I.T. after the formal decision had been reached to terminate the operation of the Digital Computer Laboratory on the Institute's campus. This is perhaps an extreme example because of the size of the undertaking but it serves to illustrate the point.

Balancing the special problems created by property disposal and accountability systems is the great growth of scientific apparatus made possible under federally sponsored research contracts in the universities. Without the generous support of equipment under federal research contracts, the universities would be even more underequipped than they are today. But there is clearly room for more freedom in property management and disposal procedures as applied to educational institutions. The present system of approvals and accountability has its roots in military procurement practices designed to protect the public interest in government contracting with industry for weapons production, and it works only tolerably well in the universities.

Federal funds are generally not available to support the expense of project termination. The revamping of space and facilities is allowable in connection with new work to be undertaken but there are limitations on such funds. As a result the universities are forced to underwrite a major part of the dislocation expenses of terminated projects. This general area deserves more attention as the volume of federally sponsored research in the universities continues to grow. Were federal funds more readily available to underwrite the house cleaning function, it seems probable that the housekeeping burden of the universities could be lightened.

Finally, relationships with sponsoring agencies should be mentioned as a factor prolonging the life of some research projects in the universities. The transfer of knowledge generated in university research programs to interested laboratories in industry and government is of prime concern to the sponsor and educational institutions. Universities have made major contributions to the nation's scientific development by participating actively in the spread of basic information and new technologies emerging from their laboratories, often at the request and support of sponsors. The universities incur a moral obligation in the acceptance of public funds that may go beyond the performance of sponsored research to include the dissemination of specific research results. This is especially true of research bearing upon national security in which the university has accepted a leading role. In the context of continuing relations with sponsors, individual faculty members may also feel responsible for providing continuity between their work and subsequent development elsewhere. Indeed, they may desire for their own satisfaction to avoid withdrawal until they are assured that competent research will be carried forward by industry or governmental laboratories. More than a few new industries have been generated in the universities by default as well as by design. For educational institutions, the removal of research projects that have reached this stage of maturity requires continuing vigilance and a readiness to exercise institutional criteria in initiating project termination decisions, regardless of their popularity.

CHAPTER IX

PROBLEMS OF ADMINISTRATION

Depending upon the volume of sponsored research on a given campus, a variety of administrative arrangements will prevail. The Harvard, Princeton and M.I.T. examples presented earlier are noteworthy because they represent a highly developed pattern of administration at three campuses on which sponsored research volume is both large in absolute terms and a significant fraction of total university expenditures (over one-fourth at Harvard and roughly one-half at Princeton and M.I.T.).

A recent study by C. R. deBurlo, Jr., entitled "Administrative Problems of Sponsored Research Programs in Small Colleges and Small Universities" points up the contrast between the large and small institutions in terms of their approach to sponsored research administration.(47) deBurlo studied four small universities whose enrollment was 4,000 students or less and whose fraction of total university budget in sponsored research was not more than 20 per cent. He also studied two colleges whose enrollment was 1,100 students or less and whose sponsored research budget was under $250,000, or a minor fraction of the total college budget. Not all of the small universities had special offices to administer

(47) Submitted as a doctoral dissertation, Graduate School of Business Administration, Harvard University, 1960. Dr. deBurlo is Comptroller at Tufts University.

sponsored research; neither of the small colleges supported such an office. In these cases the responsible person was the college treasurer, its chief business officer or accountant, a faculty committee or individual department heads.

It should be emphasized that there is no single "best" way to administer sponsored research in educational institutions. Where the research volume is small, the administrative machinery has tended towards informality; where the research volume is large, specialized offices similar to those at Harvard, Princeton and M.I.T. have been established. Our preoccupation with the larger programs of federal sponsorship is deliberate but the reader should be warned that a span of experience covering twenty-five years separates institutions who have developed large programs of federally sponsored research from many of the smaller institutions who are new entrants in this area. The administrative inexperience in sponsored research which deBurlo found in his study would cause students of organization to shudder and administrative officers in the sponsored research offices at the larger institutions to recall nostalgically some of the pitfalls they encountered in earlier days.

It will be helpful to put project administration in perspective by setting forth a few over-all objectives that a central office for the handling of the administrative, non-technical details of contract research may be expected to accomplish.[48] For the sake of convenience, let us assume that a central office for the handling of research grants and contracts has been established, although the following sections should apply to research administration on a campus regardless of the particular administrative arrangements. The objectives in contract administration should be:

1. To provide a helpful service to the faculty members so that they may "get on with their research" with an absolute minimum of distraction caused by administrative detail;
2. To insure that the institution's contractual arrangements will enable it to recover the maximum of its allowable costs;
3. To preserve the continuity of the institution's established policies;
4. To establish a focal point with which Government agencies may have continuing contacts;
5. To develop experience which may serve the institution in the design of its procedures for administering sponsored research.

(48) In examining these objectives, the writer is indebted to Mr. Richard W. Pratt of the Office for Sponsored Research at Harvard University for his permission to borrow generously from an unpublished paper presented at the Somerset Hotel, Boston, November, 1959.

The order in which these objectives are presented is not intended to reflect their relative importance. They should all be considered important parts of the whole. Let us now consider in some detail the application of these five objectives.

First, to provide a helpful service to the faculty member so that he may "get on with his research" with an absolute minimum of distraction caused by administrative detail. After the project director locates a sponsor for a research program and obtains the endorsement of proper academic authorities, an official proposal is prepared for transmission to the government agency through the office for sponsored research. This proposal normally involves two areas: (1) the technical presentation which is generally handled by the project director, and (2) the fiscal and budget area. The office for sponsored research assists in the fiscal aspects of the proposal, not only to assure that all proper items of cost are included in the budget, but also to present them in a manner which meets the agency's requirements.

The next important step in this process is the negotiation of the contract or grant itself. This function is essentially the responsibility of the office of sponsored research which is first guided by the institution's established policies and secondly, by the need for providing a workable contractual arrangement for the faculty member. It is, or should be, the primary goal of such an administrative agency to strive for a minimum of red tape and details which may harass the scientist in the performance of his work. The importance of this goal cannot be over stressed. A number of federal agencies can be commended for their appreciation of this point. Unfortunately, there are others which have a pitifully limited understanding of the problem. In the negotiation of contractual details, there can be no substitute for mutual understanding, good faith, and trust between the parties, and when these elements are lacking no contract can be designed which will afford complete protection to both parties.

The university research administrator must not only be patient and persuasive, but also must have a thorough knowledge of the workings and policies of the institution along with sound business judgment. In the same manner it is essential to have a good command of the procedures and policies of the sponsoring agency. Where the sponsoring agency is located in the Department of Defense, a thorough study of the Armed Services Procurement Regulations is important. deBurlo found, for example, that the small universities and colleges he studied were generally lacking in this regard, most of their support having come from non-military agencies such as the National Institutes of Health and the National Science Foundation.

The usual practice is for the sponsoring agency to send to the institution its standard form of contract or grant application which contains standard "boiler plate" provisions. In general, these standard forms of contract will not be acceptable and must be modified to suit the policies of the university.

In negotiating a contract or grant each party has certain policy limitations. There is, nevertheless, an area which allows sufficient flexibility to permit negotiation, and finally to settle upon a mutually satisfactory contract. It is incumbent upon the university administrator to take full advantage of the opportunity to study carefully the terms of the sponsoring agency's standard contract or grant application and to agree upon terms most favorable to his institution. In principle, federal agencies do not intend to interfere with this concept. In practice, contradictions of this philosophy have been confined to isolated situations when a government representative lacks an understanding of what makes a successful educational institution, when new agency policies have been poorly defined, or when agency operations have generated pressures which a government contracting officer may transmit without taking advantage of his pivotal ability to minimize.

Fortunately, there have been only a few situations where the federal government has imposed what are called "mandatory regulations" that were inimical to the universities' way of life (e.g., disclaimer affidavit and university responsibility for loyalty determination.) In these instances relief has been brought about by presenting valid objections by the academic community on a broad and united front. The National Federation of College and University Business Officers Association, the American Council on Higher Education, various professional societies, and ad hoc study groups have constituted the means by which organized opposition to government-imposed contract provisions has taken place. This technique is quite proper and will undoubtedly be continued when it can be demonstrated that a particular regulation is universally undesirable. For their part federal agencies have welcomed these expressions of the academic community as a means of gauging the acceptance or rejection of government rulings.

Once the contract or grant has been executed, the next stage in the process is its administration. It is important to understand that this phase of sponsored research activity continues throughout the life of the research project and depends for its success upon a close working relationship between the university contracting office and the project director or faculty member. In looking towards the fulfillment of the business aspect of research contracts, the university contract office faces the demanding problem of rendering helpful service in the contractual details without interfering with the substantive content of the research itself. In this phase of its work, the contracting office needs and depends upon the faculty member's cooperation. de Burlo's study is a compendium of illustrations on this point. A very large portion of the administrative problems arising in sponsored research in the institutions he studied grew out of a lack of understanding by the investigator of the contractual terms to which he was bound and a general lack of experience in dealing with federal sponsors.

These problems are greatly reduced when enough experience has been gained by individual faculty members or when research projects are large enough to be staffed with business officers of their own, as in the case of large departmental laboratories or major research centers on a campus. At the same time, the decentralization of responsibility for contractual matters to major research centers poses new problems for the larger universities unless there is a carefully considered plan for unified control.

The university contracting office may include a division of labor among groups responsible for such matters as the negotiation and interpretation of grants and contracts, patents, fiscal and accounting matters, property management, security, and in some cases personnel administration. The extent to which this framework of organization is expanded depends, of course, on the magnitude of the institution's over-all research volume. On some campuses where research is conducted on a small scale a single individual may constitute the institution's contracting agency.

At several of the large universities and institutes of technology, the organization of university contracting offices has undergone extensive development. At M.I.T., for example, there are fourteen administrative officers in the headquarters staff of the Division of Sponsored Research.

The second objective: to assure that the institution's contractual arrangements will enable it to recover maximum allowable costs. This objective deals mainly with fiscal and accounting problems and is largely a matter of relationships between the university contracting office and the government sponsoring agency. Usually a contract or grant contains an article which is intended to describe the allowable reimbursable items of direct cost.

In the accounting for research expenses, university administrators have learned the importance of explicitly setting forth special costs, particularly when the expenses could be cost accounted either directly or indirectly. For example, items such as vacations, sick leave, and pensions are in some instances treated as direct costs, and in other instances these may be included in the base upon which the overhead rate is established. Other categories of direct expense about which university administrators have learned to be explicit are items which are expressly not allowable unless stated in the contract; examples include the purchase of equipment and the leasing of property necessary to perform the work.

Overhead allowances have been the subject of considerable study and discussion between government and university representatives during the post-war period. We shall have much to say in a later section regarding overhead considerations. For the present it is enough to say that the cost accounting principles employed in sponsored research contracts with the federal government have had a profound impact upon the ability and willingness of educational institutions to engage in research of this kind. An example of inadequate overhead allowance has to do with the question of public liability. Due to the variety of research in which an institution may become engaged, it is very likely to have liabilities for injuries to third parties or damage to the property of third parties. Proper protection to the institution is important and can be provided by means of insurance or acceptance of such liability by the government. At the present time the public liability factor has not been adequately recognized by federal agencies.

On a campus the financial monitoring of a sponsored research project is often of value to the project director. It is usually done by providing a monthly financial summary, giving a listing of the principal categories of expense, together with the up-to-date cumulative total of disbursements. This statement also shows, after deducting outstanding commitments, the unexpended available funds for the continuance of the program. This monthly procedure is useful to the university contracting office to guard against the over-expenditure of contract funds. It has more than nuisance value to project directors, but has been a source of internal friction on many campuses. Under the present imperfect state of development of university contracting experience, the frustration of contract over-expenditure has been a fairly general experience.

Most contracts with federal sponsoring agencies contain a clause which sets a dollar limit over which the approval of the government contracting officer must be obtained before the expenditure is permitted. Reimbursement becomes exceedingly difficult when university project directors fail to observe these expenditure limits. A variety of procedures are used to overcome this problem. At M.I.T., for example, a letter requesting such approval originates with the project director and is forwarded to the government contracting officer with a copy to the Division of Sponsored Research. The contracting officer's letter of approval is sent to the project director who is responsible for keeping the Division of Sponsored Research informed when the approval is granted. This procedure has proved to be very satisfactory.

The third objective: to preserve the continuity of the institution's established policies. The competence of the university contracting office in this area is largely dependent upon the institution's policies, which in any given instance may be intricate and ill-defined or even non-existent as regards sponsored research. Such an office deals on a day-to-day basis with all the ramifications of these policies and should be in a position to understand the reasons for them. Earlier we mentioned that the criteria used in the selection of university research should be applied flexibly and with forethought about their effect upon the creative process. By the same token, the variety of problems and special situations that arise daily in an educational institution require a degree of flexibility in the general application of institutional research policy.

The fourth objective: to establish a focal point with which the government may have continuing contact. Looked at from the point of view of the federal sponsoring agency, it is difficult to overstate the case for the maintenance of a convenient channel for the conduct of business affairs. The complications introduced when educational institutions have no clearly identifiable channel for the conduct of business affairs of this type has undoubtedly led many government science administrators to think twice about the placement of a research contract on some campuses. Compared with the relatively well-ordered and well-understood research organization in industry (with which government contract officers may in large part be dealing) the organization of sponsored research at colleges and universities presents real problems. Educational institutions can render a genuine service to sponsoring agencies by giving greater attention than they have to the facilitation of research contract administration by a responsible administrative unit on their campuses.

The fifth objective: to develop experience which may serve the institution in the design of its procedures for administering sponsored research. In this age of specialization, it is unreasonable and inefficient to expect individual faculty members to possess and maintain the knowledge necessary to handle contractual details in a businesslike and expeditious manner. It is a poor use of their time to detract from the conduct of teaching and of research itself in order to insure that contractual matters and institutional policies are satisfied in the detail necessary to provide adequate protection. More important, an educational institution needs to develop a means within its organization to evaluate the effectiveness of its approach to research administration. Looked at narrowly, for purely defensive purposes, the university should maintain a cadre of skilled personnel who are at least as well equipped as their counterpart specialists in government. Viewed more broadly, the procedure for research contracting itself can have a positive and beneficial effect upon the substantive conduct of research on the campus.

If it is not already apparent to the reader, the research contracting process should be understood as a highly specialized field requiring professional competence in law, accounting and business administration. Some idea of the complexity of the research contracting problem can be gained by considering the nature of contracts currently in use at educational institutions. In April, 1959, the Engineering Colleges Research Council of the American Society for Engineering Education published the results of an excellent survey of research relations between engineering educational institutions and industrial organizations.[49]

Questionnaires concerning research contracts at educational institutions were distributed to 109 members of the Engineering Colleges Research Council. Sixty-four replies were received and thirty-two of these included standard or sample contract forms. The variety of research contracts at the institutions which responded points up the multiplicity of arrangements in use within the educational community. These contracts with the private sector shed light on the challenge of contracting with federal sponsors. They represent institutional research policies that have been developed independent of statutory or agency requirements or limitations. As such, they constitute norms against which contracting experience with federal sponsors can be compared. Fourteen principal sections of research contracts were analyzed by the Engineering Colleges Research Council. For the benefit of the reader it will be helpful to summarize these contracts as the Council found them.

(49) The report was later published by the Small Business Administration. Small Business Management Series No. 23, Washington, G.P.O., 1959.

1. Work Statement. Description of the problem, a very essential part of a research contract which defines the scope of work to be performed. Most often, in the contracts studied, this section is referred to as the "project." Nineteen (19) institutions present an abstract work statement in detail.

2. Publications. There appears to be general agreement that institutional research should provide educational contributions and that the publication of results is an important activity. Twenty-nine (29) contracts contained clauses pertaining to publications, divided as follows: Nine (9) give full publication rights to the institution. Sixteen (16) publish information after sponsor's review of it and/or approval. Six (6) will delay publication to protect sponsor's rights and interests (usually patent rights). Five (5) require that the sponsor obtain the institution's consent prior to his publication of significant results. Delays in publication from 1 month to 2 years are often specifically pointed out in the contract.

3. Publicity. Restrictive clauses in the use of the institution's name for advertising, sales, reports, bulletins, or other publicity are contained in twenty-seven (27) standard contracts. Twenty-two (22) require institution approval. Four (4) expressly prohibit use of the institution's name. One (1) contract prohibits use of the institution's name except as authority for published material.

4. Patent Rights. This section in the standard contracts contained major difference of viewpoints in the thirty-two (32) contracts examined. The primary consideration is whether rights accrue to either the sponsor or the institution. From this point, the various options involving licenses, royalties, and periods of agreement take individual forms. The practice is widespread to offer the sponsor an option of retaining or rejecting patent rights coupled with a higher or lower overhead rate, depending upon the option elected. Variations in some details are presented below. (50)

(50) For a detailed treatment of this subject, see the 241 page report University Patent Policies--A Factual Survey, 1952, and Supplement to University Patent Policies and Practices, 1955, by Archie Palmer, Director of Survey of the National Academy of Sciences. This report analyzed research, patent, copyright policies and practices of some eight hundred institutions of higher learning.

A. Sponsor Rights.
   1. Claimed at the execution of contract.
   2. Nonexclusive license and royalties to the institution.
   3. Exercised within a certain time period after notice of invention with or without fee.
   4. Linked with overhead rate percentage by election of option.
   5. Limited to patents directly in the scope of investigation.
   6. Assigned to the institution if waived.

B. Institution Rights.
   1. Exclusive license possessed by sponsor with or without royalties.
   2. Nonexclusive license possessed by sponsor with or without royalties.
   3. License assigned to sponsor.

C. Rights are determined at the time of execution of each contract.

5. Basis of Costs. This section is devoted to overhead charges. Several contracts made no reference percentage-wise, and others referred to overhead only in a general sense.

6. Supplementary Agreements Required by Contract. Appendixes and other attachments often are referred to and made a part of the basic contract.

7. Billing. Invoicing sponsors for work performed is most frequently done each month. In some instances this is done quarterly and even semi-annually. Advance payments are required in ten (10) of the contracts.

8. Renewal of Continuation. Performance beyond the terms of the original period usually requires a contractual renewal. This renewal is sometimes covered by arrangements for renewal being stipulated on the original contract. Three (3) contracts specifically state that renewals shall be made on a supplementary form, with essentially the same terms as the original contract. Four (4) institutions refer more generally to the continuation of work, stating only that renewal will be on either the same or modified terms.

9. Property. Sixteen (16) contracts mention disposition of property or special equipment acquired in connection with the work. Of these, twelve (12) convey the understanding that special equipment is retained

as institution property. Outright sponsor ownership is designated in only three (3) contracts; however, one (1) of these requires that the sponsor must request the equipment within thirty (30) days after completion of the project, or ownership transfers to the institution. In one (1) contract special equipment or equipment bought from special additional funds by the sponsor becomes the sponsor's property. All other property bought under the agreement is retained by the institution. Limitations on expenditures for equipment are frequently specified according to maximum allowable expenditures without sponsor approval or upper limits on the dollar amounts authorized in any given accounting period.

10. Completion. Contracts sometimes mention the difficulty of accomplishing final results within the time period allocated because of the nature of research. Six (6) standard contracts stated that there could be no guarantee of completion within the time period and/or funds as limited by agreement.

11. Inventor's Agreement. Eighteen (18) contracts either incorporate or refer to an Inventor's Agreement forming part of the basic contracts. This agreement obligates institution employees to assign to the sponsor all rights to inventions as discovered within the field of study together with complete and prompt reports on such inventions.

12. Time. Budgetary controls used in industry force the inclusion of a definite period of performance in almost all contracts. In addition, limitations on the period of performance are placed on contracts by some institutions. Of the thirty-two (32) standard contracts studied, twenty-eight (28) have provisions for the inclusion of dates of initiation and termination of performance. Three (3) contracts limit the contract term to 1 year, requiring renewals at the end of that time if performance is to continue. One (1) institution implies it will contract only in yearly stages.

13. Reports. The approach on the standard contracts seems to be either of a very definite policy nature, or loose to the extent that the sponsor and institution agree on the terms of each project to be undertaken. Reporting practices range widely from monthly to annually and from irregular reports to final reports only.

14. Proposal Limitation. Only one (1) institution limits its offer or proposal to thirty (30) days. There is almost universal specification that the proposals do not become a contract until approved by the authorized officers of the parent institution as well as the research director.

From the foregoing it should be clear to the reader why it is necessary for educational institutions to develop their own skill in the matter of administering sponsored research and not to rely upon federal agencies for this function. It should be equally clear that federal pressures towards standardization present real problems to the college or university which has carefully and thoughtfully developed its institutional research policies and procedures in a manner uniquely designed to serve its own purposes. The universities have been in the awkward position of urging uniform federal policies and standardization of agency practices to simplify the problem of research administration from their end. Perhaps the reader will agree that this particular problem is two-sided.

The recent report of the 1961 self-studies initiated by the Carnegie Corporation, "Twenty-Six Campuses and the Federal Government,"[(51)] presents a number of university criticisms of the administrative burden of federally sponsored research on their campuses. Most of the concern stems from the labryinth of legal and accounting procedures now required of the educational community that were unnecessary in less complicated days. In some cases the government-induced changes in university procedures are acknowledged to have been desirable from

(51) The Educational Record. April, 1963, pages 113-114.

the standpoint of more businesslike handling of university research programs, even in the absence of federal sponsorship, but the fact remains that the extra work involved is laid to the government's credit because federal sponsorship has been the dominant force shaping contract research administration in the post-war period.

An illustration of university attitudes towards administrative procedures involved in government contracting was reported in the recent Carnegie Corporation study.(52) Said the University of Notre Dame:

> "If there is one remark we would like to emphasize, it would be that these (university-government) relationships should proceed with a minimum of administrative complication and with a maximum of mutual interest, trust, and respect. To the extent that administrative procedures are designed to keep the grantee "honest," we consider them superfluous to the normal relationship between the Federal Government and the universities. To the extent that they are designed primarily to control the dealings between Government and industry, they are ill-advised and onerous when applied to universities. There is no doubt in our mind that the experience of a Government administrator in dealing mainly with business virtually disqualifies him to deal with universities, particularly when his agency insists he apply uniform policies and procedures..."

Contract and grant provisions which limit the freedom of faculty members in the prosecution of federally sponsored research pose special problems for the universities. Examples are: "buy American

(52) "Twenty-six Campuses and the Federal Government". The Educational Record. April, 1963, page 113.

clauses," agency approval required for foreign travel that may be required under a sponsored research program, and agency restrictions that limit the amount of money that can be spent on budgetary sub-totals (e.g. salary of the principal investigator or equipment) in a research project. The problem of close policing of project activities so as to comply with contract restrictions of this kind introduces a need for controls that is largely foreign to university research. In other contractual areas, such as anti-discrimination clauses regarding personnel involved in some federally sponsored research, the university which has a policy of nondiscrimination may find it difficult to comply with the spirit of the contract provision without making a campus-wide determination of race or creed--which none relish and, to the writer's knowledge, none do. As this study is being written, Professor George Kistiakowski of Harvard University is embarked upon a survey of contract provisions in federal grants and contracts that limit the freedom of action of academic personnel and encroach upon institutional research policies.

Some Conclusions on Project Administration

Under today's procedures, the time required for preparation and defense of research proposals is a shortcoming. To some extent the effort here is inescapable in view of the increasing complexity of science and engineering. It is hard to find someone better qualified to defend a proposal than its originator. The fact remains that there is an urgent need for improved methods to minimize the demand on faculty time. The nature of research itself suggests that proposals be flexible and permit maximum latitude. The need for flexibility is further emphasized by the heterogeneous settings of university research. For federal agencies this of course poses problems of designing a system to take account of the wide variety of educational institutions without discarding the advantages of uniform treatment of all where appropriate.

Sound policies for sponsoring university research are basic factors of organization. Their success depends upon the ability of federal agencies to attract and hold competent individuals in positions of importance and to permit them discretion in university relationships. A government science administrator aware of the wide differences among educational institutions can encourage or discourage the conduct of government sponsored research. If he is sensitive to conditions at an institution, he can exert a positive influence on the conduct of research there. In matters of procedure he can save himself, the university administration, and the faculty member a great deal of harassment by the thoughtful application of government standards and procedures.

In turn, it is incumbent on a university to organize its research administration in a manner compatible with the magnitude of the financial commitment. When a government representative appears with a heavy briefcase full of contractual "boilerplate" to apply to a $5,000 basic research endeavor, the university is negligent in its duty to society if it even allows him a chair to sit in while making his argument. On the other hand, universities do not have the right to ask government agencies to install separate memory sections in their electronic business machines to accommodate a completely different bookkeeping system at every institution. Nor can a university leave the business and financial management of sponsored research projects to be handled between the government and the individual investigators. The university has a responsibility to shield its scientific staff from the harassments of unfamiliar administrative detail. It has no less a responsibility to protect the government from outrageous idiosyncrasies. It has a responsibility to insure that its books will stand up under audit; that its patent policy protects the institution and the individual along with the government; that expenditures accord with the budget approved in good faith; and so on.

The representatives of government may be depended upon to insure that academic freedom does not expand into management license. But the university, in its own research interests as well as in consonance with its responsibilities as a public trust, must not leave to government alone the task of making sure that traffic flows smoothly in a street that must always be two-way.

In keeping with the permissive nature of academic organization, the primary contribution a university mechanism for research administration can make to research planning is (1) exposure of an individual's research proposal to the internal scrutiny of professional colleagues (and to the disciplines they represent); and (2) provision of the research housekeeping services which are not and should not be the concern of the individual researcher. How well these tasks are performed can best be gauged by the degree to which they may assist but not stifle faculty initiative.

CHAPTER X

THE DIMINISHING PROBLEM OF SECRECY

Among the issues in government sponsorship of university research, the matter of secrecy has contributed its share of troubles. Taken as including clearances to work on classified research--with the judgments on individual loyalty and reliability that are involved--this general question of "security" has reached deep into the principles of university administration as well as the emotional bases of academic freedom.

The strategic importance of science in such critical matters as radar, fire control systems and the atomic bomb led to the erection of secrecy barriers within and around the scientific community at the beginning of World War II. These barriers were designed to keep research of military importance secret and to insure the discretion of the scientists in it. In this difficult field--the balancing of the national need for military security with the scientific tradition of freedom to seek and disseminate knowledge--previous experience in our country was largely non-existent. It was inevitable that universities and their scientists should find the introduction of secrecy a complex responsibility.

The most acute difficulties arose following the discovery after World War II of celebrated cases of espionage in the atomic energy centers of the United States, Canada and Great Britain during the wartime atomic energy work. The troubled history of the loyalty-security program thereafter was part of the problem posed by the changed relationship of government to science, and the academic community's share was amplified by the American phenomenon of extensive application of university research to the national security.

Perhaps the most important lesson from this experience is that the security and prosperity of the United States, depending as they do on progress in science and technology, do not permit a degree of secrecy that critically hinders the scientific competition with alien interests or denies for long to the public an understanding of the nature and objectives of that competition.

Secrecy systems pose a number of practical restrictions on university campuses quite apart from the intellectual restraints. Many have a high nuisance value which a scientist, with instinctive distaste for locking doors on science, finds it easy to exaggerate or resent. Some are expensive in money and working space. Few university buildings are designed with secrecy in mind, and the result can be a distortion of the natural location of campus research. Classified projects often leave a residue of classified information that must be kept under surveillance after a project has terminated, with universities sometimes finding themselves the uncomfortable custodians of material that they can neither use nor dispose of promptly.

Understanding the need for secrecy, universities have played a leading role in pointing up the relevance of specific research programs to military operations. Disagreements generally occur not on need for secrecy but on where to draw the line, and it is natural for the university to oppose the extension of secrecy restrictions to programs and results that, in its view, might better be left unclassified. While some universities have to decline classified research during peacetime on principle, or because they have preferred peace and quiet, others have taken a larger share of responsibility for national security as represented by classified research undertakings on their campuses. These latter institutions have involved themselves in a hard search for ways and means to manage classified research so as to minimize its handicap and to limit its disruptive effect on unclassified activity. Indeed, much of the progress in defining, segregating, and declassifying military research can be attributed to the determination of a few universities to face up squarely to the problem.

Associated with the security classification of work is the security clearance of persons for reliability and loyalty. At an early stage in the development of the necessary procedures, new to government and citizen alike, all contractors, including universities, were expected to take responsibility for clearing their own staffs for the lower degrees of classification. This ruling was in due course withdrawn for educational institutions. The government now holds the sole responsibility for determining whether university staff members should have access to classified information including, of course, participation in classified research itself.

Unclassified Research

A more serious difficulty related to the now half-forgotten demand that participation in any research receiving government support, even if unclassified, be subject to certain loyalty standards.

In 1955 the National Science Foundation took the lead among federal agencies in urging the elimination of the loyalty test as a prerequisite to receiving government funds for research in unclassified areas.

In the same year a committee of the National Academy of Sciences reviewed the matter of loyalty in government sponsorship of unclassified research. In March, 1956, the committee submitted a report pointing out a number of ill-defined policies and practices of the federal agencies. The committee recommended that:

(1) The test in the award of grants and contracts for unclassified research should be the scientific integrity and competence of the individuals responsible for carrying out the research, and the scientific merits of their program.

(2) When an official of the government comes into possession of

evidence which in his opinion indicates existence of disloyalty in violation of law, he should promptly refer that information to the federal agencies of law enforcement established to deal with such matters.

(3) An allegation of disloyalty should not by itself be grounds for adverse administrative action on a grant or contract for unclassified research by scientifically competent investigators; if the indications of disloyalty appear sufficiently serious to warrant any action at all, the government in the opinion of the committee has no other course than to bring formal charges and to produce the evidence in open hearing before legally constituted authority.(53)

These summary findings and recommendations contributed importantly to a new pattern among the federal agencies which have followed in principle the suggestions of the National Academy of Sciences committee. To a certain extent the committee's work reflected the progress already made in loyalty considerations in government sponsorship of unclassified research. To a much larger extent, the committee's work contributed to bringing order into previous chaos. Thus, personal

(53) Press Release of April 4, 1956 from The White House, by James C. Hagerty.

loyalty checks within educational institutions are now limited to performers of classified research, and the responsibility for security clearances is in government hands.

The loyalty-security issue, however, continues, and presumably will so continue indefinitely. Clearly, many people feel there is an overriding need for loyalty in higher education. From this point of view, the educator, because of his influence on the young at a crucial stage of intellectual growth, must expect special attention to be paid to his motivations. The educator instinctively senses an entering wedge of prejudice to academic freedom, an old story to universities. He also resents being singled out from other citizens for potential attack of questionable inspiration. At the least, he demands that the law be clear so that the public may understand the rules, and that the process of accusation and trial be judicial and removed from partisan politics. As is well known, meeting these demands will take continuing effort on the part of all concerned. We may be heartened, however, by the progress made away from the climate of fear, suspicion, and uncertainty which followed the first public realization that we had a new and dangerous kind of traitor in our midst.

The latest episode happened to include not faculty members but students. The National Defense Education Act of 1958 required that recipients of student loans sign an affidavit stating that they neither had supported, nor were a member of, certain organizations defined as subversive. The loans are based on the principle of university participation at the rate of one dollar for each nine dollars provided by the federal government. Thus, the original loyalty requirements under the NDEA applied not only to the government's portion but also to that of educational institutions, making the universities loyalty oath administrators. A number of colleges and universities declined to participate in the new NDEA loan program until the loyalty oath provision was resolved. A great deal of discussion surrounded this question in the period 1958 to 1961. In May, 1959, the Secretary of Health, Education, and Welfare recommended the repeal of this provision to the Congress, and the disclaimer affidavit was finally rescinded in 1961.

The difficulties posed by secrecy on university campuses are not matched in industry. In his book, Government Contracting in Atomic Energy, Richard I. Tybout describes an attempt to determine whether atomic energy contractors have found it difficult to work under secrecy controls. In recent field studies conducted by the Atomic Energy Commission, there was found to be some objection to the delay caused by clearance procedures in putting new employees to work; otherwise, opinions differed. Some atomic energy contractors even pointed to practical advantages of secrecy systems. Security controls are useful as administrative systematizers, they reported, in such matters as the circulation of documents and the orderly entrance and exit of visitors and employees in restricted areas. Moreover, personal security clearance helped form an efficient working organization. The explanation was that employees with a record of poor conduct on the job are inhibited from applying for security clearance because of the close scrutiny of personal integrity and character.

Declassification

In the fiscal year 1962 federal agencies obligated a total of $1.3 billion for research in educational institutions. $732 million or some 56 per cent was placed at educational institutions proper, and the remainder was for research centers administered by the universities. Of the $732 million, it is estimated that not more than 5 per cent was for classified research on campuses. Within the research centers themselves, it is difficult to obtain an estimate of the classified fraction of their total research, but it is certainly substantial. By the assignment of a large amount of classified work to these centers, national need has been met while reducing the difficulties which would otherwise have been imposed, at least in part, on campuses.

Secrecy remains in basic conflict with the rol of universities in generating and disseminating new knowledge. In the short run, the problem can be greatly reduced through improved techniques for early discernment of research that can be declassified.

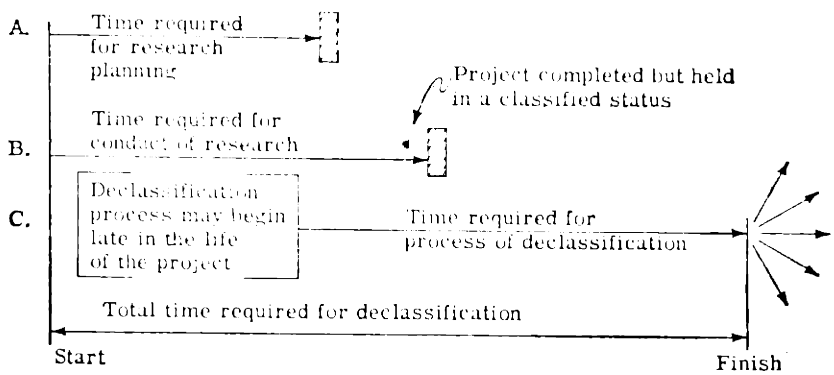
Over the long term, with care not to prejudice important government requirements for research in the field of national security, reduction of classified work on campuses must be sought through: (1) development of intellectual resources outside the educational system capable of undertaking classified research now performed by the universities; (2) increased emphasis on research as opposed to development on university campuses; and (3) increased awareness in the mission-oriented agencies that basic research, a key to national survival, does not flourish in secrecy.

Chart I presents a schematic explanation of how earlier consideration of the subject matter and objectives of a research project might permit declassification close to the projected date of completion, or indeed sooner. In real terms the earlier discernment of unclassified subject matter could greatly reduce the amount of university research that is held either in a classified or indefinite status until work has been completed and published. A great deal of progress has been made in this direction; more is needed. At a more fundamental level, the President's Science Advisory Committee has recently recommended that the Federal Council for Science and Technology re-examine the criteria for classification of published material that would best serve the interests of the nation. (54)

(54) President's Science Advisory Committee. Science, Government, and Information. Washington, January 10, 1963, page 42.

CHART I

STEPS IN DECLASSIFICATION OF A RESEARCH PROJECT



CHAPTER XI

PUBLICATIONS

A primary objective of government sponsored research in educational institutions is to generate information. Thus, federal agencies have been generous in the allowances made for publication of results. An estimated five per cent of university research costs, or some $35 million, at the current level of federal sponsorship, is allocated to the preparation, production, and distribution of reports.[55]

(55) In Federal Funds for Science X, the National Science Foundation began reporting federal obligations for scientific and technical information dissemination activities for the fiscal year 1960. The data are limited to a division between extramural and intramural performers. Hence no reliable estimates for university dissemination activities sponsored federally are available. The Foundation's annual survey acknowledges that the separation of dissemination from the performance of research itself is difficult and in some cases impractical. The Foundation's survey excludes all publication costs prior to the delivery of a completed manuscript by the investigator. It also excludes such items as dissemination costs covered in the indirect cost allowances of R & D contracts and contracts to disseminate information which may be supplemental to a grant or contract primarily for research and development. "The amount thus excluded is estimated as being quite substantial, possibly equaling or exceeding the (extramural) total reported." Quotation from Federal Funds for Science XI, 1963, page 58.

The estimate of $35 millio stated above is the writer's. It is based on NSF data for total extramu al performance of dissemination activities sponsored by the federal gc vernment. The figure reported by NSF for fiscal 1962 is $32.5 million, which should be more than doubled to reflect the under-reporting described by NSF, and then divided to reflect the share accounted for by the universities. The $35 million estimate, incidentally, is consistent with general estimates of five per cent of total R & D costs for publication as seen by research administrators at M.I.T.

Added to the cost of processing documents through such federal agencies as the Armed Services Technical Information Agency (ASTIA), the Office of Technical Services (OTS) of the Department of Commerce, the Division of Technical Information Extension (DTIE) of the Atomic Energy Commission, the Office of Scientific and Technical Information (OSTI) of the National Aeronautics and Space Administration, the Library of Congress, and others, university publications have become big business. They are important not only because of the large sums of money but also because of the crucial role they play in stimulating scientific and technological advances in both education and industry. The publication of a technical report often represents the only tangible and immediate benefit received by the sponsor in return for financial backing.

In small research undertakings, the reporting may be limited to a single publication at the conclusion. In larger, longer programs, which include a number of inter-related studies, the practice of issuing progress reports has been widely adopted. The frequency, detail, and purpose of these reports vary considerably and are usually a subject for negotiation at the time a research contract is written.

The publication of research findings serves desirable ends for both the sponsoring agency and the university. From the agency's point of view, published information is accessible for industrial and governmental laboratories where applied and developmental work may be pursued on the basis of findings made within the university. Indeed, one of the principal advantages to the federal agency is the academic propensity to disseminate new knowledge promptly and widely. In contrast to work within industrial and governmental laboratories, where proprietary interests and more extensive military classification may inhibit the free flow of information, research in universities operates on an amplification principle that stimulates the widest possible participation of the scientific community. To the sponsoring agency, publications are also an invaluable means of gathering data for future decisions about sponsorship.

A New Dimension in Publishing

Government funds have helped overcome the publications log-jam that has grown steadily since the beginning of World War II. Under government sponsorship, many of the research reporting systems have been invaluable in transmitting findings in rapidly moving fields much sooner than if only the professional journals were available. In some extreme cases editorial backlogs in the standard professional journals are running as high as eighteen months. A good example of a federally financed *ad hoc* channel is the Atomic Energy Commission's publication program in nuclear physics, which supplements the standard professional journals. The A.E.C. now issues five quarterly review journals which have been enthusiastically received by the technical community.

On the other hand, the improvisation of new publications media under federal sponsorship has not reduced the demand for space in the standard journals. Paradoxically, it has increased it. Having reported their findings to the sponsor, university investigators are no less anxious to place articles in the professional press, it being clearly in their interest to do so. Frequently, a journal article is a means of publishing research which may have grown out of a government sponsored project but which does not fall entirely within the sponsor's support. A recent government decision has been helpful to university investigators in this regard. In accordance with criteria developed by the Federal Council for Science and Technology, the National Science Foundation in an announcement to the press on October 25, 1961 urged federal agencies to underwrite the placement of articles in the professional press on research sponsored by the federal government. (The principle of levying a per page charge against journal articles in the physical sciences goes back to 1932, shortly after the establishment of the American Institute of Physics.) As a result of the NSF announcement, sponsoring agencies are now paying the current $50 per page cost and the practice of honoring this charge is now spreading from the field of physics--where it began--to chemistry and biology journals.[56]

(56) For an interesting history of this charging system see Henry A. Barton, "The Publication Charge Plan in Physics Journals" Physics Today. June, 1963, pages 45-57.

Often the fulfillment of reporting obligations to the sponsor does not satisfy the investigator that the full import of his findings has been brought to the attention of the professional community. Scientists and engineers are notoriously tradition-bound in their reading habits, and the professional satisfactions of publishing are circumscribed to a high degree by a tight circle of journals which represent the prestige organs in each field. In an excellent survey article of 300 chemists and chemical engineers and 400 physicists, Martin and Ackoff found recently that ten or less journals out of thousands that are available accounted for one-half or more of the total reading time of scientists and engineers in the United States.[57] Comparing the cost of publication with frequency of reading for particular journals, they found that the fifth ranking journal was over twice as "expensive" as the most frequently read journal; the tenth ranked journal was over three times as expensive; the fifteenth ranked journal was over eight times as expensive; the seventeenth ranked journal was over fifty-four times as expensive (defining expense as cost of publishing the journal per unit of reading time)! The study by Martin and Ackoff represents a continuing, long term program of research on scientific communication by the Operations Research Center at Case Institute of Technology.

(57) Martin, Miles W., and Ackoff, Russell L. "Dissemination and Use of Recorded Scientific Information." <u>Management Science</u>, 9, 2, January, 1963, page 335.

Clearly, the problem of giving professional visibility to federally sponsored research has profound implications for the progress of science, for the advancement of government programs, and for the choice of media employed by university scientists to disseminate research findings. The data gathered by Martin and Ackoff do not suggest that all but the top 20 or 30 journals should be discontinued on economic grounds. But what they do suggest to the writer is that economic measures of the immediate as well as the social costs of the present system might be employed to gain a deeper understanding of its practical strengths and weaknesses.

Some federal agencies have recognized the problems posed by double reporting and have permitted faculty members to publish their findings in a form which will satisfy both the sponsor and the professional press. Others have insisted upon special forms of reporting designed primarily to serve their purposes without much regard to the added work load. One effect of the resulting proliferation of scientific publications has been to bring the universities into publishing activities on a large scale. To the extent that scientific journals have become inadequate and sponsoring agencies require special reports, the universities have had to invent publication facilitie for much of the expanded volume of scientific literature growing out of their own research.

The solution does not lie within the universities themselves, although further recognition by sponsoring agencies of the burden of excessive and overly-detailed reporting can ease the problem for educational institutions. New techniques for documenting and disseminating scientific achievement will have to be devised to handle the tremendous outpouring of publications from the government's expanded sponsorship of research, both within and outside the educational community. These techniques will require significant changes in the nature and function of the professional press as we know it today.

Happily, the crisis that threatens a breakdown of scientific communication in the United States is beginning to receive the attention it deserves. In a far-reaching report, the President's Science Advisory Committee earlier this year published the results of a comprehensive study of the responsibilities of the technical community and the federal government in the transfer of scientific information. The major findings and recommendations of the ad hoc Panel on Science Information are reproduced below:

> "Transfer of information is an inseparable part of research and development. All those concerned with research and development--individual scientists and engineers, industrial and academic research establishments, technical societies, Government agencies--must accept responsibility for the transfer of information in the same degree and spirit that they accept responsibility for research and development itself.
>
> The later steps in the information transfer process, such as retrieval, are strongly affected by the attitudes and practices of the originators of scientific information. The

> working scientist must therefore share many of the burdens that have traditionally been carried by the professional documentalist. The technical community generally must devote a larger share than heretofore of its time and resources to the discriminating management of the ever-increasing technical record. Doing less will lead to fragmented and ineffective science and technology."(58)

Summary of PSAC Recommendations

For a glimpse of what may become future directions for development of scientific information and dissemination activities in the U.S., it may be helpful to the reader to scan the major recommendations (pages 2 to 6) of the PSAC Panel on Science Information. In abbreviated form they are:

A. Recommendations to the Technical Community

1. The technical community must recognize that handling of technical information is a worthy and integral part of science.

2. The individual author must accept more responsibility for subsequent retrieval of what is published.

3. Techniques of handling information must be widely taught.

(58) President's Science Advisory Committee. Science, Government, and Information. Washington, January 10, 1963, page 1. An earlier PSAC study on the question of whether the U.S. should establish a single all-embracing centralized science information service similar to the U.S.S.R.'s All-Union Institute of Scientific and Technical Information was made by an *ad hoc* panel under the chairmanship of W. O. Baker. (The Baker panel rejected the idea.) The Senate Committee on Government Operations has also issued a number of reports on the problem of dealing with scientific information.

4. The technical community must explore and exploit new switching methods.

   a. Specialized Information Centers.
   b. Central Depositories.
   c. Mechanized Information Processing.
   d. Development of Software.

5. Uniformity and compatibility are desirable.

B. Recommendations to Government Agencies

1. Each Federal agency concerned with science and technology must accept its responsibility for information activities in fields that are relevant to its mission. Each agency must devote an appreciable fraction of its talent and other resources to support of information activities.

2. To carry out these broad responsibilities each agency should establish a highly placed focal point of responsibility for information activities that is part of the research and development arm, not of some administrative arm, of the agency.

3. The entire network of Government information systems should be kept under surveillance by the Federal Council for Science and Technology.

4. The various Government and non-Government systems must be articulated by means of the following information clearinghouses:

   a. Current Efforts Clearinghouse.
   b. Report Announcement and Distribution.
   c. Retrospective Search and Referral Service.

5. Each agency must maintain its internal system in effective working order.

   a. Technical reports should be refereed or otherwise screened before they enter the internal information system.

b. Agencies must insist that their contractors live up to their contractural obligations for adequate technical reporting.

c. The Panel recommends that problems of security and declassification be studied by an ad hoc group of the Federal Council's Committee on Information.

d. Since the report literature is often poor, critical reviews of the report and related literature play an important role. Critical review journals published under Atomic Energy Commission auspices have been generally successful; we urge other agencies to undertake similar review ventures in fields of interest.

e. We believe that the large central agency depository should concentrate on being a document wholesaler, and that, where specialized centers exist, the job of preparing state-of-the-art reviews, and otherwise interpreting the literature, should be the responsibility of the specialized information center.

f. Since these latter activities are so important to the effective transfer of information, we believe that the agencies concerned should actively sponsor and support additional specialized information centers at appropriate establishments.

6. Problems of scientific information should be given continued attention by the President's Science Advisory Committee.

CHAPTER XII

PEOPLE AND PROGRAMS

Academic Salaries

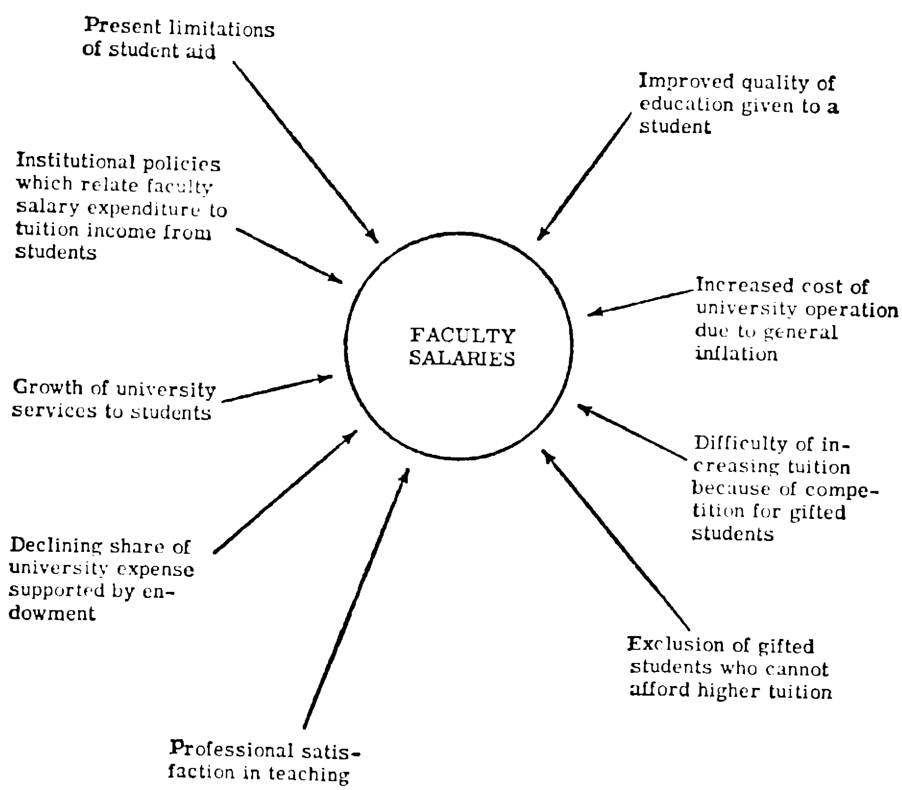
No new emphasis need be given here to the fact that salaries of educators have lagged the cost of living and the general rise in wages of the labor force in the past twenty years. Efforts to raise faculty salaries have generally been more successful during the past six or seven years than previously, but the results are still unsatisfactory.(59) "Lack of funds" sums up a host of reasons why this is so, some internal to higher education and others rooted in the values assigned to higher education in our society. Chart II displays some of these factors operating internally.

The unprecedented rise in research and development expenditures has brought stiff competition from industry and government not only for faculty members but also for technically educated students at all degree levels, many of whom have the inclination and potential for teaching. The associate professor, five or more years beyond his doctorate, all too often watches a new Ph.D. he has just steered through the process, go

(59) Seymour E. Harris has noted that as late as the middle 1950's prestige universities were paying their full professors 20 per cent less than in 1930 in dollars of stable purchasing power. "In relation to the rest of the labor force their relative economic status had declined by about 50 per cent." S. E. Harris. More Resources for Education. New York, Harper, 1960, page 73. See also the chapter by Dexter Keezer in Financing High Education, New York, McGraw-Hill, 1960.

CHART II

SOME FACTORS WHICH INFLUENCE FACULTY SALARIES



to first employment at a salary exceeding his own.

Educational institutions with large commitments to science and engineering have been hard put to attract and hold enough first-rate faculty members. Other institutions, who recognize the importance of providing research opportunity as an inducement in faculty recruiting, but whose research programs are small, face a different but no less severe pressure from the non-education sector. They lose outstanding scholars to the prestige schools because of greater economic and professional inducements. The major universities, in turn, are high on the stop list of places to which industry and government regularly turn for scientific advice, leadership, and personnel.

Few would deny that sponsored research programs help the colleges and universities meet these competitive forces by providing research opportunity to faculty members and some relief to beleaguered salary budgets. Sponsored research programs make it easier for research-oriented educational institutions generally to maintain higher salary scales than they could otherwise support. To the extent that a part of the salary budget can be charged against sponsored research, part of the burden of a higher scale, as well as periodic increases, can be shifted from general funds to the research budget. However, this kind of financing, common in industry, appears as a risk in the psychology of a university, because of the short-term nature of most federally sponsored research funding.

In the administration of academic salaries, the single most important consideration is the permanence of promises. The tenure system affects both tenured faculty and those who may be striving to achieve it. Salary administration is interwoven with tenure considerations at all levels of academic rank and tenure status. A tenure commitment is indeed serious for a university when a fully endowed "chair" requires half a million dollars. Thus, sponsored research reaches into the heart of an institution when tenured faculty participate, and deepest into university coffers when tenured faculty salaries are involved.

As a result, a variety of protective policies has grown up regarding the charging of faculty salaries to sponsored research. Some institutions (e.g., Harvard) refuse to charge tenure salaries; some will charge only a portion of tenure salaries and a portion of non-tenure salaries (e.g., Princeton); others will charge the allowable salary expense regardless of whether the faculty participant is tenured or not (e.g., M.I.T.). In general, those institutions which are relatively well off in terms of over-all endowment and endowed chairs have tended to be somewhat more courageous about not charging tenure salaries to sponsored research. Interestingly, they would appear to need the protection the least.

In sponsored research, no less than in an educational institution at large, academic salaries are important because faculty time is an essential ingredient. Thus, the treatment of faculty salaries is a central aspect of almost all financial arrangements between the university and the federal government.

Curiously, in most of the literature dealing with federal sponsorship of university research, the distance between the universities and federal sponsors has almost universally been measured in terms of differences over the reimbursement of indirect costs. The universities have been strangely silent on the question of charging faculty salaries. Yet these expenses constitute slightly more than half of the total reimbursed cost of federally sponsored research in the universities and roughly three-fourths of the total direct costs of the research they perform. Direct costs, in turn, are the basis for calculating the allowances made for indirect expenses on both federal contracts and grants.

To put the matter graphically, a 10 per cent understatement or underrecovery of faculty salaries charged against sponsored research contracts and grants would deprive educational institutions of more sponsored research income than the total amount they are now estimated to be losing through inadequate indirect cost allowances. Moreover, any failure on their part to charge the full amount allowable for appropriate faculty salaries involved in sponsored research means actual dollars of foregone income in addition to the losses they incur on indirect costs which are not fully reimbursed under present reimbursement policies.

Both kinds of losses are real, of course, but the former has a double-barreled effect. It also reduces actual cash flow to a level below the allowable level under present reimbursement policies.

The question of charging faculty salaries to sponsored research budgets encounters a range of reactions and practices within individual departments. In his excellent study of Princeton's experience in federally sponsored research, William G. Bowen enumerated the following attitudes among faculty members at that institution:(60)

On the Negative Side

1. Some regarded the practice as morally reprehensible, especially when tenure salaries are involved.

2. Some felt under more pressure to produce when their salaries were being paid in part by outside funds.

3. A few department chairmen were opposed because of the excused teaching time which sponsored research may entail.

4. Some faculty members were skeptical about morale effects of uneven teaching loads.

5. One department head feared a reduction in his general budget because the availability of sponsored research funds in any given year might mean a permanent loss in future budget sessions.

6. Some faculty members feared the University might overextend itself.

(60) Bowen, W. G. The Federal Government and Princeton University. Princeton, 1962, pages 44-47.

<u>On the Positive Side:</u>

7. Many faculty members welcomed the lighter teaching loads made possible by sponsored research.

8. There was a general acknowledgement that federal participation in the salary budgets of particular departments had enabled the University to expand more rapidly in certain areas than would otherwise have been possible.

One reason for opposition, not noted by Bowen but which has been a factor in many institutions, is the natural reservation many faculty members have about revealing their salaries to colleagues within the institution or at other schools as well. Many federal agencies, notably the National Institutes of Health and the National Science Foundation, rely upon the referee system of judging research proposals. In practice, this involves an evaluation of the scientific merits of the proposal by a panel of scientists or engineers at other institutions in much the same way as a professional paper is judged prior to acceptance for publication in a journal. In many fields the circle of competence to judge the merits of a proposal may be limited to a few dozen individuals or perhaps a hundred scientists or engineers at the most, many of whom may be in frequent professional intercourse. Faculty members who prefer privacy find little comfort in proposals which are bound to be scrutinized by a small circle of peers when salary information may be involved.

In fairness to the universities, it should be noted clearly that they face a fundamental dilemma in the matter of charging faculty salaries, and this is seen in boldest relief in those institutions whose sponsored research programs represent a major fraction of total university operations. If they seek to protect themselves in the long run from "undue" dependence upon federal sponsorship by absorbing faculty salary expense that could be charged to research budgets, they are inviting a greater acceptance of external influence in the allocation of university resources, according to the changing, short-term pattern of federal sponsorship. If they seek to recover the maximum salary expense possible under federal grants and contracts, they can minimize the external pull of sponsored research on general university funds in the short run, but in doing so they take a calculated, long-run risk of becoming dependent for a share of their total salary budget on short-term, federal funds. The short-run solution does not lie in striking a middle position between these two extremes. It lies instead in (1) an acknowledgment by each institution of the role it sees for university research in pursuing its primary educational goals, (2) a recognition that sponsored research in its present form involves inherent financial risks, and (3) the assumption of these risks up to the limit of each institution's willingness and ability to assume the degree offinancial risk required. The long-run solution lies outside the universities in an enlargement of their uncommitted funds and in a more secure basis of funding federally sponsored research.

Some schools seek to minimize the risk of unpredictable federal funding by maintaining basic academic salaries at lower levels and providing incremental payments to faculty who engage in sponsored research. But if the payment of tenure salaries out of temporary research funds means financial risks for the university, the practice of financial reward according to participation in sponsored research has deeper implications. Aside from the short-term nature of these increments, the extra pay, combined with the uneven sponsorship among academic disciplines, tends to create faculty "haves" and "have nots" and to pattern the emphasis of faculty compensation to that of research sponsorship.

In its report on Government-University Relationships in Federally Sponsored Scientific Research and Development, 1958 the National Science Foundation urged against incremental salary payments to faculty engaged in sponsored research. Some schools have nevertheless continued extra pay on the ground that faculty are provided with incentives to enter into more research than they might otherwise do. These institutions accept the potential conflict of interest between educational purposes and desire for personal income--with the attendant need for care in screening research proposals and policing the system. In their view, sponsored research not only makes a contribution to education, it has had a direct and practical effect upon their ability to maintain reasonable salaries--for research-minded faculty as well as those who are carried along by the tide.

Both industry and government have created laboratories and working conditions comparing favorably with those of universities.(61) These working conditions include opportunities to conduct research with many of the freedoms associated with academic systems. In some companies, personnel are granted leaves of absence to teach or pursue problems that interest them. Thus, comparative research opportunities as well as salary differentials can critically determine an institution's ability to hold its faculty intact. If its financial structure enforces low salary scales, it compounds the risk of losing outstanding scholars by falling too far behind industry and other institutions in providing opportunities for professional growth through research.

Two special problem areas need to be mentioned in connection with charging faculty salaries to sponsored research. The first is the question of summer employment of faculty members. The second is the present "teaching-time-released" basis of figuring the appropriate fraction of a man's time to charge against sponsored research budgets. It is worth taking the time to consider each of these questions briefly.

(61) See for example the excellent case study of the transistor discovery at the Bell Laboratories. R. S. Nelson. "Link Between Science and Invention: The Case of the Transistor." Rate and Direction of Inventive Activity: Economic and Social Factors. National Bureau of Economic Research, New York, 1962.

Summer employment can profoundly affect a faculty member's annual earnings, as well as his professional advancement. In most of the major universities faculty compensation is paid in twelve equal installments for nine months of academic duties performed. Faculty members are typically free to use the three summer months as they see fit. If a man engages in extra teaching during the summer period he may be paid an extra increment of salary based upon his regular academic year (nine months) salary. Thus, a faculty member in an institution which offers paid summer teaching opportunity may receive his regular salary during the summer months plus an increment for summer teaching--usually referred to as the "extra 1/9" or "extra 2/9th," depending upon the limit of summer employment offered by that institution. If a faculty member engages in a university-sponsored special summer study activity, he may receive extra compensation for summer employment in the same manner. If he engages in sponsored research, he may receive extra compensation, the research budget being charged with the appropriate share of his time devoted to the project during the summer. If he engages in private consulting work for the summer; he can also earn extra pay but these transactions are matters of private concern since they do not involve the university directly. On the other hand, if he devotes the summer period to unsponsored research and engages in private studies to advance his professional development, he is not entitled to receive extra summer compensation under the present pattern of summer employment followed by most of the major institutions.

The reader can see at once that a fraction as large as 2/9ths (22 per cent) can make a crucial difference in the total annual income of a faculty member, especially if he is located in a field where neither teaching nor university-sponsored study activity nor private consulting nor sponsored research opportunities exist. The problem is seen in sharpest relief in the humanities and in some fields of the social sciences where extra income-producing summer activities are virtually non-existent. Assuming that most faculty members wish to spend their summers productively, and most do, the availability of professional pursuits that <u>also</u> bring extra income is as important as the base rate of faculty compensation during the regular academic year. Summer employment opportunities in the university need to be understood clearly in evaluating the salary gap between particular institutions and between education on the one hand and industrial employment on the other.

Sponsored research plays a dominant role in determining the pattern of extra faculty compensation during the summer months. Teaching--the other main source of extra institutional payments to faculty members--is greatly contracted compared with research activity, which is not geared to the nine-month academic calendar. And since the federal government sponsors some three-fourths of all university research, the pattern of extra faculty compensation for the summer months is largely, although not completely, a matter of uneven payments controlled by federal sponsorship of university research. The shortcomings of this system are fairly self-evident, and the imbalances (some would say inequities) deserve the careful attention of students of academic administration, patrons of higher education, and the federal government alike. This writer believes that the summer period cannot realistically be divorced from the regular academic year in developing sound policies for sponsored research, no less than for other university activities. There are broad issues involved here that go beyond the care and feeding of faculty members, e.g., optimum use of educational resources, faculty development, and institutional growth.

The second question mentioned earlier concerns the present "teaching-time-released" method of charging faculty salaries to sponsored research budgets. This method of direct costing would be realistic if faculty members had no academic responsibilities other than teaching classes and if they were not expected to do research unless it was sponsored. Both assumptions are false, of course, except in the four-year institutions where research plays a minor role in the education of students--and even here faculty members are expected to play an integral part in academic affairs. The teaching-time-released approach to charging makes no allowance for the total educational responsibilities of a faculty member. It assumes that he is employed by the university to teach classes only.[62] Much of the confusion about the impact of sponsored research on higher education has its roots in this erroneous oversimplification. Its worst expression pits research <u>against</u> teaching, neglecting the other components that make up a faculty member's total responsibility to the institution. Critics of sponsored research have been more attracted by the cost accounting necessities, which seek to divide these interdependent functions, than by the joint nature of the products involved. The most naive among the detractors consistently neglect some of the joint products.

The teaching-time-released approach penalizes those institutions whose teaching loads are purposely set low to encourage research. In these institutions a faculty member is expected to do research, as well as participate in academic affairs, regardless of whether outside funds are available to sponsor research. A faculty member who neglects this fundamental ground rule in accepting a light teaching load at institutions which offer them runs the risk that his teaching performance and his

(62) It would seem to be appropriate under today's standards for that category of teacher who is not intimately a part of the institutional community but who is employed to give lectures on a special field--in academic phraseology, a Lecturer.

contribution to academic affairs may not be sufficient to gain advancement in rank, tenure, salary, prestige or other emoluments he seeks.

Under the present system of charging faculty salaries, no account is taken of the total research time a faculty member may devote to a sponsored research project. Only that portion which the institution recognizes as requiring a reduction of teaching time may be charged. The difficulties posed by this "fractional man" approach have caused some administrators of sponsored research to advocate a "total-time-released" approach, which would take into account not only the impact of a sponsored research project on teaching time but also on the other two components of his academic appointment--his <u>regular</u> research time and his other academic duties. The institutions which maintain light teaching loads might be expected to recover more of their total research costs (direct and indirect) under this scheme. And, of course, the impact of sponsored research on university finances would be that much greater.

One can be sure that federal research and development contracts in an industrial setting are costed on the basis of whole scientists and engineers, not part-time employees who are charged to the grant or contract only if their service to it requires a reduction of <u>some</u> of their other company duties.

Federal sponsors have contributed a share of the difficulties regarding the charging of faculty salaries. The National Institutes of Health and the National Science Foundation have followed a tradition of not accepting charges for any part of the salary of the principal investigator on a project sponsored by them. The Atomic Energy Commission has followed this general line. It has also expressed reservations about the charging of tenure salaries to AEC sponsored projects, although it will accept such charges if the institution makes them. By contrast, the agencies of the Department of Defense have placed no restrictions on the charging of tenure salaries or on the payment of appropriate salary expenses of the principal investigator. Private sponsors of university research similarly impose no such restrictions. For consistency, faculty salaries are also charged to privately sponsored research accounts on the basis of "teaching-time-released" but private sponsors are typically asked to pay a higher indirect cost rate than federal sponsors, which recognizes a higher degree of proprietary interest in the research they sponsor as well as the university's contribution to the project through the "fractional man" method of charging salaries.

In developing compensation policies, educational institutions have traditionally turned toward their own internal finances. In doing so they rely heavily upon the non-salary advantages of an academic community. The tenure system has added much to caution in granting salary increases. Accustomed institutional rules of thumb relating faculty salary expense to tuition and endowment income have altered more slowly than the infusion of sponsored research into university education has changed the meaning of teacher-student ratios. Restraints on tuition increases and the slow rate of growth in endowments have thus sometimes disproportionately restrained academic salaries.

Opportunities for private consulting and other professional endeavor enable many faculty members to augment their academic salaries as well as to gain experience that keeps them as teachers. At the same time, faculty consulting opportunities pose special problems. In particular, they are not uniformly available and are therefore difficult to take into account when setting salary scales.

Each institution has its own financial worries. Tax supported schools contend with the political pressures of the appropriations process; the privately supported are reminded by the bankruptcy that occurs from time to time in their midst that they operate under rigorous financial limitations.[(63)] The entire community must fear the decline in effectiveness that goes with financial distress.

(63) The University of Houston (1960) and Syracuse University (1961) are recent examples of privately endowed institutions that relinquished private control to become a part of the publicly supported state university system in Texas and New York respectively.

There is a general scarcity of economic literature dealing with the subject of faculty salaries. But the student of salary administration may find some of the references listed in the Bibliography at the end of this study[(64)] helpful in gaining a deeper understanding of the relationship between faculty salaries and sponsored research. One can hope that, as economists are attracted to the economics of higher education, labor economists, in particular, may find it worthwhile to devote special studies to the supply and demand for professorial talent (as distinguished from scientific manpower generally.)[(65)]

Most of the literature available is of a survey nature. There have been no significant attempts to treat salary, tenure and research opportunity as basic factors in the supply of university professors, or to measure the relative importance of these variables. The shape of the supply function is of particular interest. It is probably backward bending because of substitution effects among these three determinants. University professors are people too, and there is some reason to believe that income effects are operating as the general level of their compensation rises. But these are matters which deserve more attention

(64) See the Suggested Bibliography for Studies of Academic Salaries at the end of this study.

(65) For a contrary view see <u>The Academic Marketplace,</u> pages 166-170. Caplow and McGee argue that the influence of supply and demand for professional talent in the academic market is sharply limited by institutional factors, mainly prestige.

than they can be given in this paper, which has sought mainly to examine the present relationship between faculty salaries and federally sponsored research.

Research Salaries

The employment of full-time, non-tenure, research staff is common at educational institutions having substantial research undertakings. Working in close association with faculty members who supervise projects and with students who may be part of a team, these individuals add to the quality and continuity of university research.[66] They are a principal means by which the changing requirements of research, personnel and money can be accommodated without interfering with the instructional activities of the academic departments. From the project director's point of view, it is difficult to estimate from year to year how many students will be available and interested in associating with a particular undertaking. To the extent that full-time research staff is accessible, the faculty member in charge is also freed of many time-consuming aspects of experimentation; he can give more of his

(66) The writer is indebted to Dr. P. T. Demos of the Laboratory for Nuclear Science at M.I.T. for the opportunity to read his excellent unpublished study entitled, "The Non-Teaching Scientist in University Research," November, 1959. Dr. Demos conducted a private study of the role of the non-teaching scientist at a number of institutions who maintain large programs of sponsored research. This section on Research Salaries has the benefit of many insights developed by Dr. Demos. At the same time, the author takes full responsibility for the material as it is presented above.

energy toward the formulation of plans and supervision. Supervision and stimulation are especially important with students whose association may be in the form of a thesis investigation for a graduate degree.

To those who accept non-academic appointments, the opportunity to work with outstanding faculty members in an atmosphere conducive to research is a significant attraction. The freedom to publish and to develop their own understanding of their specialization in an environment free from commercial interests or restrictive regulations is among the primary reasons for accepting appointments, often at financial penalty. The contributions of these staff members to faculty-student relationships and to the substantive content of research deserve a high order of recognition. Without their collaboration, faculties could not be as productive in research and teaching. They represent an able and potentially large source of teachers to meet the expanded enrollments on the way for the 1960's. At institutions which encourage research they already play a vital role in the professional development of both students and faculty. Many are authorities in their own right and can pace rather than follow intellectual standards. Those inclined toward teaching are all the more effective for their personal association with laboratory and departmental research programs.

The readiness with which research staffs can be recruited is a matter of record. The conditions under which employment is offered and the way in which research personnel are integrated into the organizational complex vary with institutional policies as do project selection, details of contracts, and other aspects of sponsored research.

Research salaries, on the other hand, are influenced by external factors, and they present universities with questions of salary administration in which experience has been limited. Broadly speaking, research salaries are influenced by the level and structure of academic salaries on the one hand, and on the other, by the competitive behavior of the market for research manpower. Large-scale government sponsorship enables an institution to enter the market for personnel with scales which may be low because of the nonmonetary advantages of working in a university environment, but which are at least realistic.

In turn, this inflationary pressure is passed to the academic salary structure because of the internal relationship between academic and research salaries. Neither industrial nor governmental organizations are averse to recruiting faculty members and full-time research personnel for leading research positions in their laboratories. An institution with large research commitments can no longer enjoy the simple existence of determining salary policies in the light of compensation levels at other colleges and universities and by examining its own financial position. Research operations which comprise as little as 10 per cent of the university's total budget bring with them the vicissitudes of the market place and the noneducational influences which contribute to the behavior of research salaries.

An example from M.I.T. salary experience may help to illuminate this discussion. In 1958 there was a total of 312 equivalent full-time staff members engaged as professional research personnel in the campus laboratories of the Institute. These research personnel were distributed throughout the various departmental and interdepartmental laboratories of M.I.T. The units to which they were attached varied in size from the small research project supervised on a part-time basis by a single faculty member to the large interdepartmental laboratory of up to 150 academic staff members and students. For salary administration purposes these research personnel are considered separately from the academic salary structure although the conduct of their work is completely integrated with the project or a laboratory to which they are attached.

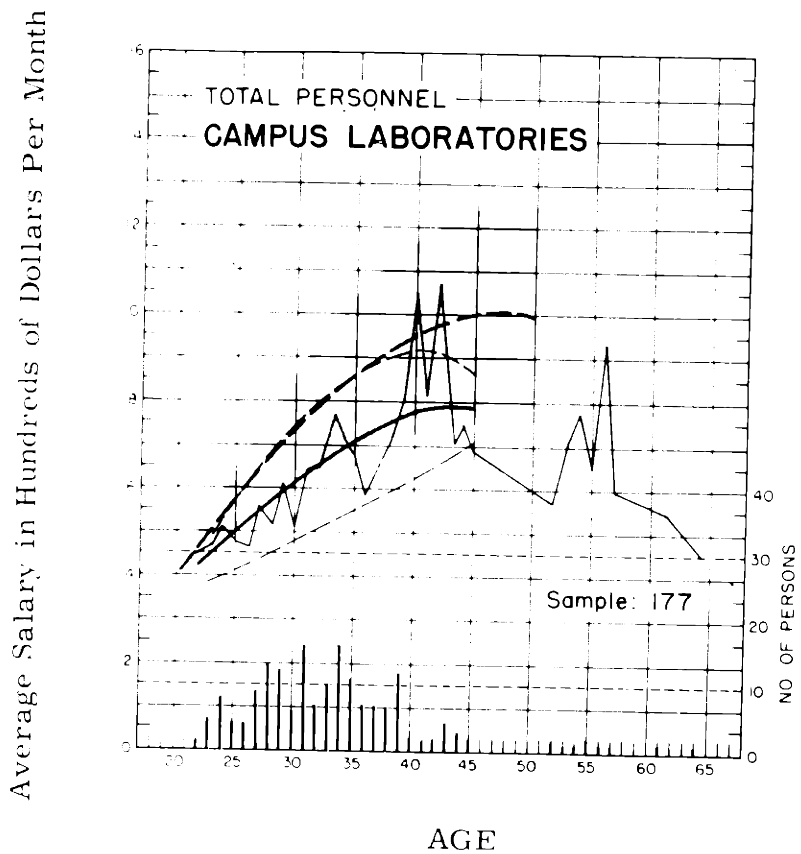
For the past few years the Institute has conducted a salary survey of some two dozen industrial and nonprofit laboratories thought to be roughly comparable in size and character with the campus laboratories of M.I.T. These salary surveys of research personnel in non-supervisory positions have been helpful in gauging the level and behavior of research salaries and other forms of compensation. They have served to provide the Institute with some measure of the gap between campus research salaries and those of outside laboratories who largely determine the market for research manpower of the type desired by M.I.T.

Chart III shows a comparison between the research salaries for full-time M.I.T. research personnel and those of the 24 research laboratories which comprised the total survey for the year 1958.

CHART III

M.I.T. SALARY SURVEY - SUMMARY, 1958

(Comparison of On-Campus Research Salaries at M.I.T. with Industrial Research Salaries)



KEY:

Total Survey
±1 Standard Deviation

---- Survey Mean

—— Group Mean - M.I.T. Campus Laboratories

Group Actual Mean - M.I.T. Campus Laboratories

Source: M.I.T. Salary Survey, 1958.

Chart III compares average monthly salary and age of full-time, non-supervisory, research personnel at M.I.T. with the equivalent personnel at the twenty-four outside laboratories included in the survey sample. All of the data shown are averages, both for M.I.T. and the outside laboratories, regardless of the degree category of the personnel in question. The shaded area represents the total survey on the basis $\pm$ 1 standard deviation from the total survey mean, which is represented by a heavy dotted line. The mean for the M.I.T. group is shown as a heavy solid line. The M.I.T. group salary data are based upon a sample of 177 research personnel. The distribution of the ages of the research personnel of the M.I.T. sample appears on the abscissa in the form of a bar graph.

The M.I.T. group mean is uniformly below the total survey mean and the gap between the M.I.T. group mean and the survey mean continues to widen over most of the age range covered by the survey. Thus, the difficulty of retaining a research staff member beyond a period of a few years increases quite apart from the tendency of research salaries for a given age, degree, and experience to increase more rapidly in outside laboratories due to competitive market effects. (On the chart this would be represented by an upward shift of the shaded area.)

Employee benefits--health and accident insurance, life insurance, pension arrangements, and other supplements--are also part of the pattern. In view of prevailing practice, these salary supplements are important for both their competitive and intrinsic value. Because of them, academic compensation becomes even more closely tied to that for research personnel.

The large university-managed research center complicates salary administration. The provision of administrative services to the major research centers requires the enlargement of the general administrative function of the university. In the national interest, the university must support the programs at these centers by offering salaries and working conditions attractive to top-flight scientists and engineers. The result is a salary structure which differs from that on campus. Yet institutions which manage research centers typically place a heavy emphasis upon research in their own campus laboratories. Consequently, in accepting the responsibility for the centers, they take on the enlarged task of managing another separate but not entirely distinct salary system.

The search continues for management procedures which increase the availability to the center of the substance of the university without producing adverse effects on the nice balance of forces sustaining that substance.

Academic Tenure

Academic tenure, as an inducement to the teaching profession, is intimately related to the need of an institution for independence in its pursuit of truth, for continuity and excellence in the exercise of its educational function. In order to encourage faculty research, an institution must recognize accomplishment as one reason for the award of tenure. The terms under which research is sponsored have a direct bearing, therefore, upon the tenure system.

The award of tenure applies only to the institution which makes it and not to the entire educational community. The prerequisites for it on one campus may differ markedly from those on another, and the practices of granting it are necessarily affected by financial position.(67) However, tenure almost always means a degree of security and recognition for the recipient, either locally or among his professional colleagues at large. The important feature, for present purposes, is the fact that academic tenure is not automatically self-regulating but is a principle of administration. As such, it is subject to subtle influence from university research relations.

Where research is a legitimate reason for awarding it, tenure is multi-valued in contrast to the granted for teaching and academic

(67) See, for example, the case studies of fourteen colleges and universities mentioned earlier in the section on faculty salaries: J. F. Wellemeyer, Jr. (ed.), Compensation on the Campus. National Education Association, Washington, 1961.

affairs alone, and thus there are extra complexities. Proved researchers are more difficult to identify than proved teachers, and the proof is certainly not found in the quantity of research performed, even in the number of papers published. There is reasonable assurance that a good teacher will continue to teach effectively, but usually less certainty that a high level of research activity will be sustained. Where research is regarded as a large part of the educational process, constant vigilance is needed to insure that tenure practices do not discriminate against faculty members who engage in little or no research but who are nevertheless important teachers.

We have noted earlier one of the principle features of the present system of sponsorship, which relies heavily upon individual faculty members to assume the initiative in securing research support. This poses special problems in the award of tenure. In order to do research, a faculty member first has to find someone willing to sponsor it. The identification of research problems and the formulation of plans are not easy to delegate administratively. Whether he himself looks for a sponsor or whether the institution does, the fact remains that his prospect of securing support will hinge on his ability to relate his research plans to the interests of sponsors--federal or private--including the university itself, when the institution supports the work. It is necessary, therefore, to safeguard against the premium that may be placed on showmanship to the disadvantage of the capable scholar whose motives are genuine but whose persuasive ability is low.

To some degree, the existence of a formal laboratory setup helps to alleviate the problem of academic salesmanship. Often, a laboratory director can secure broad program grants which underwrite the research activities of a large number of faculty members who are affiliated with the laboratory, many of whom might be inept at presenting a compelling case for themselves.

A related problem bearing upon the research-oriented tenure system is the discrimination between proved and unproved faculty members in the matter of awarding research grants and contracts. Agency administrators naturally find it easier to award research sponsorship to well-known names or to faculty members in positions of research leadership on university campuses. Often, the younger faculty member who is striving to obtain project support is in a weaker position in the prestige-laden arena of contract awards. Yet his need for research sponsorship in terms of qualifying for tenure may be greatest at a time when his credentials are the least impressive.

The relative ease with which developmental projects attract some kinds of government support can also place a strain on a tenure system which recognizes research accomplishment. Where a project accepted falls below standard--and this risk increases with the greater urgency frequently associated with development, as opposed to basic research--it is more likely the educator who loses than the project. Where a graduate thesis may also be adversely influenced, the loss is compounded. Where a non-tenure faculty member may be involved for the sake of increasing his visible research volume in moving toward tenure, the loss is further aggravated.

At the 52nd meeting of the Carnegie Foundation for the Advancement of Teaching in November 1957, the trustees engaged in an all-day discussion of the education of college teachers. Their report ended with a number of recommendations, which included as a final point: "All institutions of higher learning should accept responsibility for the continued intellectual and professional growth of faculty members."(68)

The tenure system, protecting the right of dissent in the continuing exploration for truth and in its teaching is a vital prerequisite to the process. The fact of its principal deficiency--that it also gives a degree of protection to the unjustifiably complacent and the unworthy--only emphasizes the critical significance of taste and discernment in tenure awards. As sponsored research becomes a weighty factor in the system, the quality of its administration becomes very important indeed.

(68) The Education of College Teachers, page 18.

Curriculum Effects

Curriculum developments, like most aspects of university organization, present difficulties in generalizing, especially with regard to the impact of federal research funds. What may apply in one area at a given institution might not apply to another. Curriculum developments vary widely from one institution to another and between university departments, depending upon educational philosophy, local tradition, relationship of graduate courses, if any, to undergraduate programs, research emphasis, nature of academic discipline and, most importantly, the rate of change in a particular field.

In advanced and specialized areas, courses of instruction are organized around creative individuals. What faculty members teach depends partly upon subjects inherited from the past but more importantly, upon their current outlook. The latter are in turn influenced by the on-going research programs of a university, many of which may be sponsored by federal agencies.

To gain perspective, it is significant to note that research-induced curriculum changes typically occur first at the graduate level as new knowledge or new technologies are discovered, illucidated, and reduced to fundamental principles. On the other hand, when a field reaches saturation, or when it does not benefit from a vigorous research program, curriculum changes are likely to be much slower. If they occur at all, such changes are usually made first at the undergraduate level and later in the graduate school as university departments alter their basic teaching approach.

Where improvements are sought, a common practice is to upgrade the level of undergraduate subjects by including material that might previously have been treated only in advanced courses. In extreme cases, older subjects are dropped from the undergraduate curriculum, or they are made optional as, for example, the teaching of graphics in many engineering schools today. In any case, changes in the choice of subject matter in a given field are determined largely by the rate at which the field itself is changing.

The impact of federal research funds operates through the selective sponsorship of graduate research programs. At this level the curriculum effects of research are more observable and more pronounced. At the same time, the effect of university research is by no means restricted to graduate curricula.

The presence of a top-flight graduate school, supporting vigorous research programs, is essential to high quality undergraduate education in a university polarized around science. What affects the graduate school most certainly has a profound effect upon the quality and vitality of the undergraduate curriculum. In many institutions the faculty who teach at both levels are the same, and if they are different the collaboration of graduate and undergraduate teachers in research, in committee assignments, departmental functions, and other aspects of university life produces a continuous interaction at all levels. Teachers, students, research personnel and university administrators all take part in this graduate-undergraduate interaction.

It is beyond the scope of this paper to attempt a detailed analysis of curriculum changes induced by federal sponsorship. Within the fields currently sponsored, we have noted that research proposals originate largely within the universities themselves. Thus, the curricular effect of federal research funds has largely been to underwrite the conditions for change in subject offerings by accelerating scientific progress in particular fields.

The development of the M.I.T. curriculum in the Department of Electrical Engineering illustrates some of the foregoing statements. This curriculum has attracted national attention for the fundamental changes that have been made in it as a result of swift changes in the physical sciences and electrical technology over the past twenty years. It is especially pertinent to the subject of federal research funds because the areas that have undergone drastic curriculum revision in electrical engineering have included one older area (power engineering) that was largely unsupported by federal or private research funds--an area which lagged the development of newer, better supported areas (computation, automatic control, electronics and communication) and had to be revised more slowly from the undergraduate level up.

For this example the writer is indebted to an unpublished paper by George E. Kersey, "The Government, M.I.T., and Electrical Engineering," submitted to the Seminar on Jurisprudence, Harvard Law School, April 29, 1959. Mr. Kersey notes that in 1938 there were three options in Electrical Engineering at M.I.T.--Power, Communication, and Illumination. Electronic Applications was added as a fourth option in 1942 and Illumination was dropped in 1943. By the end of World War II, after five years of intensified wartime research, there were 31 categories of specialization open to students of electrical engineering at M.I.T.! Under the leadership of Professor Gordon S. Brown, then head of the Department and now Dean of Engineering at M.I.T., options based on specialization were eliminated by 1954 and basic courses were spread over four years.

To borrow an analogy from highway planning, the rapid progress in science and electrical technology had resulted in a proliferation of courses and specialties in electrical engineering not unlike the unplanned growth of country roads that wind and twist through previously sparsely populated country to reach isolated inhabitants. The location of the roads is largely determined by the earlier settlers. When more and more residents inhabit the area, the roads become inadequate. Finally, they have to be widened or in some cases replaced by superhighways to expedite the flow of traffic. Curriculum obsolescence behaves in much the same way as the obsolescence of the winding country roads. The effect of university research is often to generate a population boom along the old roads until they become hopelessly overburdened and inadequate to the task.

We have already stressed the dynamic role of university research in the educational process. Mr. Kersey's paper points up the course by course introduction of new subjects in the electrical engineering curriculum at M.I.T. as sponsored research projects, underwritten in large part by federal funds, opened up new areas of study in digital computation, automatic control, electronics, and communication. In many instances these new courses were begun long before textbooks or formal notes were available as teaching materials. Indeed, as this paper is being written a national committee on electrical engineering education is hard at work analyzing the curriculum changes needed to assimilate and improve the teaching of semiconductor theory and application in the engineering schools. The semiconductor is hardly more than ten years old as a development in electrical technology but it has already profoundly influenced the education of electrical engineers.

When the curriculum is taken to mean the planned sequence of course requirements and electives for an academic degree, then the high rate of curriculum obsolescence introduced by the invasion of new knowledge into an area of teaching can be seen in the statistical behavior of course offerings in a particular institution. An attempt was made to determine numerically the extent of course changes occurring at M.I.T. during the ten-year period 1952-1962. While not all of the changes observed can be attributed to sponsored research programs at the Institute, there is little doubt that sponsored research has been a prime mover by generating the conditions for change.

Table 11-D summarizes the results of this survey of M.I.T. course offerings. Courses listed in the 1951-52 and 1961-62 Catalogue were carefully compared as to title and description to determine whether the courses listed in 1961-62 were either new or had changed substantially. A summation of "new" courses was obtained by adding the number of courses in the 1961-62 book which did not appear at all in the 1951-52 catalogue and the number of courses listed in both catalogues which had changed radically in the ten-year period. An effort was made to be conservative in this latter evaluation, and there is reason to believe that the number of radically changed courses was actually understated. In any case the ultimate error in the number of "new" courses is not large since three-fourths of the "new" courses tabulated in Table 11-D were not listed at all in the 1951-52 Catalogue.

(TABLE 11-D)

SUMMARY OF COURSE OFFERINGS
AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, 1952-1962

School of Engineering	# Courses 1951-52	# Courses 1961-62	"New" Courses	% "New"	% Change	"New" courses Undergrad	"New" courses Graduate
Aeronautics & Astronautics	57	61	36	59	63	10	26
Chemical Engineering	42	47	28	60	67	14	14
Civil Engineering*	129	89	45	50	35	13	32
Electrical Engineering	118	142	107	75	91	61	46
Mechanical Engineering	124	124	55	44	44	33	22
Metallurgy	57	52	12	23	21	6	6
Naval Architecture	52	29	14	48	27	3	11
Nuclear Engineering	--	27	27	100	--	--	27
Total and Average	579	571	324	57	51**		
School of Science							
Biology	35	43	22	51	63	9	13
Chemistry	71	62	19	31	27	7	12
Food Technology	27	25	18	72	67	2	16
Geology & Geophysics	56	68	39	57	70	18	21
Mathematics	79	91	46	51	58	11	35
Meteorology	36	30	9	30	25	--	9
Physics	68	77	41	53	60	7	34
Total and Average	372	396	194	49	52		
Other Schools and Departments							
Architecture & Planning	47	65	50	77	106	21	29
Economics	70	133	100	75	142	39	61
Humanities	37	80	65	81	175	65	--
Modern Languages	25	40	24	60	96	13	11
Industrial Management	46	75	54	72	117	12	42
	255	393	293				
Total & Average of all schools	1206	1360	811	76	65**		

Source: M.I.T. General Catalogue, 1951-52; 1961-62.

* includes Building Engineering and Construction
** Nuclear Engineering not included

The change for each department is given both in terms of per cent "new" courses (using the 1962 totals as the base for comparison) and per cent change, taking the same number of new courses between 1952 and 1962 and comparing them with 1952. The per cent new courses for M.I.T. at large (using 1962 as the base for comparison) was found to be 76 per cent, based on the ten-year interval. The per cent change was 65 per cent. The reader may find it interesting to observe the high rate of change in the Department of Electrical Engineering.

Advances in the technology of science and engineering may also have a pervasive effect on the total curriculum of an institution. They may originate in one or two departments but spread rapidly into other disciplines. This is particularly true of research findings and methods or research equipment that have general utility in advancing learning in a wide range of fields. Research in communication science partakes of this nature because of its fundamental bearing upon the learning process. Research on the instruments and tools of research can have a profound effect on a range of courses or in whole areas of a curriculum.

The case of computer technology offers a good example. A Long Range Computation Study Group at M.I.T. found in 1961 that close to 90 per cent of all M.I.T. undergraduates now encounter a computer directly in course work, in their senior thesis, in laboratory projects, or in some educational exercise before graduation. The M.I.T. Computation

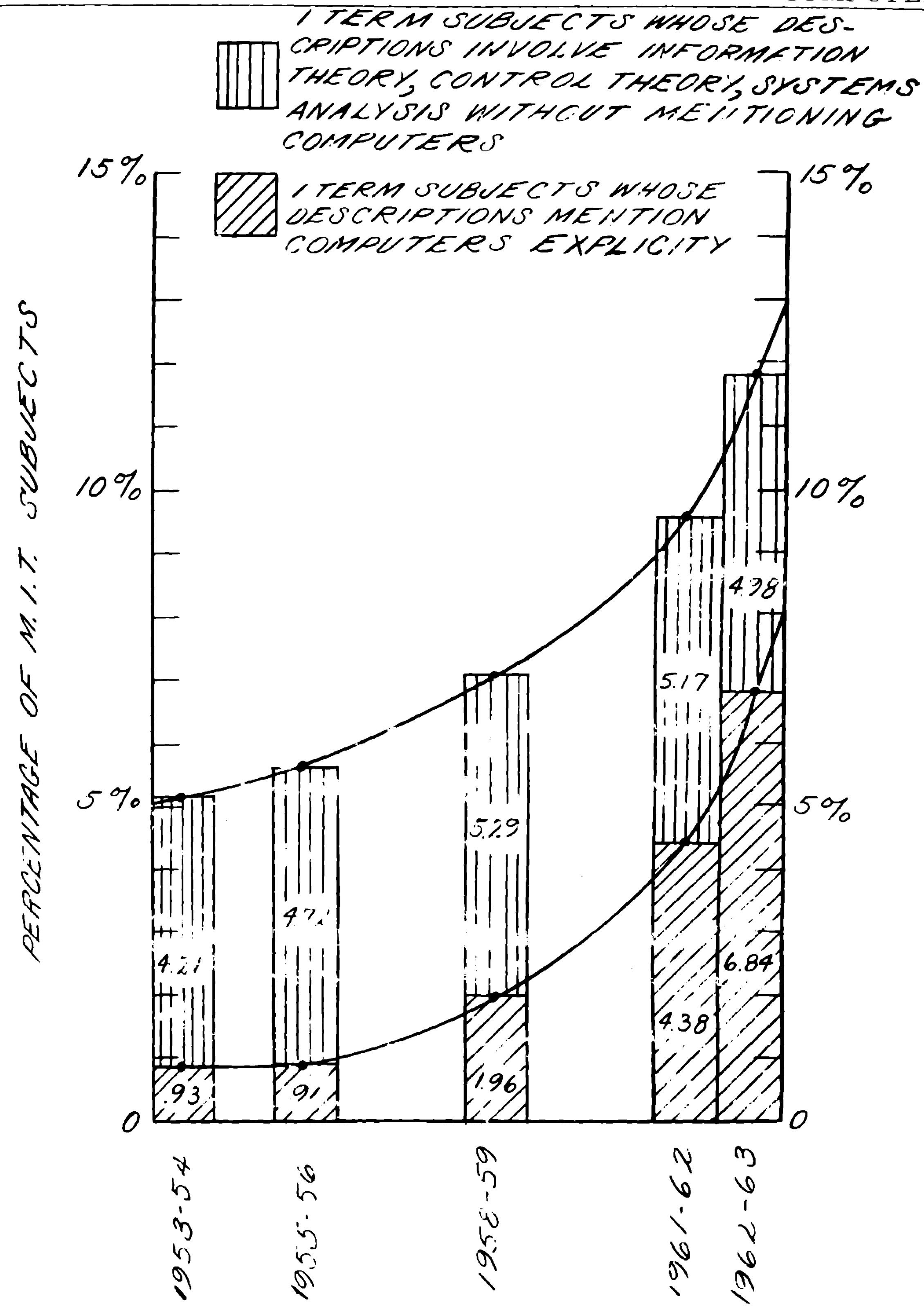
Center, in which one of some fifteen computers on the campus is located, served 7 per cent of all seniors in their bachelors thesis research, 10 per cent of all masters degree thesis students and from 15 to 30 per cent of all doctoral thesis students at the Institute in 1959-60--10 per cent of all M.I.T. students during the year. The remainder of the student body had access to computers located in other laboratories.

Figure A shows the rapid rise of M.I.T. course offerings in which the computer plays a key role, either implicitly or explicitly. No quantitative estimate of the enormous value to education of this kind of development has ever been attempted, to the writer's knowledge. The modern computer (the type possessing an internal memory that can be altered piecemeal without changing the original set of instructions to the machine completely) was a university development sponsored largely, although not entirely with federal funds. It has become a classic example of the far ranging benefits to education from university research that serves sponsor interests and the central purposes of education simultaneously. Not all sponsored research programs are quite this dramatic but there are countless examples of smaller scale effects in every field.

When these developments "invade" the curriculum they involve heavy retooling costs both in terms of equipment and retraining of faculty and staff. They are, in fact, part of the price the leading institutions willingly accept as part of the collateral responsibility of

FIGURE A

GROWTH OF M.I.T. COURSE OFFERINGS WHICH INVOLVE COMPUTERS, 1953-63



Source: Appendix 5, "Report of the Long Range Computation Study Group," April 1961, Massachusetts Institute of Technology, Cambridge, Massachusetts conducting education at or near the frontier of significant discoveries. Their full benefits and costs can rarely be evaluated accurately or assigned to a particular research project that may have started a chain reaction on the campus.

Physical Sciences Study Committee

Finally, this sketchy treatment of curriculum effects of federal research funds would be glaringly incomplete if it failed to mention the far reaching revolution in secondary school science teaching now over-spreading the United States. The universities have taken the lead in upgrading science education in the nation's high schools, and the product of their effort has already come back to roost in the college curriculum in the fields of science and engineering. Federal research funds have been merged with private support in this area of endeavor, beginning in 1956 with the widely-heralded work of the M.I.T.-sponsored Physical Sciences Study Committee.

This group, under the leadership of Professor Jerrold Zacharias of M.I.T., became concerned about the quality of high school science teaching early in 1956, well before the advent of the Russian Sputnik and the wave of interest in science which has since swept the United States. Their inventory of high school science teaching revealed that textbooks and teachers had not kept pace with the rapid scientific progress of recent years and in many cases were presenting materials over 25 years out-of-date. With leadership from M.I.T. but with effective participation of university representatives and high school educators all over the country, the Physical Science Study Committee has undertaken to make available to secondary schools a course in physics in keeping with the scientific progress of recent years and the importance of this subject for the future.

This program has already had a profound effect upon the teaching of science not only in the nation's high schools but also in the colleges as well. Introduced only five years ago, it is now in use by an estimated 135,000 students or 35 per cent of the nation's high school students studying physics, and the number of students using the new course has been growing sharply each year. So successful has this pioneering effort been that similar efforts are now under way at other universities to modernize the teaching of high school chemistry, mathematics and biology.

One of the striking lessons already learned from the experience of the Physical Sciences Study Committee is that the upgrading of science teaching is dependent upon the creation of a critical mass, and this in turn requires people and programs organized in a concerted effort. The creation of better course materials and laboratory instruction equipment, for example, requires the concentration in one massive effort of large numbers of scholars, technicians and teachers if it is to be done efficiently. This integrated approach to the modernization of science teaching has generated a new symbiotic relationship between leading university scientists and high school teachers. For the first time in decades, outstanding research scientists are participating personally in breathing the excitement of research at the cutting edge of knowledge in the physical sciences into the high school classroom. The reader may agree that the experience of the PSSC group and similar undertakings elsewhere represent an extension of the research-teaching approach to education that is taking hold so firmly in the universities.

Federal research funds to help underwrite curriculum studies in the universities are a special case of research sponsorship in the sense used in this paper. The range and speed of the effects produced by this type of sponsorship extend far beyond the influence of project research, regardless of how dramatic its impact may be on particular fields of education. At the same time there can be no doubt that the scientific engine that powers these organized curriculum changes is the project oriented university research turning over at high speed in the upper reaches of the U.S. educational system.

CHAPTER XIII

COST REIMBURSEMENT POLICIES AND PRACTICES

The question of proper payment for government sponsored university research has occupied the educational community and federal agencies in a debate running through the past 15 years. Universities have argued that government fiscal policies are unrealistic and inadequate to cover full costs. Most of their complaints have focused on the identification and coverage of indirect expenses. Sponsoring agencies have been skeptical of university functions which do not bear an obvious relation to the programs they sponsor. The number of federal agency policies with respect to university research costs has added confusion to the controversy.

Indirect cost policies are important to universities for a variety of reasons. First, universities need the money. Indirect expenses on government sponsored research contracts and grants are a major item in academic finances. Since these expenses are currently running at some $200 million a year,[69] it is clear that any substantial difference between payments and expenses incurred amounts to a large sum relative

(69) The estimated indirect expense on all federally sponsored university research (including university-managed contract research centers) was $175 million in fiscal 1962, based upon indirect cost procedures defined in Bureau of the Budget Circular A-21. See "Indirect Costs of Research and Development in Colleges and Universities, Fiscal year 1960," in Reviews of Data on Research and Development, March 1962, page 1. National Science Foundation, Washington.

to other university financing. As a matter of interest the volume of indirect expense on federally sponsored research in the universities is as large as the total amount contributed to higher education by American corporations in 1963.(70)

Second, the position taken by federal agencies in the matter of indirect cost reimbursement affects the basis of funding from private sources supporting research. Since federal sponsorship is the largest source of support for university research it tends to influence university practices in the matter of charging private sponsors for expenses incurred in privately sponsored research. It perpetuates the less-than-full-coverage concept of research support that originated and still remains in the private sector.

Third, the total climate for government sponsorship is conditioned by the terms on which universities are paid for services. Scientific relationships and financial relationships may be carried on by separate sets of persons within universities and sponsoring agencies, but the two come close together in the operation of university budgets.

Fourth, indirect cost payments have an internal influence upon faculty-administrative relationships and upon relationships among departments and faculty members. Being human, faculty engaging in sponsored research have some tendency to regard the subtraction of indirect expense

(70) See the pamphlet, Giving U.S.A., A Compilation of Facts Related to American Philanthropy, American Association of Fund-Raising Counsel, Inc., New York, 1963 Edition.

allowances from their project funds as a subsidy to university administration paid at their expense. Neither can there be a complete absence of feeling that such work is more important to the university than that in fields of less interest to the government. On the other hand, others cannot entirely avoid feeling that the university's general funds flow in disproportionate amount toward the government supported work, not only because of the necessity for covering the gap between actual costs and reimbursement on the research but also in accordance with prestige factors.

It will be helpful to the reader to stop at this point and consider a few cost concepts and their application to the problem of costing federally sponsored research in the universities. If philosophical differences over the degree to which universities "should" share in the cost of doing such research have caused difficulties, the cost accounting headaches have caused at least as much trouble. A general lack of understanding of cost accounting on all sides has added much to the confusion.

As economists and accountants know, charging something at what it costs can produce a variety of answers depending upon the context in which costs are reckoned. What is a proper element of cost in one setting is not relevant to another. The choice of cost elements to be included in arriving at the cost of something always depends upon the purpose for which costs are being analyzed.[71] Let us consider some of the definitions of cost which can be used to describe university operations.

Capital Costs vs Operating Costs (Differentiation according to Time Period of Operation)

Capital costs refer to cash outlays or expenditures for nonexpendable assets: major laboratory equipment, buildings, land, walks, roads, parking lots, and landscaping--all having a useable life of many years. Operating costs are those incurred in the course of an operating period (typically one year) for items of expense involved in conducting university operations for the period. Salaries and wages, expendable materials, services purchased, utilities, and depreciation are the major items of operating expense in educational institutions. Thus, the difference between capital and operating costs hinges on the time period over which costs are considered.

As a matter of accounting convention, colleges and universities have not depreciated or allocated the capital cost of physical plant assets in reckoning their annual operating costs on operating statements. Neither have they considered interest on assets they employ in the operation of their educational program an element of operating expense, except when they actually incur specific interest and borrowing costs in borrowing funds for some purpose, say, in the construction of dormitories. While they

(71) See the monumental study entitled Cost Behavior and Price Policy. National Bureau of Economic Research, New York, 1943. See especially Chapter II on "The Character of Costs," pages 12-28.

do report interest earned on endowment and other funds in their investment portfolio, they do not calculate interest on assets employed in their operations, except as noted above.

In recent years, "revenue-producing" facilities, e.g., dormitories, dining halls and student recreational centers have been depreciated on a straight line, forty-year basis in most instances. In addition, real estate held as an asset in endowment funds has also, by tradition, been depreciated in accordance with standard accounting practice. Thus, the interest factor and depreciation on revenue producing assets has been treated in a manner similar to industrial practice while the same expenses on assets employed in college operations have received a variety of treatment. When a college reports no surplus and no loss from its operations in any given year, the reader may be sure that the institution has not covered all of its costs because of the traditional neglect of interest and depreciation charges on capital. Private gifts and grants, and in the case of public institutions--public appropriations--have conventionally been relied upon to cover the missing elements of capital cost in the long run.

With the growth of sponsored research as a significant item in over-all operations, the universities have sought to recover depreciation expenses on land, buildings and equipment used in sponsored research programs to the extent permissible under government cost reimbursement policies and to the extent proper, in their view, in terms of the "fair share" of such university expenses incurred in carrying out federally sponsored research. Thus, the advent of large expense and revenue-producing activities of a research nature on university campuses has caused the universities to shift their ideas about campus bookeeping to take account of capital costs that could heretofore be neglected in accordance with conventional educational accounting.

The educational institutions still do not report interest and depreciation expenses on the expense side of their operating statements, except as noted earlier. Depreciation enters their revenue stream only to the extent that revenues are actually realized from building and equipment "use allowances" granted as part of the indirect cost payments made by federal sponsors of research, or as part of the revenues derived from dormitory operations.

Fixed vs Variable Costs (Differentiation according to whether costs vary with the Level of Operation at any given Time)

In economic theory costs are defined as fixed or variable with respect to changes in the level of operation. True fixed costs are only those which not only remain constant over the range of operations being considered but also cannot be avoided at zero output. In practical cost analysis these simplified concepts are rarely employable because of the variety of purposes for which cost analysis is undertaken and because of the conditional character of costs. True fixed costs are hard to identify and measure; if the time period is long enough, all costs are variable with respect to output. The economist seeks mainly to determine optimum scale of operation under theoretical conditions when costs are given when revenue considerations are specified, and when the time period for all costs is specified in advance. The cost analyst on the other hand seeks to determine the character of costs and their actual behavior with respect to changes in the scale of operation--usually for a variety of different practical purposes (operational control, tax liability determination, pricing decisions, cost reimbursement calculations, etc.). Thus, the reduction of cost theory to practice generally opens considerable latitude for differences in the treatment of costs because of disagreements over the time period involved and the output basis against which costs are actually measured.

In the debate over indirect cost reimbursement on federally sponsored research, the distinction between fixed and variable expenses has been important because the opposing schools of thought--philosophically speaking--have come to rest on the accounting approximations to fixed versus variable costs. We shall see below that these approximations have introduced problems of their own.

In general, there is little disagreement that federal sponsors should pay for both direct and indirect expenses incurred by the addition of sponsored research programs to university operations--subject, of course, to a debate about what these added costs are and to acknowledged difficulties of measurement when joint costs are involved. Thus, direct expenses have not been subject to a polemic. Federal sponsors have generally been willing to pay for direct expenses to the extent universities have been willing to declare them. Except for the two problematical areas mentioned earlier--payment of tenure salaries and the salary of the principal investigator--the direct cost front has been relatively quiet.

It is when indirect expenses are regarded as fixed with respect to education but escapable or avoidable with respect to sponsored research that the battle lines are respectfully drawn. The universities argue steadfastly that research is an integral part of education and that the two are joint products. Therefore, a cost to one is a cost to the other, especially when it comes to indirect cost determination. Federal sponsors have been restrained from completely accepting this view (1) by historical practices that favor cost participation by the universities, (2) by a certain knowledge on their part that regardless of whether federally sponsored research is being "purchased" or "supported," or whether it is fully or partially underwritten, the universities gain considerable benefits from it , (3) by a desire to get the most for agency dollars spent on university research, (4) by the political hazards of stepping too far out of line with other agencies in meeting the universities' demands, and (5) by an earnest desire to keep educational institutions from becoming overly dependent upon federal research funds. The reader will see at a glance that the indirect cost reimbursement issue has not always been properly joined between representatives of higher education and the federal government. In its simplest form it has several dimensions.

Sunk vs Incremental Costs (The accounting approximation of fixed vs variable costs)

According to accounting theory, sunk costs are past oblications already incurred or past expenditures which must be ignored as not relevant to a decision between two future alternatives. Such costs are not altered in the short run by any change under consideration, i.e., they are fixed. For example, the decision to add or subtract a sponsored research project on a university campus leaves a number of university expenses unaltered in the short run. In this context, the president's salary is an example of a sunk cost. Others are the salaries of tenure faculty members, maintenance contracts on equipment, and library books already purchased or on order. All of these expenses represent past commitments.

Once a particular kind of expense is classified wholly or partially as a sunk cost, then it becomes difficult to secure agreement on (a) whether this particular expense category is affected at all by the addition or subtraction of a sponsored research program, and (b) if so, how much. In any going enterprise (including a university) all fixed expenses are sunk costs by definition. But not all sunk costs are fixed expenses. The amount of a particular expense category that may have contributed to the sunk or fixed cost pool may well vary with changes in the volume of sponsored research.

An example is faculty salary expense, which is a past commitment that must be honored regardless of whether a sponsored research program is undertaken. But the addition of the research program may require the university to recuit more teachers to cover classroom instruction and regular academic duties if professors are excused from some of these collateral responsibilities to undertake the research program in question. Or, what is even more subject to debate, the university may purposely have established a reduced schedule of teaching and academic duties for its faculty in anticipation that most faculty members will be engaged in sponsored research. As a result, it will have started the operating period with a larger professorial staff than it would otherwise require to cover its total educational commitments. A strict interpretation of the incremental cost theory for charging sponsored research in this instance would leave the university with inadequate coverage of its research-related expenses in the particular operating period.

Another example is the annual expense of the college personnel office, which is both a sunk cost and a fixed expense with respect to university operations in the short run, but which may have to be supplemented when sponsored research activities expand. Which part of this administrative expense is incremental to the additional research, and how much?

Incremental costs are decision-making costs in the short run. They represent present and future commitments. They are the additional expenses incurred by a change or contemplated change in the level or nature of operations, i.e., they are variable with respect to output. They are the relevant factors on which the addition or subtraction of a unit of activity is theoretically based in the short run.

An example of incremental cost in colleges and universities is the added cost of faculty salaries caused by adding courses to the curriculum, or the increased power consumption cost incurred by adding a high energy magnet required under a sponsored research contract, or the extra cost of a new biology laboratory. Incremental costs can thus be current or capital expenses.

Incremental costs are not as obvious as they appear, however. An example is the purchase of a new computer to modernize registration procedures in the university or to aid in scheduling classroom use. Its acquisition may have been motivated largely by the need to make more efficient use of faculty time in registration procedures and of educational plant--both of which play a crucial role in determining an institution's ability to engage in sponsored research. Is the capital cost of the computer or its operating expense an incremental cost to a sponsored research project being contemplated?

Problems begin to arise when the incremental cost concept is resorted to as a practical approximation of marginal cost in reckoning expense factors on sponsored research. Incremental costs are sometimes loosely called "out-of-pocket" costs or "differential costs." They are the most familiar (and misleading) concept of cost to the layman (who rarely thinks of adding the cost of transportation to reach a supermarket to the "out-of-pocket" purchase price of a grocery item to determine its true incremental cost). While the economist and accounting theorist can easily agree on the close theoretical approximation between incremental costs and marginal costs, the reduction of this pair of cost concepts to practice has been fraught with misunderstanding. There has been endless confusion introduced into university research expense analysis by the popular tendency to regard incremental research expenses as only those extra costs that are obviously and unmistakably identifiable with the addition of a unit of output--i.e., "direct" costs.

The "out-of-pocket" concept of incremental cost is the culprit. It has done more to mask the true incremental behavior of university research expense than any other conceptual error in the history of cost reimbursement in the universities--save perhaps the treatment of research and teaching as separate activities. Whereas the accounting theory of incremental costs requires that all costs which change relative to output be included in determining incremental costs, the historical practice has been to stop short of the difficult measurement problem of analyzing indirect expense variations and to look simply at changes in "out-of-pocket" costs--i.e., "direct" costs.

Further difficulties arise in the distinction between the short run and the long run. In practice, most university expense categories (like manufacturing expenses) lie somewhere between fixed and variable concepts. It is realistic to describe them as "semivariable." That is, the fixed component remains constant until a critical level of student enrollment or number of classes or volume of sponsored research is reached. Then these fixed elements of cost are increased. Administrative functions and many of the physical plant expenses behave in this fashion. Economists and accountants recognize this plateau behavior of fixed costs as a change in the scale of operations from one size of plant to another (as contrasted with changes in the level of operation within a given plant size). Theoretically speaking, there are no conceptual difficulties. But in practice, cost reimbursement policies that focus on short-run distinctions between sunk and incremental costs (even when they are distinguishable) can leave the university high and dry with respect to full cost coverage on sponsored research in the long run.

The president's salary is a good example. It may be proper to regard it as a sunk cost in the short run. It is doubtful whether it is proper to regard it as a true fixed cost in the long run. Although a university does not hire two presidents when it takes on additional sponsored research, the long-term effect of an increased volume of sponsored research may be to require the president to spend increased amounts of time dealing with sponsored research problems, with the result that additional administrative officers are required to assist him in carrying out the other responsibilities of his office. University buildings are another example. The crowding in of additional research projects may not significantly raise indirect expenses in the short run. But it can easily lead to an impacted condition that can only be remedied by acquiring funds to build a new laboratory in the long run.

Against this "lumpy" behavior of costs--especially the lumpiness of indirect expenses--and against the persistent tendency to equate incremental costs to direct costs only, the universities have flatly rejected the incremental or marginal cost basis of costing sponsored research in favor of a "fully allocated" or pro rata basis for costing. Indeed, the whole history of indirect cost reimbursement policies has been marked by a gradual acceptance by federal sponsors of the principle of covering average or pro rata costs rather than incremental (or marginal) costs as the volume of federal sponsorship has continued to grow.

One expression of this shift of position on the part of federal sponsors can be seen in Table 12 which shows the percentage figure employed to calculate indirect cost payments to the universities on federally sponsored grants. Observe that the National Institutes of Health set the pattern in earlier years, and that the National Science Foundation has taken the lead in recent years in moving towards full cost reimbursement on grants. The universities have welcomed the enlightened attitude of federal sponsors. They have had no alternative but to press for the collection of average costs. Universities have so little money of their own to invest in research that they must rely on full-cost funding to cover all of the relevant items of expense. Their ability to recover this expense is sharply limited by their own neglect of interest on physical assets employed in research, by their own tendency to understate direct expenses, and by the government's limited recognition of the depreciation factor on educational buildings utilized in sponsored research.

(TABLE 12)

INDIRECT COST RATES ON FEDERALLY SPONSORED GRANTS, 1950 - 1962

(Rate Is Expressed As A Percentage Of Total Direct Costs)

	NIH	NSF	AEC	DOD	NASA
1950	8%	--	--	--	--
1951	15%	15%	--	--	--
1952	15%	15%	--	--	--
1953	15%	15%	--	--	--
1954	15%	15%	--	--	--
1955	15%	15%	15%	--	--
1956	15%	15%	15%	--	--
1957	15%	15%	15%	--	--
1958	15%	15%	15%	--	--
1959	15%	15%	15%	--	20%
1960	15%	20%	20%	20%	20%
1961	15%	20%	20%	20%	20%
1962	20%	20%	20%	25%	25%
1963	20%	25%	25%	25%	25%

Notes: (1) The rates shown refer to the dates on which new indirect cost rates went into effect. However, rates prevailing under previous research agreements are generally continued throughout the life of a given agreement.

(2) The rates as shown above can be misleading. For example, as of April 1, 1963 the NIH excludes equipment costs from the direct cost base on which the flat percentage is applied. Previously, equipment purchases up to $5,000 were included in the direct cost base on NIH grants. Hence, the "effective" indirect cost rate on some new NIH projects in 1963 may be less than the stated 20% rate as shown above.

Direct vs Indirect Costs (Differentiated according to Degree of Identifiability with the Research Project)

This particular distinction demands the least of accounting data. It seeks only to divide research expenses into two broad groups, those which can readily and unmistakably be attributed to a particular project and those which must be imputed by allocating to sponsored research a share of the general expenses incurred by a university in support of all of its activities in common.

Unfortunately, there is incomplete symmetry between direct and indirect costs on the one hand and fixed and variable costs on the other. There are both fixed and variable elements in indirect costs, and the same is true of direct costs--although almost all direct costs are variable with output. An example of fixed elements in direct cost would be the "make ready" expenses in a particular research program that requires space and utility modifications (a new steam line or improved shielding on a nuclear reactor) or perhaps land preparation in order to be in a position to accept federal sponsorship.

Both direct and indirect costs are real; neither is imaginary. But indirect costs are harder to identify with the same degree of certainty as direct costs; and there has been a tendency in some quarters, consequently, to regard indirect costs as superfluous, contrived among accountants, or at best not a vital element of expense in the costing of sponsored research. More important, there has been a persistent tendency to equate indirect costs with both fixed costs and sunk costs. A great deal of misunderstanding has grown up because of this erroneous and inexact comparison.

Finally, the distinction between direct and indirect expenses is not as clean cut as the terminology suggests. The placement of a particular category of expense in direct or indirect costs is often arbitrary, and the practices employed by colleges and universities vary considerably in this respect. Employee pension benefits and insurance plan expenses are examples of cost elements that appear as direct costs in the accounting systems of some institutions and as indirect costs in other schools.

One effect of the recent marked rise in the use of the grant form of research agreement (which computes indirect cost allowances as a flat percentage of total direct costs) is to force the educational institutions to place as many of their research expenses as possible in the direct expense category, with an attendant increase in accounting requirements at all levels of administration.

Background of Cost Reimbursement Policies

Before the federal government became a major source of funds, the research activities of colleges and universities were largely supported by grants-in-aid which assumed that a faculty member was already supported by his institution and which provided the welcome wherewithal to undertake an investigation of his own choosing. Indirect costs were regarded as a contribution by the university to the faculty member's research, giving the university also a desirable stake in the endeavor.

This system worked well as long as the volume of such support was small. It would have continued to work if the financial resources of the universities had increased in proportion to the increase in the volume of their research. But this has not happened. Not only has there been a great increase in research support, especially from public sources, but also the financial resources of educational institutions have been reduced by steady and persistent inflation--all of this in the presence of expanded enrollments.

During World War II many normal university activities were abandoned or substantially decreased so that a large fraction of personnel and space could be devoted to wartime research. The universities were anxious to contribute to the war effort under a policy of "Let's get on with the job and worry about bookkeeping later." At the conclusion of hostilities, however, as it became evident that government sponsored research would become a permanent and enlarged factor if the nation's research capacity was to be expanded, the universities were forced to take a hard look at the costs they were actually incurring and would incur. As a result of conferences between representatives of the War and Navy Departments and business officers of educational institutions, there emerged a plan of cost reimbursement, which came to be known as the "Blue Book" when the document was issued in 1947 for use by those two departments. Its principal provisions were later incorporated in the Armed Services Procurement Regulations, although it was never formally approved by the new Department of Defense or accepted by other federal agencies having such contracts.

The Blue Book Era

Numerous questions of interpretation and application arose in connection with audits and administration of contracts, requiring continuing attention. But the procedure was considered generally satisfactory by both universities and sponsoring agencies as a new way of doing business. However, other federal agencies differed in their attitude and initiated other plans and procedures, some of them distinctly less favorable to universities and consequently the subject of urgent recommendation for change.

Five federal agencies--the Department of Defense; the Atomic Energy Commission; the Department of Health, Education and Welfare; the Department of Agriculture; and the National Science Foundation--have been the principal sponsoring agencies of university research in the past decade. Where the agency was the initiator and the research was obviously of an applied or developmental nature, it was generally agreed that the universities were entitled to recover all costs, both direct and indirect. Differences of opinion began to enter in when the sponsoring agency believed that the educational institution had an equal or greater interest in the research. This led to the continuation of the doctrine of cost participation, carried over from the early days of support from the private foundations--i.e., that the sponsor and grantee should pay jointly for the indirect costs of research. The difference became wide for research in which the university was the instigator--primarily in the field of basic or fundamental research. Beginning, then, with a position that only a small fraction of total direct costs (eight per cent at most) could legitimately be allowed for the indirect costs, attitudes have changed as the operating departments of the federal government have accepted basic research as being vital to <u>their</u> long-term scientific effort.

The significant departure achieved in the 1947 Blue Book was to eliminate the arbitrary assignment of indirect cost allowances on the basis of research definitions or gradation. Its later manifestation, Section 15 of the Armed Services Procurement Regulations, continued the recognition that a mutuality of interests imposed a policy of reasonableness. A key paragraph from the principles appeared as follows:

> In determining the total cost of government research projects, no distinction shall be made between "fundamental" and "applied" research. However, when the government by contract supports a research project of the type which the educational institution might be expected to undertake as a part of its own educational and research program, it may be appropriate for the institution to agree in the contract to sustain part of the cost of the project.

With its recognized shortcomings, the Blue Book nevertheless represented for the first time a unified body of procedure and emphasized a mutual rather than a unilateral determination of indirect costs. In 1955 the National Science Foundation issued a report pointing up the disparity still remaining among agencies of the federal government in the area treated by the Blue Book.[(72)] The Foundation made a number of recommendations designed to encourage general acceptance of the Blue Book determination of cost reimbursement procedures, and the Department of Defense appointed a committee to make preliminary studies on its possible revision. In its report, the National Science Foundation took the lead in suggesting that the study be government-wide. The Director of the Bureau of the Budget subsequently, in August, 1956, organized an Interagency Committee of representatives from the several federal agencies having important commitments to university research, with the mission of developing a new set of "Principles" for the Blue Book.

(72) Submitted by the Director, National Science Foundation, to the Director, Bureau of the Budget, June 1955.

The first draft of the Principles, offered to colleges and universities for study in April, 1957, evoked a prompt, vocal reaction that was not at all charmed. In due course, the American Council on Education, the Engineering Colleges Research Council, and the National Federation of College and University Business Officers Association consolidated forces and agreed to work collectively through the American Council, the cement of the consolidation being the impression that the main intent of the new Principles was to move firmly backward. A working group was organized with membership from the three organizations.

During the remainder of 1957 and early in 1958, the Working Group held several meetings with the government's Interagency Committee, in the course of which four redrafts of the proposed Principles were prepared by the Interagency Committee. The Working Group itself presented one complete revision of the document.

On the basis of the final report of the Working Group, the Special Committee on Sponsored Research of the American Council on Education under the chairmanship of President Lee A. DuBridge of the California Institute of Technology, met with the Director of the Bureau of the Budget, in June, 1958. At that meeting it was agreed that there remained at least two fundamental issues concerning, as stated by the representatives of the American Council:

(1) The interrelationship of teaching and research.

(2) The need for alternate methods for allocation of plant operation and maintenance expenses where educational institutions do not maintain space records.

Old Wine in New Bottles

The new Principles were issued as the Bureau of the Budget Circular A-21 on September 10, 1958, designed "to provide to educational institutions recognition of their full allocated costs of research under generally accepted cost accounting principles." The Armed Services Procurement Regulations on November 10, 1958, incorporated the new Circular. To give an idea of the degree of detail that entered into this high-level effort, the primary differences of procedure between A-21 and the former Blue Book are:

(1) A change in the method of allocating the cost of physical plant operation and maintenance from a salary expenditure basis to a use-of-space basis.

(2) Elimination of "student services" cost from allowable general administrative expense, except for that proportion measured by the relationship between hours of work by students on sponsored research programs and total student hours.

(3) More complete identification and classification of indirect costs as to whether they are allowable or unallowable.

(4) Additions to "allowable costs" of the following items not previously allowed:

   (a) salaries and other office costs of deans of faculty and of graduate schools.

   (b) heads of professional schools, departmental administrative salaries, and other expenses.

(5) Increase in the use charge for library books from $0.04 to $0.08 per volume.

Circular A-21

It will be helpful to consider the present definitions of direct and indirect costs as set forth in Circular A-21 of the Bureau of the Budget. This Circular is now the most widely used basis of cost reimbursement by federal sponsors. Agencies which utilize the contract form of sponsorship follow the principles and guidelines of Circular A-21 in negotiating cost reimbursement payments to the universities.[73] Agencies which utilize the grant form of sponsorship generally follow the guidelines stated in Circular A-21 with respect to direct cost determination

(73) Circular A-21 is not used in contracts supporting the operations of a number of university contract research centers, generally those located off-campus, where fixed price contracts prevail.

but compute indirect cost allowances in accordance with a fixed percentage of total direct costs of specific research projects they sponsor.

Circular A-21 provides two systems of computation. For institutions with a relatively small volume of federally sponsored research (less than $250,000 of direct costs) an abbreviated procedure is available which makes use of the institutions' published financial reports and/or readily accessible internal records. For institutions with direct costs of $250,000 or more, a comprehensive and detailed procedure is generally employed, the results of which are subject to audit by and negotiation with a federal agency. This cognizant agency is authorized to negotiate with the institution the rate for indirect costs which shall prevail for all federal agencies employing the principles of Circular A-21 who sponsor research and development at a particular institution. At M.I.T., for example, a resident Navy auditor performs this function for the federal government.

Direct Costs (As defined by Circular A-21)

Direct costs are those identified as having been specifically incurred to perform a particular research agreement. The general types of direct costs are:

(a) Direct salaries and wages, including employee benefit expenses and pension plan costs to the extent that they are consistently treated by the educational institution as a direct rather than an indirect cost, are those applicable directly to the performance of a research agreement.

Such salaries and wages should be charged at the actual rates paid by the institution. Where professional staff paid on a salary basis work directly part-time on a research agreement, current and reasonable estimates of time spent may be used in the absence of actual time records.

(b) Direct material costs include raw materials, purchased or supplied from stock, which are directly consumed or expended in the performance of a research agreement, or are otherwise applicable directly to a research agreement.

(c) Other direct costs include other expenses related directly to a particular research agreement or project, including abnormal utility consumption. This may include services purchased from institution service operations, provided such are consistently treated as direct rather than indirect costs and are priced under a recognized method of costing or pricing designed to recover only actual costs and conforming to generally accepted cost accounting practices consistently followed by the institution. Purchases of equipment will be included under this heading only to the extent expressly provided for in the research agreement or approved pursuant to such agreement.

Indirect Costs (As defined by Circular A-21)

Indirect costs are those which, because of their incurrence for common or joint objectives, are not readily subject to treatment as are direct costs of research or other activities. The general types of indirect costs are:

(a) General administration and general expenses are those incurred for the general executive and administrative offices of educational institutions and other expenses of a general character which do not relate solely to any specific division of the institution. Employee benefit expenses and pension plan costs may be included in this category to the extent that they are consistently treated by the educational institution as an indirect rather than a direct cost.

(b) Research administration expenses are those which apply to research administered in whole or in part by a separate organization or an identifiable administrative unit. Examples of work relating to research which is sometimes performed under such organizational arrangement are: contract administration, security, purchasing, personnel administration, and editing and publishing of research data.

(c) Operation and Maintenance expenses are those incurred for operating and maintaining the institution's physical plant. They include expenses normally incurred by the institution for administration or supervision of the physical plant; janitorial service; repairs and ordinary or normal alterations of buildings, furniture and equipment; care and maintenance of grounds; utilities; and other expenses customarily associated with the operation, maintenance, preservation and protection of the physical plant.

(d) Library expenses are those incurred for direct operation of the library plus a use allowance for library books. The use allowance shall not exceed eight cents per volume per year.

(e) Use allowance is a means of compensation for the use of buildings, capital improvements, and equipment over and above the expenses for operation and maintenance when depreciation or other equivalent costs are not considered. The use allowance for buildings and improvements shall be computed at an annual rate not to exceed two per cent (2%) of acquisition cost. The use allowance for equipment shall be computed at an annual rate not exceeding six and two-thirds per cent (6 2/3%) of acquisition cost of usable equipment in those cases where the institution maintains current records with respect to such equipment on hand. Where the institution's records reflect only the cost (actual or estimated) of the original complement of equipment, the use allowance shall be computed at an annual rate not exceeding ten per cent (10%) of such cost. In those cases where no equipment records are maintained, the institution will justify a reasonable estimate of the acquisition cost of usable equipment which may be used to compute the use allowance at an annual rate not exceeding six and two-thirds per cent (6 2/3%) of such estimate. Computation of the use allowance shall exclude the portion of the cost of buildings and equipment paid for out of Federal funds and the cost of grounds.

(f) Indirect departmental expenses are those incurred for departmental administration, such as salaries of deans or heads of colleges, schools, departments or divisions, and related secretarial and other administrative expenses.

Use Charges For Equipment And Facilities

Raymond J. Woodrow of Princeton University has pointed to inconsistencies in the federal government's present treatment of interest cost and depreciation rates.[74] Mr. Woodrow uses the example of a large computer facility employed in government-sponsored research. If the university rents a computer, it can charge the full rent against research grants and contracts on an allocated basis. The rent paid to the company furnishing the computer includes a more rapid depreciation than the university itself could obtain, and also includes a profit which compensates the company not only for the funds invested but, in addition, quite properly, for the business risks. On the other hand, if the institution buys the computer it will obtain a lower allowance for depreciation and no recognition whatsoever of the income which might have been realized from the funds advanced to purchase the computer.

Mr. Woodrow further cites the disparity between the use charges

(74) Raymond J. Woodrow. "Encouraging University Expenditures on Capital Facilities for Science." Princeton, New Jersey, March 31, 1959.

which a university can make on its own capital facilities in government sponsored research and those which it must make if government owned facilities are put to use in research projects sponsored by private sources. An example would be the use of a government owned capital facility located at an educational institution (or under the management of a university) to perform research sponsored by an industrial corporation. The rates shown below are those which the university would have to charge the industrial sponsor.

(1) For land and land preparation, five per cent of acquisition costs per annum (universities receive no reimbursement for land use when they perform research under government sponsorship.)

(2) For buildings and building land installations, eight per cent of acquisition costs per annum (as compared with two per cent per annum when university buildings are used in government aponsored research.)

(3) For portable tools and automotive equipment, 25 per cent of acquisition costs per annum; for machine tools starting at 21 per cent per annum when new and scaling downward as the tool ages; for other equipment twelve per cent per annum (all as compared with 6.75 per cent per annum which a university receives as a use charge from the government for its own equipment on hand.)

These rates seem to indicate a clear recognition by the federal government that, when government property is used, a more rapid depreciation rate than is allowed to universities as well as a provision for interest costs are both reasonable and equitable. If use charges comparable to those cited above were allowed to universities and colleges for all facilities used in connection with government research grants and contracts, there seems little doubt but that many more facilities would be financed by the institutions themselves.

The exclusion of interest as a cost, and the limited depreciation allowances for university-financed facilities under research grants and contracts with the government have been major obstacles to the expansion of university research facilities from private sources. The short-run effect of interest exclusion is no less problematic for the universities. They have no alternative but to absorb as a loss either the interest that they would otherwise have earned on their own funds advanced to pay for capital facilities, or the interest that they actually pay on funds borrowed to construct such facilities.

The procedure for applying Circular A-21 in indirect cost calculations follows a two-step formula of "divide" and "allocate". First, certain university expenses are "divided" or disallowed from the general pool of unallocated expense each year on grounds that they are in no way related to the combined educational and research activities of an institution. These disallowances vary with each institution according to the functional nature of the expense. Some expenses are completely disallowed, others are only partly admitted to the pool of unallocated general expense, depending upon individual judgments of auditors and university business officers in each case and upon the Circular A-21 formula for each type of expense. Public information expenses, special lectures, catalogue costs, and investment counsel expenses are examples of disallowances from the general pool.

Second, the accounting residue is "allocated" expense by expense between research on the one hand and teaching on the other, according to some index of the relative use research or teaching makes of the particular expense category being allocated. The reader can see the broad operation of incremental cost concepts in this two-step allocation scheme, even though its avowed purpose is to arrive at a mutually agreed upon determination of average indirect expenses. By excluding certain expense categories in the first place, Circular A-21 produces a kind of hybrid between incremental and average indirect expense. Indeed it seeks only to reimburse universities for a "fair share" of their research related expenses, leaving their other general expenses uncovered.

However, the universities have been less bothered by the exclusions from the general indirect expense pool than they have been by the second step in the process--the principle of allocating the accounting residue between research and teaching. Apart from the inherent problems of calculating this allocation equitably, the universities properly contend that the two functions are interdependent. The amounts involved in the exclusions are small compared to the amounts lost to the universities by the allocation between research and teaching.

The effort made in presenting the government's and universities'' points of view on Circular A-21 was useful and productive in increasing both parties' understanding of indirect costs. Circular A-21 also presents a uniform body of procedure applicable now to most federal agencies and all types of contracts, including grants. This is a boon to the universities in most places where the A-21 formula is employed because the resulting allowances generally fall much closer to actual costs than do any fixed percentages set by law or regulation. Moreover, experience to date under A-21 indicates that the over-all financial results to universities have generally not been less favorable than under the Blue Book. But the university community failed to carry the day in dispelling the notion of university research as a marginal or incremental activity to teaching for cost accounting purposes.

So much for procedures of cost determination. It is appropriate to ask: How close do they come to actual research expenses as seen by the universities? More specifically, how fully does Circular A-21 cover indirect expenses on federally sponsored grants and contracts?

A recent study by the National Science Foundation presents an interesting comparison between the indirect cost payments which universities would have received under Circular A-21 calculations versus the indirect cost payments they actually received on federally sponsored grants in fiscal 1962.[75] A total of approximately $175 million in indirect expenses was incurred by the universities on federally sponsored research in that year, calculated on the basis of Circular A-21. $92 million in indirect expenses was incurred in connection with contracts and was reimbursed in accordance with A-21. $83 million (or 47% of the total) was incurred in connection with federal grants, calculated by NSF on the hypothetical basis of A-21. But only $47 million of the $83 million was actually reimbursed by federal sponsors who, of course, used the flat percentage basis instead of A-21 for calculating indirect expenses on grants. The universities made up the difference of $36 million, or over 40 per cent of the A-21 computation. Putting the matter more simply, federal sponsors paid less than 60 per cent of the amount they would have been required to pay, had the government's own, most generous standard been used to determine indirect cost allowances on federal grants. Moreover, the impact of this underpayment was felt by small colleges as well as the larger ones, many of the smaller institutions relying heavily upon the grant form of research agreement with federal sponsors.

The NSF study also presents an interesting comparison between

(75) National Science Foundation. "Indirect Costs of Research and Development in Colleges and Universities, Fiscal Year 1960." Reviews of Data on Research and Development, March, 1962, page 1.

large and small institutions in the ratio of indirect costs to direct costs. Based on Circular A-21 computations, 93 large colleges and universities, representing 95 per cent of the federal sponsorship of research in higher educational institutions, reported a 28.2 per cent ratio of indirect expense to direct expense. The comparable figure for 82 small schools each having less than $250,000 of direct expense for federally sponsored research in fiscal year 1960 was 32 per cent.(76)

A number of factors could be cited to explain the higher indirect cost ratio in the smaller schools but the NSF study offers few concrete clues. Most probably, the difference is due to a spreading of general administrative expense over a larger volume of sponsored research in the case of the larger institutions, coupled with other economies of scale. But this is only speculation.

In any case, these national averages for the large and small institutions lend credence to the major universities' general claim that 30 per cent on the average represents the "true" ratio of their indirect to direct expenses, while the smaller schools claim generally that their true ratio approaches 35 per cent on the average. To the extent that this university position is justifiable, it can be seen that Circular A-21 generates indirect cost payments that are only 90 to 95 per cent

(76) Ibid., pages 3 and 4.

of average indirect expenses actually incurred, while the standard flat percentage basis of figuring indirect cost reimbursement on federal grants generates only 65 to 70 per cent of average indirect expenses actually incurred. As the balance of federal sponsorship shifts markedly towards grants, the position of the universities worsens for any given level of sponsorship, and as the volume of sponsorship grows, the university deficit in absdute terms grows even greater.

The behavior of indirect expenses within a given institution provides further insights. In his study of Princeton's experience, Bowen found that the ratio of average indirect costs to direct costs declined during most of the decade of the 1950's, while the over-all volume of sponsored research at Princeton was increasing. His tentative conclusion was that incremental indirect expense must have been less than average indirect expense during the years when average indirect expense declined. He theorized that this may have been due in part of the squeezing out of research capacity in the physical plant and in the administrative structure for sponsored research at Princeton, but cautioned that the future might tell a different story. Indeed, in a few years during the 1950's the ratio of average indirect expense to direct expense actually increased.

What is especially interesting to the economist is the question of whether indirect cost reimbursement at something approaching an average rate might actually generate more funds in a given year than the out-of-pocket disbursements by a university for incremental indirect costs actually incurred in going to a higher research volume. Bowen found this to be true at Princeton.(77) At the same time, there was no evidence that the university sought consciously to expand its research volume in order to realize additional revenues to the extent that the average exceeded incremental indirect costs. Yet the fact remains that, so long as space and personnel are available, facilities and staff will tend to be utilized (if sponsorship is available under acceptable terms and conditions) up to a limit approaching capacity. The system of project-by-project approvals in the project selection process does not ask how the addition or termination of a project will affect indirect expenses in the short or long run. It merely asks if space is available and competent personnel are interested. In other words, the decision to add another research project is not based on economic motives but rather on the availability of resources needed to do the job at that time.

The fact that changes in physical plant and administrative services characteristically result in discontinuous cost functions means

(77) Bowen, W. G. The Federal Government and Princeton University. Princeton, 1962, pages 100-103.

that at near capacity universities will pay an incremental price in pressure on facilities and personnel that can never be adequately recovered in indirect cost allowances. Later, when absolute capacity is reached and facilities are planned and constructed somewhat ahead of demand, the phenomenon of declining average indirect costs will be repeated again over the relevant range of research operations. But the conclusion is inescapable that the disregard of incremental costs in project selection procedures suppresses economic forces that might otherwise hold the volume of sponsored research short of absolute capacity. As we noted earlier, the research control mechanism operates mainly through a complimentary system of academic administration and not through the project-by-project analysis of the relevant costs.

We shall close these remarks with a brief return to the substantive effect of underpayment of research costs at universities where, without regard to absolute size, research financing is large compared with other university financial operations.

A university has an obligation to maintain excellence in intellectual disciplines--some that are currently of interest to federal agencies and others that are not. Modern languages, history, social and behavioral sciences, architecture, earth sciences, literature and philosophy, to name just a few, are all essential areas of scholarly endeavor. They should not be held in check in order to cover the full costs of government sponsored research in the favored fields. On the other hand, desiring to maintain vigorous departments of physics, chemistry, biology and engineering, few universities can keep their faculty in these fields intact without undertaking a substantial volume of government sponsored research, regardless of whether the full costs are covered or not. Private sources of support are generally not available in the amounts required.

Two functions at a university, one covered by sponsored research overhead and the other not, can hardly be in wholly fair competition for inclusion in the university budget of similar items of expense. The allowability of one kind of expense under the government's rules should theoretically (as in practice it does to a degree) make funds available for application equally to other university functions. However, the budget process at a university tends to fall short of the ideal--not entirely unlike the budgets of government. All universities are obligated to conduct their budgeting so that the rich or lean financial treatment they give to their various activities is consistent with the relative importance of these activities according to institutional objectives. And where substantial amounts of sponsored research are at stake, the government should accept its fair share of the obligation, as regards the administrative procedures of reimbursement and, most vital, as regards paying the full cost of the research it sponsors.

To sum up:

(1) The use of a contract to cover government sponsored research lays heavy stress upon the old notion of a bargain between two parties with neither party "giving anything away." In the large volume of research today, a government grant must imply much the same understanding. Mutual respect and understanding can significantly add to or detract from the advantages of government sponsored research at educational institutions.

(2) Public interest requires that government grants and contracts with universities be based upon sound and unassailable cost principles. At the same time, universities are justified in their view that contract coverage of indirect costs recognizes research and teaching as inseparable functions.

(3) The treatment of indirect costs in government sponsored research programs has been strongly influenced by the pre-World War II policies of the private foundations which then properly covered less than the full costs associated with university research. When the amount was small in faculty members and dollar volume, the natural tendency was to treat research as a marginal activity for cost-accounting purposes. The treatment of research as a by-product of education is both functionally incorrect and financially unrealistic under today's expanded university research programs.

(4) Circular A-21 preserves the notion of "divide and allocate" in the matter of indirect cost coverage. This notion follows naturally from the historical practice mentioned above. In its present form Circular A-21 represents an advance over the old Blue Book but needs continuing study in the next few years.

(5) No responsible person questions that universities, in their drive to expand research facilities, have made a great contribution to research and education. But there are serious doubts about the effect of the drive in contributing to the precarious financial condition in which many institutions find themselves and to the fact that the government's position in this process has been anomalous. In carrying out the research job that the nation needs done--that colleges and universities and specific sponsors want to do--the educational institutions have found themselves acting as a breakwater against the forces of a tidal wave far beyond their ability to control or even to modulate substantially. Moreover, when the federal government encourages the universities to increase the national output of scientists and engineers, it certainly seems logical to the universities that sponsorship of the research which is an indispensable part of that training should be designed to ease financing rather than make it hazardous.

CHAPTER XIV

CAPITAL REQUIREMENTS

Working Capital

Most government sponsored university programs are paid for by a periodic transfer of funds from the sponsoring agency to the educational institution to reimburse for research expenses incurred or to be incurred during the period. On the other hand, university expenditures for salaries, equipment, materials, and services are on a continuing basis as needed. Under this system the inflow and outflow of monies are always in a state of imbalance and require some means of providing working capital and in carrying government accounts receivable. Largely as a carry-over from the government's practice of not recognizing interest as a cost under industrial cost reimbursement contracts, which include a fee for profit, educational institutions are not permitted to recover interest costs in conducting research for federal agencies.

In some instances this interest cost may be considerable. It may be represented by actual borrowing, or it may be financed by advances from endowment funds. In either case it represents a loss which can be severe if the volume of research is large. Failure of federal agencies to make prompt payment can burden an institution to the extent that many have found it profitable to maintain special staffs to expedite the payment procedure. Government budget dynamics being what they are, institutions are sometimes embarrassed by the accumulation of unpaid federal obligations at the end of the government fiscal year. One writer has noted a recent case of an institution which advanced $2.5 million from its endowment funds in order to pay its research bills after an accumulation of delayed payments from federal agencies.[78]

The variety of practices followed by sponsoring agencies further complicates this problem and has fostered special relationships solely in the matter of payment. Each agency is organized somewhat differently in the conduct of its financial affairs and in the inter-relation of its financial, contracting, and technical sections. Knowledge of the financial structure of sponsoring agencies is essential to the efficient conduct of research on a campus.

The problem of interest is not easy, because of the legal restrictions against interest and of the limited working capital in the hands of educational institutions. If a way could be found to change existing legislation, the universities would view this form of relief enthusiastically. However, the tying up of working capital can be, and is with some universities, reduced through special advance payment procedures.[79] These can be arranged so as to finance fully both grants

(78) Lloyd Morey, "Review of Circular A-21, Bureau of the Budget, for the Comptroller, Department of Defense," March 19, 1959.

(79) Advance payments are provided under certain conditions as authorized by Appendix E of the Armed Services Procurement Regulations.

and contracts for research as well as facilities construction. They can be arranged on an individual contract basis or, if the volume of research warrants, under a master pool agreement to finance all contracts of a given institution with a federal agency.

In recent years the federal agencies sponsoring the largest volume of university research have developed effective payment procedures. Some agencies newer to such sponsorship, or whose volume is small, have lagged in developing this area along with their university counterparts.

Long Term Capital Problems

The capital facilities of the universities have an obvious bearing upon their ability to conduct research. Yet until recent years most of the attention given to Government-university research relationships has been focused upon current operations, with relatively little consideration of the capital requirements involved. The dramatic growth of federal sponsorship of university research has taken place over a short span of only twenty years. Moreover, the existing capital structure of the colleges and universities in the early 1940's made it convenient for federal agencies to take for granted what was already there and to underwrite the cost of university research strictly on a use basis.

Some idea of the federal government's relative commitment to current versus capital expenditures for research can be seen in Table 13.

(TABLE 13)

VOLUME OF CAPITAL OBLIGATIONS FOR RESEARCH AND DEVELOPMENT BY FEDERAL AGENCIES, 1947 - 1963

(Millions of Dollars)

	Total Federal R & D Obligations	Federal Obligations For R & D Plant*	Percent Obligated For Capital Facilities
1947	$ 691	$ 71	10.3
1948	868	92	10.6
1949	1,105	167	15.1
1950	1,175	203	17.3
1951	1,812	330	18.2
1952	2,194	307	14.0
1953	3,361	255	7.6
1954	3,039	164	5.4
1955	2,747	212	7.7
1956	3,269	279	8.5
1957	4,381	457	10.4
1958	4,908	336	6.8
1959	7,121	429	6.0
1960	8,078	528	6.5
1961	9,606	549	5.7
1962**	11,236	970	8.6
1963**	14,448	1,764	12.2

* Includes land and equipment acquisition as well as construction of facilities.

** Estimated

Source: National Science Foundation, Federal Funds For Science, XI, Washington, 1963, pages 138, 139.

Capital outlays are currently running at roughly 12 per cent of total federal obligations for research and development.

A word of caution is in order. Most of the federal outlays for R & D plant shown in Table 13 are for in-house facilities and equipment. The sharp rise in capital spending since 1961 is largely attributable to the construction and acquisition activities of the National Aeronautics and Space Administration in connection with its manned lunar landing program, specifically the launch complexes and the test stands. NASA's capital budget was $128 million in 1961 and it is expected to rise to $1.1 billion in 1963.[80] Thus, the non-NASA component of R & D plant outlays will be under five per cent of total federal obligations for research and development in 1963.

Table 14 sets forth the general picture of federal investment in research capital. It is primarily focused on the provision of buildings and equipment to support the government's own research and development laboratories.

In the colleges and universities, all federal grants for academic facilities and equipment are related to scientific research and training, except for federal support for construction at Howard University and Gallaudet College in the District of Columbia. Unfortunately, detailed

(80) National Science Foundation, Federal Funds for Science, XI, page 45.

(TABLE 14)

ALLOCATION OF R & D PLANT OBLIGATIONS
BY FEDERAL AGENCIES, 1961-63

	1961	1962	1963
FEDERAL SITE	77%	79%	82%
NON-FEDERAL SITE	21	19	17
FOREIGN SITE	2	2	1
TOTAL	100%	100%	100%
TOTAL AMOUNT OBLIGATED FOR R & D PLANT (millions)	\$549	\$970	\$1,764

Source: National Science Foundation, Federal Funds for Science, XI, Washington, 1963, page 48.

studies have not been made on the provision of capital grants to the universities by the combined federal agencies. But an approximation can be made.

From the preceding table, we note that 19 per cent of all federal obligations for R & D plant in fiscal 1962 were for facilities and equipment at non-federal sites. This amount was $184 million, and it included obligations for R & D plant in hospitals, private industry, non-profit institutions, and universities. In a recent study of federal sponsorship of university research, the House Committee on Education and Labor reported $98.5 million in capital grants to the colleges and universities in 1962, not including AEC expenditures for the installation of reactors and accelerators (to which the Commission retains title) and not including construction of facilities by universities with their own funds under a special Defense Department program in materials science and engineering which enables them eventually to recover the construction cost through building amortization charges on DOD-sponsored research.[(81)] It seems reasonable to guess that federal capital grants to the universities were of the order of $110 to $120 million in fiscal 1962.

This estimate can be compared with an on-campus volume of

(81) U. S. House of Representatives. Committee on Education and Labor. Federal Government and Education. 88th Congress, 1st Session, Washington, June, 1963, page 8.

federally sponsored research amounting to $732 million on an obligations basis in fiscal 1962--which means that approximately 12 per cent of the total volume of federal sponsorship on the university campuses, including both R & D performance and R & D plant sponsorship, was for capital purposes.[82] The dimensions of the capital problem in the universities can thus be seen at a glance. Whereas federal sponsorship accounts for some three-fourths of all university research, federal outlays for capital purposes account for less than half of the total capital outlays by the universities for on-campus research facilities.

The most recent data on this comparison are for the fiscal year 1958. At that time the colleges and universities spent $126 million for on-campus research facilities, of which only $15 million was provided from federal sources,[83] or just over ten per cent of the total. That federal agencies are deeply concerned about the acute capital shortage in the universities is seen in the eight-fold expansion in federal grants for capital purposes that occurred between 1958 and 1962.

Today, the nation's entire system of higher education is underbuilt and underequipped. Expanding enrollments and the explosive growth of

(82) It is only a coincidence that this 12 per cent figure matches the 12 per cent figure shown earlier on the fraction of total federal R & D spending for R & D Plant.

(83) National Science Foundation. <u>Government-University Relationships in Federally Sponsored Scientific Research and Development.</u> Washington, April, 1958, page 40.

research are the principal forces at work. Other factors include the increased emphasis upon graduate study, the "stretch out" of graduate degree programs, the age and quality of educational buildings, the behavior of private philanthropy, and the heavy fixed costs involved in educational plant. In the paragraphs which follow we shall concentrate on the special capital problems posed by the acceleration of research spending in the universities, recognizing that the elements we are neglecting may be equally important; indeed, they add to the urgency of finding an adequate solution to the problem of capital in the research sector of university financing.

One of the first topics to which the reconstituted President's Science Advisory Committee addressed itself in 1958 was the problem of providing adequate capital facilities for science and technology. In its widely quoted, December, 1958 report entitled Strengthening American Science, the Committee referred to the capital deficiencies hampering research within the universities:

> Serious under-investment is handicapping programs in many fields; meteorology and climatology, inorganic chemistry, high temperature research, oceanography, radio astronomy, continental geography, and many of the newer aspects of the life sciences such as microbiology, genetics, the study of growth and the neurological foundations of behavior. In these

areas, chosen at random, and in many more, laboratory facilities and instrumentation are required on a wider scale. These are fields in which universities should be doing more research, but financing many of the required facilities is beyond their capacities to provide.[84]

Direct government financing of capital facilities at a university is a relatively new concept. The government's pay-as-you-go philosophy has generally left the universities to provide their own facilities--except where there were none for urgently needed research. Government-owned and university-operated research centers represent one example of such capital outlays. Expensive equipment which has scientific use beyond the scope or life of a particular project is another. Both off-campus and on-campus capital facilities have thus been built in response to a specific need and where inadequate private capital existed. The federal government has assumed the financing of some kinds of major projects at universities where heavy equipment outlays would otherwise preclude university participation in federally sponsored research. The Defense Department support of interdisciplinary centers for research in materials and NASA's capital grants for capital facilities for space research are prominent examples.

(84) Op. cit., page 22.

(TABLE 15)

FEDERAL GRANTS FOR UNIVERSITY FACILITIES AND EQUIPMENT, 1962

Grants to colleges and universities for facilities		$87, 800, 000
National Institutes of Health	$31, 229, 000	
National Science Foundation	44, 800, 000	
National Aeronautics and Space Administration	6, 410, 000	
Howard University	4, 400, 000	
Gallaudet College	601, 000	
Area redevelopment program	442, 000	
Grants to colleges and universities for equipment		10, 700, 000
National Science Foundation	5, 000, 000	
Atomic Energy Commission	2, 452, 322	
Department of Defense	3, 277, 000	

Source: U. S. House of Representatives. Committee on Education and Labor. Federal Government and Education. 88th Congress, 1st Session, Washington, June, 1963, page 8.

Table 15, above, presents a summary of federal grants earmarked for university facilities and equipment for the fiscal year 1962. A word of caution is in order. Research equipment expenditures under federal contracts and grants to perform research are not tabulated in Table 15; accurate estimates of such expenditures are not available and they are difficult to express because the title to such equipment may or may not vest in the universities.

The individual programs of the various sponsoring agencies are described in the recent House Committee on Education and Labor report mentioned earlier. They are worth examining in detail.[85]

National Institutes of Health

NIH has limited its grants to facilities for research and research training in the medical sciences, but has viewed most of the basic sciences as related to the medical sciences. The program, therefore, has provided broad scientific support, granting in 1962 a total of $30 million, with $27 million of this going to colleges and universities, on a 50-50 matching basis. In the last 6 years, a total of $180 million was expended by NIH on this program, 90 per cent of it in educational institutions, and the remainder in hospitals and nonprofit research organizations.

In 1962 the Institutes inaugurated a second program which provided $4,229,000 to colleges and universities for construction of specialized resource centers. These centers are designed to support research on an institutionwide and areawide basis, by providing such facilities as computing and data-processing installations, germ-free laboratories, marine biological laboratories, and reactors.

National Science Foundation

A. Facilities.--The National Science Foundation supports two programs that provide facilities to higher education institutions. The first is a program to develop graduate research laboratories which, in 1962, provided grants to 95 institutions on a 50-50 matching basis at a total Federal expenditure of $24 million. This program provided $8.4 million in the previous year. Expenditures are expected to rise to $33.5 million in 1963.

The second program, which somewhat parallels that of the National Institutes of Health, provides specialized research facilities, such as computing centers, oceanographic research vessels, nuclear facilities, and specialized biology centers. A total of $20.8 million was expended in this program in 1962, with increases, particularly in computing and nuclear facilities, projected for 1963.

(85) Op. cit., pages 8-10.

B. Equipment.--In order to provide modern scientific equipment to colleges and universities, much of it to be used for undergraduate science education, NSF made 334 grants in 1962 on a 50-50 matching basis, at a total expenditure of $5 million.

Atomic Energy Commission

A. Facilities.--The Atomic Energy Commission does not make outright grants to educational institutions for the construction of facilities. Instead, by contract, it installs and retains title to reactors and accelerators in quarters provided by the educational institutions, with the objective of enabling them to write off their investments through research conducted for the AEC.

B. Equipment.--Direct grants are made to undergraduate colleges and universities through the AEC equipment program. This is modeled after the National Science Foundation program, except that participating institutions are not required to furnish matching funds. In 1962, grants for equipment used for undergraduate instruction in fields related to atomic energy totaled $2,452,322, and brought to $22.8 million expenditures for this program in the 6 years of its existence.

Department of Defense

A. Facilities.--Like the Atomic Energy Commission, the Defense Department does not make outright grants for construction of facilities. It does, however, through the Advanced Research Projects Agency, enable institutions to construct facilities, limited chiefly to instruction and research in materials and write off the cost over 10 years. Title to these facilities is vested in the institutions. Eleven such installations are now built or being built at educational institutions at a total cost of $18.2 million.

Military departments within the Defense Department also construct and retain title to research centers near a few college campuses and contract with the college or university to manage them. In no case, however, does the Department pay a management fee, using instead the indirect cost method of reimbursement.

B. Equipment.--One Defense Department program makes direct grants to institutions for the purchase of equipment. This program is operated through the Advanced Research Projects Agency, and makes available to educational institutions about $3 million per year for equipment for materials research. A total of $3.2 million was granted in 1962.

National Aeronautics and Space Administration

The most recent agency to award facilities grants is NASA. On September 22, 1962, NASA initiated a new program of grants to universities engaged in research in space sciences. These grants, totaling $6,410,000, were made to five universities. Funds may be used for construction, and no matching is required. An expansion of this program to $10 million is contemplated in 1963.

The technology of research itself has accelerated the dependence of the universities upon the government for capital funds. While it is still possible to conduct basic research in some areas of science and engineering using small laboratory equipment and inexpensive experimental gear, this is becoming steadily less true. Large-scale computers, particle accelerators, electron microscopes and radio telescopes are a few examples of the expensive capital investments needed to open up new areas of knowledge.

Unfortunately, this steady increase in the technological complexity of modern science has posed serious obstacles to the broadening of the educational foundation on which science and engineering rest. College and universities everywhere, but especially the smaller institutions, find themselves squeezed by the growing capital investments required to participate meaningfully in modern research. Often, they can neither afford the required outlays nor justify the amounts required to federal sponsors in view of the limited size of their research staffs and the volume of research they can reasonably accept. This fundamental difficulty in the growth of science poses deep-seated problems for higher education and the nation. The national production of graduate degrees is directly involved as is the rate at which more first-rate graduate departments can be developed to meet national manpower needs in science and engineering. The group of twenty top institutions which produced half of the doctoral degrees in the country in 1940 has essentially remained fixed over a twenty-year period. There are a number of other factors involved, of course, but scientific capital in the form of facilities as well as people has played a major role in the concentration of graduate education in the U. S.

A related problem confronting all institutions, but especially the smaller ones, is the inexorable trend towards interdisciplinary organization in research. The critical size required to staff a multi-disciplinary research effort may be quite beyond the reach of schools whose commitment to research may be concentrated in one or two departments or who lack experience in interdepartmental organization. To some extent these size effects can be accommodated by the provision of capital on an intra-institutional basis, and this development has proceeded rapidly in recent years. At the same time there are inherent problems in regional facilities that may be remotely located from all but a few of the participants who happen to reside on the campus at which a regional facility is located. The pattern of regional laboratory organization has worked well so far but it is too early to tell whether it really represents an adequate solution to the problem. In particular, the institutions which have played the leading role in intra-institutional undertakings have been precisely those whose research commitments are already large, and whose experience in interdisciplinary organization is well advanced. There is a continuing need for innovation on the part of federal sponsors and higher education alike in the matter of lowering the economic barriers to participation in university research programs. Those institutions who are only now seeking to enter the research arena need far more funds than they now possess to make a running start. The price of providing research opportunity to them rises with each advance recorded in the accelerating growth of science.

Explosive Growth of Capital Requirements

Since 1945, science and technology have pushed to the center of national attention with an urgency that no previous Congress or President could have dreamed of. The spectacular accomplishments of university people in the physical sciences and in engineering have been accompanied by equally spectacular growth in the capital required for their research.

The field of particle accelerators is a good case in point. In 1930 the idea of a cyclotron was first reported in the magazine Science by Professor Ernest O. Lawrence of the University of California.

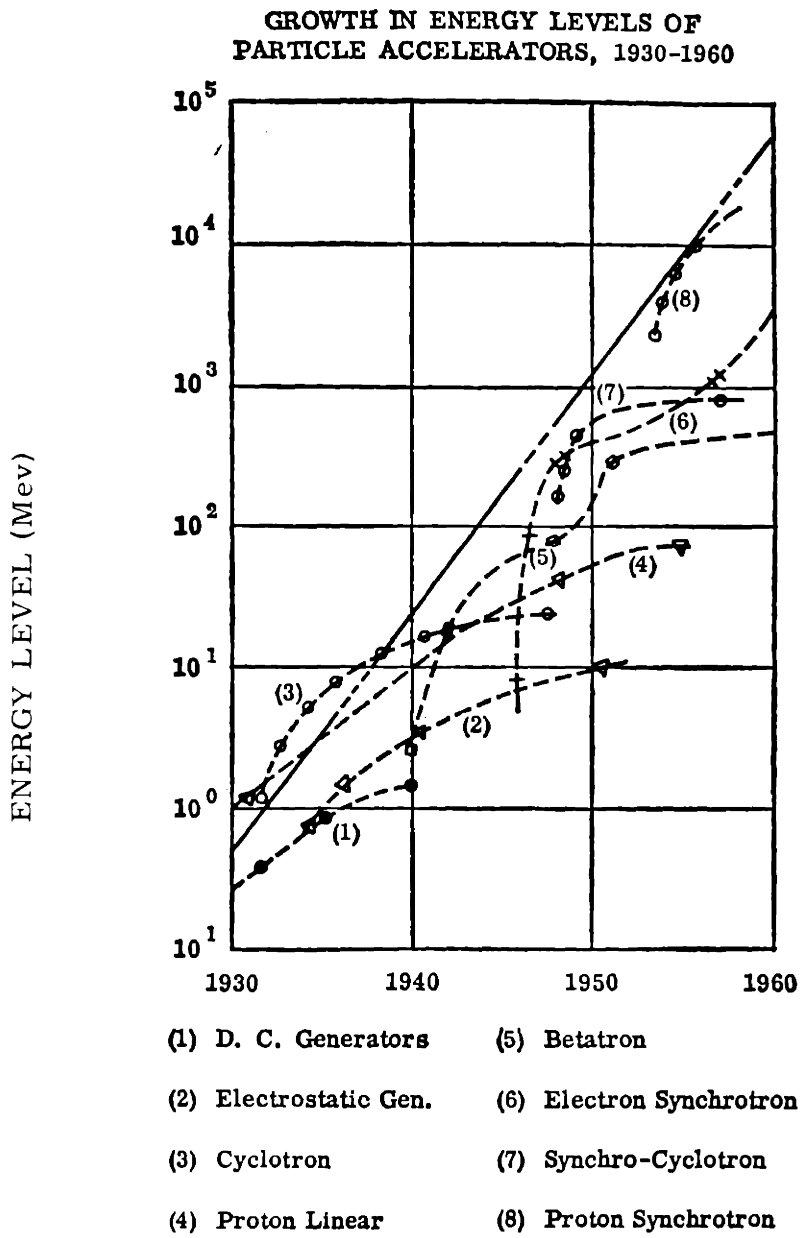
Professor M. S. Livingston traces the development of particle accelerators from this early work at the University of California and at the Cavendish Laboratory of Cambridge University.[86] Professor Livingston cites four waves of development which have dominated the particle accelerator field, based on different concepts of acceleration and focusing.

> As each type of machine was rapidly developed to approach its theoretical energy ceiling, another principle came along to provide a new step upward in energy. The voltage multiplier, the cyclotron, the betatron, synchrocyclotron, electron synchrotron, and proton synchrotron have each in turn held the voltage record temporarily.

In the short span of 30 years the energy levels achieved by the various machines has risen from 80,000 electron volts to the energy range of the large modern accelerators which range from 100 million electron volts to 33,000 million electron volts (33 billion electron volts). The CERN Laboratory in Geneva (European Organization for Nuclear Research) has a proton alternating gradient synchrotron which began operation in 1960 at 29 Bev energy. Currently in operation at Brookhaven National Laboratory is a similar machine rated at 33 Bev--the world's most powerful atom smasher. In Cambridge, Massachusetts, the largest electron synchrotron yet conceived is operated as a joint Harvard University-M.I.T. facility, under the sponsorship of the Atomic Energy Commission.

(86) M. S. Livingston, "Early Development of Particle Accelerators," <u>American Journal of Physics</u>, Vol. 27, Number 9, December, 1959, pages 626-629.

CHART IV



Source: Livingston, M. Stanley. "Early Development of Particle Accelerators." American Journal of Physics, 27, 9, December, 1959.

This machine produces energies up to 6 Bev, and was constructed at a cost of over $12 million. At current prices the capital required for particle accelerators appears to be roughly a linear function of their energy levels--costing about $2 to 2.5 million per Bev.

Professor Livingston graphically illustrates the dramatic increases in energies achieved with the several accelerator types by plotting energy on a logarithmic scale against time (see Chart I V).

The envelope of the curves which indicate the development of the various types of accelerators is found to be close to a straight line, indicating an increase of energy by a factor of ten every six years! The progress of individual accelerator types is shown by the numbered curves below the linear envelope, which gives the reader some idea of the relative order of the various accelerators on the energy scale.

An electron linear accelerator scheduled for completion in 1967 at Stanford University is estimated to cost $114 million. It is expected to develop energies up to 50 Bev. In the U.S.S.R. construction is under way on an accelerator rated at 70 Bev.

Earlier this year, a panel of scientists convened by the President's Science Advisory Committee and the General Advisory Committee of the Atomic Energy Commission urged the federal government to embark on a new 18-year program of support for high energy physics that would send the cost of the U. S. high-energy accelerator program from its present

$175 million level to $549 million by 1974 and to $600 million by 1981.[87] The panel recommended the construction of a 200 Bev machine at the Lawrence Radiation Laboratory in Berkeley, costing $240 million. It further recommended the construction of a new proton accelerator at Brookhaven which would cost as much as $1 billion in the 1970's and develop energies of between 600 to 1,000 Bev.

Clearly, no single university, or even group of universities acting jointly can hope to finance these large undertakings in the physical sciences. No one seriously questions this conclusion. The funds involved are so large that special acts of Congress and special appropriations within the departments of government are required so that the operating budgets of sponsoring agencies will not be taxed unduly. The field of high energy physics in particular is acknowledged to be closely related to the national interest, and perhaps survival.

The debate over capital facilities for universities begins to form when the capital outlay is for research in which the government's role is thought to be that of providing aid to research rather than supporting research urgently needed for national purposes. This distinction is the familiar differentiation between "supported" research and "purchased" research. It is the same distinction that has contributed

(87) "Super U. S. Atom Smashers Costing Up to Billion Urged," The Boston Sunday Herald, May 26, 1963, page A 67.

so much confusion to the controversy over the proper share of university indirect costs that government sponsored research projects should bear.

<u>Meeting The Need</u>

When the federal government provides the capital costs for research the university would cover if it had the money, it might appear that a proper university cost has been shifted to the federal taxpayer. If one looks at the total research activity of all universities in relation to the objectives of all federal agencies, however, the situation is quite different.

Charles V. Kidd has stated the difficulty of working with this distinction:

> The sum total of all federal programs for support of research in universities can be considered a declaration of national objectives and an expression of national policy. This policy is made particularly clear by the willingness of Congress to appropriate funds for the support of university research which has no immediate relevance to the operating tasks of the federal agencies and to provide funds to expand the nation's research resources. Participation in this national effort involves many universities in uncongenial large-scale research, and it creates new academic and financial difficulties for them. The total

effect of the federal activities is not entirely to help the universities do more of what they wish to do, but to involve them in the achievement of national goals which they did not set. This involvement can come about for a university as a whole even though the effect of the federal funds on individual faculty members is to help them do precisely what they want to do.

It is not valid to argue that the national interest, expressed as the operating need of a federal agency, is served when research is purchased, but that the national interest, expressed as furtherance of free research with no necessary relevance to the operating needs of federal agencies, is not served when research is supported. Equally significant national needs are met through the two different types of financing. Faculty members whose free research is supported serve the interest of the nation as surely and perhaps more importantly than when they undertake contract research at the urging of a federal agency.(88)

(88) Charles V. Kidd, American Universities and Federal Research, Harvard University Press, 1959, pages 86 and 87.

The question at issue is not whether the government should provide capital for higher education. That was settled in the affirmative with the enactment of the Morrill Act of 1862, which established land grants to institutions, and has not been seriously debated since. The question rather, in sponsored research, is how best to provide the funds--in the interests of both the government and the universities.

All of the institutional criteria which apply to the placement of research problems in an academic setting are magnified when large capital investments are involved. For one reason, the financial risks can be great for the university. For another, the choice of facilities that will enhance the development of the institution along desired lines must be made in a state of imperfect knowledge about future scientific developments in a particular field, as well as uncertainty about the future interest of university investigators. Clearly, in spite of the delicate guesswork, there is a high premium on making sound judgments. The commitment of capital funds affects not only the future patte n of research at an institution and the professional development of its faculty but also the training and education of future students. To borrow an analogy from the space age, it represents a hardening of the research base of an institution.

The short-term funding practices of the federal government make it difficult for an agency to enter into long-term commitments for capital facilities. These limitations add to the financial risks of universities when they underwrite the cost of specialized buildings and equipment with their own funds on the assumption that government agencies will amortize a large part of the capital expenditures. Some university facilities have been constructed on "expressions of intent" that failed to materialize, because of either a shift in the research focus of sponsoring agencies or changes in their amortization practices. One undesirable effect of these restrictions is the possibility that in order to recover their original investment, universities may be led artificially to favor particular research interests.

In spite of the difficulties, however, the provision of capital facilities by federal agencies has resulted in widespread improvements in university research. Their effect is often to foster growth in areas of latent potential. To take a few examples beyond the construction of large particle accelerators, wind tunnels, magnets, ultracentrifuges, digital and analog computation facilities and spectrographic laboratories have stimulated universities to make basic contributions in such important areas as aerodynamics, materials, molecular biology, automation and organic chemistry.

At a national level it would be difficult to establish meaningful correlation between the amount of government support and the potential loss of freedom in a particular field. To illustrate this point, we need only note the contrast in the proportion of support provided by the federal government in several major fields: Of all university research in physics, over 95 per cent is financed by federal agencies. The corresponding figure for the life sciences is about 70 per cent, and for the social sciences about 40 per cent. To quote one observer:

> It would be difficult to present a persuasive argument to the effect that postwar research in physics in this country is more controlled by the federal government, or less productive, or of a lower intellectual caliber, or more threatened with federal restrictions, than is research in the life sciences or the social sciences. The problem is not answered by reiterating that "he who pays the piper calls the tune." (89)

The truth is that universities have inadequate funds of their own to invest in research and must rely on factors other than funds to maintain control and balance in their research programs. Along with periodic appeals to private sources of capital, these "other" means include the adoption of and enforcement of sound policies, an uncompromising insistence upon high intellectual standards, and insistence upon government capital funds under satisfactory terms and conditions.

An alternative means of assisting with capital facilities is the adoption of policies that would provide greater incentives to educational institutions to finance from their own funds, or even from borrowed funds.

(89) Charles V. Kidd, American Universities and Federal Research, page 91.

However, as we noted earlier, the present exclusion of interest costs on research capital and the 50-year equivalent basis for depreciating buildings through the 2 per cent "use allowance" under Circular A-21 mitigates against private initiative in capital financing. During the meeting of the National Research Council in March 1959, much attention was given to the expanding needs for capital facilities at universities. The Council adopted a resolution urging that the government and private sources provide much greater assistance to the financing of such facilities. The President's Science Advisory Committee also stressed this objective in the report, Strengthening American Science.

The Committee's recommendations suggested a useful point of departure in the matter of providing adequate research capital for the universities. These guidelines would seem to be as valid today as when they were presented in 1958:

(1) In its support of science and technology, the government should recognize that adequate capital support is a necessary part of research and make provision for meeting the capital needs of the programs it supports.

(2) The Federal Council for Science and Technology should prepare a projection of the capital requirements planned by federal agencies to meet their scientific and technological needs and provide a set of priorities.

(3) In making grants and contracts, government agencies should provide, as an element of cost, for new instruments and facilities as well as continuous modernization of older equipment used by universities and nonprofit institutions.

(4) Those government departments and agencies concerned should uniformly modify their grant and contract provisions to permit universities and nonprofit research institutions to charge the full cost of research performed for the government--including overhead--and to amortize capital expenditures as an allowable cost.

CHAPTER XV

WHO SPONSORS AND WHO PERFORMS

We noted in the introductory chapter that the degree granting structure of higher education is the key to the study of federal sponsorship of university research, under the present system of support. As we come now to examine who sponsors and who performs university research, a reminder of the high degree of concentration of graduate education in the U.S. is in order.

Of the 2,100 colleges and universities within the education community, over 600 offer graduate degrees of some kind--masters, professional, or doctoral degrees. However, only about 400 are active in graduate education in the fields of science, engineering, and medicine, where federal sponsorship is concentrated.(90) Of these, scarcely more than a score can claim real distinction in more than one or two scientific fields. Only a few excel in several fields.(91)

(90) The National Science Foundation tabulated 377 colleges and universities in 1957-58. Of these, 308 received federal grants and contracts to perform research and development. See Scientific Research and Development in Colleges and Universities, Expenditures and Manpower 1957-58. Washington, 1962.

(91) President's Science Advisory Committee. Scientific Progress, The Universities, and the Federal Government. Washington, November 15, 1960, page 14.

A few universities have always awarded a high proportion of the doctoral degrees in this country. In the academic year 1962-63, for example, only 223 colleges and universities awarded a doctoral degree. Within this group, 10 universities awarding 200 or more doctorates granted over a third of all Ph.D. or Sc.D. degrees in the country.

Doctoral degrees in special fields of science and engineering are concentrated to an even greater extent in a few universities. For example, of 511 Ph.D. and S.D. degrees in physics awarded in 1957-58, 51 per cent were awarded by 15 universities. Together, California, Columbia, Illinois, Michigan, Harvard, and M.I.T. awarded 124 doctorates in physics in 1957-58, or 27 per cent of all such degrees conferred in the country. The same pattern appears in the life sciences. For example, one-third of all degrees in biochemistry (52 out of 149) were granted by the universities of Wisconsin, California, Minnesota, and Purdue in 1957-58. Graduate study in mathematics is also highly concentrated. Half of the 210 doctorates granted in mathematics in 1957-58 were conferred by 11 universities.

Federal funds for university research are assigned to faculty members in strong centers of graduate education, in fields of interest to sponsoring agencies. For example, the National Science Foundation found that in 1952 the 25 institutions receiving 66 per cent of the federal funds under grants and contracts also awarded 69 per cent of the country's doctorates in science. In 1962, the comparable percentages for the top 25 institutions were 59 per cent of the federal funds and an estimated 65 per cent of the country's doctorates in science. While there is an encouraging trend towards the support of undergraduate research, the picture of federal sponsorship remains almost entirely graduate oriented.

The resulting distribution of federal research funds shows four dominant characteristics: (1) the concentration of funds in institutions supporting graduate education in science and engineering, (2) the concentration of federal research funds in institutions whose federally sponsored research volume is in the range of $1 million and above, (3) a sharp rise in the number of institutions at the $1 million-and-over level of sponsorship, especially in the number exceeding $5 million of annual volume, and (4) a broadening in the base of participation to include more institutions as graduate education and the use of research in education grows. The following table sets forth these comparisons based on NSF data for the years 1953-54 and 1957-58.

(TABLE 16)

DISTRIBUTION OF FEDERAL RESEARCH FUNDS AMONG COLLEGES AND UNIVERSITIES, 1954 AND 1958

(Millions of Dollars)

Volume Of Federal Sponsorship	Number of Institutions		Total Sponsorship in Each Group		Group Percent		Cumulative Percent	
	1954	1958	1954	1958	1954	1958	1954	1958
All Institutions	173	308	$142	$219	100%	100%	--	--
$5 million and above	6	18	47	127	33	58	33	58
$1 - $5	30	52	68	70	48	32	81	90
$0.25 - $1	36	43	19	15	14	7	95	97
Under $0.25	101	191	8	7	5	3	100%	100%

Source: National Science Foundation. Scientific Research and Development in Colleges and Universities, Expenditures and Manpower 1953-54. Washington, 1958.

National Science Foundation. Scientific Research and Development in Colleges and Universities, Expenditures and Manpower, 1957-1958. Washington, 1962.

Comparable data for later years are not available at this writing but it is worth trying to piece together a few comparisons from other studies because of the significant changes that have taken place in the distribution of federal research monies in the period since 1958. The recent House Committee on Education and Labor report, which includes data for fiscal 1962, provides a few additional checkpoints. The most significant changes are those occurring within the composition of the $1 million-and-over group of institutions, as well as a further broadening of the total base of participants below the million dollar level.

Whereas in 1958, 58 per cent of the total federal research funds on-campus were placed at 18 institutions having an annual volume of $5 million or more, in 1962, 59 per cent of the total was placed at 25 institutions--seven universities joining the top group of sponsored research performers. This continues the trend set between 1954 and 1958 when the number of $5 million-plus performers grew from six to eighteen institutions.

In 1958, 52 institutions accounted for 90 per cent of the federal funds; by 1962 there were 100 institutions in the group who accounted for 90 per cent of the federal funds, each of whom had an annual volume of $1 million or more. Thus, the number of institutions regarded as "major" performers of federally sponsored research almost doubled between 1958 and 1962, accelerating a trend set between 1954 and 1958.

Below the million dollar level, the broadening process is limited by the remaining 300 or so institutions who engage in separately budgeted research in science and engineering. Data are not available for 1962 but between 1954 and 1958, as shown in the preceding table, the number of institutions in this size class almost doubled from 101 to 191, and there is good reason to believe that their numbers may now be approaching the "theoretical" limit (300), especially with the increased volume of federal funds available on a "support" basis and the growth of research grant programs in the National Science Foundation and NIH.

Economists are wary of statistics purporting to demonstrate concentration phenomena. In the case of federal research grants and contracts in the fields of science and engineering some misleading conclusions about "haves" and "have nots" have emerged from the statistical cross fire. Almost always, the "could nots" are lumped in with the "have nots" and a highly exaggerated picture of concentration results. For example, in the House Committee report mentioned earlier the 90%-10% split between 100 top institutions and 1600-1800 "have not" institutions is given great emphasis (sic).[(92)]

The truth is that the 90-10 split is not the result of a system conceived as an allocation of funds among 2100 institutions but a system based

(92) U.S. House of Representatives. Committee on Education and Labor. Federal Government and Education. 88th Congress, 1st Session, Washington, June, 1963, page 51.

upon the placement of grants and contracts among some 400 schools who actually accept federal sponsorship, or what may be as significant, who currently have the capacity to engage in research in the fields of science and engineering. The other 1700 institutions have not yet entered the sponsored research arena either by their own choice or through the selectivity of the sponsorship process (e.g., over 600 are junior colleges). Doubtless, many never will under the present system of selective placement of federal grants and contracts. In particular, spot checks of the distribution of federal research monies gloss over the more significant developments that are taking place within the composition of institutions that are in the actual group of performers, as well as in the top group of performers where the number of participants grows steadily at each expenditure level.

The inherent disciplines which require the government science administrator to be able to defend the professional worthiness of the recipients of agency sponsorship give reasonable assurance that the final expression reflects a genuine expansion of competence and not just his zeal for democracy. Indeed, as the less strong are helped, the first essential is a larger output, from the existing centers of strength of trained research supervisors. The national need, therefore, demands that in broadening the base the strong also be made stronger--with the government, representing all the people, winning both ways.

In this writer's judgment, the most significant product of federal sponsorship has been the release of great forces residing within American universities towards the expansion of graduate education. Even the mid-nineteenth century growth of graduate training in Germany associated with the establishment of the German Federal Institutes, does not match the post-World War II rise of graduate education in the U.S., much of which has been made possible by federal sponsorship of graduate research in science and engineering. The following table presents a striking picture of this growth in the United States.

(TABLE 17)

THE GROWTH OF GRADUATE EDUCATION IN THE U.S., 1900 - 1958

Period	Number of Institutions Awarding the Doctorate for the First Time	Total Number of Institutions Awarding Doctorates	Percent Increase Over the Previous Ten-Year Period	Cumulative Growth to 1958
1950-58	56	194	41% (1)	100%
1940-49	38	138	38%	71%
1930-39	12	100	14%	52%
1920-29	20	88	29%	45%
1910-19	12	68	21%	35%
1900-09	8	56	17%	29%
1899 & before	48	48	--	25%

Source: American Colleges and Universities, 1960 (8th Edition), American Council on Education, Washington, 1960, pages 1147-1149.

(1) This percentage increase would doubtless be higher if data were available through 1959. For example, there are now 223 institutions awarding the doctoral degree.

Although the data in Table 17 are inclusive of all disciplines and refer to doctoral degrees only, they do suggest the dimensions of change taking place at the top of the U.S. educational system. Despite the concentration of federal research funds in science and engineering, the nation is still grappling with the special problem of expanding future doctoral degree output in these particular fields. But few educators will detract from the crucial role federal research funds have played in the expansion in graduate education in science and engineering achieved since 1940.

Six federal agencies and departments--the Department of Defense; the Department of Health, Education and Welfare; the Atomic Energy Commission; the National Science Foundation; the National Aeronautics and Space Administration; and the Department of Agriculture spent over 95 per cent of the total federal funds for on-campus research during fiscal 1962, not including operating monies for the research centers managed by the colleges and universities. The National Aeronautics and Space Administration is a relative newcomer to the roster of federal agencies having substantial research programs within the educational community. NASA's predecessor, the National Advisory Committee on Aeronautics, conducted research on a much smaller scale with less resort to university resources. The following table sets forth the sources of agency sponsorship for fiscal 1962.

(TABLE 18)

AGENCY SPONSORSHIP OF UNIVERSITY RESEARCH, FISCAL 1962
(Expenditures Basis)

	Millions	Percent
National Institutes of Health (HEW)	$213.1	35
Department of Defense	197.9	32
National Science Foundation	59.3	10
Atomic Energy Commission	52.3	9
Department of Agriculture	35.6	6
Public Health Service (HEW)	19.6	3
NASA	18.8	3
Office of Education (HEW)	8.0	1
Office of Vocational Rehabilitation (HEW)	2.7	0.4
Department of State (AID)	1.2	0.2
Department of Commerce	1.0	0.2
Department of Interior	1.0	0.2
Other departments	2.6	0.4
	$613.1	100

Data may not add up to totals because of rounding.

Source: House Committee on Education and Labor, The Federal Government and Education, 88th Congress, 1st Session, U.S. G.P.O., June 1963, page 48.

Although there is talk about the critical importance of basic research, it must be recognized that the federal agencies remain principally committed to development as opposed to research. Of total federal obligations of $12.7 billion for the performance of research and development in fiscal 1963, 65 per cent was allocated to development, 23 per cent was for applied research, and 12 per cent was for basic research.(93)

These percentages represent the average for all agencies, of course. The character of work supported by the individual agencies and departments is of more direct concern to the universities. The Department of Defense, which provides the second largest amount for research in the colleges and universities (and the largest in the engineering schools), obligated 2.5 per cent of its total R & D budget in basic research in 1963 in contrast to 81.0 per cent for development purposes. The comparable figures for the Atomic Energy Commission, another large federal source of research support in the universities, were 19.4 per cent and 75.1 per cent; the National Institutes of Health (the largest supporter) obligated 33.0 per cent for basic research and 67.0 per cent for applied research.

It is this major orientation of federal funds toward development and applied research that leads to continuing caution in universities enjoying

(93) Federal Funds for Science, XI, page 23. The breakdown of federal funds in these three major categories shows an encouraging trend towards research (both applied and basic). Between 1961 and 1963, for example, the share allocated to research (as contrasted with development) grew from 26 to 35 per cent of the total. Meanwhile, basic research grew from 9 to 12 per cent.

federal sponsorship that they not be diverted from basic university objectives. The question is not whether they have yielded to undesirable influences but rather to what extent they can succeed, with federal support, in meeting their enlarged responsibilities and opportunities at a time when university goals are rising rapidly in the values of advanced societies. Qualitatively, those universities which have insisted upon rigorous standards of excellence have also gained most from federal funds. As Charles V. Kidd puts it in American Universities and Federal Research:(94)

> The most significant factor affecting university research programs has not been the federal government but the standards of excellence and discrimination maintained by the intangible social pressures of the faculty. The most important effect of the federal funds has therefore been to provide momentum in directions set by cultural values and by forces within universities.

To a large extent, the pressure for development and applied research falls outside the universities. The following table indicates the current over-all distribution of federal R & D funds, and it can be seen that the university component represents a little more than 10 per cent of all federal R & D spending, including university managed research centers. Most of the federal government's R & D is performed by private industry or by the government itself. By contrast, over half of the basic research sponsored by the federal government is performed by the universities or research centers managed by them.

(94) Op cit., page 210.

(TABLE 19)

PERFORMERS OF GOVERNMENT R & D, 1963

(Millions of Dollars)

Performer	Total Government R & D Amount	Total Government R & D Percent	Total Government Basic Research Amount	Total Government Basic Research Percent
Federal Government	$2,462	19.4	$ 298	20.1
Profit Organizations, Proper	7,764	61.2	240	16.2
Profit Organizations, Research Centers	435	3.4	24	1.6
Educational Institutions, Proper	906	7.1	484	32.6
Educational Institutions, Research Centers	668	5.3	294	19.8
Non Profit Organizations, Proper	221	1.7	73	4.9
Non Profit Organizations, Research Centers	125	1.0	38	2.6
Other Domestic	21	0.2	4	0.3
Foreign	83	0.7	33	2.2
Total	$12,684	100.0	$1,486	100.0

Data may not add up to totals because of rounding.

Source: Derived from Federal Funds for Science, XI, page 93. Obligations basis.

Within the university support sector a significant but not widely appreciated change has been taking place in the last decade. Sponsorship by military agencies now represents a smaller part of the total than at any time in the past fifteen years. Although the military agencies are sponsoring university research at record levels, the ascendance of the civilian agencies has proceeded steadily since 1952. Whereas the military agencies represented 70 per cent of the total of on-campus sponsorship in 1952, they accounted for an estimated 25 per cent in 1963. This changing pattern of federal sponsorship has been less marked in the engineering schools who continue to rely upon the agencies of the Department of Defense as the group most interested in sponsoring their research and in the medical schools who have traditionally relied upon NIH. But in the rest of the educational community, the National Science Foundation and the National Institutes of Health are rising rapidly among federal sponsors. They now represent over half of the federal sponsorhsip of university research for all institutions. Indeed, non-military agencies represent three-fourths of the total federal sponsorship. See the two tables which follow:

(TABLE 20)

AGENCY SUPPORT OF SEPARATELY BUDGETED RESEARCH AND DEVELOPMENT IN COLLEGES AND UNIVERSITIES, 1952-63 (1)

(Amounts in Millions - Obligations Basis)

Agency	1952	1954	1956	1958	1960	1962 (est)(2)	1963 (est)(2)
Department of Defense	106	81	83	118	155	201	226
Atomic Energy Commission	13	16	18	30	34	51	67
Department of Health, Education and Welfare	14	23	31	79	158	324	384
(National Institutes of Health)	(14)	(23)	(30)	(75)	(144)	(299)	(350)
Department of Agriculture	13	14	25	31	32	35	37
National Science Foundation	1	4	11	21	56	86	129
National Aeronautics and Space Administration	---	---	---	---	12	25	45
Other Agencies	4	3	4	3	4	10	18
Total	151	141	172	282	449	732	906

Data may not add up to totals because of rounding.

(1) Excludes Federal-contract centers. Data from National Science Foundation, Federal Funds for Science, series.

(2) Estimates published in Federal Funds for Science, XI.

(TABLE 21)

AGENCY SUPPORT OF SEPARATELY BUDGETED RESEARCH AND DEVELOPMENT IN COLLEGES AND UNIVERSITIES, 1952-63 (1)

(Percentage Distribution)

Agency	1952	1954	1956	1958	1960	1962 (est)(2)	1963 (est)(2)
Department of Defense	70	57	48	42	39	27	25
Atomic Energy Commission	9	12	11	11	8	7	7
Department of Health, Education, and Welfare	9	17	18	28	35	44	42
(National Institutes of Health)	(9)	(17)	(17)	(26)	(32)	(41)	(39)
Department of Agriculture	9	10	15	11	7	5	4
National Science Foundation	1	3	6	7	12	12	14
National Aeronautics and Space Administration	---	---	---	---	3	3	5
Other agencies	3	2	3	1	1	1	2
Total	100	100	100	100	100	100	100

Detail may not add to 100 because of rounding.

(1) Excludes Federal-contract research centers. Data from National Science Foundation, Federal Funds for Science, series.

(2) Estimates published in Federal Funds for Science, XI.

This changing pattern of sponsorship has in part been responsible for the widespread growth in the grant form of research agreement as contrasted with the contract form, NSF and NIH relying traditionally upon the grant form. But the more fundamental reason has been an underlying shift in sponsorship philosophy on the part of all federal agencies--a re-evaluation of the importance of underwriting basic research for its own sake as well as for its relevance to agency objectives, a deep-seated concern for scientific manpower production and a consequent, further blurring of the distinction between "supported" and "purchased" research. This blending of research and training <u>motives</u> for federal sponsorship has led, in turn, to greater freedom of inquiry on the part of university investigators, to a notable improvement in the terms and conditions of sponsorship, and an atmosphere of greater understanding between sponsors and performers conducive to a wider degree of faculty participation in the universities. Faculty members no longer look with doubt upon the effort required to convince sponsoring agencies about the relevancy of their basic research plans to agency goals. Indeed, the university community has come to look upon the federal government as the principal source of basic research funding, and in some fields practically the only available source of funding. The present system of sponsorship is thus moving in a direction eagerly and persistently sought by the universities. It is not without its faults and shortcomings but the movement is decidedly encouraging.

The most impressive evidence of federal concern for institutional needs are the newly established resource grant programs, termed "training grants" from NSF, NIH and NASA. These broadly based programs leave the utilization of funds to the discretion of recipient institutions, and they may be used in designated areas for teaching or research undertakings or both, as the institution sees fit. In addition, the National Science Foundation has instituted a small but pioneering, institutional grant program that places unrestricted funds at the disposal of university administration in accordance with the volume of NSF sponsored research in a given institution.

All of these developments signify a growing concern for institutional well-being as a means to the development of scientific resources in areas of special interest to sponsoring agencies. Recently, the Department of Defense took an impressive step by recognizing the importance of encouraging "independent" research in the universities. The DOD now permits a part of the cost of such independent research to be added as an indirect cost on DOD-sponsored research contracts. (See ASPR 15-205, 35 (h)) This provision in the Armed Services Procurement Regulation permits basic research costs that are not directly related to the performance of the particular contract being charged to be included as a "cost of maintaining scientific skills" in much the same way as "general research" in industry may be charged in part to the cost of a particular research contract.

Clearly, the beginning of a new era in university-government research relationships is at hand. It bids fair to redress some of the problems posed by the project system of sponsorship. With ample encouragement and financial support, it can provide the means of preserving the inherent values of the present system by seeking to remedy its fundamental neglect of institutional requirements as a whole.

Private Sources of Support for University Research

The universities' stake in the present system is amply illustrated by Table 22 which shows the growth of the government component compared to the growth of private and university support for university research in the period 1953-1961. While total support from federal agencies grew by 217 per cent in the seven year interval, private sponsorship lagged behind with an increase of 150 per cent. In some institutions the private component has declined in absolute terms as well as in relative volume. The same is true of university sponsored research, which grew by only 61 per cent during the period.

(TABLE 22)

SOURCES OF SUPPORT FOR RESEARCH & DEVELOPMENT IN THE COLLEGES AND UNIVERSITIES, 1953-61

(Dollars in Millions)

Year	Total(1)	Federal Agencies	Universities Own Funds	Other Non-Profit Institutions	Private Industry
1953-54	$ 450	$ 280	$ 130	20	20
1954-55	480	300	140	20	20
1955-56	530	330	155	25	20
1956-57	650	415	180	30	25
1957-58	780	530	190	30	30
1958-59	840	570	190	40	40
1959-60	1,000	720	200	40	40
1960-61	1,200	890	210	50	50
Growth Since 1953-54	166%	217%	61%	150%	150%

Source: National Science Foundation, "Trends in Funds and Personnel for Research and Development, 1953-1961", in Reviews of Data on Research and Development, Number 33, April 1962, page 2.

(1) Includes research and development in university managed contract research centers.

This is regrettable since private and university sponsorship represent important sources of support for on-campus research, and since they constitute a desirable counterbalance to university reliance upon federal funds . No one doubts that the relative ease with which federal funds can be secured has played a crucial role in turning the attention of faculty members to federal sponsors in fields where private sponsorship might also be available. At a time when private industry's own reliance upon basic research is at an all time high, the universities have not succeeded in attracting as large a share of the <u>private</u> basic research dollar as they have from federal sponsors. To some extent this has been due to a nagging lack of clarity on the part of private sponsors about the difference between research project support on the one hand and aid-to-education on the other. To some extent it has been due to the husbanding of all-too-scarce corporate research funds to support basic research in industrial laboratories on an "in-house" basis. And to some extent it has been due to intramural competition for all-too-scarce corporate support of all kinds within the universities themselves. One can hope that as private industry expands <u>both</u> its aid to education programs and its uncommitted funds for basic research that corporate sponsorship of university research can be enlarged.

Effective interaction between university research and industrial technology represents a most desirable solution to a major problem currently confronting industry and the nation--the problem of communicating the results of weapons and space research to the civilian economy. Greater industrial sponsorship of university research represents one important way that private industry can participate more actively in this interchange of knowledge. Another highly effective method is through industry participation in organized programs of scientific liaison maintained by many of the leading universities and technological institutes. There are some twenty institutions who maintain professional liaison staffs for this purpose based upon a model program developed at M.I.T. in 1948.

CHAPTER XVI

UNIVERSITY PARTICIPATION IN GOVERNMENT POLICY MAKING

Before we conclude this study, another important aspect of government - university relationships needs to be mentioned, namely, university participation in government policy making. In their advisory and consulting capacity roles, university scientists, engineers, and educators play a crucial role in determining the character of federal R & D programs--which in turn affect the nature of federally sponsored research in private industry, government laboratories and in the universities themselves.

The spectacular achievements of science and engineering during World War II convinced government officials and legislators that these fields would have far-reaching social, economic, and international consequences. Dr. Vannevar Bush's Science, The Endless Frontier, written in 1945, and the five-volume study, Science and Public Policy by the President's Scientific Research Board in 1947 urged that science be looked upon as a major national resource. Many others joined the chorus, and research in the physical and engineering sciences did indeed receive government support which, while considerably less than today, was unprecedented in peacetime. But, most of all, it was the continuing truculence and rapid rise of the Soviet Union that led to the conviction that science is not only broadly important for its own sake but vital to the national security, of which prestige is an important part. During the year after the Communist invasion of South Korea, federal obligations for research and development rose by 60 per cent, remaining in the new high area until they took still another large jump following the first Sputnik.

These added sums were distributed with judgment on where the money would be most productive in advancing the government's objectives in science and technology, as nearly as these could be determined.

Universities of course shared proportionately with other claimants. There was a corollary, however, to the increased spending that had a second, and in a sense disproportionate, effect on universities. That was the intensified call on academic institutions and individuals as advisors in government decisions, regarding science and education principally, but going beyond that to the application of scientific knowledge and method to a wide range of government policy questions, especially in fields related to the national security. Since much of the nation's intellectual capacity is concentrated in the universities, it was natural that the university scientists and the universities themselves should become prominently involved in the postwar governmental hierarchy through participation in innumerable committees, boards, panels, and study groups as well as in permanent organizations established to provide specialized knowledge on a continuing basis.

Don K. Price describes the growth of the government's "machinery of advice" as a coalescence of three major lines--the use of part-time committees, the resort to special study contracts, and the evolution of a system of operations research, to provide continuing advice. Whereas standing advisory committees serving on a part-time basis were a familiar administrative device, the employment of scientists outside government under special study contracts, and in permanent organizations for continuing advice, was entirely a post-war phenomenon. In atomic energy and national defense, in particular, elaborate structures were formed to enlist the scientific community in the exercise of executive authority. In both fields the need to make major decisions based on objective and expert knowledge led to major innovations in government decision processes. In short, as Mr. Price puts it:

> The United States is the only nation that has ever been willing to support and create private institutions to make studies on problems combining scientific and military considerations--problems of a sort that would elsewhere be considered the very heart of general staff planning. The private institutions that are now largely supported by military funds are the most important sources of independent, skeptical, and uninhibited criticism of military thinking.[95]

(95) Don K. Price, Government and Science, New York University Press, 1954, pages 143, 144.

Today, each of the military services and the Joint Chiefs of Staff are served separately by private organizations whose functions are to bring a wide range of scientific knowledge to bear upon military operations and weapons systems development. The RAND Corporation, a nonprofit enterprise with headquarters in Santa Monica, California, serves the Air Force; the Operations Research Office, a subsidiary of the Johns Hopkins University, serves the Army as does the Human Resources Office at George Washington University; the Operations Evaluation Group, located in the Office of the Chief of Naval Operations, is directed and staffed by The Franklin Institute (Philadelphia); the Institute for Defense Analyses, a nonprofit association of universities, manages the scientific organization supporting the Weapons Systems Evaluation Group which serves the Joint Chiefs of Staff. More recently, the Mitre Corporation has been organized with M.I.T. support, at the request of the Department of Defense, to provide systems analysis and engineering services for air defense and other major new communications systems. The participation of university personnel in these and other enterprises has thus become critical to our national defense and survival.

Universities have also participated in government decision-making by administering study groups. These provide advice on broad strategic problems which require an interplay of scientific, technical and political considerations. The Atomic Energy Commission and the Department of

Defense have made especially heavy use of the university study groups--for example the Lexington Study to investigate nuclear powered flight, Project Charles dealing with continental air defense, Project East River to advise on civil defense, the Hartwell Project to study sea transport during wartime, and Project Vista to examine tactics and strategy for certain conditions of large-scale war. These studies have implicated faculty members and universities in decisions of great national consequence. They represent an important means by which the government has augmented its scientific resources.

The use of the universities to organize and manage some government oriented establishments is a postwar phenomenon that has levied its price upon universities. Their strong attraction for intellectual manpower, their relative freedom of action with regard to personnel policies, and their integrity in matters of public trust have all drawn attention to the universities as a fertile environment for creating new organizations.

The responsibilities of organizing and managing these new ventures place a heavy burden upon high-ranking university administrators and correspondingly reduce the amount of time for the discharge of traditional university functions.(96)

(96) For a thoughtful and entertaining essay on the demanding responsibilities of academic administration, see the article by President Douglas Knight of Lawrence College, "The Waking Nightmare: Or How Did I Get Into This?" Association of American Colleges Bulletin, December, 1958.

Where the advice of scientific bodies under university management enters into decisions of great public interest, the universities have in some instances sought the protection afforded by numbers, as in the case of the Institute for Defense Analyses.

Heavy reliance is placed also upon individual facutly members and university administrators in part-time advisory committees. Charles V. Kidd estimates from unpublished NSF data that the total number of persons serving on such committees in 1958 was probably well over 1,000 with more than half from the educational community.(97)

Within the White House, the President's Science Advisory Committee, during the first eighteen months following Sputnik I, utilized the part-time services of 160 scientists and engineers from industry, education, and government. These consultants served on twenty-seven *ad hoc* panels which completed thirty-seven major studies and reports, about half of which dealt with ways through which science and engineering can serve national security objectives.(98)

Finally, there is the considerable number of university members who serve full time on leave of absence in government posts.

(97) Kidd, Charles V. *American Universities and Federal Research.* Cambridge, Massachusetts, The Belknap Press of Harvard University Press, 1959, page 193.

(98) "Capsule Conclusions," speech by J.R. Killian, Jr. Special Assistant to the President for Science and Technology, Symposium on Basic Research, New York City, May 14, 1959.

Beyond the contribution of public service, which is owed to government, it is fair to note that the universities benefit to a considerable extent for such loan of their skills. By filling government posts and serving advisory committees they help attune government to the needs, potentials, and realities of education and university research. We have noted that their success in influencing the scientific directions and content of government programs, especially in basic research, has not been matched in areas of management vital to them. It may seem to some on occasion that university advisors form such swarms in Washington as to obscure the sun, influencing executives and legislators out of proportion to their practical knowledge. But it remains the case that in a matter of closest personal interest to so many of them--as, for example, the stability of financial support in campus laboratories--the average researcher back home in June of any year, when the matter of his next-year commitments are at a painful peak, is from half certain to highly uncertain about what the new government fiscal year will bring. And, quite seriously, the unnecessary fret is a significant national waste.

Nevertheless, the associations fostered by university participation in advisory committees contribute to greater understanding and mutual respect, which in the end must form the basis of effective cooperation between government and the educational community.

CHAPTER XVII

EFFECTS ON THE UNIVERSITIES--THE PROBLEM OF BALANCES

There are a number of useful ways of analyzing the effects of federal sponsorship within the universities. In this study we have touched on a few of the major problem areas. Now let us examine federal sponsorship in terms of its effect upon university "balances."

It is important that we pay some attention to balance in university operations, for the translation of university goals into concrete action operates through a system of balances at all levels of decision on the campus. The choice of disciplines, the design of curricula, the recruitment of students and faculty, the operation of university budgets and the utilization of research for educational ends are largely influenced by considerations of balance. In the presence of multiple criteria by which to judge their own performance, universities strive to maintain "balance" among the resources available for university achievement. These balances, in turn, become the pivotal considerations around which universities seek to organize interacting interests on the campus into an integrated whole.

At progressively higher levels of responsibility, the character of the balances changes in accordance with the scope of the decisions required. But the adherence to a central conviction about the efficacy of a balanced approach to university pursuits pervades the academic authority structure at all levels of organization. It may start with students who seek to take a balanced load of subjects in any given semester and extend all the way to the president who may be seeking to strike a proper balance between research and teaching in the overall educational program or between graduate and undergraduate education throughout the institution.

The evaluation of federally sponsored research in the universities inevitably raises questions of balance in several areas of operation. The ten most prevalent balances cited in the literature dealing with this subject are shown below. The placement of federal research funds in the universities is said to affect the balance:

1. between research and education
2. between freedom of individual inquiry and organized research
3. among academic disciplines
4. between graduate and undergraduate education
5. between basic and applied research
6. among strong and weak institutions
7. among sources of support (private vs government)
8. between restricted and unrestricted funds
9. between new and older fields of study
10. among project, program, and institutional support.

Time does not permit an extensive treatment of these complex issues; all are important to the well-being of higher education. We shall conclude this study with a discussion of the first three items only, leaving to the reader an invitation to apply his own judgment to the remainder based upon the discussion presented in the preceding chapters.

1. The Balance Between Research and Education

Few issues in higher education, since the rise of federally sponsored research, have been more widely discussed and as little understood as this one. The heart of the difficulty lies in the semantic problem introduced by the fluctuating usage given the term "education."

While there is curiously little disagreement over the meaning of university research, educators themselves adopt a variety of definitions for the word, education, depending upon the context in which they are using the word. It is not uncommon for university representatives to speak of the profound changes taking place within education, as a result of the integration of research and teaching, and then calmly proceed to compare faculty time spent on research with classroom instruction as a measure of the "balance" between research and education. While university spokesmen will argue vehemently and in unison for the oneness of research and education when indirect cost reimbursement questions arise, many will fall back on narrower interpretations of education and call it classroom teaching when it comes to an examination of their own internal balance sheets.

This may be understandable since the research revolution that has taken place in the educational community is scarcely more than twenty years old and since it has mainly affected only 100 of the 2100 institutions of higher learning. But the time and effort wasted in the failure to join the issue properly is a national waste, and it has produced a distorted public image of university research. This writer believes that the inability of higher education to persuade federal sponsors about the oneness of research and education in the matter of cost reimbursement is due in no small way to the universities' own ambivalence in the use of the term, education. If research has indeed become an integral part of modern education in a number of fields, then it is hardly fair to university research or to education to compare their relative dollar aggregates, or faculty time spent in research versus classroom teaching. It is especially misleading for the major universities, where the research revolution in education has proceeded to an advanced state, to compare research time with classroom teaching time as a measure of the educational health of these institutions.

Of course, this line of reasoning assumes that all university research is indeed related to teaching, i.e., that classroom instruction (as one measure of teaching) has purposely been altered (qualitatively as well as quantitatively) to take account of the teaching values served by research. In practice, this ideal may be achieved only in varying degrees. But the popular inference drawn that education is sacrificed when research expands and classroom instruction declines is based on two implicit assumptions, both of which are false: (1) that education can be equated to teaching (classroom instruction) and (2) that since research and teaching (classroom instruction) compete for an individual faculty member's time, they are also competitors in the educational process. We might add a third implicit assumption that is almost always made but which is only sometimes true--namely, that an educational institution (like the individual faculty member) has only a fixed amount of time to allocate between research and teaching and cannot expand its faculty or research staff to cover its enlarged educational commitment (to both research <u>and</u> teaching).

By the use of a few algebraic symbols, these considerations can be made explicit.

Let E = total time consumed in the education process

R = time spent on research related to teaching

T = time spent teaching in the classroom

A = time spent on academic affairs (committees, etc.)

r = time spent on research <u>not</u> related to teaching

then a highly oversimplified expression for the time consumed in the educational process is given by

(1) $E = T + A$ (T = teaching load of, say, 12-15 hrs./wk.)

when a university uses no research in its educational program; and by

(2) $E = (R+T) + A$ (T = teaching load of, say, 6-8 hrs./wk.)

when a university uses research and when all of its research is related to teaching; and by

$$(3)\quad E + r = (R + T) + A + r$$

when university research is added that bears no relationship to teaching.

The reader will notice that when research becomes an integral part of the educational process there are <u>three,</u> not two, items on the balance sheet; and when non-educational research is added, there are <u>four</u> items to be considered. When most writers discuss the "balance" between research and education they invariably neglect the appreciable time faculty members spend in their academic duties (committees, etc.) indicated above by the term A. What these writers naively tabulate is R + r versus T. What they ought to tabulate in order to recognize the teaching value of research (R) is the left-hand side of the equation -- E versus r!

To this writer's knowledge no one has attempted this comparison, and it is the only one that has any meaning in analyzing the educational behavior of a research-based educational process. The important balance is <u>not</u> how much time is spent in all research versus classroom instruction but how much time is spent in research that bears no relationship to teaching (r) versus the total of all educational pursuits, (R + T) + A. (99) (100)

In assessing the effect of federal sponsorship on the balance between research and education, one must weigh the effect against a hypothetical situation of what might have been true in the absence of federal funds. This much seems clear: (a) university research is more extensive and in virtually all fields is of higher quality than it could have been without federal support, (b) the transformation of graduate education from a classroom-oriented to a research-oriented process has been speeded by the availability of federal monies but this conversion process has proceeded unevenly among the various disciplines and among different institutions. In professional schools which have traditionally laid great stress on the dignity and efficacy of "learning by doing," this development has proceeded much faster than elsewhere, (c) the total of educational pursuits has been immensely benefited by the integration of university research and teaching, but (d) federal sponsorship

(99) The empirical evaluation of the function $E = (R + T) + A$ would make an interesting and highly useful study for institutions with a significant volume of research. Fragmentary data may be available at various institutions, for example, through questionnaire data on the allocation of faculty time.

(100) In our highly oversimplified analysis we have purposely neglected another area of university activity that consumes significant amounts of time in many institutions, namely public service. See Chapter XVI. A realistic model of higher education would have to include this additional area.

has also brought undesirable influences to bear upon university operations, (e) there is no preordained level of research that accompanies teaching in any particular field, much less in a given institution or in higher education as a whole. What may be desirable as a "norm" in nuclear physics may not be applicable to organic chemistry, or to psychology. There have been no systematic attempts to arrive at generally valid standards in each field. On the other hand, institutional standards do evolve from practical experience, and it is both useful and informative to the management of higher learning to examine the changing educational balance between research and teaching (R and T in our notation). It is also important not to confuse this particular balance with the institutional balance between non-educational research and the total of educational pursuits (r versus E in our notation).

One must conclude the university research and education have both benefited enormously from federal sponsorship. To the extent that they have been integrated properly, the gains have been two-sided. When the universities have failed to perform this integration, or when conditions of sponsorship have precluded it, university research has suffered less than education. But both have lost.

2. The Balance Between Freedom Of Individual Inquiry And Organized Research

Federal sponsorship has not stifled the initiative of the individual, despite the size and complexity of the total research effort in the colleges and universities. Indeed, the most immediate effect of the project system of sponsorship has been to give expression to the research plans and aspirations of individual faculty members. On the other hand, universities have sought a measure of protection for themselves and for the individual by organizing research extensively on a group basis. This thrust has accompanied the large scale, interdisciplinary demands of modern research. The result has been to give a major impetus to organized research in the universities and to pose a new choice to the individual faculty member whether to "go it alone" or affiliate with a team effort on the campus, usually in a formal laboratory or "center" organization.

The post-war achievements of university research are weighted heavily on the side of integrated effort but it remains true that individual researchers have made seminal contributions to science and engineering, working independently or in very small groups. Some examples at Harvard, Columbia and M.I.T. are: Enders at Harvard--measles virus isolation; Sheehan at M.I.T.--penicillin synthesis; Townes at Columbia--maser discovery; Collins at M.I.T.--helium cryrostat; Shannon at M.I.T--information theory; Watson and Crick at Harvard--DNA molecule structure. It remains a challenge of the first order to universities and to the federal government alike that the continuing search for a viable pattern of research organization keep inviolate the freedom of the individual to pursue his research interests in a manner deemed best by himself.[101]

The encouragement of broadly-based program research by federal sponsors is helping to overcome some of the present short-comings of the project system, i.e., the time required to submit detailed proposals and the problem of finding support for the younger man or the man of unproved ability. But the desire to safeguard the interests of the individual can only be met adequately if a practical way is kept open by the universities, in their relations with sponsors, for individuals to exercise continuing freedom of choice about their participation in group or independent research.

3. The Balance Among Academic Disciplines

The present interest of federal agencies in university research produces a concentration of funds in three major fields--life sciences, physical sciences, and engineering. Over 90 per cent of the $4.4 billion obligated for research (not including development) by the federal government in fiscal 1963 was for studies in these three major fields, both within and outside the educational community. The social sciences and psychological sciences each accounted for 2 per cent of the total. Other sciences accounted for the remaining 5 per cent.[102] Roughly the same

(101) In a June 12, 1963 speech to M.I.T. alumni, President Stratton emphasized this central concern in reporting on the progress of new research programs at the Institute.

(102) National Science Foundation. Federal Funds for Science, XI, page 120.

distribution of federal funds for basic research occurred in fiscal 1963.[103] Detailed information on the breakdown of this support within education is not available at this writing. However, the proportions shown in Table 23 for the fiscal year 1957-58 give an indication of the heavy weighting of funds.

(TABLE 23)

FEDERAL SPONSORSHIP OF ON-CAMPUS RESEARCH BY MAJOR FIELD, 1957-58

(Millions of Dollars)

	Federal	Total On-Campus	Percent Federal
Life Sciences	$ 88 (40%)	$141	62%
Physical Sciences	78 (36%)	98	80%
Engineering	45 (21%)	68	66%
Social Sciences[1]	9 (3%)	23	39%
Totals	$219 (100%)	$329	66%

Data may not add up to totals because of rounding.

(1) Includes psychological sciences and other sciences.

Source: National Science Foundation. Scientific Research and Development in Colleges and Universities, Expenditures and Manpower 1957-58. Washington, 1962, page 21.

During fiscal 1957-58, for example, the federal government sponsored 80 per cent of total on-campus research in the physical

(103) Ibid., page 37.

sciences, 62 per cent in the life sciences and 66 per cent in the branches of engineering. Today, these percentages are significantly higher, resulting in an over-all figure for federal sponsorship of about 75 per cent of the total of on-campus research.

These impressive percentages belie the fact that there are significant gaps within each of the three major fields sponsored heavily by federal funds. Engineering is a good example. As late as 1958, the Engineering College Research Council estimated that almost 25 per cent of the nation's proved research capacity in engineering schools was idle in 1956-57 for lack of funds.

This estimate was based on the amount of time the faculties of 108 engineering schools could have spent on more research without interfering with teaching, committed research, committee assignments, and other responsibilities. Only 10 per cent of the institutions in the study answered no to the question of whether any excess research capacity was available on their campuses; the reamining 90 per cent answered yes in varying amounts. In the Council's words:

> The areas of engineering science which appear to be most in need of intensive basic research are metallurgy (high and low temperature), ceramics (ceramics, coatings, etc.), aeronautics (shock tubes, wind tunnels, etc.), civil engineering (water and waste treatment), isotopes, heat transfer,

servomechanisms, and high-speed computers. More could be named.

In an age of rapid technological advancements there will always be a strong demand for more knowledge, especially basic knowledge. Though they are ready and willing to contribute, our schools may not be able to act without substantial financial assistance.(104)

What was true of engineering in 1956-57 is also true today in a number of engineering disciplines, in the earth sciences and in a number of fields in the physical sciences. These gaps in coverage within the better-supported fields point up a major shortcoming of the project system of funding and the difficulties of finding suitable ways to finance the less supported fields, notably the social sciences and the humanities. The need for increased understanding in these "have not" fields has been heightened by the same forces that have prompted the explosive rise in federal spending for research in the physical sciences and engineering. Recently, encouraging developments have strengthened the standing of the social sciences in the federal government. In particular, their increased recognition by the National Science Foundation and the White House is encouraging. Within the past five years, the federal agencies

(104) Engineering Colleges Research Council, "A Survey of Research in the Nation's Engineering Colleges, Capabilities and Potentialities, July 1956-July 1957," published in June 1958.

have roughly doubled their support of research in the social sciences. However, the amount is still pitifully small ($95 million compared with $12.7 billion for all federal R & D) even though the direction and rate of change are significant. Meanwhile, total federal obligations for research have quadrupled.

Speaking of the imbalance among disciplines resulting from the dearth of federal research funds in the social sciences and in the humanities, President Goheen of Princeton said recently:

> "It is in and through these fields that students will glimpse and grasp the accumulated human wisdom and the fresh evaluative insights that are needed to guide the utilization of scientific discoveries and technological innovations to worthy human ends. In these fields, often moderate library purchases or additional leaves for scholarly research are the intellectual equivalent of a cyclotron or electron microscope. Relatively small infusions of funds can go a long way. Yet we must confess having a long way still to go to be able to make them available in sufficient magnitude."(105)

(105) Robert F. Goheen, "Federal Financing and Princeton University," The Educational Record, April 1963, page 176. President Goheen later stated his personal conviction that wide ranging federal support for the humanities and social sciences might be undesirable because of the greater likelihood of adverse political pressures and federal interference in these fields.

An illustration from the field of economics will point up the lopsided balance resulting from federal funding. In an area as relevant to federal interests as the economics of research and development, the National Science Foundation recently tabulated 203 projects conducted at all colleges and universities in the United States.(106) Twenty-eight of these were personally financed by the investigators themselves; 48 by the universities and the remainder with partial or full outside support. In the same year, the number of federally financed research and development projects in universities was of the order of 20, 000 to 25, 000. As this paper is being written, the House Rules Committee is hotly debating an unprecedented bill which would provide $500, 000 a year in federal grants to aid in the collecting, preserving, editing and publication of major American historical documents.(107)

It should be apparent to the reader that research in the social sciences and in the humanities is over twenty years behind the other sciences and engineering in the matter of federal sponsorship. In fact, the present debate over federal subsidy to research in history is reminiscent of the heated discussions in the late 1940's that preceeded the establishment of the National Science Foundation and the subsequent

(106) National Science Foundation. "Current Projects on Economic and Social Implications of Scientific Research and Development, 1960." Washington, NSF 60-79, page 2.

(107) "U.S. Subsidy For Historians Raises Ruckus," Boston Globe, August 11, 1963.

wide-ranging federal support for the natural sciences and engineering. It is, of course, grossly misleading to lump the humanities with social sciences; federal support for the former is virtually nonexistent today.

In the unsupported fields such as the social sciences, humanities, architecture, and fine arts the universities have shouldered the heavy burden of insuring that their commitment to the total span of knowledge has not been distorted by the uneven availability of research funds among academic disciplines. Most university spokesmen agree that the unsupported fields have benefited on balance through the displacement of university and private funds to the unsupported fields. However, the process works imperfectly and is subject to certain budgetary rigidities within the universities. At the same time, there seems little doubt that many of these fields have been "carried along" so to speak by the freeing up of monies that would otherwise be applied in the short run to the life sciences, physical sciences and engineering. However, this process of balancing has also posed significant financial risks for the universities, quite apart from the inadequate coverage of average research costs by the federal government in the well-supported fields. The financial effect has been to siphon off funds that might otherwise be set aside for the maintenance of university capital in the supported fields to insure the health and vigor of the other fields in the short run. To the extent that unrestricted funds are available to help in this process of averaging, the universities' burden has been enormously lightened. To the extent that private and federal research capital are available, the incursions into the university capital account have also been kept within manageable limits. But there is no assurance that these ameliorating factors will continue to operate in the future as they have in the past.

Epilogue

The federal government is clearly committed to a dominant role in stimulating, promoting, and supporting scientific progress in the United States. More than ever before, the nation's strength in science and engineering resides in the quality and resiliency of our educational system, in these specialized fields and a host of others. During the past twenty years, the universities and the federal government have entered upon a course that has been responsible for significant changes in our society. There is good reason to believe these changes will continue and accelerate in the decade ahead.

In seeking to strengthen our university resources for the challenges and opportunities of this scientific age, greater public recognition, understanding, and appreciation of intellectual pursuits are prime requisites. As the great English mathematician and philosopher Alfred North Whitehead put it in 1916:

> In the conditions of modern life the rule is absolute. The race which does not value trained intelligence is doomed. Not all your heroism, not all your social charm, not all your wit, not all your victories on land or at sea, can move back the finger of fate. Today we maintain ourselves. Tomorrow science will have moved forward yet another step, and there will be no

appeal from the judgment which will then be pronounced on the uneducated.

When higher education is viewed as the link between science and economic progress, institutional considerations appear more urgent than ever. In seeking to mobilize our educational resources to promote economic growth, the nation addresses itself to the broadest possible concerns in the field of higher education. For the rate at which scientific progress can be absorbed and diffused into the economy is a function of the general rise in the educational level of the work force, not alone of our educational progress in the specialized fields that set the scientific pace. Thus, in the broad sphere of economic endeavor the national interest more nearly matches the concern of educational institutions, who remain commited to the total span of knowledge and to the total educational process that supports it.

Translated into economic terms, the nation's return on its investment in university research will be highest in the long run when (a) the institutional environment in which advanced learning flourishes is at peak strength, and (b) the educational system as a whole is performing at the highest possible level. To achieve this ideal, substantially greater attention needs to be paid in the future to the total educational role of the colleges and universities than has been true throughout most of the period since the beginning of large scale application of federal funds to university research. As we noted earlier, encouraging progress in this direction has already begun.

Those universities which have generated new economic opportunities for the nation have done so primarily because they are strong centers of scholarship, teaching, and research. The economic contributions they have made are generally by-products of their success in advancing learning. Their larger economic impact has come not from a utilitarian emphasis in teaching, in research or in public service. They have made their greatest contribution to the economy by their inherent emphasis upon intellectual breadth and depth and by their idealistic aims. In short, they are dedicated to the broadest possible purposes of our society. But given a high degree of academic strength and intellectual vigor, they have made and are certain to continue to make important contributions to economic growth.[108]

(108) The writer is indebted to Dr. J. R. Killian, Jr. for his permission to paraphrase this concluding paragraph from an unpublished paper presented to the Governors Conference, Miami Beach, July 22, 1963.

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