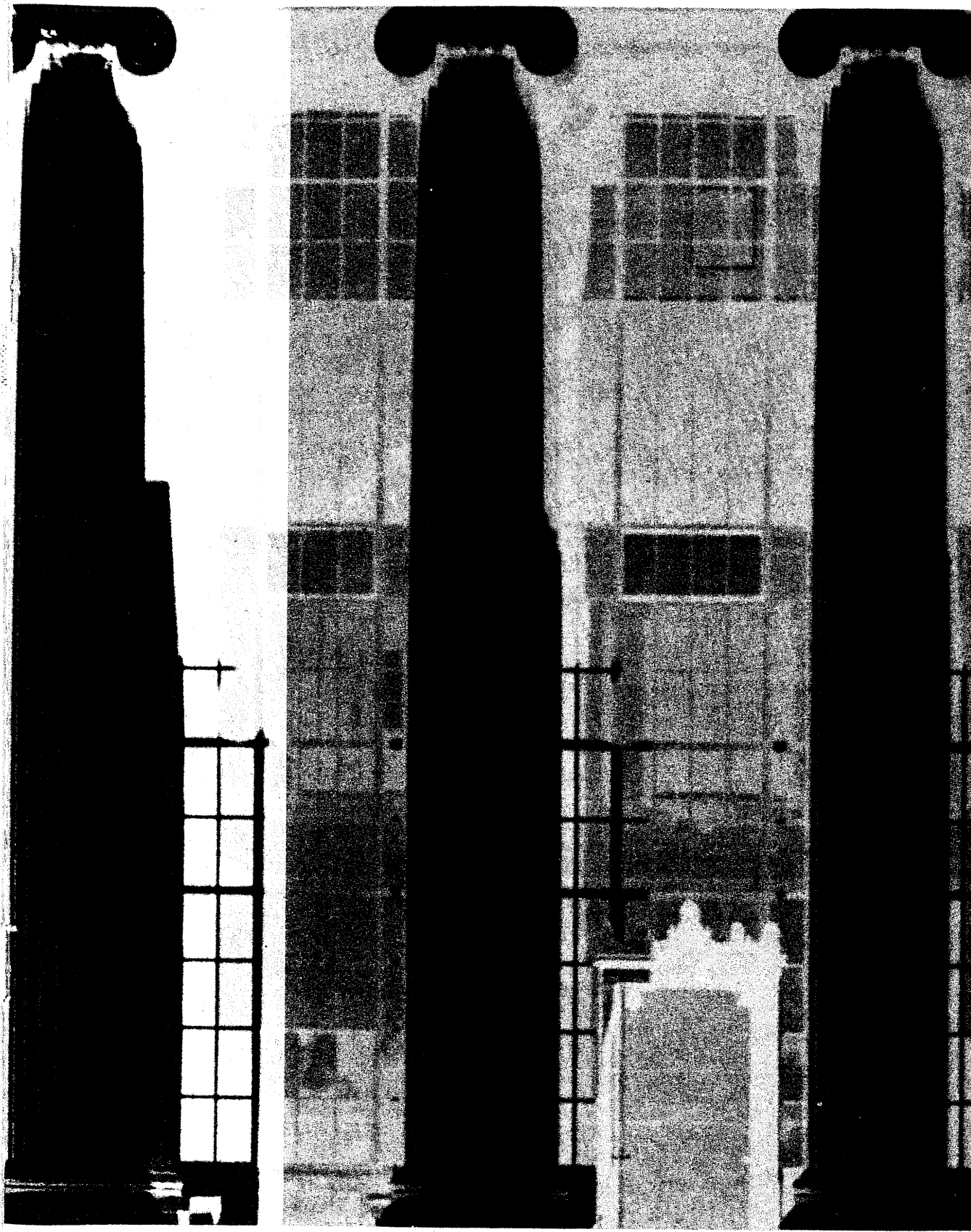


The President's Report 196



MASSACHUSETTS INSTITUTE OF TECHNOLOGY

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

FOR THE ACADEMIC YEAR ENDING JULY 1, 196

The President's Report 1961

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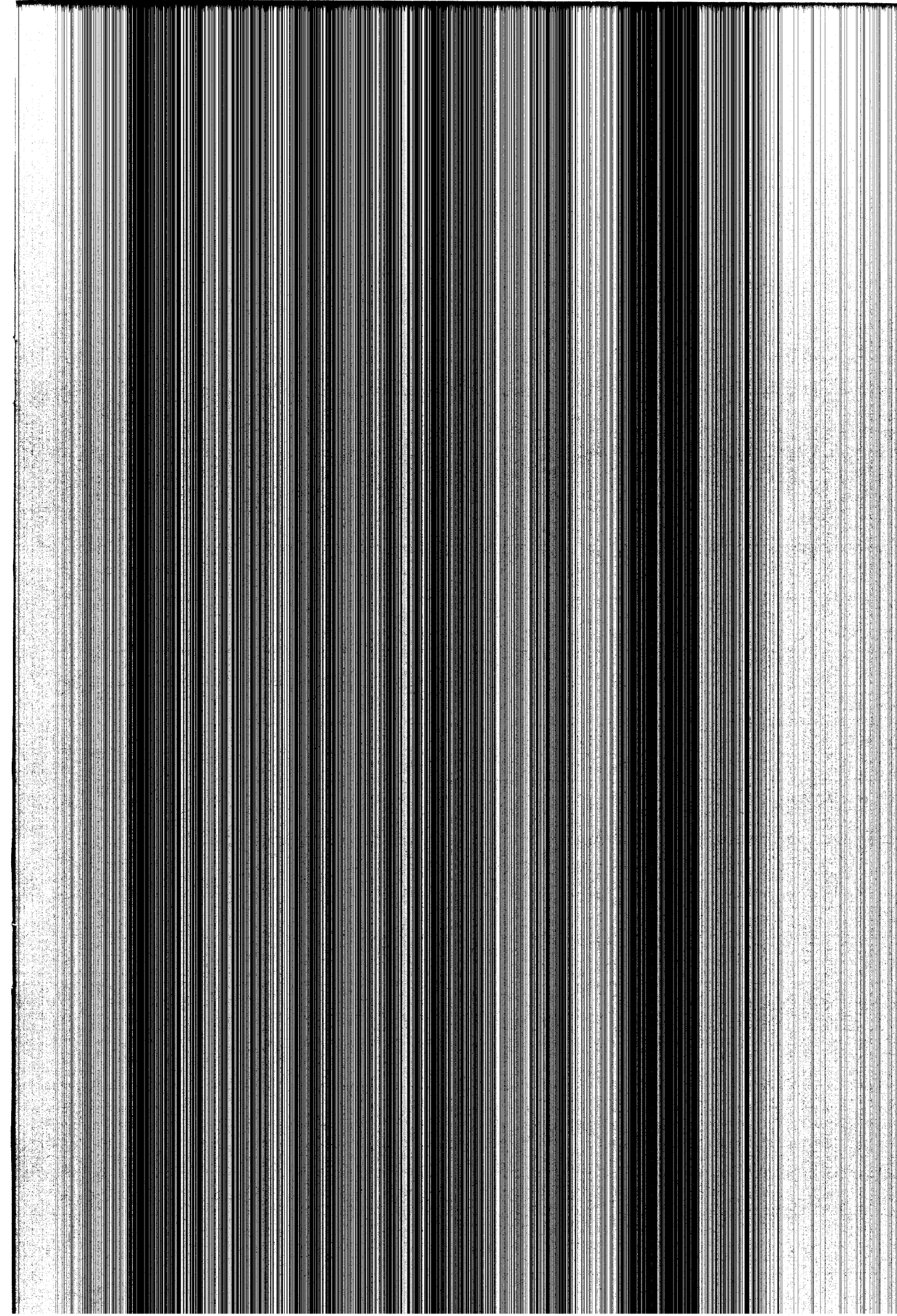
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REPORT OF THE PRESIDENT

To the Corporation By any standard, the celebration last April of our Centennial was a magnificent success. The anniversary of our charter was marked by a ceremonial convocation on Sunday, the ninth, that paid appropriate tribute to a century of great achievement. The conferences that preceded the Convocation illuminated brilliantly the problems and obligations that lie ahead.

Those of us who were occupied with the planning and directing of events during that busy week found it difficult at the time to rise above the mass of detail and to judge the effect of the whole. But on looking back, from conversations with our guests, from innumerable letters that have flowed in from every part of the world, it becomes abundantly clear that the Centennial Program created an indelible impression, that it was truly a momentous occasion for M.I.T. I believe that many of our visitors from abroad carried home a wholly new conception of the Institute — of the range of its interests, of its methods and goals and quality; that our alumni were proud of their Alma Mater; that many students gained a new understanding of the character and influence of this institution of which they are now a part.

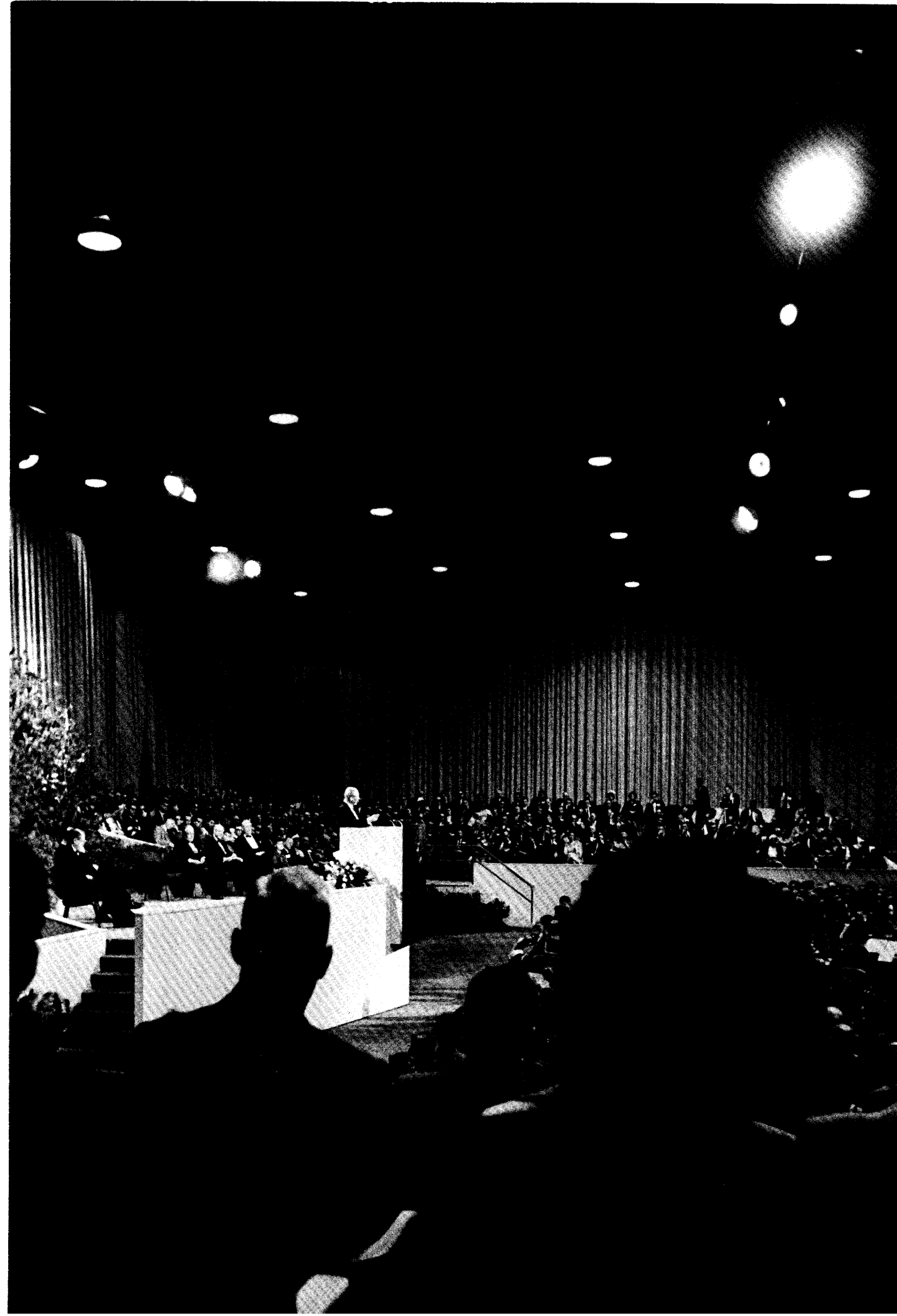
The principals in the Centennial Convocation at the ceremony marking the anniversary of the charter.

Yet I suspect that the most profound effect of all was upon our own faculty and administration. We who are the current prime movers in shaping the growth and development of M.I.T. are perhaps too close to the scene to view the transformation of recent years in detached perspective or to grasp fully its implications. Certainly the discussions that revolved about the central theme of the Centennial Program have provoked new thoughts upon the role of the Institute in the modern world. The interweaving of science and engineering with every aspect of the economic, political, and social life of the nation emerges again and again as the dominant movement of the twentieth century. This was the idea about which Professor Warren K. Lewis and a faculty committee after World War II formulated their recommendations for the development of educational policy at M.I.T. It was a conception that seemed sufficiently precise ten or twelve years ago to define and delineate the area of our interests. But already that area has become immense, embracing or touching upon almost every conceivable human activity. The horizons of opportunity are expanding too rapidly for any one institution to stretch to them all. And so, sooner or later, we shall be compelled to make some hard choices. Our resources are large but nonetheless limited. Within those resources, we shall be wise to build strength by a concentration of effort on a few objectives.

Highlights of the Centennial Celebration: the Academic Procession to the Convocation; M.I.T. faculty reporters summarizing the International Conference on Scientific and Engineering Education at the First General Assembly; and (next page) The Right Honorable Harold Macmillan at the Third General Assembly.







A Heritage of Change The Centennial stimulated much discourse on the early history of the Institute. William Barton Rogers was truly one of the great innovators in American education, and the story of the inception and maturing of his ideas can be told again and again with profit. For every pioneer in ideas there is a lesson in the patience, the extraordinary tenacity, the singleness of purpose with which Rogers pressed forward towards the realization of his plans in the face of seemingly insuperable obstacles. There were vested interests in the legislature opposing the charter. The Civil War dealt the plan an almost fatal blow. Time and again, in the course of those early years, the Institute balanced perilously on the brink of bankruptcy; and at each crisis the persuasive eloquence of Rogers, the basic soundness of his ideas, his vision and courage, rallied an intellectually sympathetic community of Boston to give material support.

The two volumes of Rogers' correspondence edited by his wife, the biography of Francis Amasa Walker by James Phinney Munroe, the excellent history of "Boston Tech" by Dean Samuel C. Prescott — all are invaluable sources of information on the founding and early development of M.I.T. Some day we must add to these a coherent account of the flow of ideas that have influenced academic aims and the methods of teaching at the Institute throughout the century. They can be understood only when placed in the context of the great industrial and intellectual movements of the times. The Industrial Revolution in Britain, and to a lesser degree on the Continent, had a profound impact upon the social and political thought of the nineteenth century. Out of this ferment emerged radically novel views on the purposes of education. In many countries technical institutions appeared, each a model expressing local and national interpretations of the new conceptions. It was the great virtue of Rogers that he was able to draw deeply from these fresh currents of thought, to profit from British, French, and German example and experience, and to fashion a wholly new institution in harmony with

American attitudes and character, and responsive to national needs.

For more than sixty years the interests of M.I.T. were focused almost exclusively upon architecture and engineering. The content of the curricula and the mode of teaching accurately reflected the contemporary state of industrial enterprise in the United States. Then in 1930 there began a second period of innovation and evolution of educational policy that continues to this day. President Compton moved first to establish basic science on a sound and equal footing at the Institute. Sometime thereafter followed the slow transformation of engineering marked by a replacement of empirical information with fundamental theory and a vastly firmer grounding in mathematics and the physical sciences. This latter movement, as everyone knows, was enormously accelerated by the technical implications of the Second World War.

We are indebted also to Karl Compton for the steps he took to encourage the development of the social sciences at M.I.T., and I shall have more to say shortly on how they have prospered. Thirty years ago the undergraduate sampled from a random set of "general studies" to fortify his general education. These have long since been replaced by systematic programs of electives in the humanities and social sciences that are coherently related to the required core courses of the freshman and sophomore years. And finally, the School of Industrial Management has taken its place with the four other schools of the Institute to cultivate and develop the bonds that are linking engineering and the physical and social sciences to the methods, the attitudes, and the concepts of modern management.

ENGINEERING EDUCATION This report — even in a centennial year — is hardly an appropriate medium for extended comment on a century of growth and development. If I have touched lightly here on certain events of our past, it is partly, as I have said, because of my hope that someone competent in the field may be encouraged to examine the evolution of M.I.T. from the standpoint of a history of ideas;

and partly as background for one further comment.

A modern university is a dynamic enterprise. By its very nature it is resistant to the common afflictions of old age, for it is nourished by an unremitting flow of youthful minds in quest of new knowledge and fresh ideas. Consequently a university is in constant flux — revising the substance of its teaching, expanding the fields of its interest.

At its beginning — or even thirty years ago — M.I.T. was in essence a school of engineering with a plan of education materially influenced by the empirical methods of the day. Now engineering at the Institute shares and competes with four other strong schools for the interest of students and faculty. I am conscious that a number of older alumni and friends of M.I.T. have at times viewed these developments of the postwar era with serious misgivings, fearful that broad departures from a single-minded dedication to the education of engineers may weaken the quality of our total effort. This concern has in many instances been deepened by a dramatic transformation in the character of engineering education itself — a change marked by the abandonment of many courses in shopwork and drawing, an increased emphasis upon a foundation in science and mathematics, and a growing interest in graduate work and research.

To all who share this concern I owe the firm assurance that M.I.T. will remain deeply committed to engineering education. There is at the moment, in my judgment, no area of Institute activity more thoroughly alive and moving; nor will one discover elsewhere in the faculty any greater preoccupation with the substance of curricula, with methods of presentation, or with the definition of professional aims and attitudes. But I must also add that in the view of an overwhelming majority of my colleagues, engineering education would fail to flourish in isolation; it will thrive in competition and association with its neighboring fields. In my annual report of a year ago, I commented at some length upon the manifold nature of current engineering requirements. It would be foolhardy for a single institution to undertake to meet every need. The technologies of American

industry are presently engrossed in the most rapid and far-reaching advances of all history. As we make our judgments on how M.I.T. shall educate its young engineers, we must look to the forefront of industry itself for our models; for the cutting edge of industrial enterprise today shapes the common practice of a few short years ahead.

IDEALS AND VALUES I have one further comment on our centennial celebration. The week opened with an international conference on education in science and engineering. Then the distinguished members of the several panels met to speculate upon future progress in the physical and biological sciences; and to examine the impact of modern science upon man's view of himself, upon art, upon industry, and upon world affairs. Through all these conferences there ran the one central idea to which I alluded earlier in this report — the penetrating influence of science and engineering in the whole of modern society.

In our letter of invitation to the conferees, we wrote that “the peace, stability and welfare of the world depend in great measure on the skill and human understanding with which modern technology can be brought to bear on its problems.”

The grave mood in which a number of participants at the Centennial viewed the future, as well as the nature of the occasion, unquestionably conveyed in some of the conferences the impression of an excessive reliance upon science and technology as our sole remaining hope for a world in chaos. There have since been a number of thoughtful letters and comments to remind us that as man progresses in knowledge, he does not necessarily progress equally in virtue. Perhaps Dr. Charles Malik, a participant in the discussions, has captured the essence of a concern for balance most clearly. In a letter from which I quote he writes: “Nor was the question raised of how, granting fully the dangers to survival and agreeing that they must be averted, the race would then live: what values would permeate it, what ideas would motivate its endeavors, what spirit would guide it, what gods it would serve.”

M.I.T. is an institution built upon science and engineering. Here, if anywhere, one should look for commitment to the concepts of science and faith in the power of its methods. But it would be a serious misreading of the temper and purpose of M.I.T. to conclude that our vision of life is no larger than the satisfaction of material wants, that we have no hope of peace other than through an arsenal of weapons, or that we are guided in our own lives by no principles other than the physical laws of nature. The whole evolution of the Institute seems to me to belie the narrow view; the actions and interests of members of our faculty, their intellectual and spiritual concerns, speak eloquently for themselves.



The Social Sciences In the light of the concerns of the Centennial for the larger influences of science upon society, I think it appropriate to review this year the state of the social sciences at the Institute. That we should have become occupied with these areas was inevitable, and the Institute has a clear obligation to cultivate especially those that relate most directly to modern developments in engineering, science, and mathematics. M.I.T. has recognized this responsibility and has responded with strong and growing support to work in the social sciences in the School of Humanities and Social Science and elsewhere. These activities are giving to the Institute an entirely new dimension that few not associated intimately with M.I.T. yet appreciate.

It is a simple truth that the interests of the great physical and social sciences were never more interwoven than today. The overriding practical problems of our time — defense; disarmament; the economics of change; the politics of peace; the relationships among industry, science, and government — require joint technical and social analysis. The very progress of science is influenced by the broader social context, and the advances of engineering affect all our human institutions.

In our decision to encourage the growth of certain key social sciences at M.I.T., we determined not only to build on strength, but also to exploit particularly those that have special relevance to our central concerns with science and engineering. We hope to create more points of contact between the social and physical sciences and to foster more fruitful collaboration between them. In this way, in spite of enormous pressures for growth, we can delimit the domain of our interests and the way in which we allocate our resources to them.

We have given special attention to those fields in which mathematics and statistical techniques are playing an increasingly important role. This is, of course, completely compatible with our M.I.T. style, with our desire to be governed in our approach to problems by a sense of the quantitative, the analytical, the mathematical. But by no

means are we seeking to build our social sciences in the image of the physical. We recognize full well the many differences in set and attitude that distinguish them. An exaggerated insistence on emphases that are too narrow or criteria that are too rigid will only defeat our long-range objective of making the social sciences an integral part of the modern scientific university. Each field must be free to develop in its own way, to follow with complete freedom its own professional instincts.

From this point of view, the flowering of the social sciences at M.I.T. represents a new experience for us. Accustomed as we are to the demonstrable factual data of the physical sciences, we must accept the larger subjective element of judgment that enters into the social sciences in their present state. Since developments in many of these areas are open to a variety of interpretations, we must foster, within the limits of our aims and resources, a range of views and interests. The ultimate safeguard, however, lies not in seeking an impossible balance among modes of thought, but in recruiting a faculty of the highest intellectual power and integrity. This we have done.

In my report of a year ago I touched on a faculty survey of the social sciences which gave highest priority for development to fields of economics and economic history, political science, and psychology. I want now to comment briefly on the current status of these fields at the Institute and to examine in passing our commitments and our hopes in these areas.

ECONOMICS The oldest social science at M.I.T., economics is still by a sizable margin the largest. The teaching of economics goes back to 1881 and Francis Amasa Walker. General Walker, the Institute's third president and one of its great builders, was an authority on political economy — as economics was then called — and his understanding of the processes in American industrial development notably influenced his views on the education of engineers. He gave an outstanding lecture course on political economy and was the author of a distinguished



text in the field. He also brought other economists to the Institute.

Yet, until well into the modern era of M.I.T., economics remained largely a service department for the School of Engineering. Only since World War II has the department matured and assumed a truly professional character. Today it is universally conceded to be among the most distinguished. Indeed, by any of the usual measures — the stature of its teachers, the quality of its research, the achievements of its graduates — it ranks in the small handful of leaders. This year the president of the American Economic Association and the presidents-elect of the Econometric Society and of the Industrial Relations Research Association are members of this department. This year, too, M.I.T. was selected as first choice by more Woodrow Wilson Fellows in economics — eighteen out of eighty — than any other school in the country. The strengths which have won this kind of recognition within the profession are substantial indeed. They were achieved, essentially, by encouraging economics at M.I.T. to chart its own professional course; by the development of a distinguished graduate curriculum and of a major research program; and by insistence on the same standards of excellence we demand of our scientific and engineering departments. As a consequence, we have accomplished in economics the same kind of comprehensive renovation of purpose that Karl Compton undertook at an earlier date for the School of Science.

Economics at M.I.T. is also an important resource for other areas of teaching and research, and for the School of Industrial Management in particular. Management education at M.I.T. grew out of our teaching in economics, and today the teaching and research of the Department and the School reinforce one another more strongly than ever. Much of the research of the Department bears directly on the interests of the School — research on the economics of particular technologies; on the problems of measurement of productivity and output; on the contribution of technical progress to economic growth; on the origin and growth of

new enterprises. Through this close relationship between the Department and the School, we also enjoy a fruitful interchange of theoretical and practical points of view.

The history and current role of economics at M.I.T. is the model for our development of other social sciences. We have now established sections of political science and of psychology within the Department of Economics and Social Science. Both are fields in which student and faculty interest is keen and in which we have unusual opportunities to make important contributions.

POLITICAL SCIENCE Because of the interweaving of technology with all the affairs of the modern world, and especially with those of government, we have set high priority on the development of political science. It is an area in which we have been moving rapidly ahead. This June we awarded our first Ph.D. degrees in this field, and there are now about thirty doctoral candidates within the Section. In addition, some five hundred undergraduates take elective courses in political science each year.

The Section now offers courses in six fields of political science, all of which are related to other interests of the Institute: international relations and foreign policy, political communication, defense policy, government and science, political and economic development, and political theory and comparative politics. Besides providing opportunities for combining work in political science with a scientific or engineering field, the faculty of the Section maintain close ties with their colleagues in economics, psychology, industrial management, and city and regional planning.

In the past two years, we have developed superlative strength in the field of comparative politics of developing areas, and through the association of the Section with the Center for International Studies we probably have as strong a faculty as is to be found anywhere in the politics of development. In support of this work, the Institute received two notable gifts this year. One, the donation of \$500,000 from Dr. Arthur W. Sloan and Dr. Ruth C. Sloan of Washington,

D.C., establishes a professorship in political science with emphasis on African studies. Not only does this gift provide an important new endowed professorship, but it also recognizes in a most dramatic way the growing stature of political science at the Institute.

The second grant is one of \$475,000 from the Carnegie Corporation for research in training on the politics of transitional societies. The grant will make possible expansion of our research on the problems of nation-building in transition countries such as the newly emerged African and Asian nations. It, too, gives substantial recognition to the quality of our program. The Carnegie grant, among other benefits, establishes graduate fellowships both for course work at M.I.T. and for field work towards the doctoral thesis. We are enthusiastic about the values to be derived from this aspect of the grant which will permit us to send our students overseas for on-the-spot research in developing areas.

We have enjoyed magnificent opportunities for field studies in other areas of our political science activities through the generous support of the Maurice and Laura Falk Foundation, the Ford Foundation, and the Rockefeller Foundation. The Ford Foundation has also underwritten much of our work on government and science, and the Rockefeller Foundation this year supported a new seminar on arms control. This seminar brought together some thirty individuals in the Cambridge academic community with strong interests in both the technological and political aspects of this subject. We very much hope that this may prove to be the beginning of a substantial new research program on defense policy.

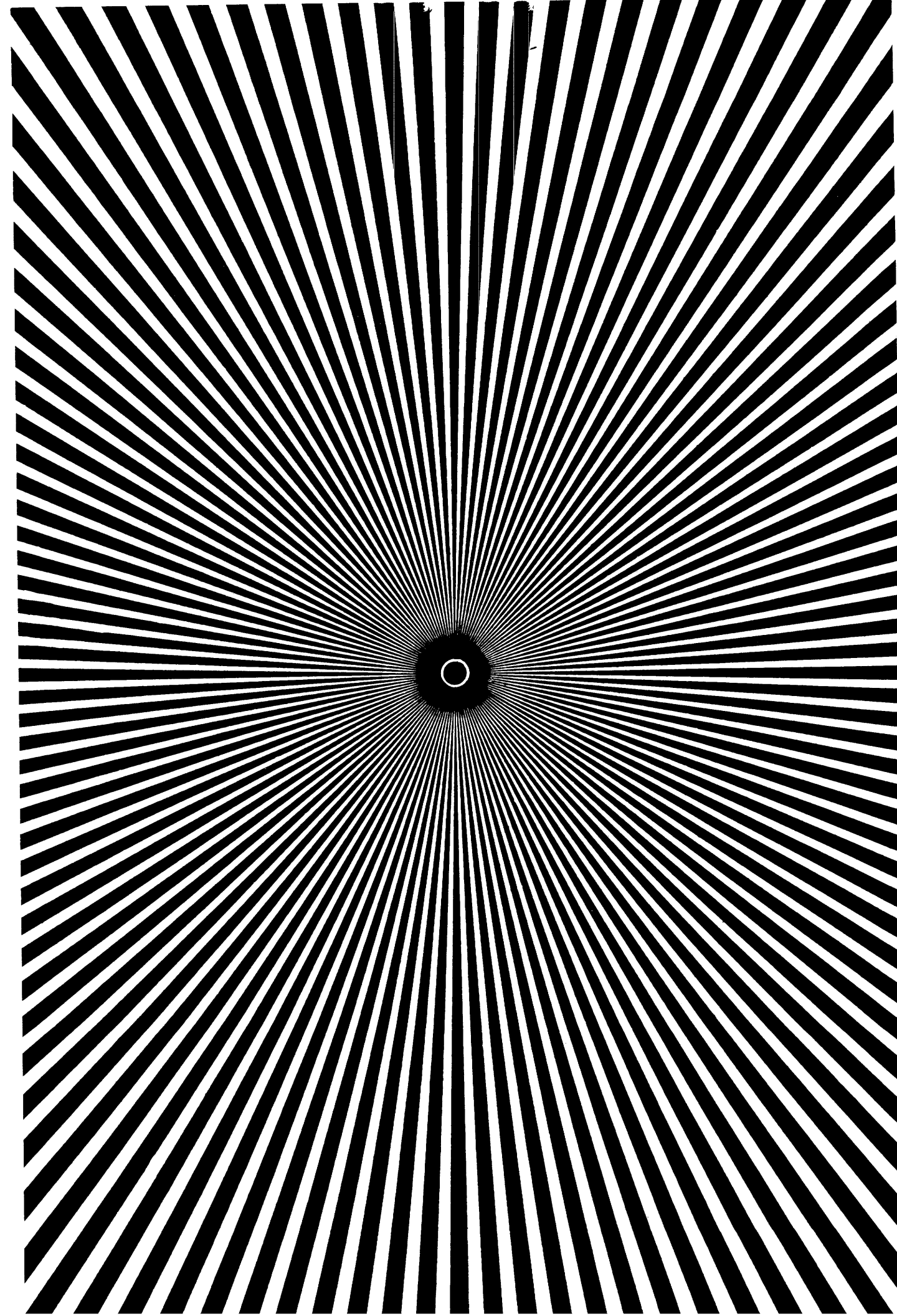
This brief sampling of our progress in political science is intended only to suggest the vitality of this field at the Institute. It has grown quickly, but without overstretching itself. It has set high standards in research, and it has developed both its undergraduate and graduate courses in a most creative and constructive spirit. This new venture for M.I.T., in sum, has met with outstanding success.

PSYCHOLOGY The example of political science has encouraged us to press forward even more vigorously with our plans to establish a psychology section within the Department of Economics and Social Science. The Institute already has great strength in psychology, both within the Department and elsewhere; and we have made marked progress this year in planning for a graduate program. This effort is being led by Professor Hans-Lukas Teuber, whose appointment I reported last year and who has now moved his research projects in physiological psychology from New York to Cambridge. Professor Teuber has brought with him a number of research associates and four postdoctoral fellows. In addition, we hope to make two additional faculty appointments in psychology soon.

To provide space for the new Section, the Institute has acquired the Central Scientific Company building at the corner of Amherst and Ames Streets. All three floors of this structure, which is located adjacent to our main academic group, will be devoted to an expansion of our teaching and research in psychology. When the necessary renovations are completed during the coming year, the building will be equipped with undergraduate and graduate laboratories, seminar rooms, animal quarters, and testing, observation, and office facilities.

The work of the Psychology Section will encompass three general areas: social and developmental; experimental; and physiological and comparative psychology. Our teaching in all three areas will put special emphasis on the experimental and the mathematical. And in our research we hope to create new opportunities for interdisciplinary cooperation. This hope reflects the fact that psychology, especially in its quantitative aspects, is already intimately associated with many areas of Institute activity.

The relations of our experimental group with other M.I.T. activities, for example, have already had an important influence on the development of experimental psychology in this country. Our collaborative efforts include studies in such fields as communication and coding theory, automatic



pattern recognition, signal detection theory, computer simulation of intelligent behavior, and others. There are many psychologists at the Institute concentrating on problems of this kind, and there are more at Lincoln Laboratory who are also concerned with problems of perception and observation and man-machine interactions.

The new Section's work in physiological and comparative psychology will have similar opportunities for collaboration with research in progress in the Department of Biology and in the Center for the Communication Sciences, where investigations in communication biophysics are focused on the principles of organization of the central nervous system and on biophysical information handling. There are also a number of psychologists in the School of Industrial Management, and it is to be hoped that the work of the Section in social and developmental psychology will develop complementary ties with this management group. The latter is working on problems of morale and motivation, of executive leadership, and of creativity in the industrial setting; while the former is primarily concerned with the process of socialization.

Even a cursory review of the sites of interest in psychology at M.I.T. is impressive. The discipline has prospered on this campus, even though we have taken few systematic steps in the past to promote its growth. It has insisted upon recognition, really, and we are now committed to a sound program of development. No one here doubts the wisdom of this decision. The chief problem, indeed, will be to achieve a sense of professional unity among our psychologists without weakening those productive interdisciplinary ties that have given M.I.T. psychology a stamp and style that is all but unique.

LINGUISTICS The decision was also made this year to offer a program leading to the Ph.D. in linguistics beginning in the fall of 1961, and we are in the process of establishing appropriate new sequences of work in linguistics for both undergraduate and graduate students. This work will be directed by the Department of Modern Languages, which

Stationary but moving —
a perception problem
studied by M.I.T.
psychologists.

(135) * WHAT HAS IT.Q

(136) * WHAT DOES WATER FIND WATER AND FOUR BLUE PLANTS ON THREE BLACK AND RED ROOFS FOR.Q

(137) * SHE MAKES A RUG NOWHERE.

(138) * ... Y ... FIVE RATS DOES HAS TREE ADMIRE THREE STOVES.

(139) * ... GRILEY AND ...

(140) * ... WOODS AND A NEWSPAPER ISN'T

(141) * ... TRAGIC AND BRIGHT.Q

(142) * ... SMALL ROOM AND COOL.Q

(143) * ... OLD SIDES AND A ... FUNNY AN

(144) * ... MAKE THE ... SMOKE

(145) * ... COOL

(146) * ... FUNNY IN

(147) * ...

(148) * ...

3. $C_0 V C_x V C_y$ NAV) $x+y \leq 4$

→ vowel red.

4. $[\leq a] x [\leq a, b] b [\leq b] I \rightarrow 2 (011)$

4. $1 x [\text{bena}] x \rightarrow 142x$
at word bound.

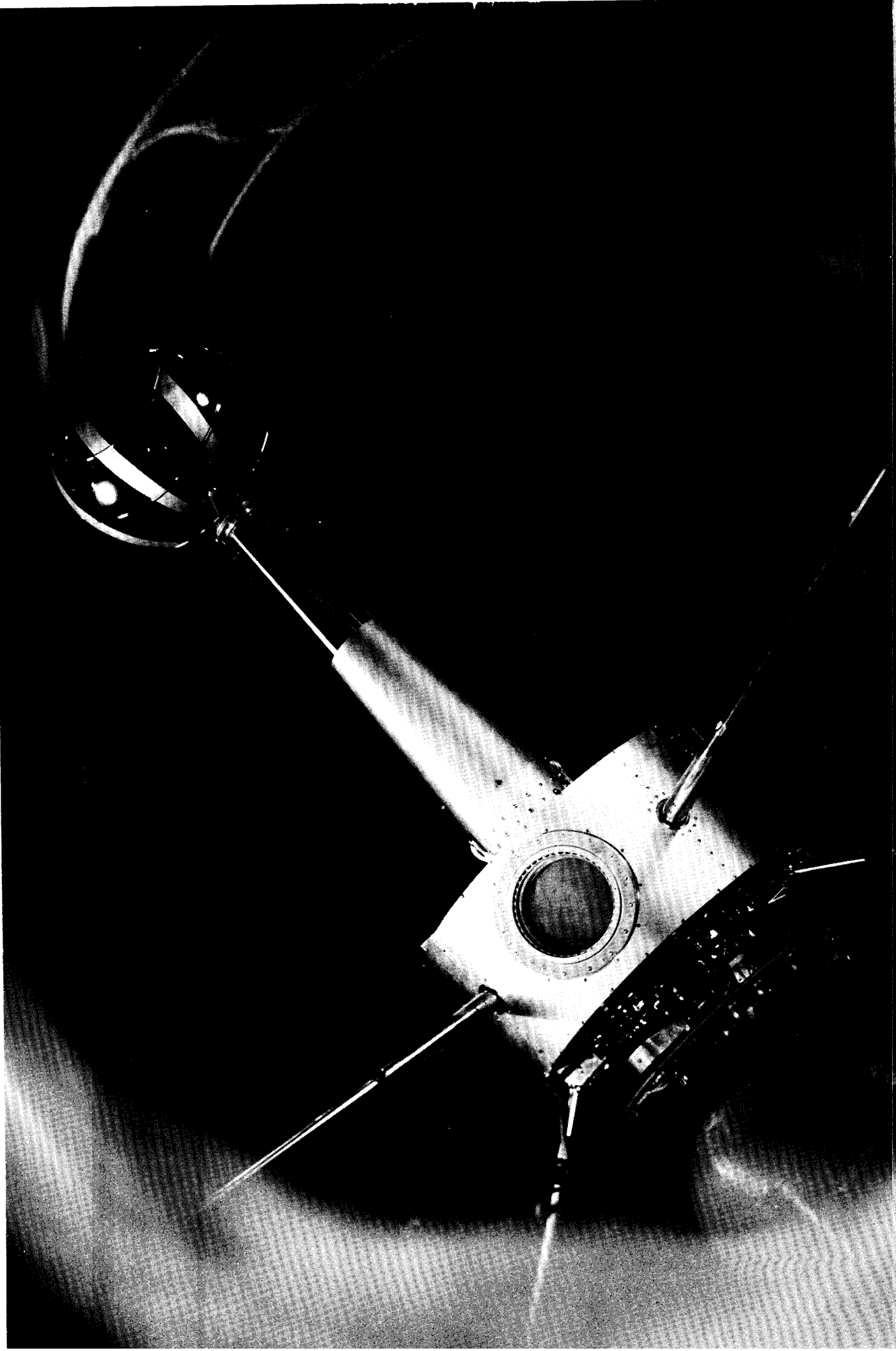
5. $i] \rightarrow i]$

Research in linguistics: sentences generated from random words in a computer programmed for language study, and a mathematical expression for the rules of stress in English words.

has been carrying out important basic research in linguistics for a number of years. It is significant that among the first students we have accepted for this graduate program are majors in mathematics and physics as well as in linguistics.

Our concern with linguistics actually derives from the efforts of Professors Norbert Wiener and Claude Shannon in their pioneering work on the mathematical theory of communication. The study of the logical relationships within languages employs mathematical techniques comparable to those used in the general area of information theory. Moreover, recent developments in computer design, switching theory, and other similar areas are of first importance in the field of applied linguistics and in linguistic analysis.

It is not surprising, therefore, that much of our research in linguistics has taken place in the Center for the Communication Sciences, where linguists work in close association with mathematicians, electrical engineers, and physicists as well as with biologists and psychologists. This cooperative research has been carried forward in both theoretical and applied linguistics. We have a central concern with the structure and logic of language. We have also undertaken a number of promising applied projects, including work on mechanical translation and on machine perception and synthesis of human speech. These examples are typical of the kind of research through which M.I.T. has gained an international reputation in linguistics. Now, with our new doctoral program, the prospects for the rapid further development of this field at the Institute are exceedingly bright.



Research and Teaching In my report for the year 1959, I discussed at some length the concept of interdisciplinary centers. Because of their implications for the organization of teaching as well as of research, they mark in many respects the most significant development of recent years on this campus.

In essence these centers have been designed for the advancement of new fields which cut across traditional disciplinary lines and to which members of several departments are drawn by broad common interests. Although the centers share the objective of bringing together different disciplines for a joint attack on highly complex problems, their patterns of organization depend on individual circumstances. Thus the oldest of these groups, the Research Laboratory of Electronics, which celebrates this year its fifteenth anniversary, draws principally upon the Departments of Electrical Engineering and of Physics for the direction of its program but also attracts students and faculty from at least nine other fields. The Center for Earth Sciences is an alliance formed primarily to advance the mutual interests of two departments, Geology and Geophysics and Meteorology, although with the completion of the new building we anticipate an increasing involvement of Physics, Chemistry, and Mathematics. The proposed Center for Aeronautics and Astronautics is supported by the department of the same name and will be concerned with a variety of problems — physical, mathematical, and biological — the consequences largely of advances in the exploration of space.

In sum, we view the centers as extending and supporting the activities of the existing departments rather than supplanting them. Nonetheless, they constitute a notable evolution in the organization of M.I.T., a certain duality of administrative structure. They foreshadow also substantial increases in the facilities for and the commitment to research at the Institute.

The Second Century Program includes a number of such centers among its major goals, and the past

Deep space probe to measure interplanetary "plasma" (neutral ionized gas), one of two research devices put in orbit by N.A.S.A. and the inter-departmental Laboratory for Nuclear Science last year.

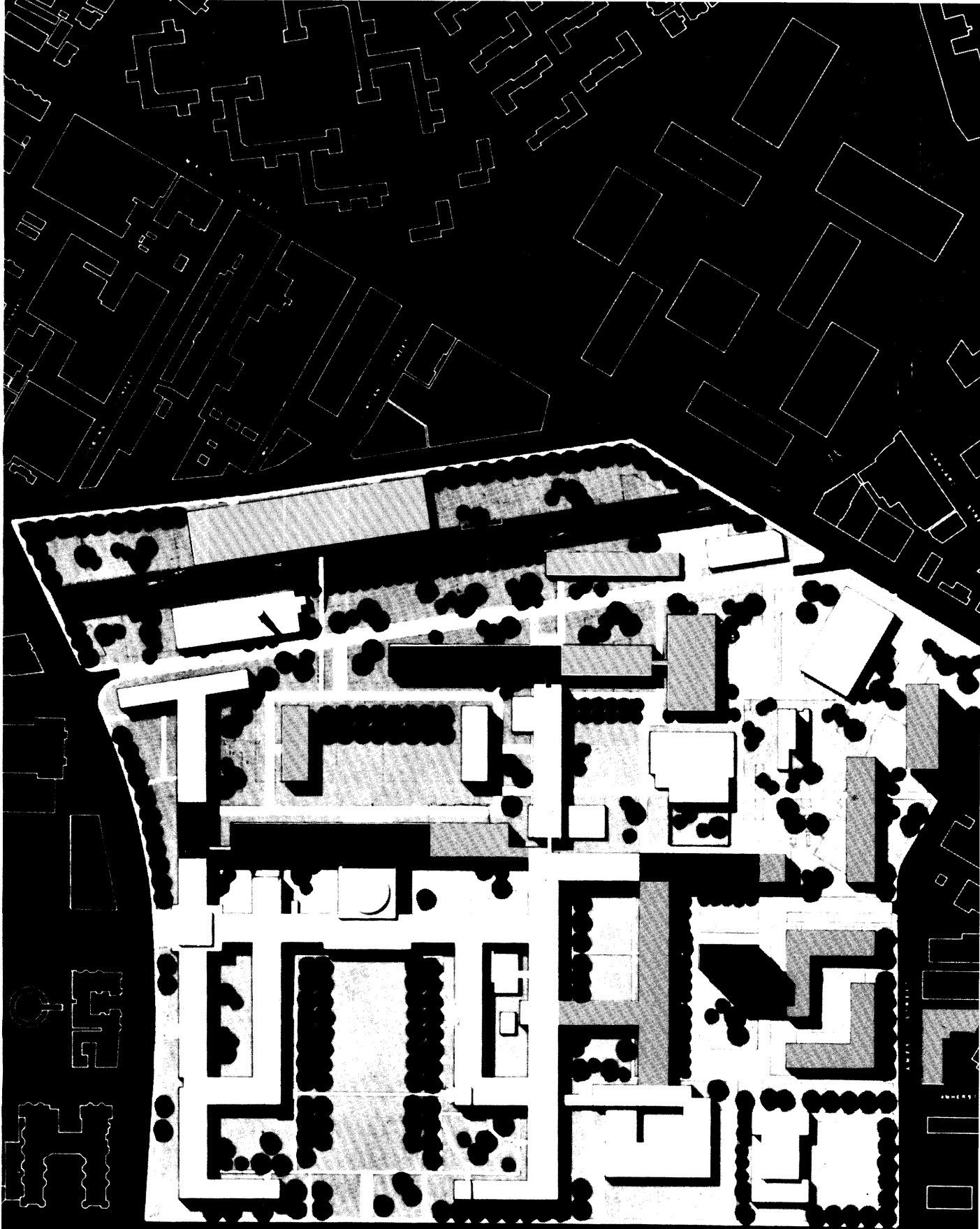
months have seen highly encouraging progress towards their achievement.

Revised plans for the Green Building to house the earth sciences have been approved and should be ready for bidding in November. This structure will rise to a height of twenty stories on the East Campus, and we have every hope that it will be ready for occupancy in 1963.

The first provision for the greatly augmented program in the life sciences was made this year with the replacement of the greenhouse on the roof of the Dorrance Building by permanent laboratories to be devoted to cellular and molecular biology. We are also well along in our plans for the design of a new building to extend eastward beyond Dorrance, between the swimming pool and the Green Building. These plans contemplate a structure of eight floors, effectively doubling the space presently available to the Departments of Biology and of Nutrition, Food Science and Technology.

In June, the Advanced Research Projects Agency announced a \$3,275,000 contract to further research in materials at M.I.T. This will be incorporated into the larger program of the Center for Materials Science and Engineering outlined in earlier reports. There is perhaps no other new field that affects directly the interests of so many departments; and all have cooperated magnificently in planning new curricula and new teaching laboratories in this rapidly developing area. With the hope that the next few months will see funds in hand for construction, work has begun on the architectural design of the Center itself. Current planning calls for a building of approximately 150,000 square feet gross, located just north of the central dome. This location, as well as other sites proposed for the new centers, is shown in the plan on the opposite page.

With the development of the centers, the coming few years will see the most active period of construction on our campus since the completion of the main buildings in 1916. The magnitude of the undertaking, the importance of wise site location, and the desire to preserve unity and architectural harmony with earlier structures have presented us with



The New Centers



Future Expansion



Existing Buildings

- A Aeronautics and Astronautics
- B Materials Science and Engineering
- C Communications Sciences
- D Life Sciences
- E Earth Sciences

a planning problem of major dimensions — a problem not to be resolved in isolated pieces but to be viewed as a whole. In our current plans, the North Campus will receive particular attention since it is destined to be the future location of the Centers for Materials Science and Engineering, for Communication Sciences, and for Aeronautics and Astronautics. A number of temporary structures, relics of the last war, will soon disappear from this area. The locations indicated in the plan are only tentative, and the total plan has yet to be approved. Nonetheless, there is beginning to emerge a concept of buildings and courts to the north in keeping with the original ideas of Welles Bosworth, the architect of the 1916 plan. We are convinced that this new development will add beauty and dignity to the entire campus.

To these brief notes on the progress of the centers, I should add a few words on two other new facilities of primary importance for the support of research at the Institute.

In July 1960, the Office of Scientific Research of the Air Force contracted with M.I.T. to establish the National Magnet Laboratory. The Institute has undertaken to design and construct a high-field magnet and to carry on a program of research in solid state physics and related areas involving intense magnetic fields. The cost of the facility alone will amount to an estimated \$6 million. Some 8,000 kilowatts will be required to produce continuous magnetic fields of approximately 250,000 gauss. There is no comparable laboratory anywhere. Excellent progress has been made on the design, and it is anticipated that construction will begin this fall.

The second facility is the Cambridge Electron Accelerator, a 6 billion electron volt synchrotron for research in high-energy particle physics. Design of the accelerator, which is a joint undertaking of Harvard and M.I.T., was begun in 1956 under the sponsorship of the Atomic Energy Commission. Construction is now nearing completion, and trial operations are planned for December, 1961. One of



the major facilities of its kind in the country, it will have an important influence upon the development of high-energy physics at M.I.T. As in the case of the Magnet Laboratory, the Cambridge Accelerator will also be accessible for research to the larger scientific community.

Neither the growth nor the importance of the interdisciplinary centers should obscure the fact that research continues to develop within every department of the Institute. For some time the level of total research activity has been steadily mounting. I shall make no attempt to record here the advances made on many fronts over the past year; these will be found in the separate reports of the deans and the department heads and, most comprehensively, in the published literature. But I do wish to comment on certain long-range implications of this expanding commitment to research.

To appreciate the actual significance of this growth, one must understand that there are two categories of research programs at M.I.T. The first category is purely academic and completely interwoven with the educational objectives of the departments and interdepartmental centers. The second category, including principally the Lincoln Laboratory, the Instrumentation Laboratory, and the Operations Evaluation Group, is primarily our response to our clear obligation as a leading institution of science and engineering to contribute to the national defense.

As a matter of convenience, in fact, the Lincoln and Instrumentation Laboratories are frequently referred to as the "Defense Laboratories." This term is unfortunate to the extent that it obscures the basic contributions that both Laboratories are making to the advancement of pure science, to fundamental engineering, and to education. Some of the finest work in the country in solid state physics and in the communication sciences will be found in the reports of the Lincoln Laboratory, and Professor Charles S. Draper, its Director, has an abiding concern for the teaching functions of the Instrumentation Laboratory. There is a healthy interflow of both staff and information

between the laboratories and the academic departments, and these cordial and beneficial relations are growing.

Yet the fact remains that the primary missions of the Lincoln and Instrumentation Laboratories are directed towards certain basic and critical problems in the national interest. For an educational institution, moreover, these are huge efforts entailing large technical and administrative responsibilities. For example, during the fiscal year 1961 the level of operations in this research category, including indirect charges, reached \$57 million. Only an overriding sense of national duty can justify our assumption of obligations of such an order. And the lumping of these sums with other figures on academic expenditures leads to distorted impressions of sponsored research at M.I.T. and of the dependence of the Institute upon federal funds.

With these comments as background, I want to confine my attention in this report to the departmental and inter-departmental research I have placed in the first category. We might call this simply "academic" were it not, as I have noted, that there is work in the Lincoln and Instrumentation Laboratories that equally merits this term. Nevertheless, we are speaking here of the kind of research activity that takes place in every university. It is located on the campus, in the laboratories of the Institute. The multitude of projects express the interests and choices of faculty and students. There are no limitations on the right to publish. The departmental and central administrations assist in the procurement of funds, but the responsibility for direction rests entirely with individual professors.

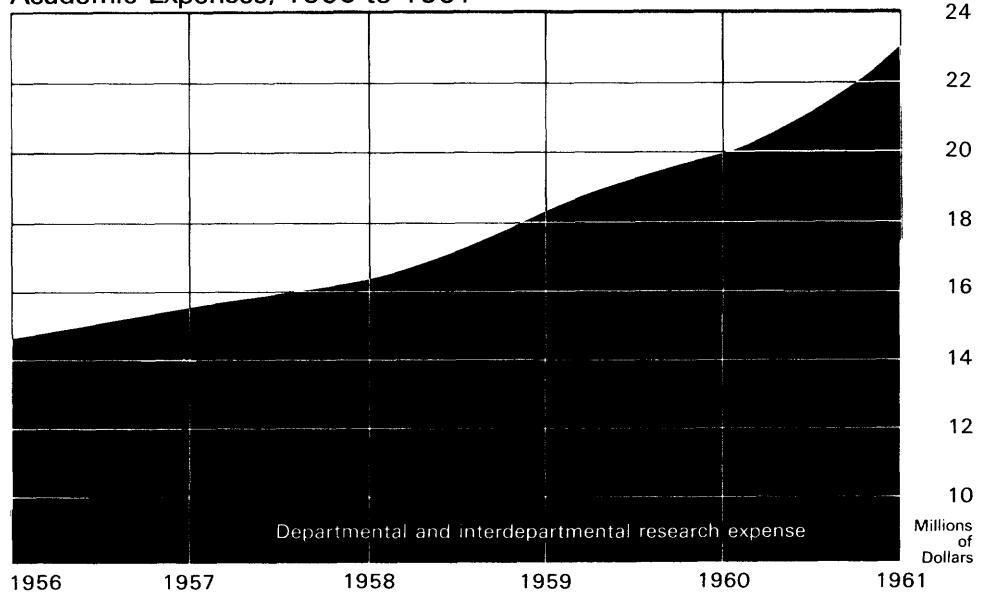
All this research is fundamental and basic in character and of a kind wholly appropriate to an academic institution. In the case of the departments of science, this fact is taken for granted. But I wish to add most emphatically that our work in engineering, in its own way, is equally fundamental. Obviously and properly, research in these fields is in large measure directed towards an understanding of basic, difficult engineering problems. Frequently it is possible to make progress only by simulating in the laboratory actual engi-

neering conditions. But there is no place for development in the technical sense, much less for product design.

It is the rising volume of these activities that we must examine with care and with concern for their influence upon the ultimate character of the Institute. The two curves below show total expenditures for departmental and interdepartmental research since 1956 and the corresponding increase in educational expense. Each curve has been adjusted to reflect its appropriate share of general and administrative expense and of the costs of plant operations.

The four curves plotted on the opposite page, indicating the number of people in various categories engaged in research, give a deeper insight than dollar volume into the nature of changes taking place. There has been a notable increase in the participation of faculty and instructors and relatively little change in the numbers of personnel who are appointees of the Division of Sponsored Research. Over the past five years educational expense has increased 56 per cent, while the costs of departmental and interdepartmental research have grown approximately 80 per cent. Within this same period the total number of those associated with sponsored research, exclusive of students,

Academic Expenses, 1956 to 1961



in the academic departments and centers increased only about 18 per cent.

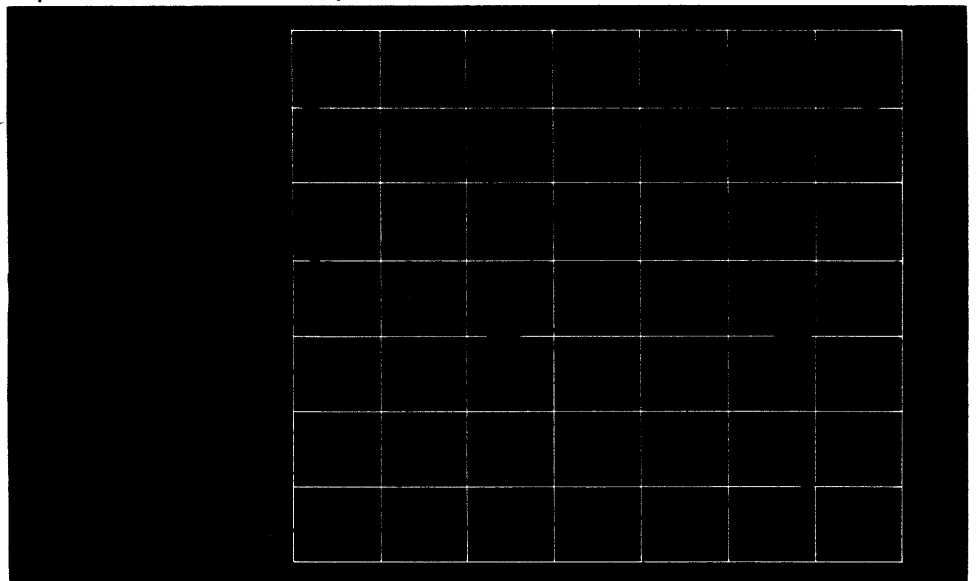
From these figures we can draw certain tentative conclusions.

First, although the net growth in personnel is quite moderate, there has been a significant shift from full-time D.S.R. staff to faculty, instructors, and research associates. This has been accompanied, as we shall see later, by a corresponding increase in graduate student participation, through research assistantships and numerous fellowships.

Second, while the dollar volume growth is related in part to the increase in academic staff, it is preponderantly due to increases in salary and wage levels; the rising costs of apparatus; and the constant need to replace equipment because of the rapidity of technical advance.

Third, the level of expenditure for academic research seems in reasonable balance with the total academic budget. Thus, if we consider true academic expense to be represented roughly by the sum of the two components of educational and research expenditures in the chart on the opposite page, we find that research accounted for about 43 per cent of the total. These figures might be altered slightly by other premises as to what constitutes educational expense,

Departmental and Interdepartmental Research Personnel, 1954 to 1961



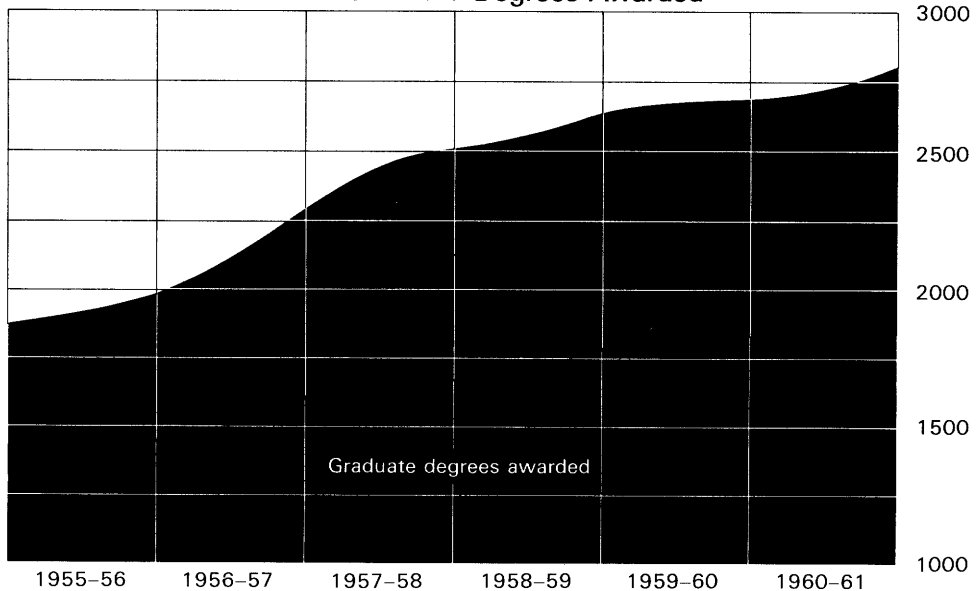
but I believe that they reveal accurately the proportional role of research in our combined academic activities.

Changes in graduate enrollment in any university afford another measure — indirect but significant — of expanding research interests. The accompanying chart illustrates the increase in recent years of both graduate student enrollment and graduate degrees awarded at M.I.T. The rapid rise in total enrollment at the beginning of this period led to a tightening of admission policy. A systematic growth of the Graduate School was planned, but at a slower rate in keeping with the development of our resources. The effect of these decisions is apparent from the leveling off of the curve.

The critical gauge of our “productivity” as a teaching institution, however, appears in the total number of graduate degrees actually awarded. The flattening of this curve over the past two or three years is more pronounced than that for enrollment. In other words, the rate at which students enter our graduate school is greater than that at which they depart with degrees, despite the more rigorous requirements for admission.

Several factors account for this effect. Some graduate students, of course, abandon the effort before attaining

Graduate Enrollment and Graduate Degrees Awarded



degrees. The enrollment figures are also affected by the inclusion of special students taking only part-time work. About 19 per cent of the total graduate enrollment fell into this category during the past year.

But there is at least some evidence that the attrition or "fall-out" may be a less important factor than the "stretch-out." The time consumed in preparation for advanced degrees appears to be lengthening. The Physics Department, for example, reports that the average time taken for the doctorate in that field has lately extended to 4.5 years. This means that many students, as Professor William W. Buechner points out, are spending five or six years in the Graduate School.

No doubt a principal reason for this extension lies in the expanding range and complexity of graduate studies. Probably an even more important reason is the increasingly active participation of students in research as an essential part of graduate experience. All this is understandable, but nonetheless it can also become costly — costly to the student, costly to the institution, and costly in terms of making M.I.T.'s educational opportunities available to others. Granting that education should be a continuing process throughout life, the formal ties of a student to graduate school ought hardly to become a career.

For the past fifteen years the federal government has been steadily increasing the national investment in pure and applied science through the medium of our universities. Grants from private foundations and from industrial corporations have added substantially to the accumulating capital of scientific knowledge. This policy of investment is supported by convictions that the advance of science is indispensable for the sustained progress of an industrialized society as well as for the safeguard of its freedoms.

The concept of a national policy for science has been expressed with particular clarity in a statement entitled "Scientific Progress, the Universities, and the Federal Government," issued last November in Washington by the President's Science Advisory Committee. It is to the credit

of this statement that it warns firmly against an excessive emphasis upon the material returns alone of scientific investigation. "Science yields a return in the quality and humanity of our civilization. Science is not merely an inducement to progress, it is an affirmation of man's respect for nature and a way to the fulfillment of some of his highest capacities. Science is enriching, but at its best it is much more: it is enlarging to the spirit."

For whatever reason — for economic progress, for military security, for more subtle intellectual motives, or for all these reasons together — the encouragement of graduate study in science and engineering and the promotion of basic research have become national goals. The desire to fulfill them is stimulating a flow of public and private funds into the universities.

Since the end of the Second World War the availability of financial support for research has increased by many orders of magnitude. My own academic generation is prone to forget the mere trickle of research monies in the days before the War, and few of the younger members of our faculties have as yet experienced real austerity. There can be no question that this postwar enlargement of our means for research has altered — and in my judgment permanently and inevitably altered — the academic character of most institutions of higher learning.

The impact of federal funds for research and the strong emphasis upon the physical and biological sciences have been subjects of much thoughtful study and discussion. Panels under the auspices of some of the learned societies and foundations, including a committee of the National Science Board, have made investigations and have issued reports. The past year has produced a bumper crop of statements by college presidents, foundation officers, columnists, and others. A recent issue of the *Wall Street Journal* discussed "campus research" at some length, with particular reference to M.I.T. Most of these statements have tended to "view with alarm" the current trends. Some comments have been thoughtful and constructive; but many appear to

have been based on narrow preconceptions and an astounding mass of misinformation.

No one will gainsay the fact that the new status of science presents the modern university with an array of exceedingly complex problems. Of these, the enlarged role of research is only one.

For private institutions there is a legitimate concern for the ultimate influence of large sums of federal money on their freedom of action.

There is a very real concern in many quarters that the more opulent support of science is being offset by starvation of the arts and humanities.

The contemporary pressures on individual faculty members have become at times almost intolerable. In these days it is difficult for a scholar even to keep abreast of the surging advances that are reported from every frontier of his professional field. Involvement in research is almost the only way to maintain true competence and understanding. There are, moreover, countless other demands and opportunities competing for the attention of the distinguished professor: advisory committees to the government; industrial consulting; technical conferences and international meetings in New York, Tel Aviv, Moscow, or Tokyo — each instance justifiable or inescapable, but in sum exacting a toll in time and energy.

Finally, therefore, and most seriously, there is the concern of the undergraduate who enters a distinguished institution to experience the influence of gifted minds, only to find himself in a seemingly unequal contest for attention.

All these, indeed, are critical matters. There are no simple answers. Most certainly it is a delusion to imagine an eventual return to some original state of academic virtue and bliss. There are, however, positive, constructive actions to be taken.

First, as to federal funding. Given the nature of modern science, it is inconceivable that private institutions will be able to support an acceptable level of basic research from private sources alone. Our national aim, consequently,

should be directed towards the development of patterns of grants and contracts for federal and corporate support that assure adequate freedom of action on the part of the university. This by no means entails a disregard for the proper interest of the sponsor or reasonable procedures for accounting. The University Grants Committee in Britain provides a rather successful example of what can be done, even though such a plan could not be adapted directly to American usage. There is every reason to believe that more effective safeguards can be developed. Federal agencies are thoroughly alert to the problem. Within the past five years there have been substantial improvements in granting procedures, particularly by the National Institutes of Health and the National Science Foundation. If university faculties and administrations will work sincerely and thoughtfully with the granting agencies, I am confident that we may anticipate further progress.

The fact remains, of course, that if a private institution is to preserve its independence, it must derive its support from a diversity of sources and maintain among these sources a proper balance. In my judgment such a balance does now exist at M.I.T., and reserves are being accumulated systematically to provide a reasonable measure of continuity in periods of fluctuating support.

Next, with regard to the question of balance between the arts and the sciences, one must ask whether the cause of the arts would be advanced by imposing limits on the progress of science. I think it highly questionable to argue that money now expended for physics, biology, and mathematics would otherwise fall like manna upon collegiate departments of history, philosophy, and literature. On the contrary, the example of the sciences ought to set new measures and standards of public and private support in every field of learning. Some of the most articulate protagonists for the liberal arts will be found among scientists. The Science Advisory Committee report, from which I quoted earlier, repudiates most emphatically "any notion that scientific research and scientific education are the only

kinds of learning that matter to America.”

Of all impeachments of the contemporary academic world, the one most difficult to dismiss is the charge that a multitude of extraneous influences is diverting attention from the basic function of teaching. Although this criticism on many occasions has been misdirected and grossly exaggerated, there is sufficient evidence of a need for reappraisal of academic responsibilities. This is a matter that affects every major university in the country. It is not a question that can be left to administrators and trustees to worry about; it is a problem that university faculties themselves must take in hand.

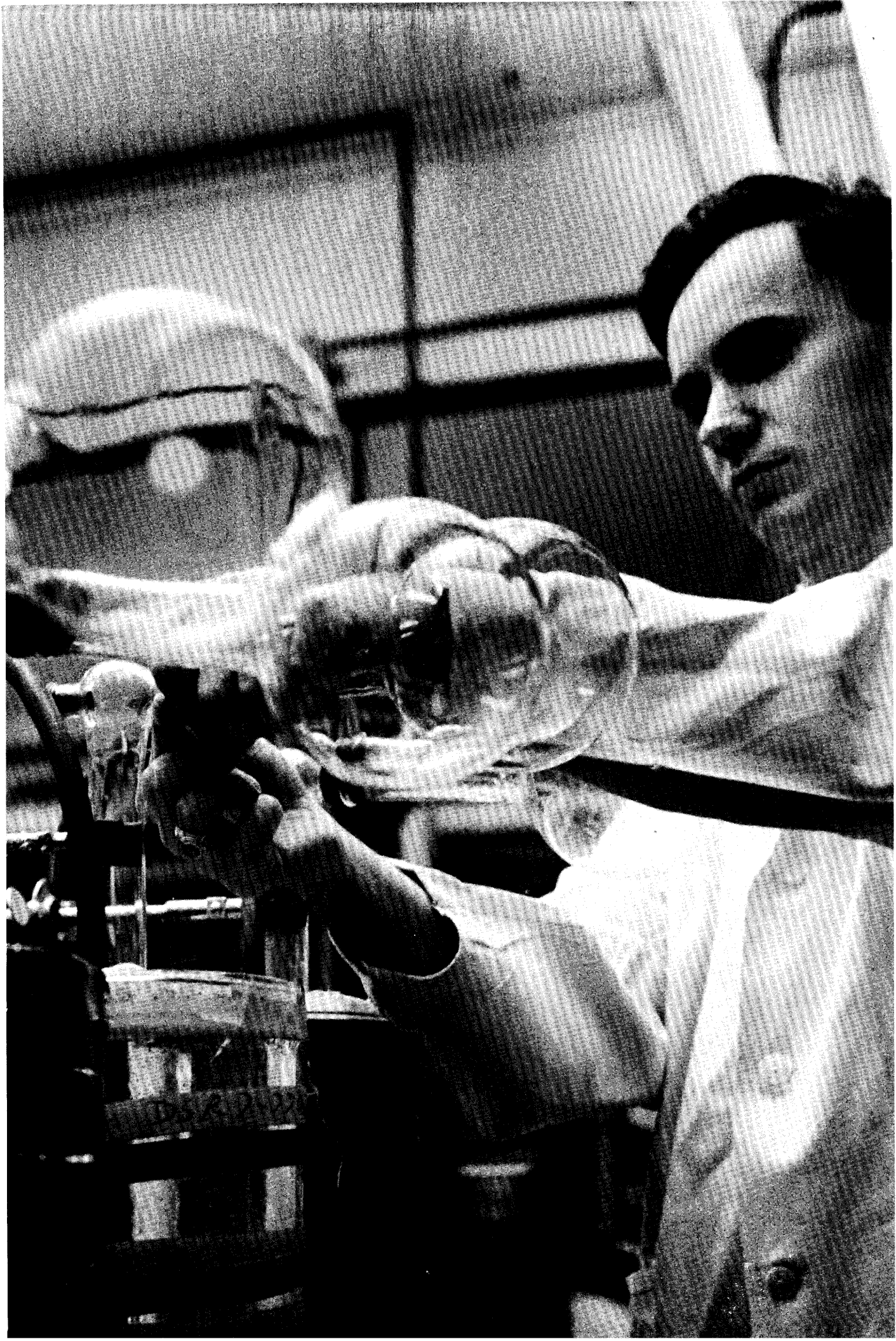
No one contests the indispensable role of research in the modern university. The point has been clearly made — as in the Seaborg report — that basic research and graduate education go best together. New knowledge may well be the substance of progress, but it is our students who are destined to carry on the search. Consequently I find it a disturbing symptom of a growing disorder in academic values when universities bid against one another for faculty with the lure of a relative freedom from teaching responsibilities.

Again I believe that there are positive measures that one may take to counteract the trends of the day, or to turn them to the advantage of teaching. In this respect I find the position of M.I.T. exceedingly strong.

First, there is an unremitting effort to increase the participation of undergraduates as well as graduate students in the research programs of the Institute. This past year there were 67 undergraduates working with 115 graduate students in the Laboratory for Nuclear Science; 50 senior theses were completed in the Research Laboratory of Electronics; nearly 50 students carried on projects and theses in the nuclear reactor facility; and some 300 individual students made use of our 709 computer in connection with class work. These reports from a few of the larger centers are indicative of conditions that prevail in every part of the Institute. For the student with interest and initiative, there

are almost limitless opportunities for individual investigation and informal association with members of the faculty.

Our second objective has been a major program to stimulate improvements in undergraduate laboratories and in the methods and materials of teaching. Although this is the kind of activity that lacks the dramatic public appeal of a new discovery, the sum total of these efforts at M.I.T. over the past year has been truly impressive. They are in fact too manifold to describe in detail, but I shall draw upon the reports of the deans to convey some idea of what is going on.





Undergraduate Education A year ago I discussed plans for the advancement of engineering education under a grant of \$9,275,000 from the Ford Foundation. We have made substantial progress toward realizing some of the major goals of this program. Throughout the School of Engineering we have introduced wholly new courses and strengthened existing subjects to broaden and deepen the scientific base of our engineering education. Concurrently, we are devising new activities to give increased importance to those elements of design and synthesis which lie at the heart of the engineering point of view. The role of the laboratory, especially, is being revised and enhanced, and I think it important to discuss in some detail this significant development.

Every department in the School of Engineering is reviewing its laboratory subjects to eliminate the stereotyped kind of experiment. Experiments that are open-ended, with an authentic flavor of research, are replacing the pre-set and pre-programmed. These changes will stimulate students to rely more on their own knowledge and imagination rather than on the authority of the instruction sheet. Finally, wherever we can plan it, students are being associated with faculty research activities so that they may work as interns on a real engineering project or on engineering problems in the research centers.

There is enthusiasm in the faculty for the benefits to be derived from bringing young engineering students into actual contact with authentic engineering work. As a consequence, we have sought to coordinate the refurbishing of space for undergraduate teaching with the development of space for graduate and faculty research. Because of this interplay between undergraduate teaching and graduate teaching and research, and because of the interdepartmental character of many of the new subjects, a chain reaction of change has occurred. Illustrative of this reaction is the current conversion of the Heat Power Laboratory of the Department of Mechanical Engineering into an interdisciplinary Engineering Projects Laboratory for both teaching

and research. This undertaking, under the direction of Professors Robert W. Mann and Kenneth R. Wadleigh, involves the construction in Building 3 of approximately 5,000 square feet of new floor area as well as the rearrangement of 17,000 and the rehabilitation of 16,000 additional square feet.

The new Laboratory will bring together five “subcritical” departmental laboratories into a new interdisciplinary complex. It is intended that faculty and students from other departments will also participate as this new Laboratory evolves. Although the Laboratory is being developed especially to provide a richer experimental and design experience at the junior year, its facilities will support the work of about twenty faculty members, five instructors, fifty teaching and research assistants, twenty additional graduate research students, and two hundred undergraduates of whom fifty will be working on theses.

This kind of “mix,” we believe, will promote a close relation between teaching and research and between faculty and students. It should make authentic experiment a more integral part of the undergraduate’s experience. It will help us achieve, more easily and earlier, the involvement of undergraduates in parts of graduate research. There is virtue also in the variety of efforts that will be included in this Laboratory, and in the greater intimacy of sponsored and student research.

Actions such as these, to capitalize on the research environment of the Institute, are occurring in nearly every engineering department; they will strengthen the primary purpose of our laboratories as places to learn experimentally what cannot be learned wholly by theoretical analysis. They bring into sharper focus the engineering point of view and the interactions between theory and experiment. We are convinced that in many instances it is much more important and meaningful for students to carry out small research projects than to follow the fixed pattern of the conventional laboratory course. This is the kind of experience that gives

each student perspective on all his courses.

These exercises also place a premium on the creative and constructive talents of the students. Typically, the solution to a problem depends on the student's own initiative and independence of action. It is he who decides what to measure and how and what experimental apparatus to choose or construct. We give him some guidance, of course, but we urge that he learn as much as possible through his own experience. Often he can benefit more from what goes wrong than from what goes right.

The subject Engineering Projects I, developed this year by Professor Erik L. Mollö-Christensen in the Department of Aeronautics and Astronautics, is an interesting example of this concept. This new projects laboratory is open from nine to five every day, rather than for the traditional three-hour slot, and — by student request — on some holidays and weekends. Once a student project is set up it remains in place, and technicians, tools, and equipment are always at hand. These are not trivial considerations.

Engineering Projects I was given twice this year, once to juniors and once to seniors, with outstanding success. Some of the project reports would have been acceptable bachelor's theses; and the staff — some ten members of the faculty, one for every five students, participated as advisers — is enthusiastic about the value of the effort. Most importantly, the laboratory achieved in good measure its basic purpose of giving the students solid opportunities to acquire experimental techniques and to learn about experimentation as a method of inquiry.

NEW TEACHING TECHNIQUES In moving forward with these changes and innovations in the role of the laboratory, much traditional work of essentially a demonstration character has been redesigned as an adjunct of the lecture, or abandoned. Never before in our history have we been so concerned with teaching techniques and tactics. Throughout the School of Engineering, departments are experimenting with the use of motion pictures, television, and other modern teaching aids. Films, for example, often



can capture the essence of an experiment in a way that even the most effective lecture-demonstration cannot. They also provide a way for reproducing some of the most complicated and advanced experiments; and they may occasionally replace the job of repetitious lecturing so that teachers may have more time for real discussion.

Work on the development of motion picture films has progressed most rapidly in the area of fluid mechanics under Professor Ascher H. Shapiro of our Department of Mechanical Engineering. With his leadership a national committee of professors has been organized, and his M.I.T. film on "Vorticity" served as a pilot demonstration for a series on fluid mechanics now being prepared. It is expected that some twenty teaching films, together with supporting text material, will be produced over a three-year period at a cost approaching \$1 million. Support for the activity has been sought on behalf of the national committee by Educational Services, Incorporated, the nonprofit corporation that has worked so effectively for the Physical Sciences Study Committee's program to strengthen secondary school physics and related subjects.

In the Department of Metallurgy, Professor Morris Cohen is using closed-circuit television to bring laboratory techniques into the classroom. A television camera mounted on a microscope transmitting to two viewers makes it possible for the entire class to observe a single microscope picture as the teacher identifies the important information that it provides. This use of television has added a new dimension to the lecture; and by removing repetitive demonstration experiments from the laboratory, it saves these hours for more fruitful purposes. Since the television is under the control of the instructor, it is also more efficient and more effective than the laboratory demonstration.

"TAKE-HOME" LABORATORIES We are also seriously investigating ways of providing our students with opportunities for experimental homework. In fields where the equipment involved permits, laboratory homework might become as important as the traditional paper-and-

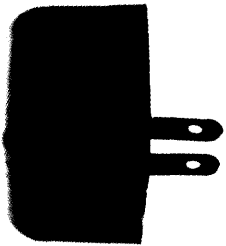
Closed - circuit television brings microscope image to a metallurgy class.

pencil assignment. This novel development can play an essential part in our modernization of the laboratory and in our attempt to strengthen the laboratory as a primary learning aid. Success in this new teaching technique will depend largely, we believe, on the invention of inexpensive apparatus and of simple experiments.

One notable example of this kind has occurred in the Department of Electrical Engineering where, under the leadership of Professor Richard D. Thornton, we conducted this spring a trial of electronic circuits kits for home use. The purpose of these kits is to provide a means for students to build in their rooms a number of simple electronic circuits of the type needed in electrical engineering laboratory subjects. Made possible by the use of transistors, these kits consist of such basic components as resistors, capacitors, and diodes, along with plug-type mounting boards. Toothpicks are used to wedge separate leads in the mounting terminals, permitting rapid assembly of circuits and complete salvage of all components. Boards and components are assembled in a kit that takes as little space as a textbook.

Since the student may now take his laboratory to the dormitory, he relieves greatly the strain on other laboratory facilities. Much more important is the fact that he will be able to tinker at will in electronic circuits, on his own time, for as long as he likes. This kind of freedom of pace and of approach should make the home laboratory as important a source of ideas as the textbook. It should develop in our students a better "feel" for laboratory work. While these new kits underwent a laboratory trial in the spring, the "take-home" feature will have its first large-scale test this fall. We also plan to make the kit available in sample quantities to other colleges.

Most of these developments and others in the technology of teaching could not have been undertaken without the support of the Ford Foundation grant. The modernization of laboratories, the creation of lecture demonstrations, the use of such new teaching tools as television and film — all these take time and money. If they seem to make our



A "take-home" electronics laboratory: components and plug board (opposite), power supply and connectors (above).



teaching more efficient, I must emphasize that the question of costs is complicated. It will be only after some years of experiment that we can know with any certainty what the economic gains may be. I must emphasize also that our principal objective is simply to make our teaching better. What we are seeking, particularly in the development of teaching aids, is the more effective utilization of our faculty. We hope that these new approaches and aids can relieve the teacher of much that is routine so that he may devote more time to discussion and counseling and to the other aspects of education that make the fullest use of his highest talents.

THE TUTORIAL APPROACH In this spirit we have been re-examining the traditional lecture-section method of course organization. Several departments have arrived independently at the conclusion that the typical section, which is uneconomically small for lectures, is also too large for significant two-way student-faculty communication. Accordingly, a number of engineering departments experimented this year with dividing some sections into small tutorial groups of four or five students each. The results of this approach have been dramatic, especially in values other than grades: in stimulating deeper thinking, in promoting meaningful student-faculty discussion, in generating student enthusiasm, in helping students become articulate and expressive, in developing in our students a sense of belonging.

The tutorial approach, promising as it is, also presents problems. It can be costly in faculty time and energy. If a department is to develop a tutorial system, it seems essential that machines and devices must also be developed to do the routine section work, particularly that of reviewing problems. To help solve this manpower problem, the Department of Electrical Engineering, which experimented successfully this year with small weekly conferences as a replacement for section meetings, is undertaking a study of the use of teaching machines. Such devices can increase the effectiveness of homework exercises and provide immediate feedback as to the nature of errors. An initial self-teaching program



of 500 to 1,000 questions is being developed, and it will be tried out on a pilot group in the near future.

While I have concentrated in these remarks on innovations in the School of Engineering, a similar spirit pervades the Institute. These advances are discussed in the separate reports of the Deans, and I shall not attempt even a cursory review here. There are, however, two developments in teaching which, because of their broad implications for the Institute as a whole, demand special mention. **SCIENCE TEACHING CENTER** In my report last year, I described the establishment of a Science Teaching Center under the direction of Professor Francis L. Friedman and outlined its principal objectives. Focusing initially on developing new methods and substance in the teaching of elementary college physics, the Center received this spring a grant from the National Science Foundation which will support an important part of its program. The Center has already made good progress in generating new laboratory experiments and devising new patterns of using experimental equipment.

An optics kit has been developed, for example, which is being manufactured commercially at relatively low cost. This kit, like the one in electronic circuits, has been designed for laboratory homework. We believe that it may enable students to learn by personal experience *outside* the scheduled laboratory much of geometrical and physical optics. These kits were issued to a number of M.I.T. undergraduates during the past year, and more extensive trials will be undertaken in the coming months.

Other kits covering other subjects are being developed to increase the range of experimental homework. Work has also started on a number of experiments to introduce beginning students to the realities of relativistic and quantum phenomena. In addition, a few experiments which entail great expense or advanced techniques are being prepared for films so that we may investigate the effectiveness of this approach to college physics teaching. The Center has also made a start on a new systematic selection

“At home” resonance experiment in kit form includes turntable motor, spring, weight, markers, damping fluid, stand, and pulleys.



of topics for an experimental syllabus designed to put more emphasis on the concepts of modern physics in the elementary course.

The problems with which the Science Teaching Center is concerned reflect national needs, and the work of the Center is attracting national interest. The optics kit was tried this spring at Amherst College and de Pauw University and, with the cooperation of the Commission of College Physics, will be tried at other colleges next year. With National Science Foundation support, Professor Anthony P. French, Head of the Department of Physics at the University of South Carolina, and Professor James Smith of the Department of Physics at the University of Illinois will participate in the work of the Center as Visiting Professors. Through the generosity of the Bell Telephone Laboratories, Inc., Alan Holden of their staff will also be with us in a similar capacity. And Professors Eric Rogers and Aaron Lemonick of Princeton University will serve as consultants during the coming year. Through this growing chain of collaborative relationships we have high hopes that the work of the Center will become an effort of national significance.

FRESHMAN SEMINARS A second development with important implications for our total educational plan has come with the adoption by the faculty of a new Undergraduate Seminar Program which will be offered to part of the 1961 freshman class. Under this program more than forty seminar subjects will be given, largely by senior members of the faculty, for freshmen who want an early taste of independent study of a tutorial nature. As defined by the Undergraduate Seminar Committee, under the chairmanship of Professor Edwin R. Gilliland, these seminars will be designed to provide "a close association between the students and a faculty member of a less formal nature than that existing in the regular classroom or laboratory subjects; and an opportunity for serious study with a high degree of individual responsibility and freedom in planning and executing a selected program."

In most cases, there will be four to eight students in a seminar. The program will cover a broad spectrum of topics and will rely variously on discussion, reading, research, individual and group laboratory projects, and other teaching forms. The following sampling of seminar titles merely suggests the potential of the whole:

INDUSTRIAL DYNAMICS Professor Jay W. Forrester
Students will participate in the "industrial dynamics" research program of the School of Industrial Management by developing models of processes that interest them and experimenting with the design and implications of the selected system.

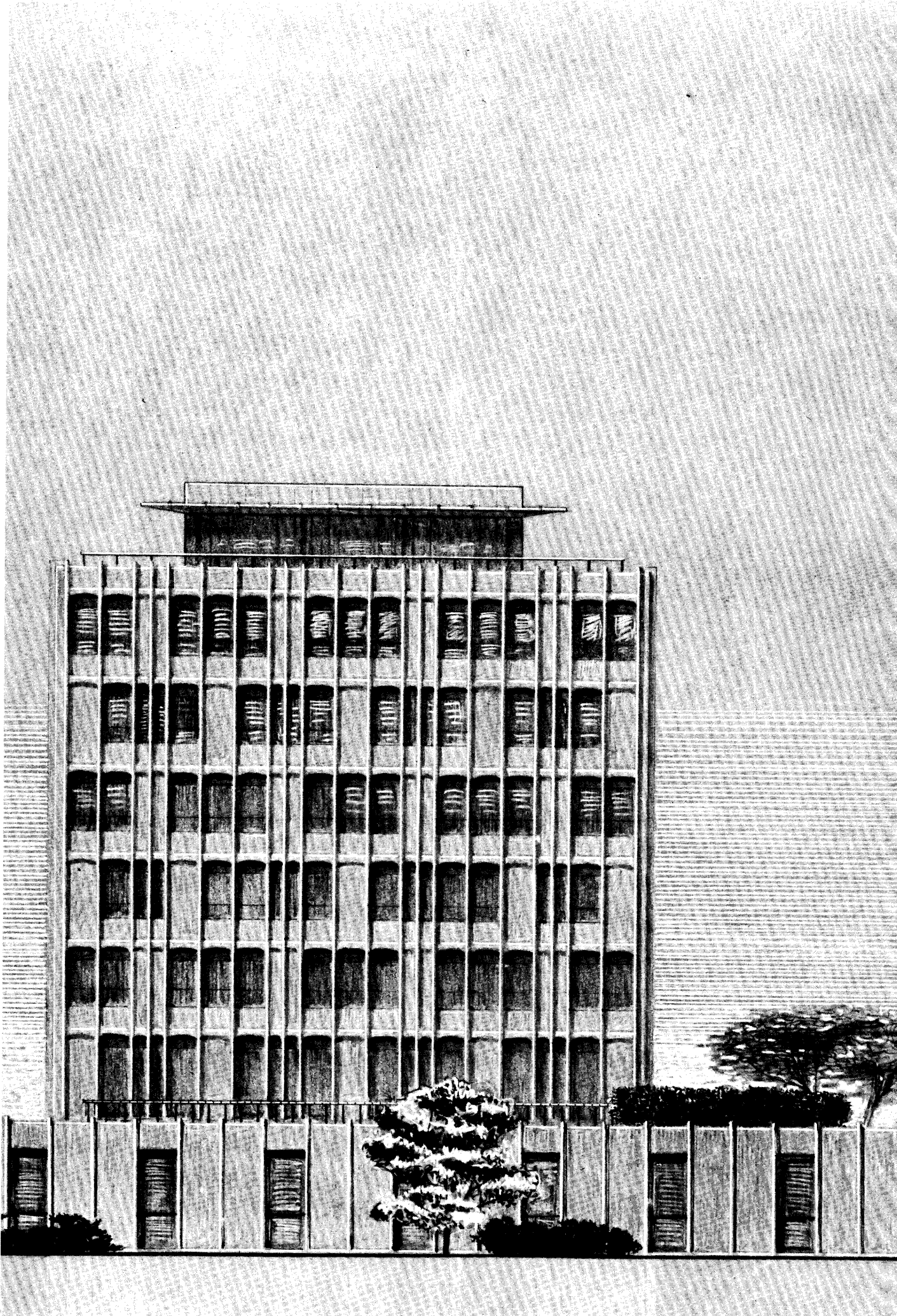
INORGANIC CHEMISTRY Professor Charles D. Coryell
Tutorial discussions, with problem work but without laboratory, will be held on structural inorganic chemistry. The main goals are to put modern physical inorganic chemistry in perspective with the rest of science and technology and to help the student acquire information and intellectual skills for a career in science.

NERVOUS SYSTEM Professor Patrick D. Wall
The discussions in this seminar will center on the behavior of man and animals and the nervous system. The group will have close contact with graduate students and postdoctoral fellows working in the field. They will have many opportunities to observe experimental work in progress. Reading assignments will be set and discussed.

SOCIAL SCIENCE Professor Elting E. Morison
The group will study the use of the scientific method of investigation in the effort to develop further understanding of some human situations. Readings will be taken from the fields of sociology, psychology, social psychology, and fiction.

ENGINEERING PROJECT Professor Charles S. Draper
Seminar students will discuss and collaborate with engineers engaged in laboratory work in the fields of measurement and control, and in guidance for flight vehicles. Each student will be allowed to give special attention to a project which he selects from a number of possibilities.

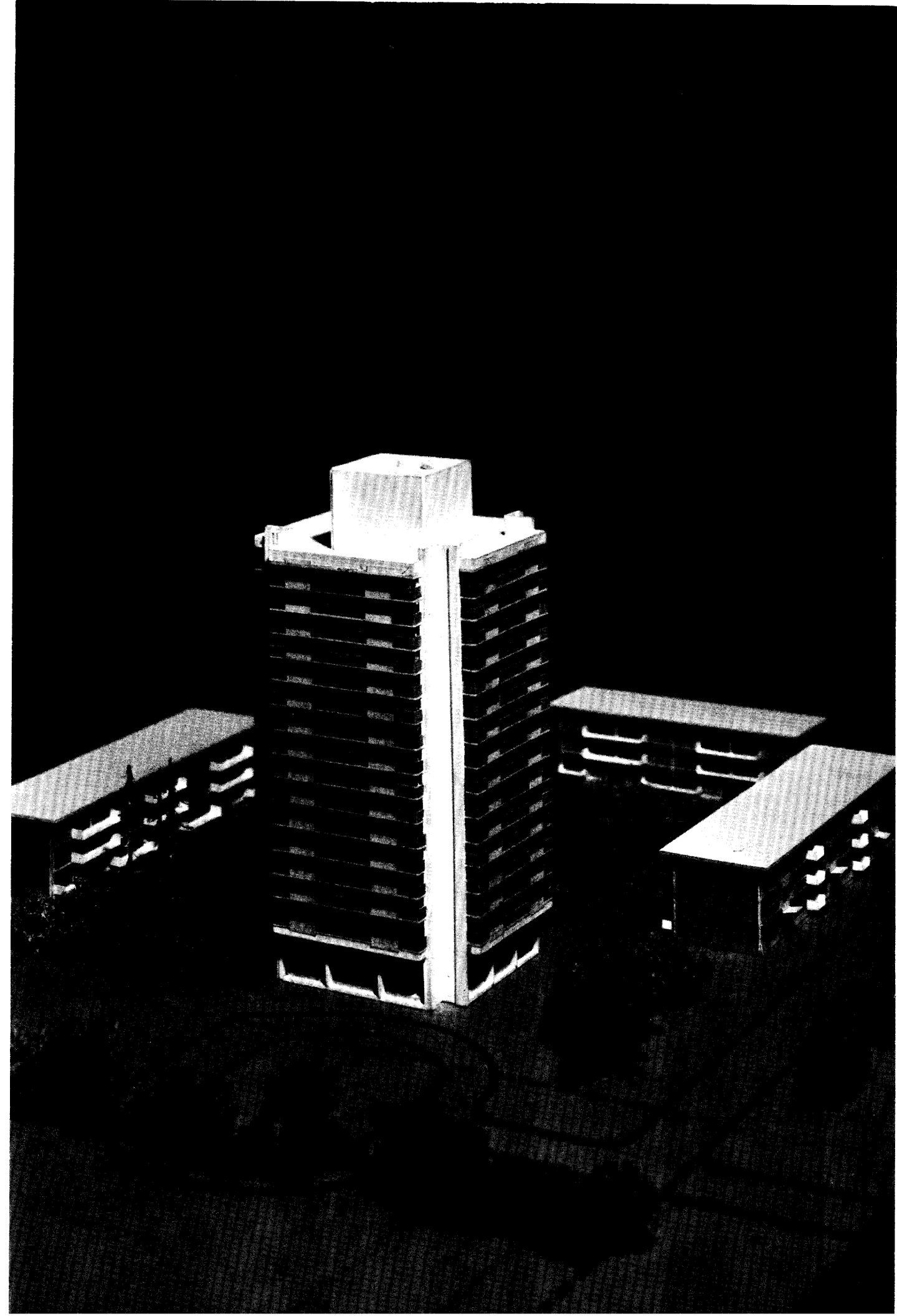
The new seminar program represents an important educational experiment for the Institute. There is general enthusiasm about its possibilities; and while the practical problems to be solved in administering it are not easy, neither are they insuperable. If the program is successful, it can have a significant influence on future educational developments on this campus.



The Second Century Fund My report of one year ago opened with the announcement of a \$66 million Second Century Fund for M.I.T. In September the program was launched formally at a planning conference in Cambridge attended by prominent alumni from every part of the country. Over 3,500 are now participating in this great campaign. The demands upon time, thought, and energy are tremendous, yet the response on every side has been magnificent. No undertaking has ever demonstrated more dramatically the loyalty of our alumni or the confidence of our friends.

As of this writing, well over \$40 million has been contributed or pledged to the goals of the Second Century Fund. I have every reason to hope that a year from now I shall be able to report the successful accomplishment of our objectives. It will be difficult then, and it is impossible now, to pay adequate tribute to all those who are providing leadership and support. In this brief statement of progress I wish only to express on behalf of my colleagues on the faculty and administration our most sincere gratitude to the many who are working so hard and so effectively for M.I.T.

Sketch for the new
Women's Dormitory.



Statistics of the Year The following paragraphs report briefly on various aspects of the Institute's activities and operations during the 1960-61 year.

REGISTRATION In 1960-61 student enrollment was 6,289 as compared with 6,270 in 1959-60. We estimate that enrollment this fall will be about 6,300. Married students this year accounted for 46 per cent of the graduate enrollment and 4 per cent of the undergraduate. One hundred and fifty-five women were enrolled, 77 of whom were graduate students.

Enrollment in the Graduate School was 2,797. There were 152 officers from the United States armed services enrolled for advanced degrees.

Students who entered M.I.T. last year held degrees from 316 other colleges and universities, 178 American and 138 foreign. The foreign student population was 702, representing some 11 per cent of the total student body. These students were citizens of 69 different countries.

DEGREES AWARDED The table below shows the number of degrees awarded by the Institute in various categories for the academic years 1959-60 and 1960-61.

	<u>1959-60</u>	<u>1960-61</u>
Bachelor's degrees	824	801
Master's degrees	698	703
Engineer degrees	83	93
Doctoral degrees	199	213
	<hr/> 1804	<hr/> 1810

PLACEMENT About 400 employers visited the Placement Bureau between October 15, 1960, and April 15, 1961; and some 1,500 students met employers' representatives in 8,410 interviews. Starting salaries continue to rise, and the average offer to this year's graduating seniors was \$550 per month. The average offer to master's candidates was \$650 per month and to doctoral men, \$850 per month.

TUITION AND STUDENT AID Increasing costs have necessitated an increase in the tuition fee from \$1,500 to \$1,700, effective with the opening of the 1962 Summer

A study model for housing units for married students to be built on the West Campus beginning early in 1962.

Session. Tuition has risen sharply in the last few years, but financial aid to M.I.T. students has increased at an even faster rate. According to a recent survey, undergraduates at only one other institution now receive more financial support per student enrolled.

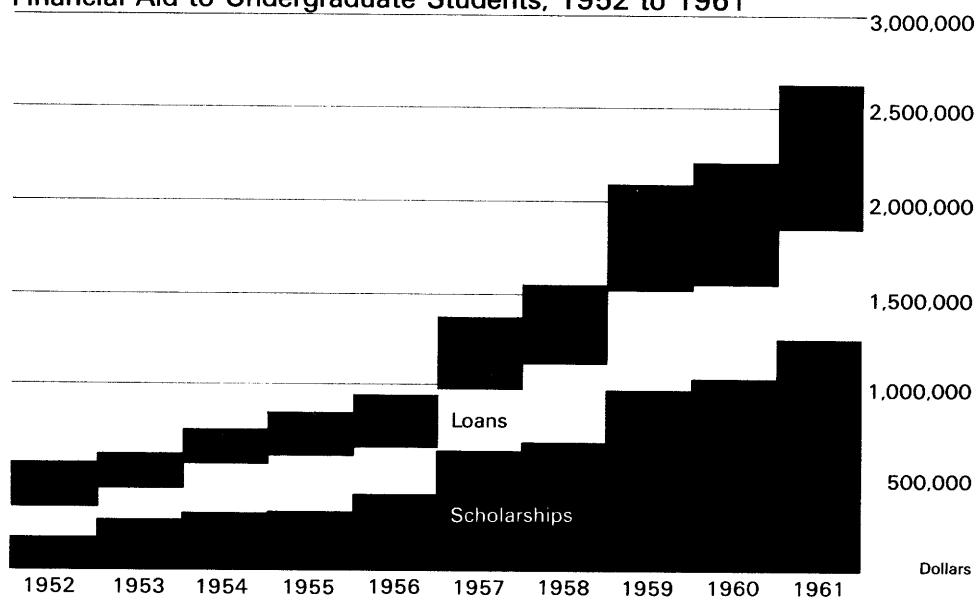
This year 1,493 undergraduates, or 43 per cent of those enrolled, received \$1,286,691 in scholarship aid and \$574,312 in loans. These two categories of direct aid totaled \$1,861,003 — an increase of nearly 20 per cent over the combined figures of a year ago. And for the second successive year gifts in excess of \$1 million have been added to the scholarship endowment which, at the close of the year, stood at \$8,500,000.

Undergraduate earnings, as reported by the Manager of Student Personnel, amounted to \$160,400 for services on the student staffs of the dining halls, dormitories, and libraries; in laboratories and other divisions of the Institute the amount reached \$644,600, bringing the total of undergraduate student earnings to \$805,000 for the college year.

In brief, through scholarships, loans, and campus employment, \$2,666,000 was made available to undergraduates during the past year.

Graduate students this year received \$356,020 in staff awards, \$165,535 in loans, \$73,650 in scholarships, and

Financial Aid to Undergraduate Students, 1952 to 1961



\$686,821 in fellowships, for a total of \$1,282,026. The corresponding figures for last year were \$261,088, \$170,943, \$145,520, and \$502,598, respectively, for a total of \$1,080,149.

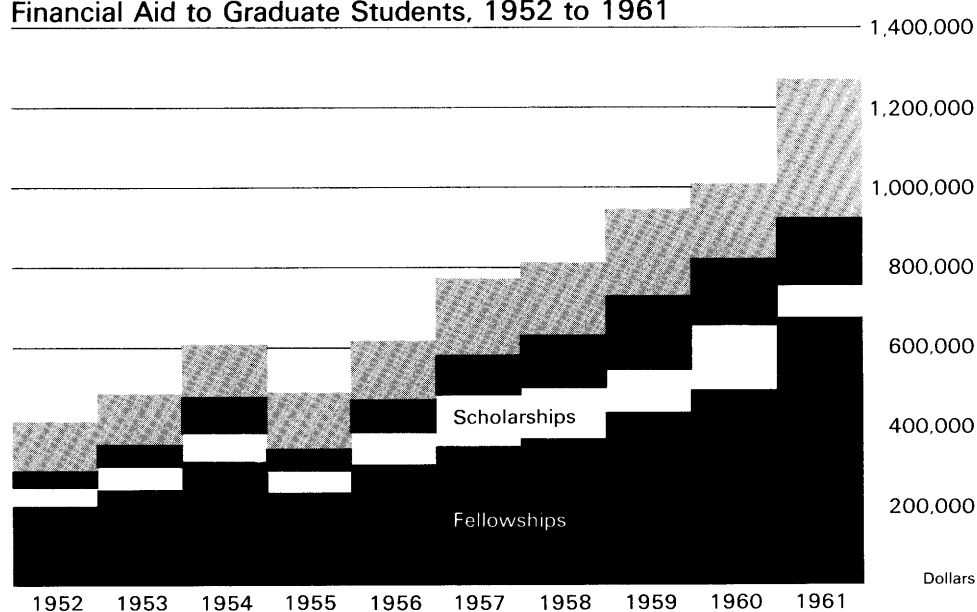
In addition, 118 students received \$47,900 under the Installment Credit Plan. This compares to 54 students who received credit of \$14,400 under this plan last year, the first in which it was in effect.

The bar graphs on these pages show the history of recent increases in financial aid to undergraduate and graduate students at the Institute.

FINANCES During the year 1960-61 the Institute's academic expenses — excluding the expenses of departmental and interdepartmental research and of the Lincoln Laboratory, Instrumentation Laboratory, and Operations Evaluation Group — amounted to \$29,889,000. This compares to academic expenses of \$25,468,000 in the preceding year. The increase resulted primarily from salary and wage adjustments for faculty and other employees of the Institute and related increases for general expenses, including the increased cost of an improved benefits program for the entire staff.

Part of the increase in academic expenses was met by a greater use of gifts and other receipts and by increased tuition income of \$1,168,000 resulting from the higher

Financial Aid to Graduate Students, 1952 to 1961



tuition rate of \$1,500 in effect during 1960-61. The year was also the third in which the five-year Faculty Salary Adjustment Fund was used for teaching salaries.

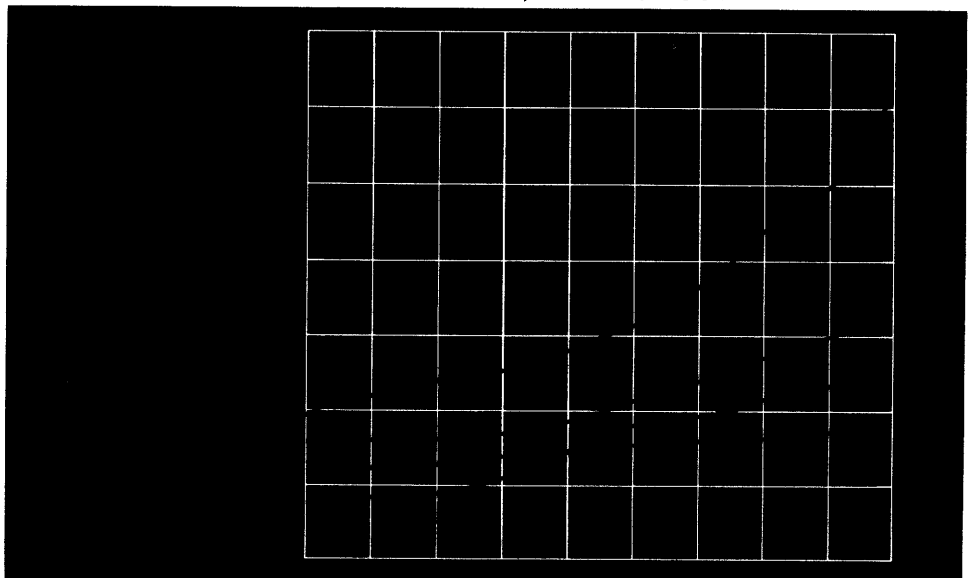
Departmental and interdepartmental research expenditures increased from \$17,355,000 to \$20,314,000; and the operations of Lincoln Laboratory, Instrumentation Laboratory, and the Operations Evaluation Group increased from \$48,787,000 to \$56,996,000.

The Institute's investments at the end of the fiscal year had a book value of \$121,706,000 and a market value of \$191,252,000. During the year the educational plant assets increased from \$44,814,000 to \$49,269,000.

The rate of income earned last year on the funds sharing in the general investments was 6.29 per cent on the average book value, compared to 6.36 per cent in 1959-60. The total income on the general and special investments was \$5,957,000, compared to \$5,346,000 in the previous year.

GIFTS Gifts in 1960-61 amounted to \$14,584,000. As reported separately by the Treasurer, this total includes gifts for the improvement of engineering education, for the earth sciences program, for basic research, for student aid, and for the women's dormitory building, as well as undesignated

The Growth of M.I.T.'s Funds and Plant, 1943 to 1961



contributions received during the year for the Second Century Fund. It also includes \$495,000 given directly to the Alumni Fund, but it does not include Second Century Fund pledges payable over a period of years.

Among the notable pledges received during the year, two are for the establishment of funded professorships. The first is the gift of \$500,000 from Dr. Arthur W. and Dr. Ruth C. Sloan mentioned earlier in this report; the second is the gift of \$500,000 from Mr. and Mrs. John J. Wilson of Brookline, Massachusetts, for an endowed chair in the life sciences.

Members of the M.I.T. Corporation and their foundations have now pledged over \$12,000,000 to the campaign.

The response from major corporations to the special appeal of the Second Century Fund has resulted in unprecedented levels of giving from private industry. Outstanding corporate pledges made during the year include grants from Campbell Soup Company, The Gillette Company, The Martin Company, Monsanto Chemical Company, Union Carbide Corporation, U. S. Steel Corporation, American Telephone and Telegraph Company, Minneapolis-Honeywell Corporation, Bethlehem Steel Corporation, and Raytheon Company. There has been one grant of \$1,500,000, another at \$1,000,000, and several at \$500,000 each. The response from smaller companies also is demonstrating in a most substantial way their confidence in M.I.T.

J. A. STRATTON