ORA 69-192-S1

Proposal to

Graduate Facilities Branch
Bureau of Higher Education
U.S. Office of Education

A COMPUTING CENTER BUILDING

Submitted by

The University of Michigan
Ann Arbor

January 31, 1969

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Submitted to the Graduate Facilities Branch
Bureau of Higher Education, U.S. Office of Education
400 Maryland Avenue, S.W.
Washington, D.C. 20202

1.1 Title of Proposal: A Computing Center Building

1.2 Project Identification: All academic and research units of The University of Michigan will be eligible to use the proposed facility.

1.3 Name and Address of Institution: The University of Michigan
Ann Arbor, Michigan 48104
Washtenaw County
Congressional District: 2nd

1.4 Location of Project: Same.

1.5 Cost and Grant Request Data:
1.51 Total Development Cost of Proposed Facility: $1,535,000
1.52 Total Amount Requested from Office of Education under Title II Graduate Facilities Program: $ 455,383

1.6 Other Federal Agencies (or Other Office of Education Programs) from Which Assistance Has Been or Will Be Sought in Financing this Project: None.

1.7 Assurances:
1.71 Assurances to Bind with Proposal: Attached.
1.72 Civil Rights Act of 1964 Title VI Assurance of Compliance has been filed (No. 32-0560, dated January 7, 1965).
1.73 The undersigned agrees to comply with all assurances and reporting requirements of the Office of Education and also with all applicable laws and regulations of the U. S. Government. (See Appendix I.)

1.8 Institutional Representative:
Name: Bruce W. Arden
Title: Associate Director, Computing Center, & Associate Professor of Communications Sciences
Telephone: 313-764-4143

1.9 President or Legally Authorized Officer

Signature: H. W. Hildebrandt
H. W. Hildebrandt
Title: Secretary
Telephone: 764-7203
Date:

SECTION II. DESCRIPTION OF APPLICANT INSTITUTION

2.1 CURRENT STATUS OF APPLICANT

The University of Michigan, established in 1817, is governed by the Regents of the University. Since 1850, the Regents have been elected directly by the people of the State of Michigan, thus allowing a measure of independence in the determination of the University's policies that has been of inestimable benefit.

The chief administrative officer of the University is the President. The Vice-President for State Relations and Planning, the Vice-President and Chief Financial Officer, the Vice-President for Academic Affairs, the Vice-President for Research, the Vice-President for University Relations, the Vice-President for Student Services, and the Secretary of the University are the University's other executive officers.

The University is now comprised of eighteen schools and colleges, as well as many institutes, centers, museums, and bureaus. Certain units have a University-wide service function: most obviously, the University Library, which includes a Graduate Library to be housed in a building now under construction with the support of funds granted by the Office of Education under Title II of P. L. 88-204 in 1965 (Grant No. 2-0027). The Computing Center, for which a new facility is the subject of this proposal, is a comparable unit in this respect.

The various academic units of the University are accredited by their respective organizations. Faculty members of the University are prominent in these organizations. The University's Horace H. Rackham School of Graduate Studies is a member of the Association of Graduate Schools, which

has only 45 members. An indication of the quality and teaching effectiveness of the University's graduate programs is given in a 1966 publication of the American Council on Education, Allan N. Cartter's *An Assessment of Quality in Graduate Education*, which cites The University of Michigan among the top ten graduate institutions in the country, and second of the state universities.

Of the more than thirty teaching departments of the University which availed themselves of the services of the Computing Center within the last fiscal year, eight have been selected to represent the Center's users: the Departments of Civil, Electrical, Industrial, and Mechanical Engineering of the College of Engineering; the Departments of Computer and Communications Sciences, Physics, and Political Science of the College of Literature, Science, and the Arts; and the School of Business Administration. The following pages therefore do not purport to assess the total quantitative or qualitative significance of the Computing Center's services to the University's graduate academic and research programs, but rather to suggest the Center's vital importance by indicating its role only in relation to users chosen both for their diversity and their reliance on the facility. A similar procedure was followed in the 1965 application for support of the Graduate Library.

Section 14.12 of the Regents' Bylaws describes the function and organization of the Computing Center as follows:

> The Center shall provide computing service for teaching and research units of the University and maintain computing facilities to be available to faculty and students for instructional and research purposes. The Center shall be in charge of a Director, responsible to the Vice-President for Research, appointed by the Board upon recommendation by the President.

He shall be assisted by an Executive Committee consisting of the Vice-President for Research or his representative and six members of the University Senate, appointed by the Board upon recommendation by the President. The appointed members shall hold office for terms of three years, two members being appointed each year.

2.2 FUTURE PLANS

School of Business Administration--The education of business students ideally should enable these students to think clearly about a business problem, organize their approach to a situation in a methodical manner, and make decisions based on such information as can be found. Also, the business school graduate should have an understanding of general business economics and should be familiar with the opportunities and responsibilities of management. The computer has already changed business in many respects. And there is every reason to believe that it will continue to be a powerful tool of management. As a result, it is becoming increasingly clear that experience with the computer is an essential element in the preparation for management.

The Graduate School of Business Administration at The University of Michigan currently offers a substantial number of courses and opportunities for training in the use of the computer and its relationship to real business problems. This is substantiated, in part at least, by the present level of computer usage by the graduate students of the school. In spite of this present level of usage, it is the opinion of the faculty that the computer and its attendant technology are not being employed as fully as might be desirable as a tool for comprehensive business education. Computer-based business games have been and are in operation at a number of institutions,

but in general, these games seek only to use the computer as a *means* of teaching business. It is the premise of the Michigan business faculty that the business graduate of the 1970's should be taught both about business and about the computer in an integrated fashion.

The time-shared computer provides a great opportunity to teach computer sophistication and business ideas simultaneously. Probably the best way of becoming faciliar with the way a computer can work is the experience of interaction at a terminal. The apparently personal attention the computer gives each user enables the user to develop ideas quickly and receive reactions to them at once. To convert this computer versatility into a teaching tool for business education, however, it must be possible for the students to interact with the computer in a *business* environment. The student must be permitted to advance his understanding of business by communicating with system programs on such fundamentals as budgeting, production planning, cost analysis, and investment decisions, to name a few. The future plans of the Graduate School of Business Administration include steps that will bring about a more integrated use of the computer in teaching both about business and about the computer. The success of these steps depends to a great extent on greater and more frequent access to the University computer system as well as expanded computer facilities.

Department of Civil Engineering--Something over 20% of the graduate curriculum of the Department of Civil Engineering relies on the use of the Computing Center. About 75% of the dissertations of the Department's doctoral candidates involve the use of the facility. The areas of systems analysis and operations research are now gradually being incorporated into

the educational program. The effective use of these techniques will demand an increasingly heavy use of the University's computing facilities in the future.

The Department hopes to add new or replacement members to its staff in (a) construction engineering (assistant or associate professor), (b) transportation (assistant or associate professor), and (c) hydrology-coastal engineering (also at the junior faculty level).

Department of Computer and Communication Sciences--The Department plans to add faculty members in the subjects of automata theory, natural language (speech science), software development, and the simulation of natural systems, and perhaps in information retrieval, and computer-assisted instruction. The rate and rank at which these are added will depend on budgetary considerations. It is likely that any people added in software development would have joint appointments with the Computing Center.

The above list of subjects also indicates the new courses the Department would like to teach on a regular basis, and the research areas likely to be taken up.

The field of communication sciences is concerned with understanding on a theoretical basis the communication and processing of information by both natural and artificial systems. Two general areas of study are particularly important to the communication sciences: (1) the technical study of natural and artificial languages as modes of communication, and (2) the investigation of information processing both in natural languages and in various types of artificial languages, including codes used in communication

systems, instructional and design languages for digital computers, and the formal languages of mathematical logic. In the investigation of information processing systems, attention is directed toward fixed and growing automata, adaptive systems, nerve nets, programming systems, automatic speech recognition systems, and adaptive behavioral systems.

Department of Electrical Engineering--The rapid advances in electrical engineering technology characteristic of the two decades following World War II are continuing, particularly in the computer and solid-state fields. As a result, the research program of the Department is continually experiencing significant changes. Relatively new areas, such as integrated circuits and devices, modern optics, digital computers, communication systems, power systems, quantum electronics, and computer-aided design, are growing rapidly. Many graduate students have been trained in these important fields and are currently active in industry and academic circles. The Department expects to award about 25 Ph. D. degrees annually over the next few years, and an increase is also expected in the number of M. S. E. degrees to be awarded (see Section 7.6).

The Department's future plans for its curriculum will depend, in large measure, not only on developments within the field but also on the experience it will have with certain recently instituted innovations. An example of such innovations at the graduate level is a joint program with the Department of Aerospace Engineering in Computer, Information, and Control Engineering. This program, which began during the current term, will focus attention on the "systems activities" at the University.

The Department has plans to add possibly two faculty members (one full professor and one assistant professor) in the digital computer area within the next three years, particularly in the area of logical design and graphical displays.

Department of Industrial Engineering--The Department offers programs leading to a Bachelor's degree, an M. S., an M. S. in Engineering, and a Ph. D. In each of these programs, courses covering the following four areas are available:

1. Human Performance
2. Management, Administration, Organization Theory
3. Operations Research and Management Science
4. Computers and Information Processing Systems

All four of these areas currently utilize the computer to varying extents, and it is anticipated that the computer will become a more and more integral part of both the courses and research in industrial engineering.

Industrial engineering is a growing area. In the past three years the number of undergraduates has increased from 205 to 242, the number of Master's students from 51 to 63, and the number of Ph. D. students from 34 to 43. This growth is expected to continue.

The plans for the Department will require doubling the number of faculty within the next three to five years. It is expected that most of the new faculty will be entering at the Assistant Professor level.

The Department plans to expand its offering of graduate courses to cover adequately the range of academic subjects assigned to it. Proliferation of courses is, of course, undesirable and the Department strives for

adequate enrollment in courses since courses with small enrollments are an inefficient use of faculty time.

The Department currently finds that support for research can be obtained in larger amounts than can be undertaken by present faculty and space. Since it is likely that this state of affairs will continue into the foreseeable future, research areas and sources of support can be chosen in a way that contributes to the objectives of the Department in terms of education, research results, and service to the professor and the community. The criteria for selecting research areas are:

1. The research must be in problem areas that are important to the nation and of sufficient interest to at least one faculty member who is willing to assume responsibility as principal investigator.
2. The research must be suitable for participation by graduate students (and, if possible, undergraduates as well).
3. The research should have some potential impact on the curriculum in terms of new courses, new methodologies or new course material for existing courses.

The plans for graduate education are designed to continually improve the performance of the department both academically and financially. Academically the quality of the program will be improved by emphasis on potential and performance in recruiting of faculty and students. Graduate programs will be expanded to satisfy anticipated future needs, e.g., five year programs, professional programs etc. There will be a continual attempt to improve financial performance by increasing the number of degrees awarded without sacrificing quality of the program or of the student and without increasing the burden on the faculty.

Department of Mechanical Engineering--The Department presently has strong teaching and research programs in the areas of the thermal fluid sciences, design, materials and manufacturing. New laboratories have recently been established in the area of computer-aided design and work will soon be expanded both in that laboratory and in the areas dealing with automatic control, materials, manufacturing and numerical programming and bioengineering with specific emphasis on biomechanics. A great deal of the present work is computer-based and it is anticipated that the use of the computer as a computational device as well as an analytic and evaluation tool will increase significantly in the near future.

The Department is presently considering the acquisition of new faculty in the area of biomechanics and materials, manufacturing, automatic control. Funds for these new faculty will come largely from State appropriations and research projects.

Department of Physics--The Department's plans for the future include participation in the new National Accelerator Laboratory at Weston, Illinois; a tutorial approach to advanced graduate courses; a pre-seminar for incoming graduate students to hasten their understanding of research-level seminar material; research in the scattering of metastable atoms, an upper-atmosphere phenomenon; and the use of computers in teaching.

Department of Political Science--The Department has expanded greatly in recent years, and most of the new additions are trained in and committed to the use of quantitative techniques that require a heavy use of computers.

Industrial engineering has in the past played a vital role in the improvement and efficienty of productive processes. These same techniques are now being applied in other areas in non-profit and governmental institutions. For example, the Hospital Systems Improvement Project employs 6 industrial engineers working with 20 hospitals in the Michigan area, utilizing industrial engineering and operations research techniques. Cooperative efforts with industry are being expanded. Graduates of the Industrial Engineering programs are in great demand by organizations in Michigan and elsewhere.

The political science programs that will contribute most to the state are those in urban studies and simulation of the urban environment, which will be primarily carried out by those members of our faculty who have appointments in the Institute of Public Policy Studies (formerly Institute of Public Administration). Given the current interest in urban problems, the importance of these programs is obvious.

Graduates of the Department of Computer and Communication Sciences go into teaching and research. The Department has trained about thirty persons at the M. S. level, most of whom now work in the computer industry, who have not gone on to the doctorate.

Although the Graduate School of Business Administration is, in a sense, a national institution, it serves and draws on the resources of the State of Michigan in particular and the Great Lakes States in general. Its service to the area is exemplified by: (1) Research into various aspects of the Michigan and Great Lakes States economy, performed by the School's Bureau of Business Research together with various members of the faculty; (2) The

development and presentation of various short courses and seminars aimed at helping the State's and the region's business community; and (3) the training of students, many of whom are drawn from Michigan and the surrounding Great Lakes states, in business at both the masters and the Ph. D. level.

The School draws on the resources of the region by maintaining close relationships with the business and industrial community of Michigan and its neighboring states. In this way, the state of the "art of business" at the School is kept current and the students are provided with the latest business methods and concepts as well as the developing concepts of the future.

The continuous production of well-educated graduates in mechanical engineering has had and will continue to have an important influence on the general economic plan in the State of Michigan and the Midwest, as they do in all portions of the country. Perhaps of special significance to the large manufacturing area of Southeastern Michigan and along the Chicago-Pittsburgh axis will be the Department of Mechanical Engineering's work in computer-aided design and manufacturing technology with special emphasis on automatic programming of production which can result from a marriage of the work in automatic control, materials, computer programming and manufacturing processes.

The next two or three years likewise will involve additional data processing needs; expansion is envisaged of programs in the simulation of the urban environment, survey work in urban areas, the comparative electoral behavior project already underway, and, even more importantly, an increasing use of computers by our graduate students. Thus the expansion of the use of data processing facilities will be largely independent of the growth in faculty and students.

Within the next two years, one new man must be added in political theory, one in international relations, and one in American national politics. In cooperation with the Institute of Public Policy Studies, at least three appointments will be made in the general areas of organizational theory and behavior, urban politics, and, possibly, simulation of the urban environment.

2.3 ECONOMIC RELATIONSHIPS

The proposed facility will improve both the graduate instructional and the research programs of the Computing Center's users, which in turn will benefit the eventual employers of the graduates, the sponsors of the research, and society as a whole. For instance, expanded or improved programs in water resources engineering, water pollution abatement, and transportation engineering have particular significance in relation to economic problems confronting Michigan and the other Great Lakes states, but are also pressing in other regions. The Department of Civil Engineering expects the graduate programs (which involve heavy use of computing facilities) to expand markedly in these areas during the next ten years.

SECTION III. CONSTRUCTION TIME AND FUNDING SCHEDULE

3.1 *Estimated Construction Time Schedule*

		Month	Year
3.11	Bidding Documents to be Completed	July	1969
3.12	Date of Advertising for Bids	August	1969
3.13	Contract to be Awarded	October	1969
3.14	Work to be Completed	April	1971

3.2 *Financial Plans*

3.21 Source of Funds for the Proposed Facility:

The Regents of the University, at their June 21, 1968, meeting, approved allocation of University funds, coupled with this request for Federal participation for construction of the Computing Center Building at a total project cost of $1,535,000. No other Federal funds are being requested.

3.22 Dependency of Construction Plans and Schedule upon Receipt of Federal Support:

Lack of Federal support is likely to necessitate a serious reduction of the scope of the project, since no other outside support is being requested.

3.3 *Availability of Site*

3.31 Ownership of Site: See Appendix I.

SECTION IV. PROPOSED FACILITIES BUDGET

4.00			New Construction
.10	Purchase of Lands		$ -0-
.11	Purchase of Buildings		-0-
.12	Preliminary Site Clearance		-0-
.13	Surveys and Testing		-0-
.14	Architectural Fees		65,500
.15	Resident Inspection of Construction		17,300
.16	Construction		1,195,000
.17	Built-In Equipment		-0-
.18	Site Improvements	$60,000	
	Utility Connections	$64,000	
			124,000
.19	Construction Contingency		92,300
.20	Essential Legal and Administrative Expenses		-0-
.21	Capitalized Interest		-0-
.22	Movable Initial Equipment		40,000
.23	Works of Art		-0-
.24	Prorated Cost of Central Utility Facility		-0-
.25	Total Development Cost Including Capitalized Interest		1,535,000
.26	Total Development Cost Excluding Capitalized Interest		-0-
.27	Total Eligible Development Cost		1,535,000

SECTION V. AREAS, COSTS, AND GRANT REQUEST CALCULATION

5.1	Item	New Construction
a.	Total Gross Sq. Ft. in Facility	29,720
b.	Total Net Sq. Ft. in Facility	19,648
c.	Efficiency Ratio	66.11%
d.	Total Eligible Development Cost	$1,535,000
e.	Development Cost Per Gross Sq. Ft.	$51.65
f.	Development Cost Per Net Sq. Ft.	$78.13
g.	OE Graduate Net (Title II) Sq. Ft.	17,487
h.	Percent OE Title II Participation	89%
i.	OE Graduate Gross (Title II) Sq. Ft.	26,451
j.	Total Eligible Development Cost for Title II	$1,366,150
k.	Amount Requested	$ 455,383

It will be apparent that a facility like a Computing Center has an integrated space utilization that does not permit strictly physical analysis. However, records of expenditures are kept so as to identify activities by course level, research involving graduate student participation, etc. The use is based on allocations of expenses for computer services. The use rate is uniform for all such services. Total expenditures for computation during the winter term of 1968 (the most recent for which figures are available) were as follows:

Activity	Amount	Percent
Academic staff projects	$ 61,265.13	10.308
Graduate courses and theses	133,817.68	22.516
Undergraduate courses and health-related courses and theses	65,910.20	11.090
Sponsored research	333,334.56	56.086
Total	$594,327.57	100.00%

Using these figures to establish a criterion of eligible space, it has been determined that 89% of the total expenditures for this period were for activities representing eligible Title II space. This figure has been used in the above calculation.

SECTION VI. PRESENT AND REQUESTED FACILITIES

6.1 PRESENT FACILITIES

6.11 *Description of Present Facilities*--The Computing Center of The University of Michigan was established nine years ago, in July, 1959, in part of the ground floor of the North University building, formerly a plant maintenance and storage facility. About 6,400 gross square feet were allocated to house the IBM 704 computer and, for a time, the type 650 computer, as well as for public work space and staff offices.

A project conducted by the College of Engineering, supported by the Ford Foundation, and the establishment of the Center itself almost at once led to a demand for more public space. Two additional rooms were renovated in 1959 and added to the Center's space, bringing the total gross square footage to 7,200.

In June, 1962, when the model 709 was about to be replaced by the 7090 computer, additional space, including part of an inside loading area, was enclosed to bring the total to about 8,400 sq. ft.

In this growth sequence, the space allocated to the main computer remained at about 2,000 sq. ft., although the number of components per square foot increased to well above the recommended maxima for good operations. The advent of the model 67 computer forced an expansion into contiguous space. The computer area was enlarged in November, 1966 (by removing a central hall and incorporating a counseling room, a keypunch room, and public work space), to about 4,000 sq. ft. This space now accomodates the presently installed duplex model 67 and its associated communications equipment, but no major enlargement of the area is possible any longer.

To compensate for the lost office and public work space, an attached garage was renovated at the same time and some offices and a basement in an adjacent wing were made available. The basement area, previously used for the storage of geological core samples, was converted to faculty and programmer offices even though it was far from ideal. With these additions, the total square footage occupied by the Center (including toilets, halls, walls, air conditioning, etc.) increased to about 17,000.

The Center employed 19 persons when it was first established; it now has a staff of 76, not including supporting IBM personnel (their number has risen from 2 to 10 in the same period). When the first machine became operational, there were about 400 active computer users; there now are more than 4,000 requests for authorization to use the machine per semester. In brief, the work has increased by a factor of 10, the staff by a factor of 3, and the computer space requirement has doubled. The present building, never designed as a facility for a computing center, never well suited to accommodate the power, air-conditioning, communications, and security requirements of a computer installation has been successively modified on an *ad hoc* basis until further expansion is impossible.

Of the "overall existing teaching and research facilities" of The University of Michigan, it may be said, in general, that they exhibit a strength and diversity reflecting 150 years of enlightened public and private support of an institution dedicated, almost from its beginnings, to the indivisibility of education, research, and service. Some indication of this character may be apparent from Table I, which lists the numbers of the teaching faculty, by rank,

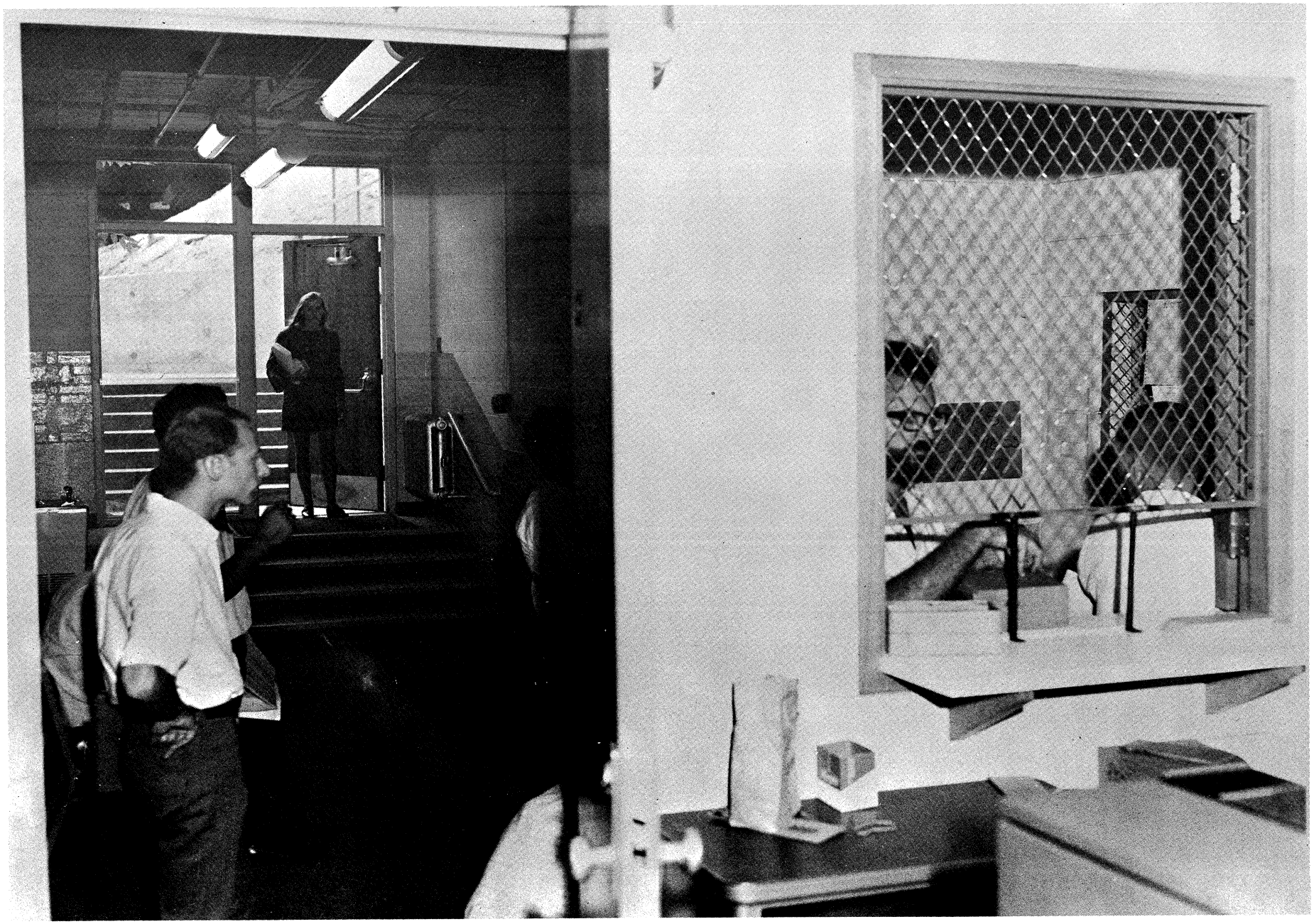


Fig. 1

Main entrance as seen through machine room door
with dispatch window at right.

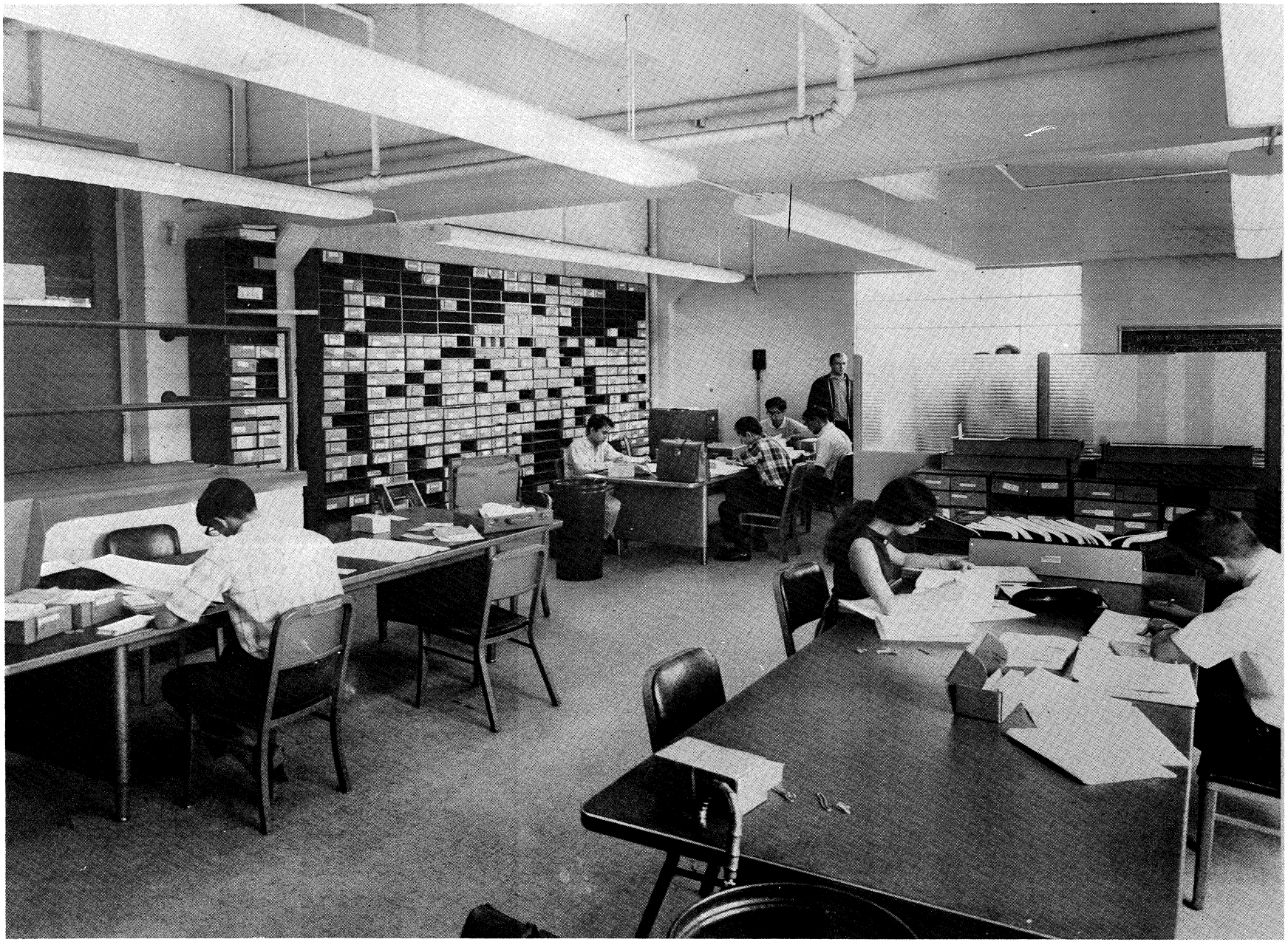


Fig. 2

Public work space with partitioned counselling area at right.

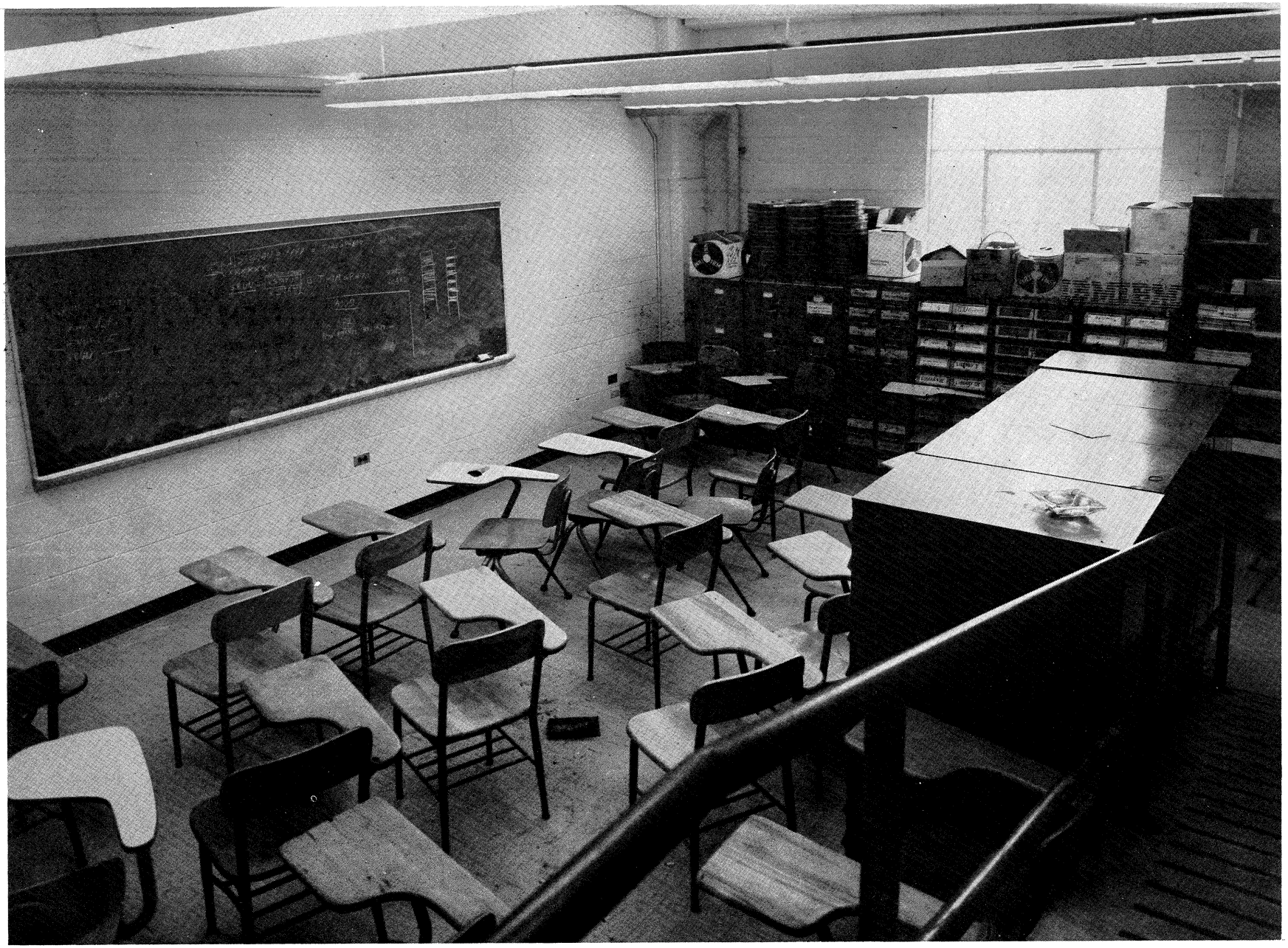


Fig. 3

Seminar room and storage.

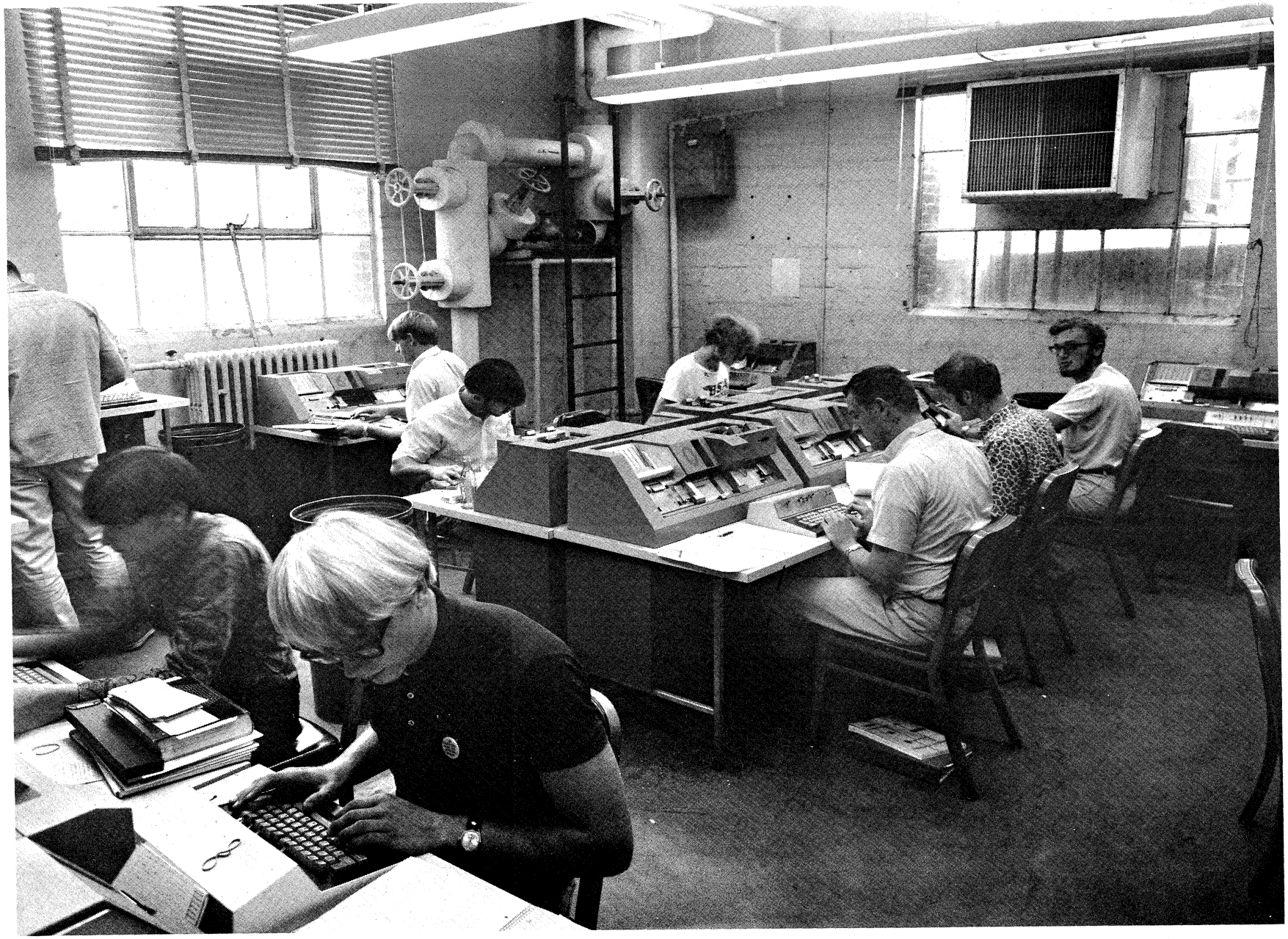


Fig. 4

The keypunch room.

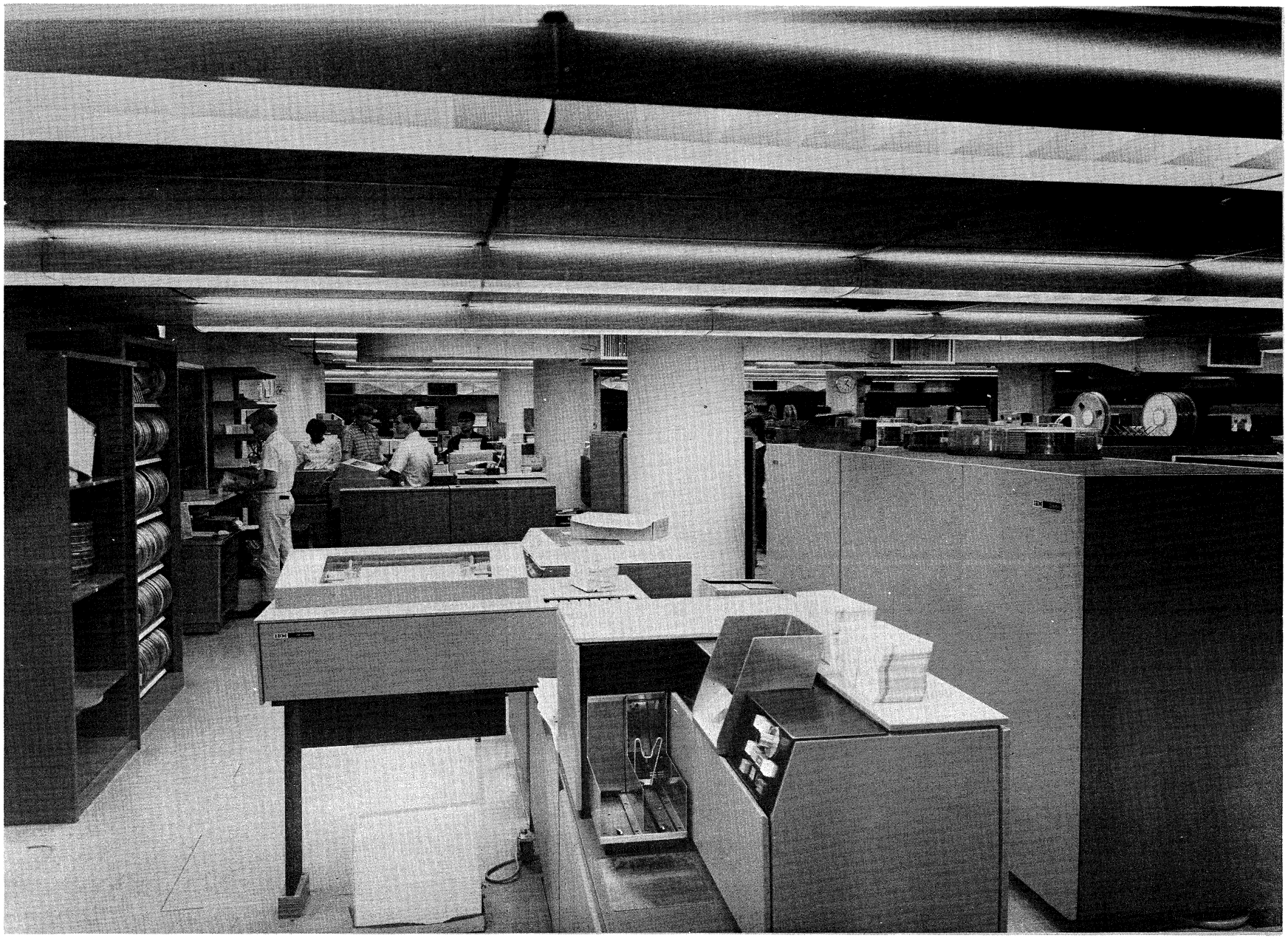


Fig. 5

Machine room on dispatch window side.

TABLE I.

DISTRIBUTION OF TEACHING FACULTY BY RANK AND UNIT*

1967-68

Unit	Prof.	Assoc. Prof.	Asst. Prof.	Other**	Total
College of Architecture and Design	41	12	17	12	82
School of Business Administration	39	11	10	6	66
Dearborn Campus	8	30	19	28	85
School of Dentistry	38	17	23	37	115
School of Education	47	27	23	71	168
College of Engineering	136	80	61	30	307
Flint College	11	12	13	30	66
Law School	40	9	3	7	59
College of Literature, Science, and the Arts	436	188	244	142	1,010
Medical School	143	126	141	140	550
School of Music	60	12	9	45	126
School of Natural Resources	20	11	7	8	46
School of Nursing	9	15	16	44	84
College of Pharmacy	4	5	4	3	16
School of Public Health	37	43	27	34	141
School of Social Work	18	14	20	7	59
Physical Education	4	13	16	30	63
TOTAL	1,091	625	653	674	3,043

*Figures represent positions, not individuals, i.e., those holding joint appointments are counted in each of their units.

**Not including teaching fellows.

of the University's constituent schools and colleges, themselves an indication of the University's complexity. (The Horace H. Rackham School of Graduate Studies has no separate faculty of its own but serves as the unit through which the Ph.D. and numerous other graduate programs are administered.)

The University's various libraries have approximately 3,600,000 bound volumes in their collections. Among the specialized collections are the William L. Clements Library of Americana, the Michigan Historical Collections, a Transportation Library, and libraries serving all the academic departments. Particularly strong holdings have been acquired in Oriental materials, medical and public health volumes, the natural and social sciences, and mathematics (the strength of the latter is attested to by the presence of *Mathematical Reviews* at the University). The libraries' staff, the second largest in the nation of university libraries, is more than 425; the total annual budget for the Library is about $4,000,000.

The variety of the University's specialized research centers, organizations, institutes--many of them offering graduate and undergraduate students the opportunity to participate in research--can perhaps be suggested by listing some of the outstanding units: the Museums of Anthropology, Archeology, Paleontology, and Zoology; the Herbarium; the Botanical Gardens, a 280-acre tract with specially designed laboratory and classroom facilities; the Biological Station, about 9,000 acres between Douglas and Burt Lakes, 260 miles north of Ann Arbor, which has been used for instruction and research in aquatic studies since 1909, and now has an all-weather lakefront

laboratory building as its most modern facility; the Great Lakes Research Division of the Institute of Science and Technology, which maintains a number of research vessels on the Great Lakes; the Space Research Laboratory, on the University's North Campus, which houses many of the activities of the major units (the Space Physics Research Laboratory, the High Altitude Engineering Laboratory, and the Radio Astronomy Observatory) involved in space research; the Area Centers (Chinese Studies, Japanese Studies, Near Eastern and North African Studies, Russian Studies, and South and Southeast Asian Studies); the Cyclotron Laboratory; the Environmental Simulation Laboratory of the School of Natural Resources; the Institute for Social Research, comprised of the Survey Research Center, the Research Center for Group Dynamics, and the Center for Research on the Utilization of Scientific Knowledge; the Institute for the Study of Mental Retardation; the Highway Safety Research Institute; the University of Michigan Population Program; the Institute of Labor and Industrial Relations; the Center for Research on Learning and Teaching; the Center for Research on Language and Language Behavior; and the Center for Human Growth and Development. About 2,000 graduate students are currently participating in sponsored research conducted through these and other University units.

The total dollar volume of research activity for the fiscal 1967-68 year at the University was $62,107,019, including support from all sources. Details of the research support for the eight units selected for the purposes of this application as representative users of the Computing Center are presented in Section 7.4.

6.12 *Future Use of Present Space*--The University's present plans are to retain all the present space, apportioning it among those units and activities most likely to benefit from it when the Computing Center's new facility is ready for occupancy. It appears very likely that research activities, in which graduate students are generally heavily involved, will be housed in the present space, depending on compatibility of use, proximity to related activities and personnel, etc.

6.2 PROPOSED PROJECT

6.21 *Description of Proposed Project*

The design of the new Computing Center Building combines many special concepts for a flexible space intended to house large-scale data processing systems for both present and future facilities. In order to appreciate these features and concepts, several facts about computing systems need to be examined:

A. While Large Scale Integration (LSI) and other advances in technology will reduce the physical volume of the logic in present equipments, the need for more complex logic may well cause an increase in total volume of future systems.

B. The demand for large direct access files will surely cause the volume occupied by future systems to be larger than present systems. These devices may be needed to provide increased storage capacity at a rate of $400*10^6$ bytes per year for the near future (and at rates that are probably greater beyond that period). This leads one to anticipate a rate of growth of total machine system volume at a rate of approximately 20% per year.

C. The demand for both batch and interactive computing will cause a need for growth in both I/O equipment and data communications facilities. In this area, two factors will help restrain the role of growth of machine system volume:

(1) The I/O facilities are very likely to increase data handling rates per unit of equipment thus allowing more data to be handled in roughly the same physical volume. The net rate of growth is estimated at 5 to 10% per year.

(2) The use of integrated circuitry by both the telephone company and the computer manufacturers will allow for substantial increases in data communication capacity with only small increases in package volume. Also the "bandwidth" of data communications channels is very likely to increase substantially in the near future. The net rate of growth is estimated at 5% per year.

The above suggests that, no matter what space use is made when the building is first occupied, the total building space may be filled with the machinery of computation systems within 10 years.

As a result of this awareness, the new Computing Center Building incorporates some long familiar concepts of computer programming to minimize the "fixed" or "bound" space to allow for orderly and systematic growth of the computing facility. This has been done with the use of two "core" units containing the fixed building facilities like stairways, restrooms, elevators, air-conditioning and power shafts.

Second, the use of the "core" units permits a completely open and maximally flexible central space on three levels. By providing

a complete computer floor for the entire internal space, the building will allow for orderly rational system growth (and also allow for flexible general office and workspace use in the interim). All power, air-conditioning, communications, special cooling and other facilities will be contained within the computer floor space as well as all computing systems cables.

Thirdly, by the clever use of prestressed concrete T-beams all internal columns are eliminated and a clear span of 60' by 120' is available for systems occupancy on all three floors.

Finally, it is important to understand the fundamental importances of the three-level concept. Computing systems, like all systems depending upon the propagation of electromagnetic radiation to achieve information transmission, is inherently faced with an upper bound on the propagation velocity of about one foot per nanosecond. This means that if systems are to get significantly faster the systems must minimize the physical length of cabling. Taken to the obvious limit, the apparent shape for an "ideal" Computing Center Building would be a sphere with the fastest memories or storage units and processors at the center and slower, more voluminous devices located in "layers" at increasing radius from the central units. This type of design, if it were not for obvious fundamental building fabrication problems and costs, would minimize cable length and maximize the speed of the system. The best realizable shape for an "ideal" computing center is an approximation to the sphere, namely a cube. The three-level rectangular structure will approximate the "ideal" sphere in a highly practical way. "Over and under" computer designs are already being built for research and military purposes and commercial systems are certain to follow in the future with this design.

Already existing systems will benefit by reducing cabling in the multiplexor channel "daisy chains" and by permitting the functional separation of the relatively dusty and dirty operations of card reading, punching and line printing into an area contigious to the public input/output and work areas. This will also increase the reliability of systems components more sensitive to dust and dirt (such as high density magnetic tapes, discs, data cells and drums).

The use of prestressed concrete beams is designed to allow for the placing of strategically located cable sleeves in the web sections of the beams. This will enable the vertical organization, placement and operation of the systems to maximum advantage without constraining the fundamental building structure with fixed columns and cable shafting.

Other important features recognize the increasing importance of total system reliability to the University community. More and more remote systems depend on central computing services obtained through communications facilities from a continuously operational central system. The present duplex IBM/360 67 already provides automatic load switching among the Central Processing Units. A similar improvement in the air-conditioning system and primary power systems is included in the new plans. These facilities are a practical compromise between maximum reliability and cost. Complete backup in manually reconfigured mechanical and electrical systems will provide this capability.

A complete backup facility will guarantee continous operation except for extremely low probability incidents. The air-conditioning system looks to the increasing importance of liquid-cooled processors

and memories by providing a primary chilled water source for use in both the distributed air-conditioning heat exchangers and directly in the computing systems itself. Modern computing systems are characterized by some units with very large energy dissipation, such as memories and processors, while others have low energy release, such as controller, switch console and some electromechanical devices. This poses a very difficult problem in maintaining a proper system environment. The proposed design allows for a distribution of modular cooling units to match the distribution of heat release.

The foregoing brief discussion emphasizes the flexibility, modularity and growth potential of this new building for the computing system proper.

Other equally important aspects of the design are directed at present needs and immediate occupancy requirements.

The building design readily accomodates a functional organization for the use of the space in many activities that engage the members of the University community with computing.

The core structures permit the control of personnel traffic flow and effectively organize the building to serve its community of users. It is recognized that both batch and remote terminal use will flourish and complement each other. This space is provided for on-site work and counseling as well as remote user counseling. Equally important are spaces for giving demonstrations and lessons on the effective use of the systems. It is well known that this educational role is crucial to the successful operation of the facility.

The Computing Center currently has more than 5,000 user identifications active in the system and this number grows at nearly 300-500 users/month. The education of these users is critical.

A novel feature is the recognition of the interactive of remote terminals and the batch processed system. Since a user may originate a batch processed job from a remote terminal, he must pick up his printed results at the Computing Center. A drive-in window is designed to help speed this type of use.

Finally, flexible space for research, administration and operation is provided to match the dynamices of the system itself. By providing computer flooring over the entire space, it will be possible to grow in an evolutionary manner. This will be in marked contrast to most earlier computing building designs.

Location

The Computing Center Building will be located on North Campus just south of the Institute of Science and Technology on North Campus Boulevard and just west of University Printing building on Beal Avenue. The site is within easy walking distance of the proposed College of Engineering complex, the Chrysler Center for Continuing Engineering Education, and the North Campus Commons. Figure 6 is an aerial photograph of the site.

The Building

This three-story masonry building is the first phase of a planned expansion of the I.S.T. complex. The building is a simple rectangle in plan with a small service-core appendage on the north and on the south. Elevator, stairs, toilets, janitor's closets, duct shafts and pipe chases are housed in these external cores,

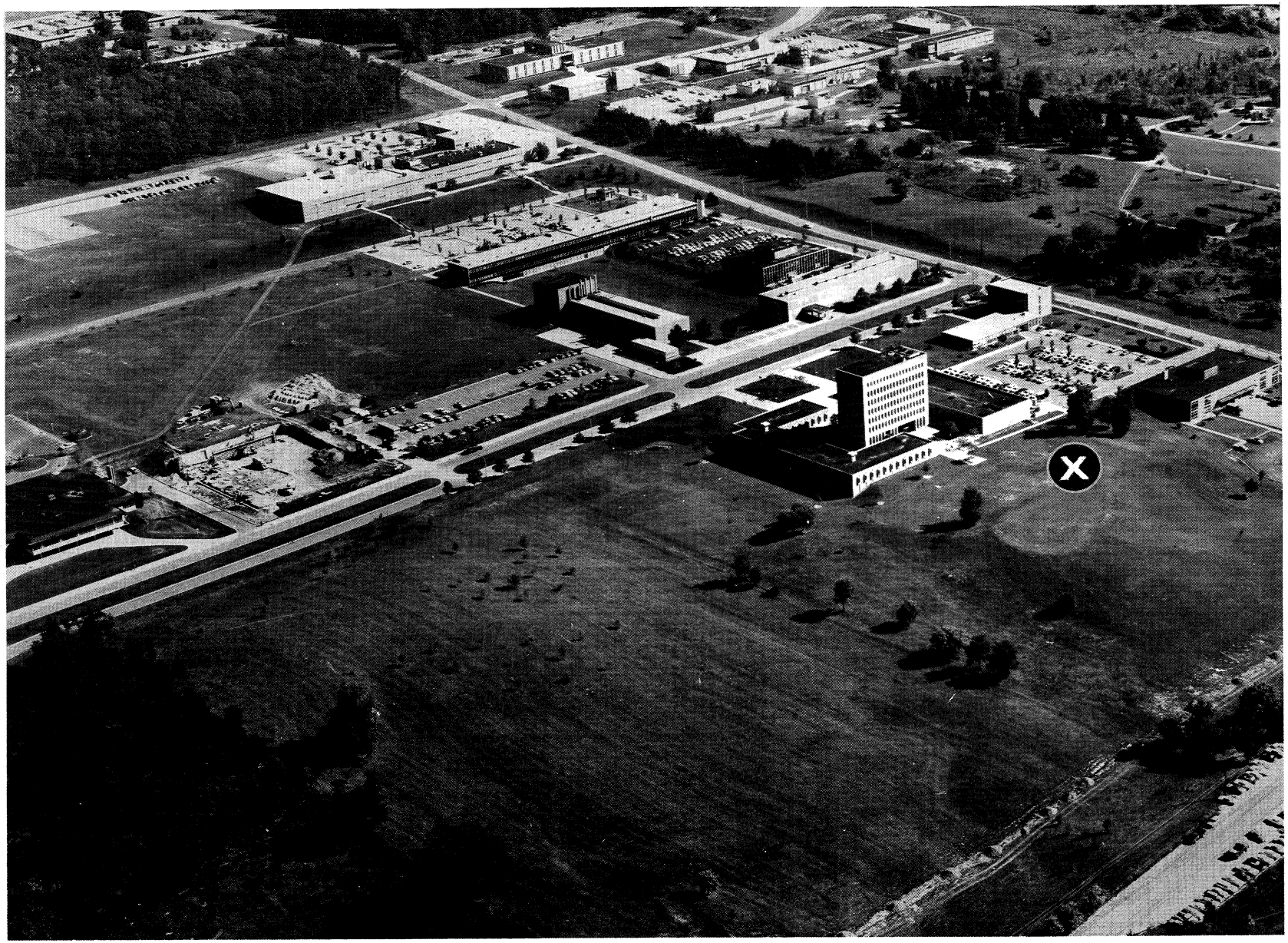


Fig. 6

Aerial view of proposed site for new Computing Center.

which allows for future expansion to the north and/or the south. The structural system is clear-span, precast-concrete double tees carried by load bearing masonry exterior walls.

The Basement Floor is entirely assigned to mechanical and electrical equipment, including service entries for all underground utilities and for steam from new and existing boilers in the I.S.T. building.

The First Floor contains all public functions, including Reception and Control, I/O Dispatch, Users Terminals and Workroom, Seminar, Keypunch Room, Counseling, and Demonstration and Display. General Receiving and Paper Storage open directly off a truck dock. A particular feature of the I/O Dispatch function will permit direct contact between vehicular traffic and dispatch via a drive-in window arrangement.

The Second Floor provides at-grade entrance from the north and includes the Computer Room, and an adjacent open office landscape area housing Programmers, Systems Analysts, Staff Terminals and Electronics and Customer Engineer Shops. Future expansion of the Computer Room may encompass the entire floor and can be easily accomplished by removing the low-height partitions.

The Third Floor is similar to the Second Floor, except for office use. These spaces are administrational and include Director, Associate Directors, Assistant Director, Administrative Assistant, Business Manager, Research Associates, Programmers and related conference, Secretarial Records, and Library facilities.

Mechanical

The mechanical system will be composed of a central chilled water system and cooling tower providing 100% standby capacity, with remote air-conditioning apparatus in the computer space. Cooling tower shall include wet sump basin, vertical discharge fans, trays and frame to control condenser water between 85-95°F.

Packaged air-conditioning equipment complete with fans, chilled water cooling coil, drain, steam heating coil and steam reheat elements, humidifier, filters and cabinet enclosure to match computer equipment. Units shall be vertical downdraft air discharge model, adapting the floor plenum space as the supply air duct with floor grilles or outlets provided by the floor system to distribute the conditioned air to the computer space. Return air to the units shall include a completely prewired control center to maintain temperature and humidity year-round. Perimeter radiation will be provided where required.

Heating Plant - gas/oil fired firetube forced draft boiler for low pressure steam system located in existing I.S.T. Building boiler room. Steam and condensate piping to be underground in conduit system. Existing I.S.T. Building heating plant will be used as emergency source of steam to serve Computing Center.

Fire protection system consisting of hose standpipe and a sprinkler system where required at Paper Storage area.

Make connections to storm sewer, sanitary sewer, water and gas. Underground utilities services brought to within 5'-0" of building.

Electrical

Service to the building will be supplied from the campus primary distribution system; for reliability, two services are recommended.

The substation shall comprise two primary load-break air interrupter fusible switches; manual transfer, two non-fusible load-break primary switches; dual ended substation. Secondary protection shall be fusible circuit-breaker type.

Distribution voltage for environment control, 3 phase power and fluorescent lighting shall be 277/480 V, 3 phase, 4 wire for non-computer receptacles, incandescent lighting and single phase motors. Distribution voltage for computer leads shall be separated 120/208 V, 3 phase, 4 wire.

Generally, the lighting shall be fluorescent, laid out in a linear pattern. In the computer areas, lighting level shall be 100 f.c. maintained.

Auxiliary systems: manually controlled clock system; telephone raceway system; public address system; fire alarm system; fire detection system.

Connections will be made to power and communications. Underground utilities and services will be brought to within 5'-0" of the building.

6.22 *Assignable Space by Departments*

Not applicable.

6.23 *Room Tabulation of Net or Assignable Space*

See Appendix II.

6.3 LIST OF FIXED EQUIPMENT

The total estimated cost of the fixed equipment is included in Section IV, Proposed Facilities Budget.

6.4 LIST OF MOVABLE EQUIPMENT

The total estimated cost of the movable equipment is included in Section IV, Proposed Facilities Budget. A list of movable equipment will be submitted for approval after a grant has been awarded.

SECTION VII. STUDENTS AND STAFF

7.1 NUMBER OF STUDENTS AND STAFF

7.11 *Total Present Enrollment of the University*

Graduate enrollment	14,095
Undergraduate enrollment	25,429
Total	39,524

Part-time students are included in the above totals; no separate records are kept for them.

7.12 *Numbers of Present and Anticipated Personnel in Graduate Teaching and Research*

School of Business Administration

	Present		Five years after completion	
Personnel	Total	FTE	Total	FTE
Academic Staff	90	70	105	85
Postdoctoral Res. Fellows	--	--	---	--
Research Associates (not students)	25	15	50	25
Research Technicians (not students)	14	12	25	20
Supporting Personnel (Clerical, Technical, and other)	152	67	200	100
Graduate Students--Full-time				
(No. in M.S. Program)	595	595	750	750
(No. in Doctoral Program)	82	82	130	130
Graduate Students--Part-time				
(No. in M.S. Program)	308	100	450	150
(No. in Doctoral Program)	20	5	32	8

Department of Civil Engineering

	Present		Five years after completion	
Personnel	Total	FTE	Total	FTE
Academic Staff	29	25	30	27
Postdoctoral Res. Fellows	--	--	--	--
Research Associates (not students)	--	--	--	--
Research Technicians (not students)	--	--	--	--
Supporting Personnel (Clerical, Technical, and other)	10	10	10	10
Graduate Students--Full-time				
(No. in M.S. Program)	39	39	50	50
(No. in Doctoral Program)	30	30	40	40
Graduate Students--Part-time				
(No. in M.S. Program)	6	4	12	8
(No. in Doctoral Program)	9	6	12	8

Department of Computer and Communication Sciences

	Present		Five years after completion	
Personnel	Total	FTE	Total	FTE
Academic Staff	14	5.5	20	10.5
Postdoctoral Res. Fellows	1	1	--	--
Research Associates (not students)	1	1	1	1
Research Technicians (not students)	--	--	--	--
Supporting Personnel (Clerical, Technical, and other)	5	5	8	8
Graduate Students--Full-time				
(No. in M.S. Program)	--	--	--	--
(No. in Doctoral Program	69	69	100	100
Graduate Students--Part-time				
(No. in M.S. Program)	--	--	--	--
(No. in Doctoral Program)	--	--	--	--

Department of Electrical Engineering

Personnel	Present		Five years after completion	
	Total	FTE	Total	FTE
Academic Staff	51	35	60	45
Postdoctoral Res. Fellows	--	--	--	--
Research Associates (not students)	28	28	30	30
Research Technicians (not students)	50	46	53	51
Supporting Personnel (Clerical, Technical, and other)	22	20	25	25
Graduate Students--Full-time				
(No. in M.S. Program)	2	2	5	5
(No. in Doctoral Program)	34	34	49	49
Graduate Students--Part-time				
(No. in M. S. Program)	15	8	16	9
(No. in Doctoral Program)	41	21	44	21

Department of Industrial Engineering

Personnel	Present		Five years after completion	
	Total	FTE	Total	FTE
Academic Staff	19	15.27	40	26.5
Postdoctoral Res. Fellows	--	----	10	10
Research Associates (not students)	9	6.75	27	20
Research Technicians (not students)	1	1	4	4
Supporting Personnel (Clerical, Technical, and other)	15	14	30	30
Graduate Students*				
(No. in M.S. Program)	32	17.9	65	30
(No. in Doctoral Program)	25	7.7	50	30

*No distinction is made between part-time and full-time students; all students are considered full-time. Practically all faculty are involved in both graduate and undergraduate teaching, and a division of the full-time equivalent is not feasible.

Department of Mechanical Engineering

Personnel	Present		Five years after completion	
	Total	FTE	Total	FTE
Academic Staff	58	54	65	60
Postdoctoral Res. Fellows	2	2	4	4
Research Associates (not students)	1	1	2	2
Research Technicians (not students)	15	15	18	18
Supporting Personnel (Clerical, Technical, and other)	10	10	12	12
Graduate Students--Full-time				
(No. in M.S. Program)	60	60	80	80
(No. in Doctoral Program)	40	40	60	60
Graduate Students--Part-time				
(No. in M.S. Program)	25	10	40	15
(No. in Doctoral Program)	2	1	10	4

Department of Physics

Personnel	Present		Five years after completion	
	Total	FTE	Total	FTE
Academic Staff	55	53	62	62
Postdoctoral Res. Fellows	4	4	10	10
Research Associates (not students)	17	17	25	25
Research Technicians (not students)	17	17	20	20
Supporting Personnel (Clerical, Technical, and other)	106	75	125	100
Graduate Students--Full-time				
(No. in M.S. Program)	29	29	35	35
(No. in Doctoral Program)	133	133	160	160
Graduate Students--Part-time				
(No. in M. S. Program)	4	2	10	10
(No. in Doctoral Program)	--	--	--	--

Department of Political Science

	Present		Five years after completion	
Personnel	Total	FTE	Total	FTE
Academic Staff	47	38	60	43
Postdoctoral Res. Fellows	1	1	4	4
Research Associates (not students)	--	--	--	--
Research Technicians (not students)	--	--	2	2
Supporting Personnel (Clerical, Technical, and other)	5	5	7	7
Graduate Students--Full-time	Total: 224	109	300	
(No. in M.S. Program)	(computed	on basis	of 4 courses	
(No. in Doctoral Program)	per term	being a	full load)	
Graduate Students--Part-time	Total: 9			
(No. in M.S. Program)				
(No. in Doctoral Program)				

7.13 *Undergraduate Enrollment by Departments*

School of Business Administration	280
Department of Civil Engineering	187
Department of Computer and Communication Sciences	30
Department of Electrical Engineering	494
Department of Industrial Engineering	242
Department of Mechanical Engineering	420
Department of Physics	176 (2,178*)
Department of Political Science	355 (3,200*)

*Total enrollment in undergraduate courses. No part-time enrollment figures are kept.

7.2 RECRUITMENT OF NEW PERSONNEL

7.21 *Recruitment of Faculty*--New faculty positions to meet the expanding demand for undergraduate and graduate instruction on the use and application of computers will be established in the departments where the needs are perceived. Positions contemplated for the future by representative departments have been mentioned in

Section 2.2. These positions will be funded from College and Departmental budgets. It is unlikely that there will be additions to the senior academic staff of the Computing Center. The present senior staff all hold relevant professional appointments, but have the development of the computer facilities of the institution as their primary responsibility. As the system expands and the type of services available to users diversifies, a Service Manager will be added to supervise the provision of efficient services to the routine user. This position would be funded from the operating budget of the Center.

In addition, the group of programming assistants, counselors, machine operators, etc., will be maintained at the level optimal to user demands. Such positions are usually non-academic, but may be filled part-time by advanced graduate students.

:2 *Faculty and Students from Minority Groups*

Special efforts at The University of Michigan to attract faculty and students from minority groups include, on the undergraduate level, the Opportunity Award Program which combines special recruitment efforts, substantial financial aid, and counseling and tutorial assistance. Currently, 445 undergraduates, of whom more than 90% are Negroes, are enrolled at the University under this program.

At the graduate level, efforts to recruit and assist students from minority groups are being made by a number of the University's schools, colleges, and departments: among others, the Medical

and Law Schools, the Schools of Dentistry, Social Work, and Public Health, and the Departments of Physics and of Economics. The Horace H. Rackham School of Graduate Studies is providing significant financial assistance in four separate programs to individual students and to departments seeking to recruit minority-group students, and has just hired a counselor to work with minority-group students.

The University's exchange program with Tuskegee Institute, begun in 1963 and supported by the U. S. Office of Education under Title III of the Higher Education Act of 1965 for the last three years, has produced, among other benefits, Negro graduate students in a variety of programs--e.g., public health, education, anatomy, and mathematics.

Dr. William Cash, formerly of the U. S. Office of Education, began his duties as Human Relations Coordinator on September 1, 1968. In this newly created position, Dr. Cash is directly responsible to the President, with assignments including efforts to increase the number of minority-group students, faculty, and staff. Dr. William Haber, who retired in June, 1968, as Dean of the College of Literature, Science, and the Arts, is serving this year as Special Assistant to the President, and has been asked to assist in the recruitment of black faculty members.

Although the number of Negro faculty members remains disproportionately small, more Negroes are now on the faculty than ever before, partly because of the University's continuing efforts to take affirmative action in the recruitment of

minority-group members. Among units whose faculty now include Negroes are the Schools of Education and Music, and the Departments of Art, English, Mathematics, Microbiology, Pediatrics, Political Science, Psychology, and Romance Languages. Prominent administrative positions are presently held by Negroes in the Graduate School, the Office of Academic Affairs, and the Office of Student Services.

7.23 *Average Graduate Record Scores*--The criteria used by the various academic units of the University in evaluating applications for admission to their graduate programs differ sufficiently to necessitate individual description of each department's requirements.

The School of Business Administration requires applicants to take the Admission Test for Graduate Study in Business. At the M. A. level, entering 1968-69 students had an average of 568; at the Ph. D. level, 637. An overall consideration of an applicant's qualifications by the Admissions Committee, rather than any minimum GPA, is the determining factor in admissions.

The Department of Civil Engineering does not use the Graduate Record Examination for admission of graduate students. Normally, applicants must have at least a B average in their undergraduate programs to qualify for consideration. Exceptions may be made if the applicant is recommended strongly by a member of the faculty, but a 2.7 average is minimum.

The Department of Computer and Communication Sciences requires applicants to submit Graduate Record Examination scores, but no minimum score is required for admission. The applicant's academic record, the nature of the institutions he has previously attended, and his career objective, as well as three references, are evaluated in determining his admission.

The Department of Electrical Engineering requires a 2.8 average of Michigan graduates and a 3.0 average of other applicants. Graduate Record Examinations are not required.

The Department of Industrial Engineering takes into consideration the overall record of applicants to the graduate department, including grade point average and scores on the Graduate Record Examinations. However, there is no minimum average or score which is used to disqualify an applicant. In general, admission standards are equivalent to those in the major engineering schools in the country.

The Department of Mechanical Engineering requires a 3.0 GPA of all applicants except graduates of Michigan or other highly rated universities. The Graduate Record Examination is now required at both the master's and doctoral level, a criterion, in effect slightly more than a year, expected to be helpful in evaluating the records of applicants from unfamiliar schools.

For the present students enrolled, the following are some average data dealing with the Graduate Record Examination. M.S.E. students: Verbal, 576; Quantitative, 753; Advanced Engineering, 701. New Ph.D. students: Verbal, 613; Quantitative,

726; Advanced Engineering, 555. For graduate students whose applications were rejected the following applies: Verbal, 451; Quantitative, 702; Advanced Engineering, 621.

The Department of Physics does not require Graduate Record Examinations, but may use them in evaluation if available. Applicants are judged on their academic records, especially in physics, mathematics, and chemistry. The standard GPA requirement is 3.0. References are used when available; personal interviews are encouraged.

The Department of Political Science has analyzed the Graduate Record Scores of its students as follows:

		Male	Female
Verbal	600	71%	67%
Quantitative	700	81%	96%
Achievement	600/70%		

A B average in undergraduate work is required of applicants. Although Graduate Record Examinations are required, no minimum score is set for applicants. Letters of recommendation are not required, but may help in evaluation if avialable.

7.3 SALARY LEVELS

TABLE II

Salary Levels By Rank in Selected Departments*

Unit	Prof.	Assoc. Prof.	Asst. Prof.	Other
Business Administration	$23,883	$16,136	$13,735	$13,049
Civil Engineering	28,102	16,930	13,780	12,400
Computer & Communication Sciences	24,593	22,032	------	11,154
Electrical Engineering	23,888	18,246	16,218	------
Industrial Engineering	25,218	20,683	17,204	11,090
Mechanical Engineering	24,063	17,496	13,717	9,756
Physics	21,427	14,355	12,252	------
Political Science	21,269	16,504	12,317	10,915

*Twelve-month basis. Includes average salaries of full-time persons working the University year (9 months), which has been equated to 12 months (by 11/9) for comparability with those appointed full-time 12 months. (The calculation allows for a one-month vacation.)

7.4 ANNUAL RESEARCH SUPPORT

School of Business Administration

Source		Fiscal 1967-68
Federal Support		-0-
	Subtotal	-0-
Non-federal Support		
University Budget		$ 10,725.05
Industrial Support		2,723.36
Other Sources:		
Ford Foundation		2,000.00
John H. Seeley Foundation		262.95
Miscellaneous Donors		158.58
	Subtotal	$ 15,869.94
GRAND TOTALS		$ 15,869.94

Department of Civil Engineering

Source	Fiscal 1967-68
Federal Support	
National Science Foundation	$ 45,647.21
Public Health Service	50,154.01
National Aeronautics & Space Administration	8,430.87
Other Federal Agencies	
Department of the Interior	46,291.03
Department of the Army	49,709.97
Department of the Navy	7,412.96
Subtotal	$207,645.98
Non-federal Support	
University Budget	846.37
Industrial Support	103,091.06
Other Sources:	
Michigan State University	6,045.37
Michigan State Highway Department	9,974.17
Auto Safety Foundation	3,567.32
City of Pontiac	624.29
Subtotal	$125,148.58
GRAND TOTALS	$331,794.63

Department of Computer and Communication Sciences

Source	Fiscal 1967-68
Federal Support	
Public Health Service	$ 96,713.65
National Aeronautics & Space Administration	98.98
Other Federal Agencies	
Department of the Navy	553.03
Department of the Army	57,601.51
Subtotal	$154,967.17
Non-federal Support	-0-
Subtotal	-0-
GRAND TOTALS	$154,967.17

Department of Electrical Engineering

Source	Fiscal 1967-68
Federal Support	
National Science Foundation	$ 121,848.44
Public Health Service	754.91
National Aeronautics & Space Administration	2,113,982.74
Other Federal Agencies	
Bureau of Fisheries	10,029.15
Department of the Army	664,371.65
U. S. Air Force	1,182,330.74
Department of the Navy	391,514.48
Federal Aviation Administration	52,585.73
U. S. Department of the Interior	23,478.78
Defense Communications Agency	27,176.69
Subtotal	$4,588,073.31
Non-federal Support	
University Budget	7,892.59
Industrial Support	170,581.58
Other Sources:	
Southwest Center for Advanced Studies	623.61
Michigan Department of Public Health	650.41
Thermo-Nuclear Fusion Gen.	323.82
Penn State University-Ordinance Res. Lab.	62,816.65
Subtotal	$ 242,888.66
GRAND TOTALS	$4,830,961.97

Department of Industrial Engineering

Source		Fiscal 1967-68
Federal Support		
Public Health Service		$165,493.91
Other Federal Agencies		
Department of the Army		242,162.44
	Subtotal	$407,656.35
Non-federal Support		
University Budget		209.00
Industrial Support		32,089.36
	Subtotal	$ 32,298.36
GRAND TOTALS		$439,954.71

Department of Mechanical Engineering

Source		Fiscal 1967-68
Federal Support		
National Science Foundation		$ 125,364.03
Public Health Service		47,075.19
National Aeronautics & Space Administration		87,405.07
Other Federal Agencies		
Department of Commerce		11,143.19
National Bureau of Standards		17,863.99
Department of the Army		1,001,872.53
U. S. Air Force		96,935.36
	Subtotal	$1,387,659.36
Non-federal Support		
University Budget		1,202.10
Industrial Support		176,956.81
Other Sources:		
Miscellaneous Donors		65.05
	Subtotal	$ 178,223.96
GRAND TOTALS		$1,565,883.32

Department of Physics

Source	Fiscal 1967-68
Federal Support	
National Science Foundation	$ 363,240.08
Public Health Service	158,185.59
National Aeronautics & Space Administration	10,245.75
Other Federal Agencies	
U. S. Air Force	156,575.21
Atomic Energy Commission	1,793,184.15
Department of the Navy	396,959.52
Subtotal	$2,878,390.30
Non-federal Support	
University Budget	6,095.25
Industrial Support	4,104.08
Other Sources:	
Sloan Foundation	9,050.92
Miscellaneous Donors	320.00
Subtotal	$ 19,570.25
GRAND TOTALS	$2,897,960.55

Department of Political Science

Source	Fiscal 1967-68
Federal Support	
National Science Foundation	$ 9,302.83
Subtotal	$ 9,302.83
Non-federal Support	
University Budget	1,876.42
Industrial Support	734.60
Other Sources:	
Carnegie Corporation	599.53
Cosgrove-Elfreda Research Project	868.37
Miscellaneous Donors	1,170.90
Subtotal	$ 5,249.82
GRAND TOTALS	$14,552.65

7.5 NUMBER OF GRADUATE STUDENTS AIDED

School of Business Administration

Source	Fellowships & Traineeships	Research Assistantships	Teaching Assistantships
Office of Educ.			
NDEA	8		
Other O. E.			
NSF			
NIH			
NASA			
University	4	9	17
Others	127	6	
TOTALS	139	15	17

Department of Civil Engineering

Source	Fellowships & Traineeships	Research Assistantships	Teaching Assistantships
Office of Educ.			
NDEA	2		
Other O. E.			
NSF	5	9	
NIH	3		
NASA		1	
University	1		12
Others	27	16	
TOTALS	38	26	12

Department of Computer and Communication Sciences

Source	Fellowships & Traineeships	Research Assistantships	Teaching Assistantships
Office of Educ.			
NDEA	6		
Other O. E.			
NSF	3	3	
NIH			
NASA	2	3	
University	3	1	11
Others	6	29	
TOTALS	20	36	11

Department of Electrical Engineering

Source	Fellowships & Traineeships	Research Assistantships	Teaching Assistantships
Office of Educ.			
NDEA	2		
Other O. E.			
NSF	12	8	
NIH			
NASA	1	6	
University		14	53
Others	3	86	
TOTALS	18	114	53

Department of Industrial Engineering

Source	Fellowships & Traineeships	Research Assistantships	Teaching Assistantships
Office of Educ.			
NDEA	4		
Other O. E.			
NSF	7		
NIH			
University	2	38	19
Others	10		
TOTALS	23	38	19

Department of Mechanical Engineering

Source	Fellowships & Traineeships	Research Assistantships	Teaching Assistantships
Office of Educ.			
NDEA	6		
Other O. E.			
NSF	7	9	
NIH	3	4	
NASA	2	12	
University	6		9
Others	11	13	
TOTALS	35	38	9

Department of Physics

Source	Fellowships & Traineeships	Research Assistantships	Teaching Assistantships
Office of Educ.			
NDEA			
Other O. E.			
NSF	4	11	
NIH		4	
NASA		1	
University	4	6	27
Others		81	
TOTALS	8	103	27

Department of Political Science

Source	Fellowships & Traineeships	Research Assistantships	Teaching Assistantships
Office of Educ.			
NDEA	12		
Other O. E.			
NSF	5		
NIH	1		
NASA			
University	26	23	48
Others	73		
TOTALS	117	23	48

Financial assistance offered by, or available through, the University consists of (1) scholarships, fellowships, and grants-in-aid; (2) student loans; and (3) student employment.

The largest source of scholarship, fellowship, and grant-in-aid money is in a series of Expendable Restricted accounts. These accounts represent federal grants; endowment earnings; foundation grants to schools, departments, and individuals; gifts from industry, associations, civic groups, and individuals. Well over half the total Expendable Restricted payments to students are related to instructional and research expenditures. Payments are often intrinsic parts of students' graduate training and research programs.

Approximately 1,000 graduate fellowships and scholarships are provided annually for students at all levels of graduate study. Most awards range from the cost of a single term's fees to $3,000 plus term fees for two and one-half terms. Recipients are appointed by, or nominated by, the departments and programs in which the applicants are enrolled. Among these fellowships and scholarships are several which are specially endowed or provided. These awards, supported by friends of the University, are subject ro renewal from year to year. The Alumnae Council offers fellowships to women with a B. A. from an accredited college or university. Awards are made on the basis of personality, achievement, and scholastic ability.

Fellowships established by the Ford Motor Company and the Detroit Edison Company through the Michigan Memorial-Phoenix Project fund work at the predoctoral level. The release, control, and utilization of nuclear energy may be studied by a graduate student in engineering, physics, chemistry, mathematics, or the social sciences.

The University has one of the largest student loan fund operations of any university in the country. Private gifts and endowments and the National Defense Education Act play the largest role in providing these loans. Loan funds are available to graduate students after financial need has been established in a statement of the applicant's financial resources and expenses for the academic year. Considerations for a maximum loan limit include the ability to repay, the degree program, and professional objectives. A student can apply for a loan after he has been admitted or at any time during the school year. These University loans usually carry a 3% interest rate per year.

The Office of Financial Aids is responsible for informing students of the many opportunities for employment in the University and in the community. The four major areas of student employment are in research, University housing, teaching assistantships, and University libraries. Approximately 2,000 graduate students were employed in research programs in 1966-67. Teaching fellows and assistants received more than $3 million that year.

7.6 GRADUATE DEGREES AWARDED

UNIT	YEARS*					
	1963-64	1964-65	1965-66	1966-67	1967-68	1975-76
Business Administration						
Master	301	282	360	383	386	415
Doctorate	8	7	7	9	7	15
Civil Engineering						
Master	44	33	43	46	45	70
Doctorate	8	6	2	5	8	15
Professional	1			1		
Computer and Communication Sciences						
Master	12	7	13	11	11	25
Doctorate	2	5	8	7	11	18
Electrical Engineering						
Master	72	66	106	90	109	150
Doctorate	12	14	21	23	20	50
Professional	1	1	1	1	2	20
Industrial Engineering						
Master	6	23	20	25	29	60
Doctorate	3	5	2	5	5	15
Professional		1		2		10
Mechanical Engineering						
Master	58	61	57	79	78	100
Doctorate	16	2	12	9	11	16
Professional			1			
Physics						
Master	38	27	41	29	28	30
Doctorate	23	12	8	22	27	30
Political Science						
Master	29	16	18	37	35	50
Doctorate	7	10	12	9	15	20

*The University's fiscal year is from July 1 to June 30.

SECTION VIII. RESEARCH AND GRADUATE EDUCATION

8.1 BASIC RESEARCH AND GRADUATE EDUCATION IN PARTICIPATING DEPARTMENTS

School of Business Administration--The Graduate School of Business Administration was established in 1924 to offer instruction in Business Administration leading to the Master of Business Administration Degree. A few years later, work leading to the Degree of Doctor of Philosophy was added.

The main purpose of the School is to provide a strong program of professional education for young men and women who wish to achieve responsible positions in business organizations and academic institutions. In keeping with this purpose, the School engages in continuing research devoted to fundamental business problems and keeps its curriculum abreast of important trends. Just recently, both the masters program and the Ph.D. program were re-examined and restructured to meet new requirements of both the business and academic communities. For example, the masters program was restructured to include such Core Areas as Management Foundation, Management Decision, Environmental, and Integrative Capstone Core. This restructuring involved the addition of several new courses among which are Human Behavior and Organization, Analysis Planning and Control, Business, the Economy and Public Policy, and Business Policy.

The programs of the school are continually under review and it is anticipated that courses will be added and deleted as dictated by the changing requirements of the business and academic communities.

The general research program of the School covers practically all the functional areas of business. For the most part, the specific programs and projects are centered in either the Bureau of Business Research, the Institute for International Commerce, or the Bureau of Industrial Relations, all of which are integral parts of the Graduate School of Business Administration.

Some of the research projects currently underway include:

Development of a Financial Model for a Public Utility

Development of a Computer Based Business Environment

Investigation of Methods for Airline Parts Logistics Management

Study of the Organization and Regulation of International Air Transport

Study of the United States-Canadian Automotive Agreement and its effect on the replacement parts market

Development of a Method for Human Resource Accounting

These projects, each under a faculty member, are staffed by research fellows drawn from the School's Ph.D. program and by research assistants drawn from the School's M. B. A. program. Present space shortages limit the number of projects that can be undertaken, as well as the number of research fellows and research assistants that can be used. This latter restriction is particularly confining since it limits the number of graduate students who can obtain practical research experience as a part of their training.

Department of Civil Engineering--In 1853, the first professor of Physics and Civil Engineering began a course of studies at The University of Michigan which led to the first degree program offered in the 1855-56 catalog. At that time, one of the courses offered, "Machines," introduced students to the mysteries of the new steam engines. From such a beginning, the first two degrees were conferred in 1860. In 1911, the field of engineering mechanics was separated from the Department of Civil Engineering, and the Department underwent a complete reorganization. From a single professorship in Civil Engineering, the Department expanded to five professorships in the areas of civil, structural, hydraulic, municipal and sanitary, and geodetic engineering. In 1915, in cooperation with the State Highway Department, a highway laboratory for physical testing was established and has served the State for many years. In 1922, a Chair of Transportation Engineering was set up within the Department.

In the 1940's, staff research increased sharply, and laboratory facilities for hydraulics, structural, and sanitary engineering were enlarged. Following a postwar peak enrollment in 1949, new emphasis was placed on the quality of teaching and research. Professor Frank E. Richart, Jr., the present Chairman, has been responsible for the establishment of enlarged laboratories for sanitary engineering, soil mechanics, and structural dynamics. The Department's present quality was recognized in 1966, when it was cited by the American Council on Education as one of the ten outstanding civil engineering departments in the nation.

Six areas of research and teaching illustrate the interests of the Department: structural dynamics, soil mechanics, earthquake engineering, transportation and highway engineering, hydraulic engineering, and sanitary and water resource engineering.

In the area of structural dynamics, the rapidly evolving utilization of plastic analysis in the design of steel frames has led to revised and updated course work (513. "Design of Metal Structures;" 514. "Rigid Frame Structures"). The Department has been a leader in the development of matrix procedures of structural analysis and in the use of the electronic digital computer for their application. (618. "Computer Analysis of Structures"). Another area of interest is the development of reinforced concrete constructions. (515. "Prestressed Reinforced Concrete;" 518. "Design in Reinforced Concrete"). Among current research projects underway are studies of high-strength structural steel, Elastizell concretes, and composite building units.

Since 1924, the Department's work in soil mechanics has produced significant studies of bases for highways and highway structures, pavement performance, and the performance of pile-driving hammers. A new laboratory, completed in 1964, has helped greatly to increase research activities. Present and future work in soil mechanics is expected to stimulate teaching and research in structural dynamics, and hydrodynamics, which, combined with soil mechanics, will provide a basis for new programs in earthquake engineering. Current investigations include various analyses of soil stability and a study entitled "Strain-History Sensitivity Limit for Soils Subjected to Vibrations."

In the field of earthquake engineering, methods of processing strong-motion records and reducing instrumental data to a form suitable for processing by a digital computer continue to be a major concern. Earthquake ground motion is being studied as computed from accelerograms and as recorded by displacement meters. Field studies of earthquakes have included those at Skôpje, Yugoslavia, Anchorage, Alaska, Adapazari, Turkey, Caracas, Venezuela, and Konya, India. The Department has representation in the Universities Council on Earthquake Engineering Research and on the NAE Earthquake Inspection Team. Research on earthquake resistence is presently being conducted.

In transportation and highway engineering, students are trained in existing technologies and prepared to meet the rapidly changing requirements of the future. Design and operational determinants in railroading and in airport planning and design (543."Soils in Highway and Airport Engineering;" 644. "Airport Planning and Design") are being considered at the professional level. Current efforts in this area include highway planning, involving the evaluation of highway needs and analysis of possible system developments in terms of money, manpower, location, and type of a given highway. The basic concern of researchers in highway design is with the operational requirements of traffic or geometric design. Physical design features with which faculty members are currently concerned include drainage and bridge design as well as pavement structure (547. "Principles of Pavement Design"). New concepts in material testing have been instituted in which advanced statistical techniques are used. Departmental researchers

are also concerned with the cost-effectiveness of traffic control devices and with the development of optimal control strategies in traffic networks. Practical applications of these developments are now being tested in Detroit, Michigan.

During the past six years, a major graduate research program effort in hydraulic transients has been developed at the University. Two transient-flow laboratories are constantly active. An analysis of waterhammer in piping systems has extended to a study of the pulsatile blood flow through the arteries. Further extensions have led into studies of vibrations and resonance in hydraulic systems, including large hydro-projects as well as missiles, pumping systems, nuclear submarines, and nuclear power plants. More recently, theories in the control field have been developed concerning the motion of valves in liquid and natural gas systems and the motion of gates to control long open channels. Projects carried out in the University's Lake Hydraulic Laboratory (established in 1947) have provided many graduate students with research experience and doctoral work. Basic research projects have been conducted on such topics as wave refraction and diffraction and the determination of forces on submerged structures. The newest project is a model testing program to determine the best harbor arrangement for protecting the penstock of a pumped storage plant that will be built on the eastern shore of Lake Michigan. Two representative current projects in this area are entitled "Propellant Line Dynamics" and "Pulsatile Flow through Distensible Tubes."

The ever-increasing problem of water pollution has had a definite impact on the research and teaching conducted in sanitary and water-resources engineering. The treatment plant of the future, which will concentrate on special techniques designed to remove specific categories of pollutants, has received a good deal of study at the University. Research in ion exchange, oxidation, ion flotation, the extraction of trace nutrients and bacteriologically mixed cultures is being conducted. Studies in the computer-aided design and analysis of water resources systems provide a new approach to the problem. Other investigations concern cost-performance effectiveness of water reclamation and recycle and the determination of a rational base for establishment of effluent changes (581. "Applied Chemistry of Water and Waste Water").

Department of Computer and Communication Sciences--The communication sciences are interdisciplinary in nature, with foundations primarily in five bordering disciplines: mathematics (algebra, analysis, numerical analysis, logic, and probability); electrical engineering (communication through noise, signal detection, switching networks, feedback, and control systems); physiology (cellular, neural, vision, hearing, and speech); psychology (sensory capacities, perceptual and motor skills, psychophysics, performance capacities, conditioning, learning, and problem solving); and linguistics (structural and mathematical).

Since its inception in 1957, the Communication Sciences program has given 36 Ph.D.'s and many more M.A.'s. Ph.D. dissertations have been written on switching theory, logical nets, probabilistic automata, parallel computers, cellular automata, algebraic automata theory, character recognition, formant analysis, aural physiology, speech analysis and synthesis, speech production, neural networks, heart simulation, simulation of genetic populations, pattern recognition, signal detection, and problem solving.

All faculty members engage in research, and many of them are attached to research units in the university. Among these are: Computing Center, Logic of Computers Group, Systems Engineering Laboratory, Human Performance Center, and the Mental Health Research Institute. All of these facilities employ research assistants.

The Computing Center has a developing time-sharing system based on an IBM 360/67. There are a number of remote terminals on campus. The Logic of Computers Group computing facility is especially designed for the investigation of adaptive systems and is attached to the main time-sharing system. A portion of the first electronic computer, the ENIAC, is on exhibit at the Department.

Department of Electrical Engineering--The Department of Electrical Engineering was established in 1895, six years after a degree in the field had first been offered at the University by the Department of Physics. Courses in electric and magnetic fields and in electronics were made requirements in 1922 and 1931, respectively, the latter representing the first such requirement by an engineering school

in this country. The Department today numbers about 60 professors, and has a graduate student enrollment of about 300. Participation of graduate students in the Department's various research activities is extensive.

Currently, investigations are being conducted in such areas as gaseous plasmas, electromagnetics, solid-state circuits, devices and materials, computer design and automata theory, automatic control systems, large-scale and stochastic systems, energy systems, electron-beam dynamics, electro-optics, and neurophysiological systems. An investigation of both the microscopic and macroscopic properties of high-temperature, high-density gaseous plasmas involves a digital computer simulation using Monte Carlo techniques. Among electromagnetic studies are investigations of the radiation, propagation, scattering, and diffraction of electromagnetic energy and its interaction with anything in its path. New methods are being developed to increase or decrease radar cross sections. Research in electrostatics has included the development of what is believed to be the most rugged and reliable open-air electrostatic generator yet produced. Future plans call for the optimization of these machines, the development of compact models without compromising performance, and an investigation of the relationship between size, voltage, and current as the size is markedly increased.

Solid-state studies include research on semiconductor material properties, the development of new device concepts, and investigations of the use of these devices in various electronic systems. A continuing program is concerned with the development of computational

algorithms for the analysis and optimization of general forms of linear networks. Laboratory facilities exist for the fabrication and processing of materials and devices; an integrated circuit facility for both instruction and research in linear and microwave integrated circuits is currently under development.

Work in computer design and automata theory pertains to the development of mathematical models of information-processing systems, design algorithms, and computer arithmetic.

In the area of automatic control systems, research is being conducted on the application and extension of transform techniques to time-varying, discrete-time, linear systems. One large-scale continuing project is concerned with the application of automatic control system theory and digital computers to the problems of electronic warfare, communications, and counter-measures.

Investigations in energy systems include a study of a method being developed for rapid selection of a small number of devices from among all possible new transmission alternatives. A computer program with built-in design experience is being written.

Research in electro-optics is presently aimed at improving data recording, processing, and display, and extending the applications of holography.

Investigations in neurophysiological systems emphasize cybernetic studies involving the systems aspects of animal and human nerve functions. Research on the application of engineering principles to the understanding of neurophysiology, on the interface between biological and engineering systems, and on neural processes for possible engineering applications is currently underway.

Among the Department's major research units are the Cooley Electronics, Electron Physics, Electro-Optical Sciences, Neuorphysiological Systems, Plasma Engineering, Power Systems, Radiation, Space Physics Research, and the Systems Engineering Laboratories.

Department of Industrial Engineering--A course in scientific shop management was announced as part of the mechanical engineering curriculum in 1915. A five-year program, leading to the B.S.E. in industrial engineering was introduced in 1924, and in 1934, the fifth year of study, which was confined to industrial engineering, became a Graduate School program. A four-year curriculum in industrial engineering was initiated in 1946. In 1952 the Department of Mechanical Engineering was renamed Department of Mechanical and Industrial Engineering. In 1956 the Department of Industrial Engineering was established as a separate unit. It is the youngest department in the College of Engineering. Initially it was concerned with the more traditional industrial engineering subjects of work measurement, production processes, engineering economics, and management engineering. To these areas have been added operations research, management sciences, computer-aided design, and design of information-processing systems. The traditional areas have been continuously revised and merged and the recent and traditional techniques have been blended to form a spectrum ranging from well-structured large-scale systems problems to problems primarily human related both at the level of the individual (human performance) and at the level of the organization (management engineering and organization theory).

The first M.S. was awarded in 1960 and a total of 191 have been awarded. The first Ph.D. was conferred in 1959 and a total of 26 have been granted.

Research and development projects currently in progress include: mathematical programming; prediction of human performance on manual tasks; allocation of resources for required medical programs; defense systems and operations research; industrial flow processes; computer graphics and computer aided design; hospital systems; design of information processing systems; industrial engineering practices in small business.

Department of Mechanical Engineering--The first official mention of mecahnical engineering at the University appeared in the Regents' proceedings for December, 1868. It was then that Professors DeVolson Wood and Stillman W. Robinson requested the Regents to establish a course in mechanical engineering, and to include a program description and degree requirements in the University's catalogue. On motion of Regent Sill, the request was granted. Thus began the program that within a century would be responsible for more than 8,000 of the degrees awarded at Michigan.

As a separate course, mechanical engineering did not have an entirely successful beginning. After just two years, the Regents abolished the degree of Mechanical Engineer, resolving that the course work be absorbed into an extended program in civil engineering. Professor Wood continued to teach the orphaned ME courses, but resigned in 1872 to become Dean at Stephens Institute of Technology.

It was not until nine years later that Mechanical Engineering got an effective advocate: Mortimer E. Cooley, a graduate of the U. S. Naval Academy (1878) and an Assistant Engineer in the U. S. Navy. Cooley was detailed to the University as Professor of Steam Engineering and Iron Ship-building, and his first assignment was to establish mechanical engineering courses within the Department of Civil Engineering. A month after he arrived, his title was changed to Professor of Mechanical Engineering--which meant that after 11 years of dependence, ME was once again recognized as an independent specialty.

The first B.S. in mechanical engineering was awarded in 1885; the first M.E. degree, in 1895; the first M.S.E. in mechanical engineering, in 1902; the first M.S.(M.E.), in 1920; and the first Ph.D. in 1931. Over 1,000 master's level and 100 doctoral degrees have been awarded by the Department.

The graduate programs leading to the M.S.E. and the Ph.D. degrees have flourished in recent years, and the general trends in education will undoubtedly make them still more important in the coming years. These programs have been carefully examined and revised by our faculty during the past two years. The 30-hour program leading to the Master's degree includes two courses elected from the areas of materials, stress analysis, and dynamics; two courses elected from the areas of thermodynamics, fluid mechanics, and heat transfer; and two courses in graduate-level mathematics. These requirements are intended to provide the student with breadth of coverage at a relatively advanced level, while still allowing him enough flexibility to specialize in greater depth in an area of particular interest to him.

Students who continue for the Ph.D. must demonstrate sufficient background and breadth of knowledge in the doctoral preliminary exam, which has been revised to consist of written and oral exams in four of the six areas mentioned above plus one elective area. After this exam, the doctoral program includes advanced course work, demonstration of proficiency in one foreign language, and the doctoral dissertation.

Research in the Department today is extensive and varied, including experimental and analytical investigations of problems exemplified below. Research projects give both graduate and undergraduate students an opportunity for employment, as well as valuable experience in the design and construction of experiments and equipment, the use of specialized instrumentation, and the analysis of advanced problems.

On the Main Campus, the Department occupies facilities in the West Engineering and East Engineering Buildings. On the North Campus, its facilities are in the Automotive Engineering and Fluids Engineering Laboratories. Most of its 14 laboratories are located in these two North Campus buildings. Many of those laboratories serve a dual purpose, being utilized not only as teaching laboratories at both undergraduate and graduate levels but also as research facilities. The nature and scope of the research efforts in these laboratories cannot be described here in detail, but a brief description of the types of problems studied recently and currently in progress should indicate the variety of activities and interests within the Department.

In the Automotive Engineering and Combustion Laboratories, extensive research has been conducted for many years on fundamental problems related to industry. This research is particularly relevant today in view of increased public emphasis on problems related to vehicle and highway safety and to air pollution. Examples of this research include studies of basic combustion phenomena, wall-quenching, the relation of carburetor metering to exhaust emission, computer simulation of carburetor flow, the effect of mixture motion on combustion, combustion phenomena in supercharged engines, tire mechanics, vehicle reliability, vehicle brake stability, and road-tire interface conditions. Several of these and other projects are being conducted in conjunction with the University's recently established Highway Safety Research Institute.

The general areas of design and automatic control include the Department's Automatic Control, Computer-Aided Design, Mechanical Analysis, and Mechanical Design Laboratories. In addition to teaching responsibilities in the areas of automatic control, instrumentation, dynamics, mechanical analysis and design, considerable research efforts are in progress in such fields as the reliability of mechanical components, basic research in biomechanics, development of orthetic and prosthetic devices (in conjunction with researchers from the University's Medical School). There is great emphasis on the areas of digital, analog, and hybrid computers, dealing with methodology and programs for simulating mechanical systems, including the use of graphic display.

Research in the Materials Processing Laboratory deals with problems and phenomena involved in various types of machining, in numerical control, plastic deformation, and welding. In the Rheology and Fracture Laboratory, a number of studies are currently in progress concerning the basic properties and behavior of solids, including yielding, strain-hardening, strain-aging, fatigue, sliding friction, and solid-interface behavior.

Research in the Thermal-Fluid Sciences has been conducted for a number of years on a wide variety of subjects, and includes work in six Department laboratories. Problems dealing with cavitation in liquid-metal flow, multi-phase flow phenomena, and acoustics are being studied in the new Cavitation and Multi-phase Flow Laboratory. Current research in the Fluid Dynamics Laboratory is concerned with rarefied gas flow, low-density transport properties, and unsteady and separated flows. Many investigations have been conducted in the Heat Transfer Laboratory, examples of which include the effects of high and low gravity on heat transfer, boiling phenomena, oscillating flows, problems related to thermal design of nuclear reactors, transient pressurization of cryogenic vessels, thermal stresses, radiation, and stationary and oscillatory stability. Studies involving rehological properties of lubricants and fluid film thickness by optical interference techniques are presently being conducted in the Lubrication Laboratory. In the Power and Fluids Laboratory, current research deals with viscous flow in ducts and blade passages, and with problems related to jet pump performance and switching characteristics of fluid amplifiers. Research on cryogenic phenomena thermodynamic properties, thermal diffusion, and direct energy conversion is conducted in the Thermodynamics Laboratory.

Department of Physics--Physics was first taught at the University in 1843, under the name of natural philosophy. In the early 1870's the lectures and recitations in physics began to be accompanied by demonstrations. The first instructional laboratory was opened in 1878, and the first laboratory building was erected in 1887-88. Under H. S. Carhart, who was in charge of physics from 1886 until 1909, the Department advanced rapidly, and began to establish its reputation for research. Particularly noteworthy in the Department's pre-World War II history was a series of summer seminars, beginning in 1928 and lasting through 1941, on theoretical physics, supplemented by informal symposia on the most recent developments. Among the lecturers who came to Ann Arbor were H. A. Kramers, Enrico Fermi, Arnold Sommerfeld, Wolfgang Pauli, Werner Heisenberg, Niels Bohr, P. P. Ewald, H. A. Bethe, J. R. Oppenheimer, and E. O. Lawrence, and the Department's own George E. Uhlenbeck, S. A. Goudsmit, Otto Laporte, D. M. Dennison, and Kasimir Fajans also participated.

Presently, research is being conducted in high-energy, atomic, molecular, and low-temperature physics, cosmic rays, spectroscopy, shock waves, radiocarbon dating and low-background counting, and other areas. Spark-chamber and scintillation-counter techniques are being used to study the properties and interactions of elementary particles. Michigan physicists working in this area pioneered in the development of spark chambers for use in high-energy experiments. In bubble-chamber research (the bubble chamber was invented at the University in 1955 by Donald Glaser), construction and testing of a unique heavy-liquid bubble chamber were recently completed; the chamber is being

used at Argonne National Laboratory. Presently, new particles are being sought in antiproton-proton annihilations, using bubble-chamber film from a liquid hydrogen chamber at Argonne. Other experiments involve studying the decay properties of already discovered particles and testing the validity of what are known as "symmetry principles" which are supposed to be obeyed by all elementary particles.

Michigan physicists are studying cosmic-ray air showers at the Chacaltaya laboratory (17,500 ft.) of the Bolivian University near La Paz, observing large air showers and studying the detailed properties near the central cores. Ideas of the origin of cosmic rays, their composition, and the interactions of nuclear particles at energies beyond those obtainable from accelerators will be tested by the observations. An exciting new aspect of the research is the observation that radio pulses are generated by air cosmic ray showers. These pulses are currently being studied.

A program of experimental investigations in nuclear physics is being carried on in the Department's Cyclotron Laboratory on the North Campus. In addition to nuclear structure studies, many other investigations are being conducted, as, for instance, detailed studies of the mechanism of a nuclear reaction.

Investigations in nuclear spectroscopy are concerned with the precise measurement of the energy levels of nuclei and the evaluation of the properties of these levels and of the radiation following a nuclear transition between levels. Among the different techniques used to measure the many and varied nuclear properties are measurement

of beta spectral shapes, angular correlation, conversion, electron and gamma ray intensity, gamma ray spectroscopy, precision timing, etc.

The present program in molecular spectroscopy consists of experimental research in both the far and the near infrared, using high-resolution spectrometers, and in theoretical caluclations. The area of interest includes both the simpler poly-atomic molecules and the larger molecules of biological importance.

Work in shock-tube research has two basic aspects, the fluid-dynamic study of shock waves and the spectroscopic study of shock-generated, high-temperature plasmas. Presently, spectral line broadening and ionization processes in optically thick plasmas of mercury gas are being studied for the first time. Shocks in water vapor are also being investigated.

In cooperation with the Museum of Anthropology, the Department operates a radiocarbon dating and counting laboratory as a service for investigators from outside as well as from within the University. Two CO_2-CS_2 Geiger counters are operated continuously, dating about 5 specimens per week.

An apparatus which produces beams of H^+, He^+, and He^{++} is in operation. These beams are being used to study charge transfer processes. An understanding of the interactions involved has important implications for plasma and upper-atmosphere physics.

Nonlinear interactions between matter and intense laser-produced radiation are being studied. Interest is presently centered on optical fluid harmonic generation in atomic gases and vapors, particularly cesium where a resonant effect is predicted.

In low-temperature research, experiments are in progress to study quantized vortex rings and lines in liquid helium and to use charged particles as probes to study the nature of the superfluid state.

Four members of the Department have varied and active interest in biophysics. Areas of research include the supra molecular and molecular structure of biological systems, problems of vision, and theoretical biophysics. The group has been successful in studying the physical nature of photopigment molecules (rhodopsin) in retinal photoreceptors. Research is also being conducted on newly discovered early electrical signals which are thought to be generated as the result of the first interaction between visible light and rhodopsin.

In theoretical physics, work is proceeding on general mathematical properties of theories and on weak interactions of "elementary" particles. A second important area of research is in strong and electromagnetic interactions. Models of the particles, i.e., of their composite structure either in terms of particles like themselves in a self-consistent manner (so-called bootstrap) or in terms of more fundamental particles (e.g., quarks), are proposed and tested.

Almost all the investigations mentioned here, as well as others being carried on in the Department, involve the participation of doctoral students.

Department of Political Science--The Department evolved from courses taught in the Department of History and in the Law School. In 1860, when the country was passing through a constitutional crisis, Thomas M. Cooley was appointed to teach constitutional law. A School of Political Science, with a curriculum of undergraduate and graduate work leading to the doctorate, was established in 1881. Under the leadership of Cooley and Charles Kendall Adams, this School attracted considerable attention both in the United States and in Europe. Twenty years later, courses in political science were again offered by the Department of History. John A. Fairlie, who taught courses in administrative law and municipal administration, rendered important service to the State as a member of the Constitutional Convention of 1907.

In 1910 the Department of Political Science was officially established, and Jesse S. Reeves became the first chairman. Interest in municipal administration increased under R. T. Crane, who came to the University in 1913. After World War I an increasing interest in government resulted in expansion of the Department. Joseph R. Hayden was especially concerned with the administration of the Philippine Islands, and served for several years as Vice-Governor. As departmental chairman he was succeeded by Everett S. Brown and the late James K. Pollock, Jr. After World War II, there was a further expansion of activities, with specialists in regional areas, international relations, and public administration.

The past five years have again seen great expansion of the department. The change has been not only in the number of faculty members but even more dramatically in general orientation because of retirements and resignation. The present department is young (thirty members are under the age of thirty-five); twenty-nine of its members have joined it in the last five years. Most of the new members possess the research tools and interests that encourage and facilitate the use of complex data-processing facilities, that is, they are associated with the academic movement in political science often referred to as "behavioral." This is also true of our graduate training program: all our students are exposed to the new technology, and an increasing proportion now make extensive use of it in their graduate program. This is a tendency that we encourage and expect to expand.

Translated into specific research projects, this means an ever-increasing involvement in comparative studies of electoral behavior that involve, at present, national plus elite surveys in ten countries; an expanding project concerning the inner city of Detroit; research on Congress that involves interviews and roll-call analysis; a cross-cultural study of bureaucratic elites; simulation of budgetary processes in urban areas (to be expanded into a project of simulation of an urban environment); several large studies of political socialization involving large samples; and many other projects of which these are representative. Increasingly, graduate students are involved in the studies and, especially, make use of the data archives that these

studies make possible. The computer is used for data analysis in graduate courses in the areas of statistics, electoral behavior, legislative behavior, political socialization, and comparative politics. A special course is taught in computer simulation, and computer simulation is included in a special summer seminar on mathematical analysis in political science.

8.2 PROGRAMS OF PRINCIPAL PERSONNEL

Percentage of Time Devoted to Teaching and Research

Unit	Teaching	Research
School of Business Administration	76	24
Department of Civil Engineering	80	20
Department of Computer & Communication Sciences	70	30
Department of Electrical Engineering	65	35
Department of Industrial Engineering	68	32
Department of Mechanical Engineering	80	20
Department of Physics	65	35
Department of Political Science	65	35

8.3 RESEARCH AND TEACHING TO BE IMPROVED BY THE PROPOSED FACILITY

The proposed facility will enable the School of Business Administration to (1) increase the number of graduate students at both the Ph.D. and the M.B.A. level who can be given the opportunity to participate in

active research projects, thereby expanding the ability of the School to give practical research training to interested students; (2) increase the general scope of the School's research activities through greater sophistication in developing methodologies for testing new concepts in business and economics; (3) provide greater opportunity for faculty participation in research; (4) shorten the time lag between the development of concepts and their use in the curriculum of the School; and (5) provide, in the case of computer use, the means for a greatly expanded interaction between the students of the School and the computer.

The Department of Civil Engineering anticipates that research in computer control of engineering processes and automatic real time control of mechanical and fluid operations will be initiated in the near future. The location of the proposed facility, near the engineering laboratories, will be a definite advantage during the development phase of this work. The improvement of the efficienty of the services to be provided by the new building, thus increasing the Computing Center's dependability, will of course be a permanent advantage.

The Department of Computer and Communication Sciences trains many of its graduate students as consultants and researchers in the Computing Center and expects this activity, as well as those of the faculty, to be significantly enhanced by the availability of more space, appropriately designed.

The Department of Electrical Engineering needs additional space for all its graduate research activities, including the computer area. The proposed facility will help to alleviate some of the current pressures.

The Department of Mechanical Engineering uses the present computer facilities as an integral part of both its teaching and research. Essentially all the Department's professional engineering courses use the computer in one way or another. Frequently, the entire class is assigned a computer code word; the student works out the solution or evaluation of a problem by the use of the computer. Five remote consoles are available to the students in the College of Engineering, two of them in this department. All the Department's research programs use the computer extensively. In the area of the thermal sciences the computer is the only way many problems can be solved; classical mathematics simply is inadequate for this task. Furthermore, for those problems in which classical mathematics is suitable, the computer is required to reduce the results to numeric form.

The Department of physics looks forward to well-organized work areas, storage areas, service windows, and direct observation of the equipment in a building specifically designed as a computing center. The user-oriented facility proposed here, offering vastly improved access, will relieve the Department of many of the difficulties experienced presently.

The Department of Political Science expects significant improvements resulting from the availability of additional space; the over-burdening of the present facility by far more persons than can be accommodated has forced the Department to send auxiliary equipment elsewhere, not so much to lessen the attendant inconveniences as simply to get its work done.

8.4 BIOGRAPHICAL INFORMATION

Biographical data on the Computing Center's Executive Committee and key personnel are presented in the following pages.

BARTELS, ROBERT C. F.

Director and Chairman,
Executive Committee,
Computing Center;
Professor of Mathematics

Education: Univ. of Wisconsin: Ph.B., 1933, Ph.M., 1934, Ph.D., 1938.

Positions Held: Academic

Univ. of Wisconsin: Grad. Asst., Dept. of Math., 1934-38; Univ. of Mich.: Dept. of Math.: Instr., 1938-45, Asst. Prof., 1945-50, Assoc. Prof., 1950-57, Prof., 1957--; Director, Computing Center, 1959--.

Other: Bell Telephone Labs.: Tech. Asst., 1927-30; Consolidated Motion Pictures, Quality Control. 1933-34; Dept. of the Navy, Bureau of Aeronautics, Aero. Engineer, 1942-45; Oak Ridge Natl. Lab. Inst. of Nuclear Studies, Research Participant, 1954-55; NIH, Computer Research Study Section, Member, 1962-66; Argonne Natl. Lab., Review Com. for Appl. Math. Div., Member, 1965-68.

Selected Publications:

"Resolution of Boundary Problems by the Use of a Generalized Convolution" (with R. V. Churchill), *Bull. Am. Math. Soc., 48*: 276-82 (1942).

"Torsion of Hollow Cyliners," *Trans. Am. Math. Soc., 53*: 1-13 (1943).

"On Surface Waves Generated by Traveling Disturbances with Circular Symmetry (with A. C. Downing), Univ. of Mich. Engineering Research Institute Report, ONR Contract NObsr-52379, 1953; pub. in *Proc. 2nd U. S. Natl. Cong. of Applied Mech.*

"Topics on the Numerical Solution of Partial Differential Equations," Oak Ridge Natl. Lab., Contract No. W-7405-eng-26, 1-59 (1956).

Discussion of V. Streeter and C. Lai, *Water-Hammer Analysis Including Fluid Friction*, in: *Proc. Am. Soc. Civ. Eng., J. Hydraul. Div., 89:* No. HY1, 208-210 (1963).

JACQUEZ, JOHN A.

Member, Executive Committee, Computing Center; Associate Professor of Biostatistics and of Physiology

Education: Cornell Univ.: 1940-43; Cornell Med. Coll.: M.D., 1947.

Positions Held: Academic
S-K Div. of Cornell Univ. Med. Coll.: Instr. (Biol.), 1952-53; S-K Div. of Cornell Grad. School of Med. Scie.: Asst. Prof., 1956-58, Assoc. Prof., 1958-63; Univ. of Mich. Med. School, Assoc. Prof. (Physiol.), 1962--; Univ. of Mich. School of Public Health: Assoc. Prof. (Biostat.), 1962--.

Other: Sloan-Kettering Inst.: Res. Fellow, 1947-50, Asst., 1950-53, Assoc., Div. Exper. Chemo., 1956-60, Assoc. Member, 1960-62; Rockefeller Inst. for Med. Res.: Vis. Investigator in Path. & Bact., 1947-48.

Scholarships, Fellowships, Hon. Soc.: State scholarship to Cornell Univ., 1940; Cornell Univ. Scholarship, 1940-43; Phi Beta Kappa, Phi Kappa Phi, Cornell Univ.; Nat. Cancer Inst. Postgrad. Res. Fellow, 1948-50; Sigma Xi.

Professional Memberships: Am. Assoc. for Cancer Res., AAAS, The Harvey Soc., Am Physiol. Soc., Biophys. Soc., ACM, Soc. Ind. Appl. Math.

Selected Publications:

"Relationship of Iodine Ingestion to Iodine Excretion in Pregnancy" (with H. J. Dworkin and W. H. Beierwaltes), *J. Clin. Endocrin. Metab.*, *26*: 1329-42 (1966).

"Quasilinerazation and the Estimation of Chemical Rate Constants from Raw Kinetic Data" (with R. Bellman, R. Kalaba, and S. Schwimmer), *Mathematical Biosci.*, *1*: 71-76 (1967).

"A Model of the Renal Cortex and Medulla" (with B. Carnahan and P. Abbrecht), *Mathematical Biosci.*, *1*: 227-61 (1967).

"Transport of Amino Acids in Ehrlich Ascites Cells: Competitive Stimulation: (with J. A. Schafer), *Biochim. et Biophys. Acta*, *135*: 751-60 (1967).

JACQUEZ, JOHN A.

Selected Publications: (continued)

"Competitive Stimulation: Further Evidence for Two Carriers in the Transport of Neutral Amino Acids," *Biochim. et Biophys. Acta, 135*: 751-55 (1967).

"Change in Na+ Uptake during Amino Acid Transport" (with J. A. Schafer), *Biochim. et Biophys. Acta, 135*: 1081-83 (1967).

LESCH, JAMES E.

Member, Executive Committee, Computing Center; Assistant to the Vice-President for Academic Affairs

Education: DePauw Univ.: A.B., 1943; Purdue Univ.: grad. studies, 1946-50; Univ. of Mich.: grad. studies, 1956-57.

Positions Held: Academic

DePauw Univ.: Teaching Lab. Asst. (chem.), 1942-43; Purdue Univ.: Teaching Asst. (physics), 1946-50; Cornell College: Instr. (physics), 1950-51; Univ. of Mich.: Res. Asst., 1954-55; Res. Assoc., 1955-58; Project Rep., 1958-59; Asst. to Director of Univ. of Mich. Res. Inst., 1959-61; Asst. Dir. of Res. Admin., 1961-62; Asst. to Vice-President for Academic Affairs, 1962--.

Other: Department of the Navy: ONR, Anti-Submarine Warfare Branch, Scientific Officer, 1951-54.

Professional Memberships: Sigma Pi Sigma.

SMITH, J. E. KEITH

Member, Executive Committee, Computing Center; Professor of Psychology and Research Psychologist

Education: Iowa State Coll.: B.S., 1949; Univ. of Mich.: A.M., 1952, Ph.D., 1954.

Positions Held: Academic

Iowa State Coll.: Teaching Asst. (math.), 1948-49; Res. Asst. (Stat. Lab.), 1949-50; Univ. of Mich.: Survey Res. Center: Asst. Study Dir., 1950-51; Res. Asst. (Psych.), 1951-52; Teaching Fellow, 1952; Res. Asst., 1952-53; Res. Train. Fellow, Social Science Res. Council, 1953-54; M.I.T.: Lincoln Lab.: Staff Psych., 1954-64; Univ. of Mich.: Professor of Psych. and Res. Psych. (Mental Health Res. Inst.), 1964--.

Other: Consulting ed. for *Psych. Bull.*, Consultant for Child Health and Human Dev. Comm. (NIH), Behav. Sci. Train. Comm. (NIGMS).

Professional Memberships: Am. Psych. Assoc. (Fellow), Am. Stat. Assoc., Biometric Soc., Inst. Math. Stat., Psychomet. Soc., Psychonomic Soc., Phi Kappa Phi, Pi Mu Epsilon, Psi Chi, Sigma Xi.

Selected Publications:

"Vowel Recognition Using a Multiple Discriminant Function" (with L. Klem), *J. Acoust. Soc. Am., 33*: 358 (1961).

"Decision Theoretic Speaker Recognizer," *J. Acoust. Soc. Am., 34*: 1988(a) (1962).

"Some On-Line Uses of Computers in the Behavioral Sciences," presented at Am. Assoc. for Public Opinion Res. conf., Groton, Conn., May 14, 1965; Univ. of Mich. MHRI Preprint 161.

"Multivariate Analyses of Variance and Discriminant Functions," presented at Am. Psych. Assoc., Sept. 7, 1965; Univ. of Mich. MHRI Preprint 177.

"The Organizing Efficiency of Theories: the N/V Ratio as a Crude Rank Order Measure" (with J. D. Singer and K. Deutsch), *Am. Behav. Scientist, 9*: 30-33 (1965).

STREETER, VICTOR L.

Member, Executive Committee, Computing Center
Professor of Civil Engineering

Education: Univ. of Mich.: B.S.E., 1931, M.S.E., 1932, Sc.D., 1934.

Positions Held: Academic
Ill. Inst. Tech.: Assoc. Prof., 1941-45, Prof., 1945-54; Univ. of New Zealand; Vis. Fulbright Lec., 1952; Univ. of Mich.: Prof., 1954--; Univ. of Colo.: Vis. Prof., 1963.

Other: U. S. Bur. of Reclamation: Hydraulic Lab. (Denver, Colo.): Junior Eng., 1934-35,Asst. Eng., 1936-38, Assoc. Eng., 1938-39; U. S. Section of Internatl. Boundary Comm.: Assoc. Hydraulic Eng., 1939-41; David Taylor Model Basin, Assoc. Eng., 1942; Armour Res. Found.: Supervisor of Fluid Mech., 1945, Chairman, Fluid Mech. and Thermodyn. Div., 1945-47; Res. Prof. and Dir., Fundamental Fluids Res., 1947-54.

Professional memberships: F. ASCE, M. ASEE, M. ASME (Fluid Transients Comm.), M. IAHR.

Honors and Awards: Sigma Xi, Iota Alpha, Phi Kappa Phi, Chi Epsilon; Freeman Travel Scholarship, ASME, 1935-36; Collingswood Award for Juniors, ASCE, 1938; Citation, Univ. of Mich., 1953; James Clayton Fund Award, Inst. Mech. Eng., 1967.

Selected Publications:

"Computer Solution of Surge Problems," Inst. Mech. Eng., London, Symposium on Surges in Pipelines, Nov., 1965, *Proc. 1965-66, 180*: 3E, 1-21.

Fluid Mechanics (4th ed.), McGraw-Hill Book Co., 1966.

Hydraulic Transients (with E. B. Wylie), McGraw-Hill Book Co., 1967.

"Valve Stroking for Complex Piping Systems," *J. Hydr., 93*: HY3, ASCE, 81-98 (May, 1967).

"Waterhammer Analysis of Distribution Systems," *J. Hydr., 93*: HY5, ASCE, 185-201, Proc. Paper 5443 (Sept., 1967).

TAYLOR, ROBERT C.

Member, Executive Committee, Computing Center
Professor of Chemistry

Education: Kalamazoo Coll.: A.B., 1941; Brown Univ.: Ph.D., 1947.

Positions Held: Academic
Brown Univ.: Instr., 1947-49; Univ. of Mich.: Instr., 1949-53, Asst. Prof., 1953-58, Assoc. Prof., 1958-62, Prof., 1962--.

Other: Brown Univ.: Manhattan Project Res. Chemist, 1942-46.

Professional Memberships: Am. Chem. Soc., Am. Phys. Soc., AAAS, Alpha Chi Sigma, Sigma Xi.

Selected Publications:

"Raman Spectra and Vibrational Assignments of Aluminum Borohydride and Some Isotopic Derivatives" (with A. R. Emery), *Spectrochimica Acta, 16*: 1455-63 (1960).

"Vibrational Frequencies, Assignments, and Force Constants for Some Compounds Containing Boron-Nitrogen Dative Bonds," *Advances in Chemistry*, Series No. 42, Am. Chem. Soc., Washington, D. C., 1964.

"Spectroscopic Studies of Lewis Acid-base Complexes. I. Vibrational Spectra and Assignments for Trimethylamine Complexes of Boron Halides" (with R. L. Amster), *Spectrochimica Acta, 20*: 1487-1502 (1964).

"Vibrational Spectra and Assignments for $(CH_3)_2NPF_2$" (with M. A. Fleming and R. J. Wyma), *Spectrochimica Acta, 21*: 1189-94 (1965).

"Fluorophosphine Ligands. III. Syntheses Involving PF_2I. The Preparation and Characterization of μ-Oxobisdifluorophosphine, Cyanodifluorophosphine and Tetrafluorodiphosphine" (with R. W. Rudolph and R. W. Parry), *J. Am. Chem. Soc., 88*: 3729 (1966).

WROBLESKI, WILLIAM J.

Member, Executive Committee, Computing Center; Associate Professor of Statistics, School of Business Administration

Education: Univ. of Mich.: B.S., 1953, M.S., 1954, Ph.D., 1963.

Positions Held: Academic

Univ. of Mich.: Institute for Social Research: Res. Asst., Statistics, 1954-55; Dept. of Mathematics: Res. Asst., Res. Assoc., 1955-61; Institute of Science and Tech.: Res. Assoc., 1962-64; School of Bus. Ad.: Asst. Prof., Statistics, 1963-66; Assoc. Prof., 1966--.

Professional Memberships: Member, Exec. Comm., Detroit Chapter, Institute of Management Sciences; Sigma Xi, Delta Sigma Pi.

Selected Publications:

"Applications of the Scientific Method and Statistical Methodology to Large Scale System Evaluation," *Proc. Symposium on Prediction of Performance of Large-Scale Systems*, Vol. I, 1959.

"A Large Scale Sequential Field Observational Program Used in Response Surface Estimation for a Complex Stochastic Structure," *Proc. 4th Conf. on the Design of Experiments in Army Research, Development, and Testing*, Office of Ordinance Research, Report No. 59-2, 1959.

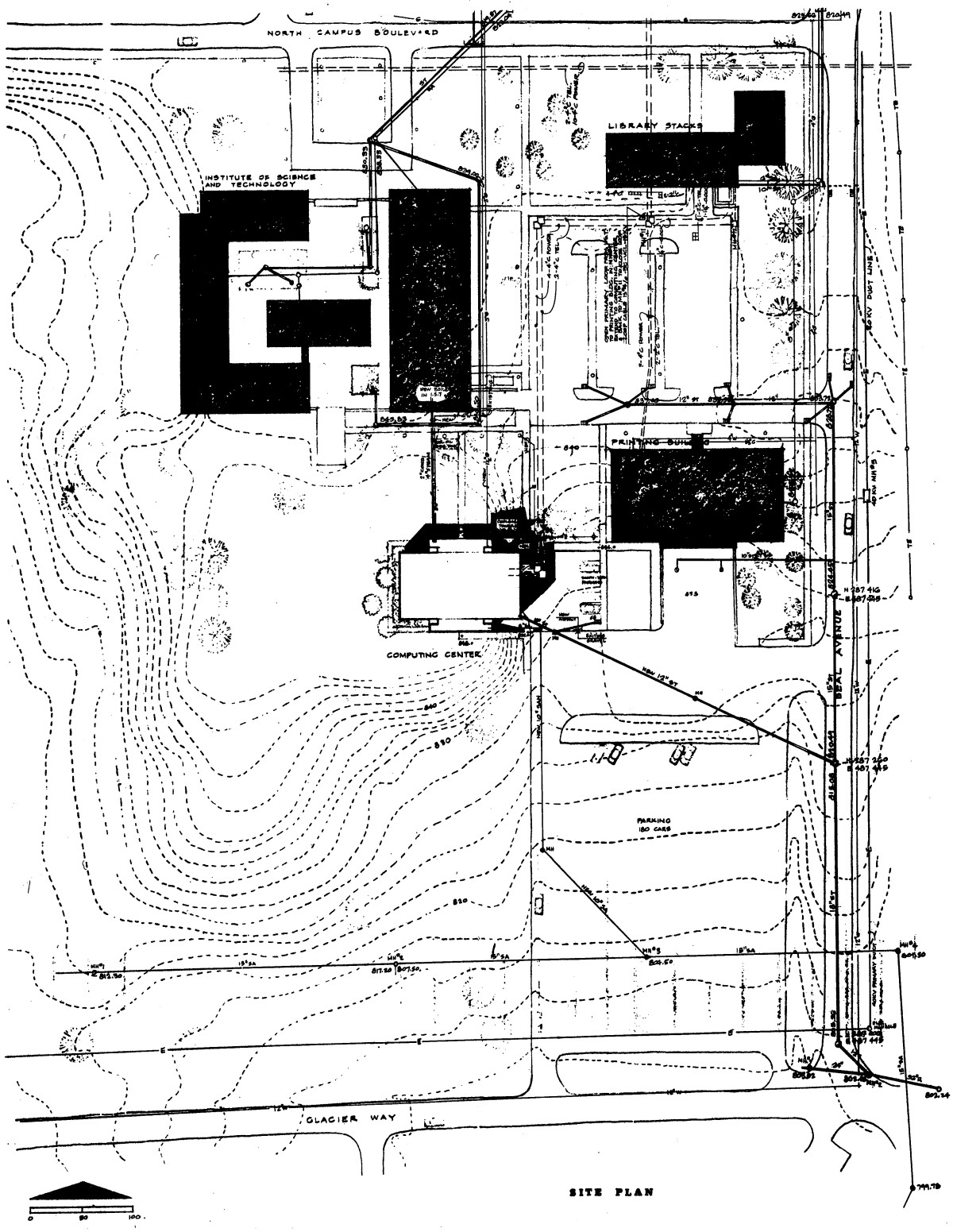
"Theoretical and/or Experimental Phenomenological Laws of Ballistic Missile Electromagnetic Radiation Examined from the Point of View of the Theory of Stochastic Processes," *Trans. BAMIRAC 1960 Summer Study of the State of Knowledge of Missile Phenomenology for Ballistic Missile Defense*, October, 1960.

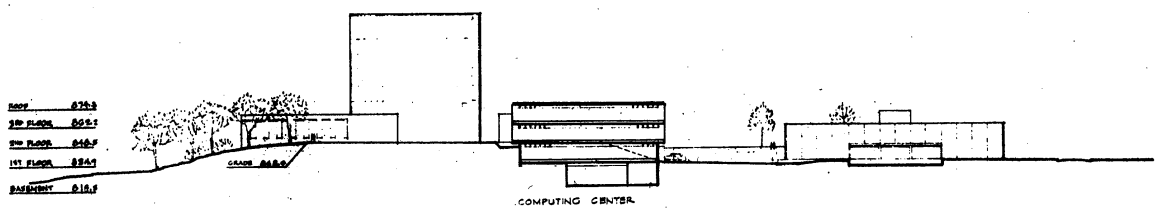
Extensions of the Dwyer-MacPhail Matrix Derivative Calculus with Applications to Estimation Problems Involving Errors in Equations, Univ. of Mich. ORA Report 05266-1-77, 1963.

"Forecasting," *Foundations and Tools in Operations Research and the Management Sciences*, 1965.

SECTION IX. ARCHITECTURAL REQUIREMENTS

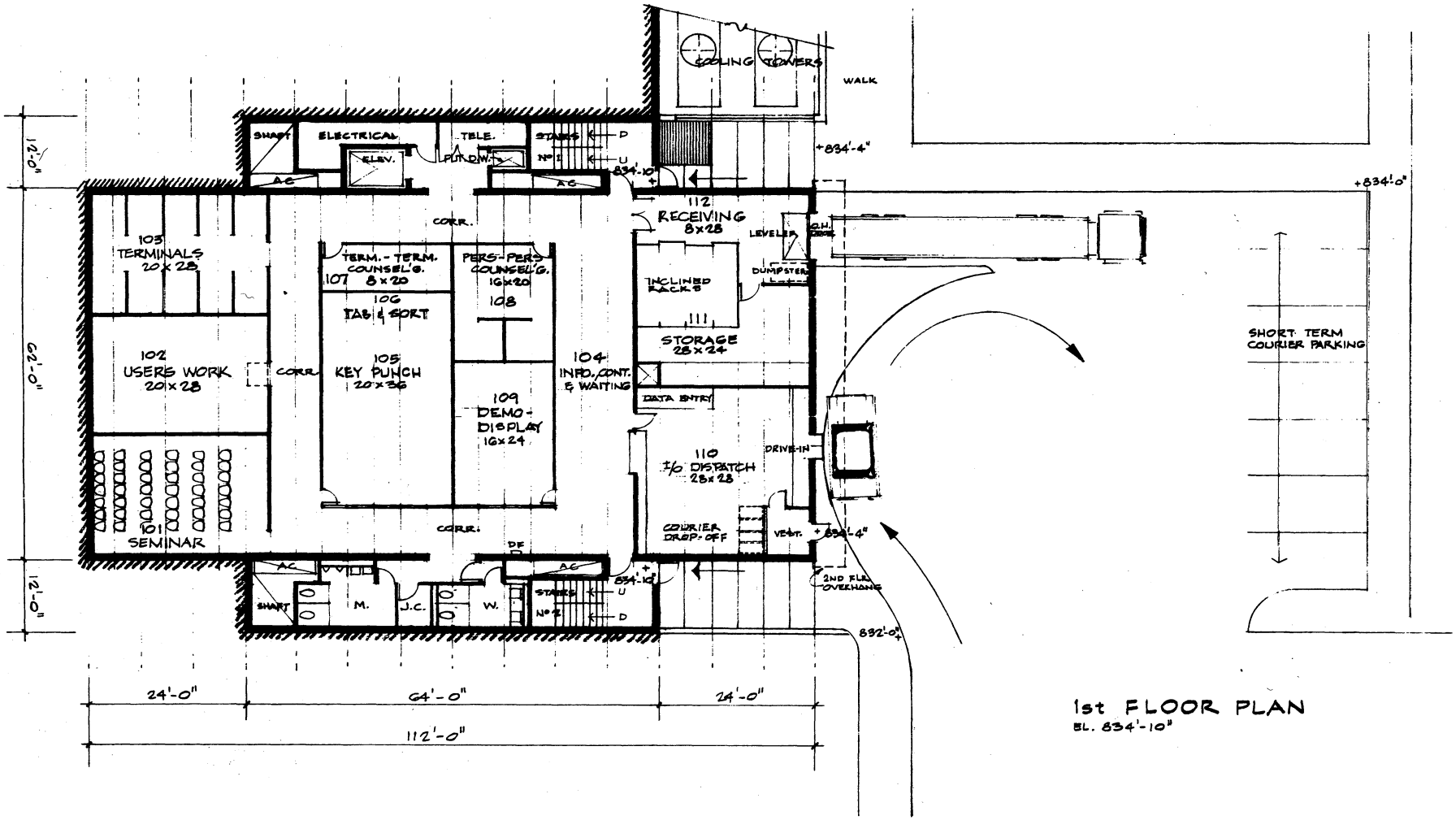
Reproductions of Site Plan and Floor Plans



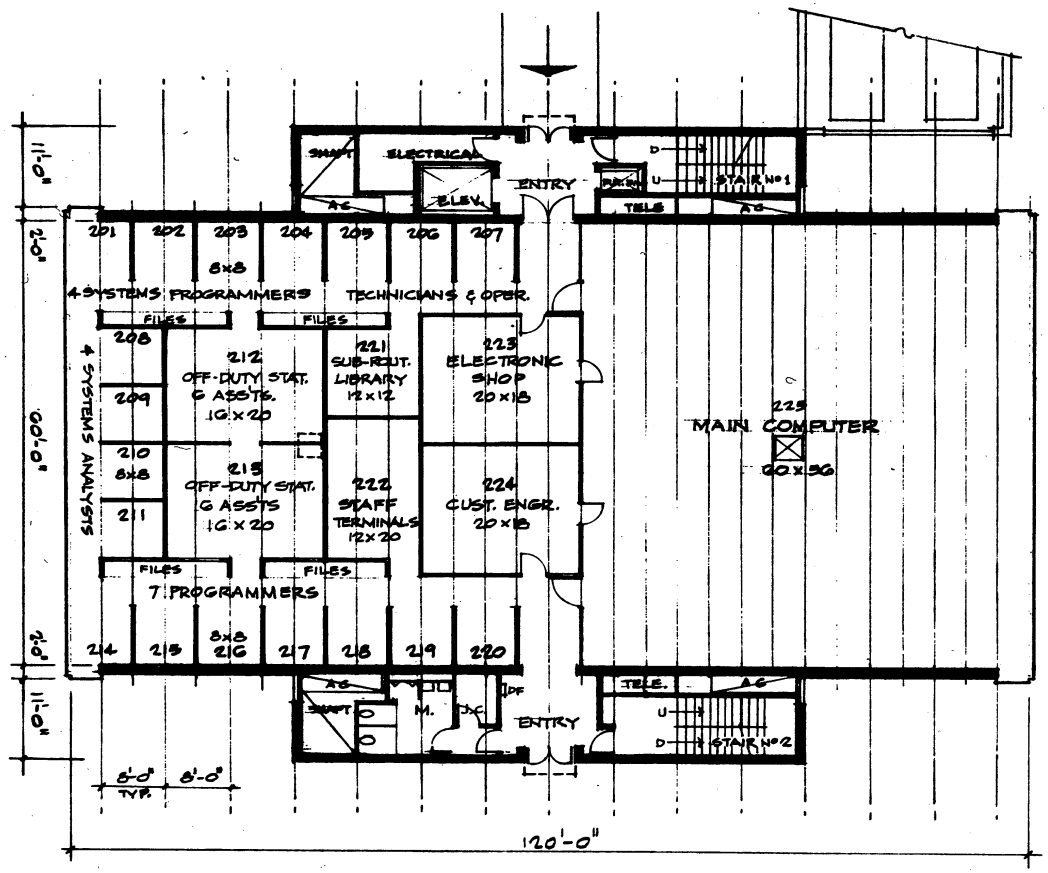


SECTION

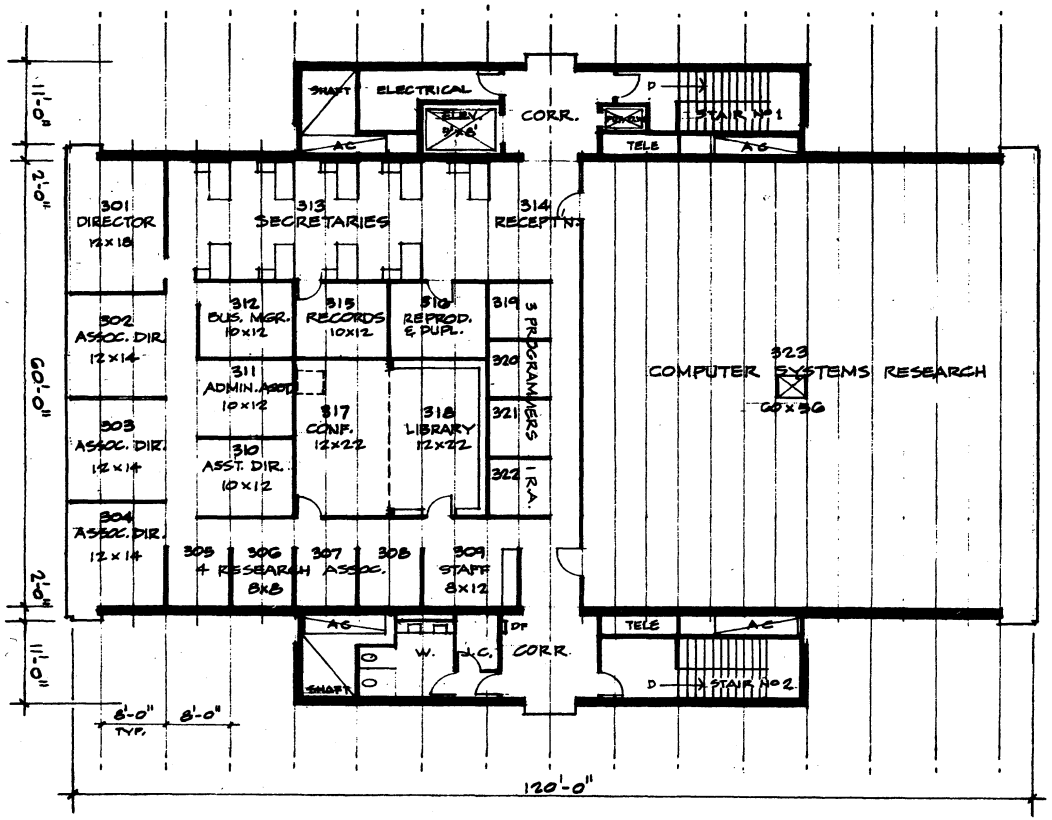
UTILITIES SITE PLAN & SECTION



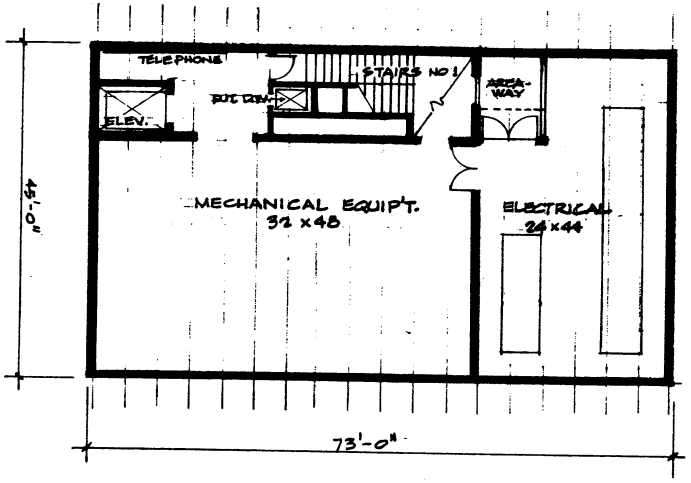
1st FLOOR PLAN
EL. 834'-10"



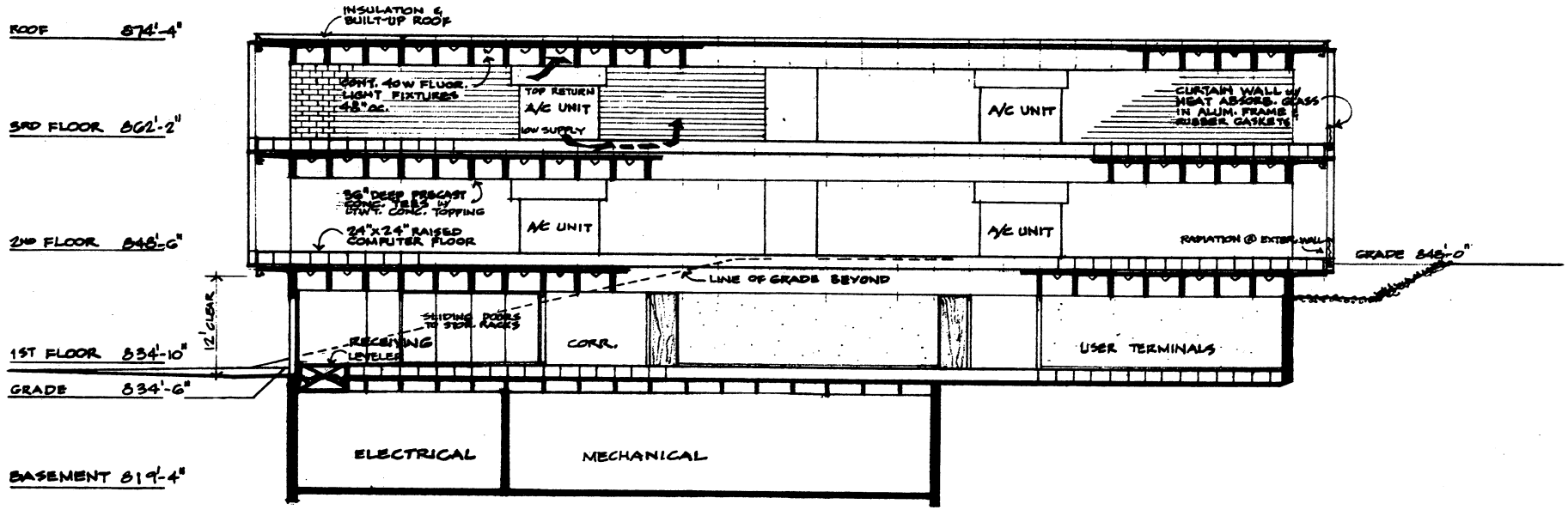
2nd FLOOR PLAN
EL. 848'-0"



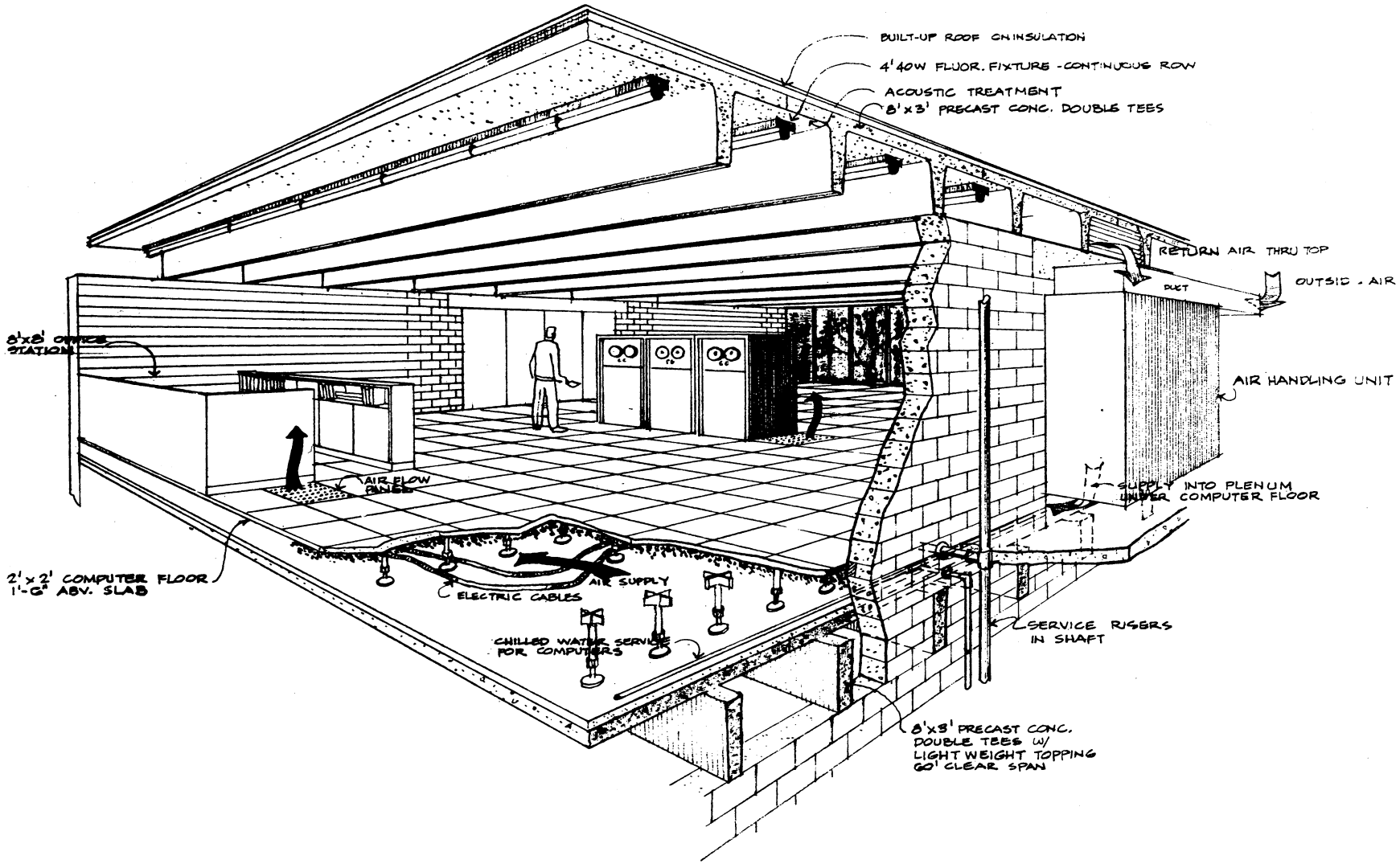
3rd FLOOR PLAN
EL. 862'-2"

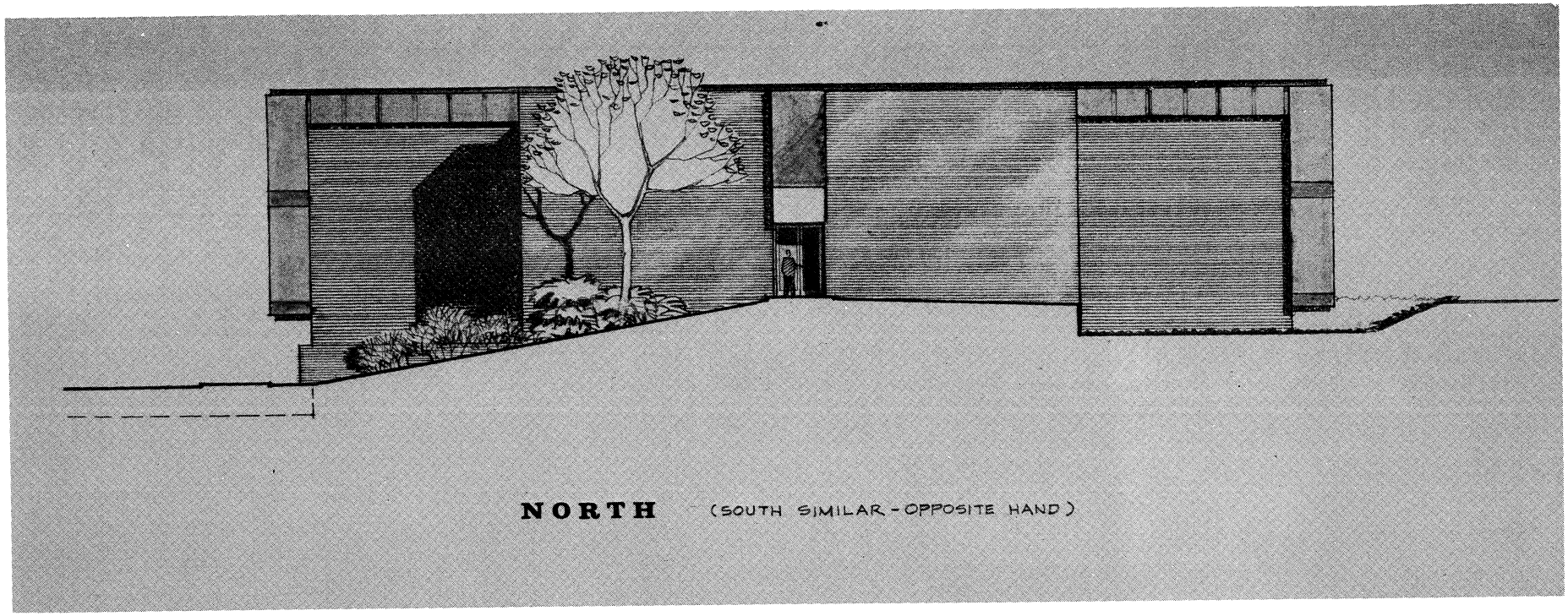


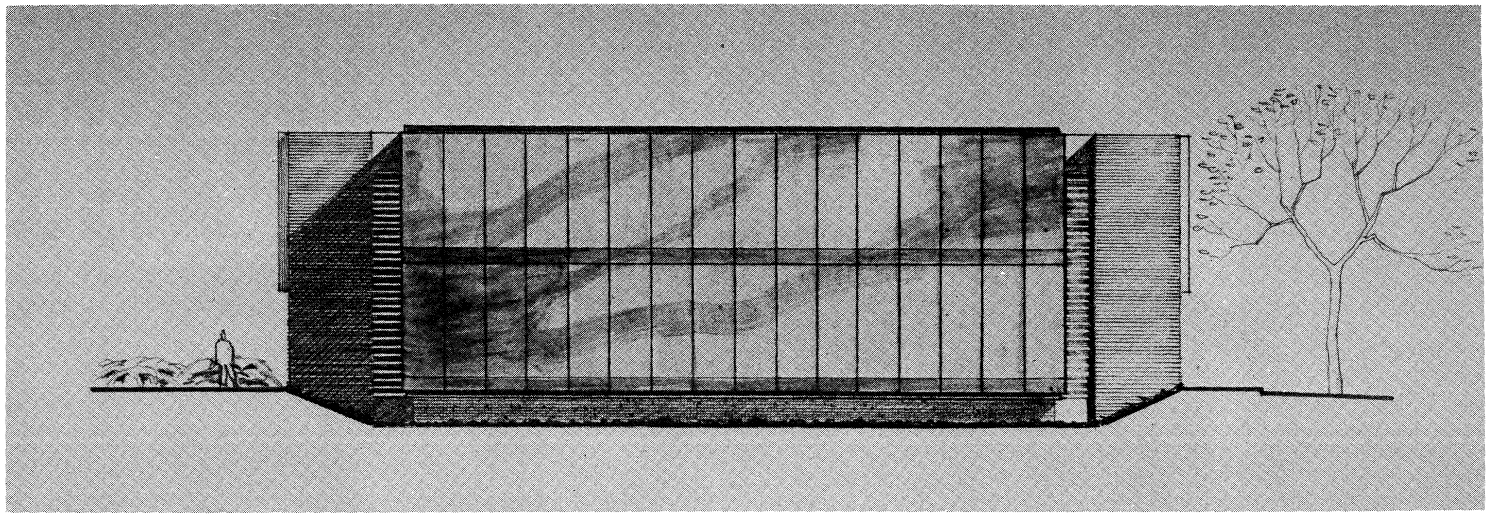
BASEMENT PLAN
EL. 819'-4"


ROOF 874'-4"
3RD FLOOR 862'-2"
2ND FLOOR 848'-6"
1ST FLOOR 834'-10"
GRADE 834'-6"
BASEMENT 819'-4"
INSULATION & BUILT-UP ROOF
CONT. 40W FLUOR. LIGHT FIXTURES 48" oc.
TOP RETURN
A/C UNIT
LOW SUPPLY
A/C UNIT
CURTAIN WALL w/ HEAT ABSORB. GLASS IN ALUM. FRAME & RUBBER GASKETS
36" DEEP PRECAST CONC. TEES w/ LIWT. CONC. TOPPING
24"x24" RAISED COMPUTER FLOOR
A/C UNIT
A/C UNIT
RADIATION @ EXTER. WALL
GRADE 848'-0"
LINE OF GRADE BEYOND
12' CLEAR
SLIDING DOORS TO STOR. RACKS
RECEIVING
LEVELER
CORR.
USER TERMINALS
ELECTRICAL
MECHANICAL

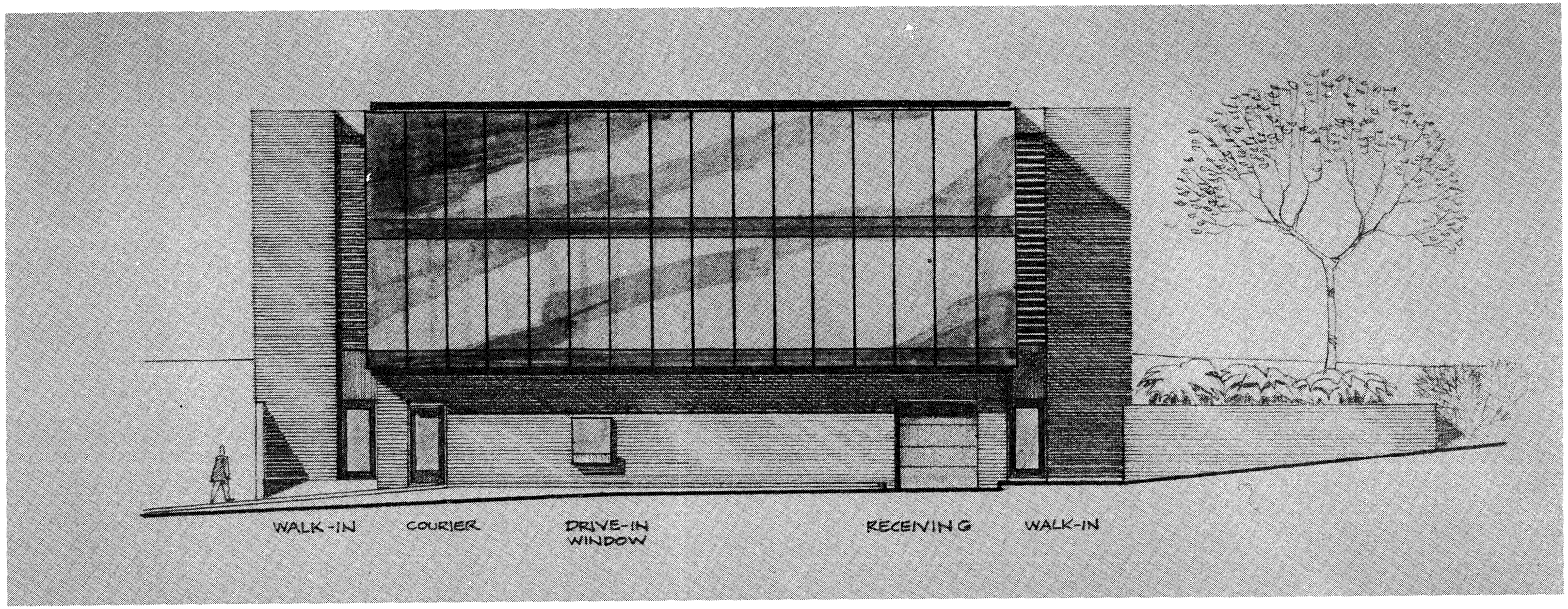
SECTION


BUILT-UP ROOF ON INSULATION
4' 40W FLUOR. FIXTURE - CONTINUOUS ROW
ACOUSTIC TREATMENT
8'x3' PRECAST CONC. DOUBLE TEES
RETURN AIR THRU TOP
DUCT
OUTSIDE AIR
AIR HANDLING UNIT
8'x8' OFFICE STATION
AIR FLOW PANEL
SUPPLY INTO PLENUM UNDER COMPUTER FLOOR
2' x 2' COMPUTER FLOOR 1'-6" ABV. SLAB
ELECTRIC CABLES
AIR SUPPLY
CHILLED WATER SERVICE FOR COMPUTERS
SERVICE RISERS IN SHAFT
8'x3' PRECAST CONC. DOUBLE TEES W/ LIGHT WEIGHT TOPPING 60' CLEAR SPAN

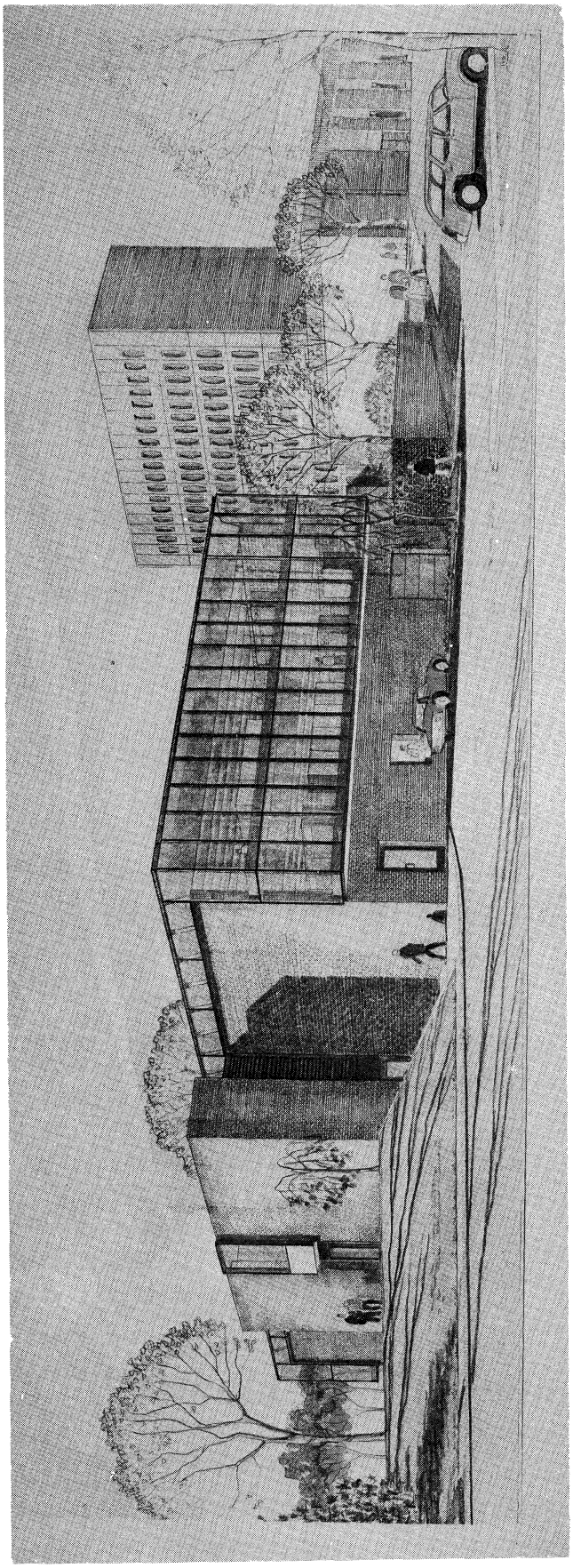

NORTH
(SOUTH SIMILAR - OPPOSITE HAND)



WEST



E A S T



APPENDIX I

The University of Michigan

ANN ARBOR

E. A. CUMMISKEY
WILLIAM P. LEMMER
University Attorneys
3040 Administration Building

January 15, 1969

Department of Health, Education & Welfare
Washington, D. C.

Gentlemen:

Re: Title to Proposed Computing Center Site

I have examined abstract of title covering the site of the proposed Computing Center, which is to be located in the Southwest Quarter of Section 22, Ann Arbor Township (now annexed to the City of Ann Arbor), Washtenaw County, Michigan. The Regents of the University of Michigan has good and marketable title to the entire quarter section free and clear of all encumbrances.

Title in fee simple was acquired by The Regents of the University of Michigan in 1950, and the property has been tax exempt since that date, it being a part of the North Campus of the University of Michigan. The University has access to the proposed Computing Center site from all directions.

Very truly yours,

E. A. Cummiskey

E. A. Cummiskey

EAC/es

The University of Michigan

ANN ARBOR

E. A. CUMMISKEY
WILLIAM P. LEMMER
University Attorneys
3040 Administration Building

January 15, 1969

Department of Health, Education & Welfare
Office of Education
Washington, D. C.

Gentlemen:

Re: Application for Grant to Cover Costs of Computing Center

The Regents of the University of Michigan is a public educational corporation created by the Michigan State Constitution to operate the University of Michigan. It has been held by the Supreme Court of the State of Michigan to be a constitutional corporation of independent authority, and it has legal authority to apply for the grant and to finance and construct the proposed facilities.

At its June 21, 1968 meeting, the Board of Regents of the University of Michigan by official action designated a site for the proposed Computing Center on the North Campus of the University of Michigan, selected an architectural firm to perform the architectural work for the project, and authorized the submission of a request for a federal grant for a part of the cost of the project, as will appear from a certified copy of a portion of the minutes of the June, 1968 meeting attached hereto and made a part of this opinion.

By virtue of Section 3.07 of the Bylaws of The Regents of the University of Michigan currently in effect, W. K. Pierpont, Vice President and Chief Financial Officer, has authority to execute the application approved by the Board of Regents, including all understandings and assurances contained therein, and to provide such additional information as may be required. In the absence or inability of Mr. Pierpont to act, then in his absence the documents may be signed by Howard R. Cottrell, Controller, or H. W. Hildebrandt, Secretary. The pertinent portions of

Bylaw Section 3.07 are as follows:

"2 (b) All contracts for sponsored research and supplements thereto, including agreements for fellowships, scholarships, and grants-in-aid and all contracts covering payment for tuition and supplies may be executed by the Vice-President and Chief Financial Officer, and his signature shall be certified by the Secretary where such certification is requested; provided, however, the Vice-President and Chief Financial Officer is authorized to delegate to designated representatives authority to execute contracts and/or applications for grants or contracts where the amount involved is less than $250,000 and where the commitments anticipated fall within the normal activities of the University.

"2 (c) All discharges of mortgages and cancellations of land contracts may be executed by any two of the following officers; the President, the Vice-President and Chief Financial Officer, the Secretary, and the Investment Officer."

Very truly yours,

E. A. Cummiskey

E. A. Cummiskey

EAC/es

"Approval was given to the site assignment for a computer center on the North Campus, the selection of the architectural firm of Tarapata and MacMahon for the architectural work for the project, and the submission of a request for a federal grant for a part of the cost of the project."

I, H. W. Hildebrandt, Secretary of The Regents of the University of Michigan and official custodian of the minutes, hereby certify that the foregoing is a true extract from the minutes of the meeting of the Regents of the University of Michigan on June 21, 1968, and that the foregoing approval was unanimously adopted at a meeting in which a quorum of the Board of Regents was present and voting.

H. W. Hildebrandt
Secretary

Dated: January 15, 1969.

ASSURANCES

The applicant agrees to incorporate into any contract for construction work related to this proposed grant project or modification thereof, all applicable provisions for equal opportunity in employment, pursuant to Executive Order 10925, as amended by Executive Order 11246, and further assures compliance with all provisions of Section 170.2 of the Regulations governing administration of the Graduate Academic Facilities Program.

January 27, 1969

APPENDIX II

ROOM TABULATION OF NET OR ASSIGNABLE SPACE

	Net Area	Work Stations
ADMINISTRATION		
Director	216	1
Conference	264	10
Administrative Assistant	140	1
Records & Business Manager	120	1
Secretarial	640	8
Receptionist	192	1
Subtotal	1,562	22
RESEARCH & INSTRUCTION		
Associate Director	504	3
Research Associate	480	5
Systems Analyst	384	4
Programmers	1,040	10
Briefing - Seminar	560	42
Counselors	640	12
Technicians	304	3
Subtotal	3,912	79
LIBRARY		
Reading Room	264	8
OPERATIONS & COUNSELING		
Assistant Director	140	1
System Programmer	448	4
Subroutine Files	144	
Counsel - Terminal	160	2
Counsel - Person	320	4
Maintenance - Customer Engineer	360	6
Electrical Shop	360	6
Users Area	560	30
I/O Dispatchers	784	5
Information & Waiting	720	—
Subtotal	3,996	58

	Net Area	Work Stations
EQUIPMENT		
Computer Room	6,720	
Keypunch Room (includes tabulation and sorting)	720	18
Terminal Cubicles	560	10
Staff - Terminal	240	6
Demonstration	384	50
Subtotal	8,624	84
SERVICE & STORAGE		
Storage	896	
Duplicating & Reproducing	120	2
Records & Files	120	
Commons Room	144	—
Subtotal	1,280	2
NET AREA	19,648	253
GROSS AREA	29,720	
NET/GROSS	.662	