**Summary**

Diseases have always been present in plants and have caused many changes in the lives of men. They have influenced what men ate, what they wore, the shelter they used, and so on. Industries have flourished and have disappeared. Famines have occurred; populations have moved; even the outcomes of wars have been influenced. Important plants are frequently attacked. Losses each year in the United States are held down from unknown enormous sums by various control measures. The control of disease is one of the promising means by which developing countries can maintain and advance themselves. Dedicated scientific men, no doubt, will continue serving mankind by their research, extension, and teaching about plant diseases, if given the opportunity. They will need to cooperate with colleagues in related fields.

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# Plans for Project Intrex

## M.I.T. proposes to establish an experimental basis for the design of future information services.

Carl F. J. Overhage

Project Intrex is a program of *in*formation *tr*ansfer *ex*periments directed toward the functional design of new library services that might become operational at the Massachusetts Institute of Technology and elsewhere by 1970. This project has been established with the twofold objective of finding long-term solutions for the operational problems of large libraries and of developing competence in the emerging field of information-transfer engineering. The project will be carried out in the School of Engineering in close concert with the M.I.T. libraries.

In the university of the future, as it is visualized at M.I.T., the library will be the central facility of an information-transfer network that will extend throughout the academic community. Students and scholars will use this network to gain access to the university's total information resources, through Touch-Tone telephones, teletypewriter keyboards, television-like displays, and quickly made copies. The users of the system will communicate with each other as well as with the library; data just obtained in the laboratory and comments made by observers will be as easily available as the texts of books in the library or documents in the departmental files. The information traffic will be controlled by means of the university's time-shared computer utility, much as today's verbal communications are handled by the campus telephone exchange. Long-distance service will connect the university's information-transfer network with sources and users elsewhere. Figure 1 presents a schematic view of this concept.

Today we do not know how to specify the exact nature and scope of future information-transfer services. We believe that their design must be derived from experimentation in a working environment of students, faculty, and research staff. A favorable situation for such experimentation exists at M.I.T. at the present time. There are library users in all academic categories who are accustomed to the experimental approach and who will cooperate in meaningful tests of new services. In Project MAC, M.I.T. is already carrying forward a broad study of machine-aided cognition that will greatly stimulate the rise of new concepts in information transfer.

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### Planning the Project

The experimental plan for Project Intrex was formulated in August 1965 at a conference sponsored by the Independence Foundation. The membership, from both inside and outside M.I.T., was divided among librarians and documentalists, scientists and engineers, and some representatives of architecture, linguistics, mathematics, philosophy, psychology, and publishing. The report of the Intrex Planning Conference has been published (*1*). The purpose of this article is to present a brief overview of the experimental program recommended by the conference. This article borrows extensively from the language of the report, and thereby attempts to capture the consensus of the participants in the conference rather than present exclusively my own viewpoint.

Three mainstreams of progress in the field of information transfer were intensively discussed: (i) The modernization of current library procedures through the application of technical advances in data processing, textual storage, and reproduction; (ii) the growth, largely under federal sponsorship, of a national network of libraries and other

information centers; and (iii) the extension of the rapidly developing technology of on-line, interactive computer communities into the domains of the library and other information centers.

The university information-transfer system of the next decade will result from a confluence of these three streams. Rapid advances in information transfer by on-line computer systems will greatly extend the scope of information services in the academic community, but only if they are supported by the resources of a modernized university library and by integration with coordinated networks of local and national resources. The experimental program recommended by the planning conference, therefore, combines the exploitation of on-line computer technology with the modernization of some current library procedures, with emphasis on the former.

Although our discussions extended over a very large range of possible experiments, the recommended program is addressed mainly to the broad problem of *access*—in particular, access to bibliographic material, documents, and data banks. A core program dealing with this information-transfer function has been formulated, together with supporting activities and recommended extensions. Four sets of activities are proposed for this core program: augmented-catalog experiments; text-access experiments; network-integration experiments; and fact-retrieval experiments.

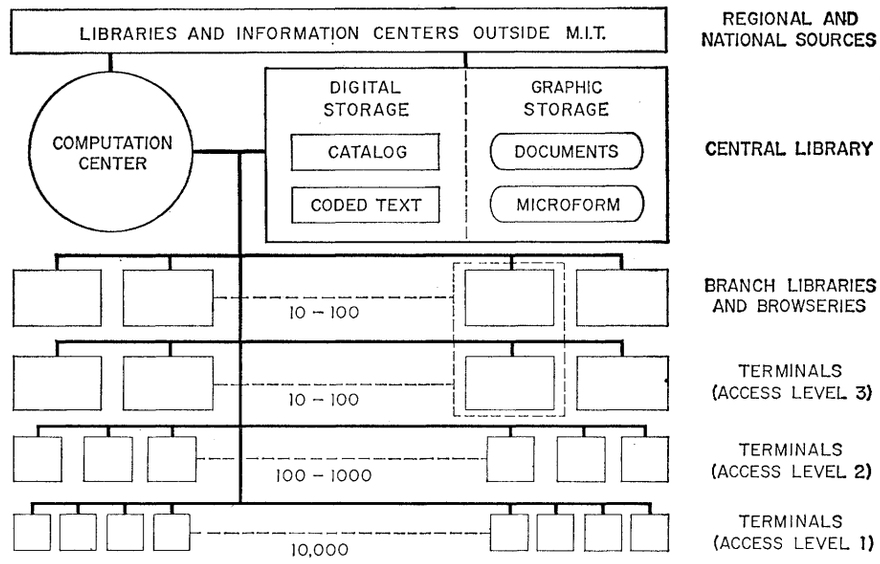



Fig. 1. Schematic representation of an information-transfer network. Information stored in digital or in image form is accessible from terminals throughout the community. The computation center will control the flow of information in the system. The number of terminals will vary from between 10 and 100 for the best-equipped to perhaps 10,000 for the simplest.

## The Model System

To provide an environment for the performance of the Intrex experiments, the planning conference recommended the establishment of a facility called a "model library" as a place to test new ideas experimentally and to investigate competing technologies. Only by coming to grips with the real, everyday problems of setting up and running a pilot system can the project assemble the experience required to evaluate its experiments, just as it is only by serving the real needs of real users in the university community that the results of the experiments can be valuable.

The choice of the field or fields for this model has not yet been made, but it seems probable that early experiments will deal with the literature of aeronautics, astronautics, and space, and with that of materials science and engineering.

In its early stages, the model library will display, in readily attackable form, most of the basic problems of university libraries. It will therefore afford an excellent opportunity to combine the procedural background developed in the M.I.T. libraries with the capabilities of an on-line computer system for solving such problems as the selection, acquisition, and weeding of materials and the control of serial publications. But the main purpose of the model library is to serve as a medium for the activities in the core program which will now be outlined.

In an information-transfer system involving any form of storage we shall need a directory that describes the items in the store and indicates their location. In the library of today, this finding tool is the catalog. William S. Dix, the Librarian of Princeton University, has aptly called the catalog "one of the great achievements of the human intellect" (*2*). "Without it," he writes, "or something just as good, all but the smallest of libraries would be chaotic and useless." The catalog has become the central device that controls all operations in a large research library. Its functions and its size make it the primary target for the application of digital storage and computer control.

The advantages of the digitally encoded catalog are numerous. The user can manipulate it more easily than the conventional 3- by 5-inch cards in file drawers. Access to the catalog can be provided in many terminals at locations remote from the library. Information on each entry can be called up selectively, so that the amount of detail can be increased as the search is narrowed down. New information can be added to an entry at any time, and old information can be deleted at will. The catalog becomes a dynamic tool which develops in response to the changing needs of library users. Many of the important features of machine-manipulated bibliographic tools have already been demonstrated in experiments at a number of libraries. A comprehensive citation index of the journal literature of physics has been provided by Kessler (*3*) for the time-shared computer system of Project MAC at M.I.T.

Variable depth in the catalog will permit the user to range from abbreviated entries showing only author, title, and location, through standard descriptive cataloging, to augmented catalog entries which may include references to abstracts and reviews of the item; citations of the item, and citations given in the item; the type of material, level of approach, and aim of the author; informative comments by authors, editors, librarians, and users; extracts, such as prefaces, tables of contents, and summaries; cost and source information; additional subject indexing; and records of use of the item.

Not all the information that will be

found in the completed catalog will be incorporated from the first. An evolving entry is expected, with author, title, data, and location being entered early in the process and other data being added and deleted during the life of the catalog.

The augmentation of the catalog in depth would be accompanied by an augmentation in coverage, so that journal articles, reviews, technical reports, theses, pamphlets, conference proceedings, and class notes would be as comprehensively described as books are.

Operational experiments with such a catalog would seek answers, for a variety of bibliographic searches, to such questions as the following:

What simplest code will specify a document? What is the contribution of each tag? What is the most efficient search strategy? What is the best file organization?

In addition to its primary function in bibliographic search, the catalog will also have important uses in browsing experiments, in inventory control, and in recording user interaction with the information-transfer system.

## Text Access

The library user who has succeeded in identifying the documents he wishes to consult will expect a good information-transfer system to display or deliver these documents to him, with minimum delay and at a convenient location near his study or laboratory. Various techniques for providing such access are available.

The traditional library provides access by lending the original document, but that method is incompatible with the principle of guaranteed access, which should govern the information-transfer systems of the future. We must find ways of providing transient or permanent access that do not preclude the concurrent access to the same document by other users of the system.

The loan of duplicate copies, in either full size or microform, is a possible technique. Other important possibilities are visual displays on optical or electronic screens.

For permanent rather than transient access, full-size paper copies are the most obvious solution. Such copies can be made directly from the original document, or they can be derived from microform copies of the original. They can be produced at a distance by signals transmitted over electrical circuits in either analog or digital form. Permanent copies might also be supplied to users in reduced size, either on paper or on film.

The many different optical, photographic, and electronic techniques implied in this outline can be combined in different ways to provide access to text at various cost levels and with different speeds of response. The general system schematically presented in Fig. 1 shows information terminals, arranged in three access levels, that will be provided in quantities which reflect differences in cost and complexity.

The planning conference was not specific in recommending particular devices or combinations, but the nature of the recommended experiments will be clearer if some illustrative terminal equipment is mentioned here, however little it may resemble the ultimate configurations of the terminals.

In Fig. 2, the minimum equipment is shown for a rudimentary information terminal that might be provided in every office of a university. The Touch-Tone dial of the telephone handset could be used to interrogate the computation center; replies to a limited range of requests for directory service could be received as automatic voice signals. In this way, a user might ascertain, for example, the dates of the latest issues of journals available in the central library. Microform copies of documents could be delivered by mail in response to telephone requests. A microform reader in the office would be used to display material thus received, as well as information already available in a personal file.

For the more advanced resources of the next higher level, shown in Fig. 3, the user would move a short distance from his office to one of several information terminals in his department or laboratory. Here he would be able to consult the university's union catalog by means of a teletypewriter console; the text of digitally encoded documents could also be printed out on the teletypewriter. For the field of science or technology appropriate to the location of the terminal, microform copies of documents would be available in a local satellite store; microform copies of other documents would be sent by messenger from the central library. Microform readers in the terminal would be equipped with printers so that permanent copies of selected material would be immediately available when demanded.

Figure 4 shows the comprehensive facilities that might be associated with a terminal located in the future equivalent of a branch library. For more effective dialogues with the union catalog, a television-like display with optional print-out would take the place of the teletypewriter printer. For access to full text, the local store would be supplemented with high-speed links to the central library. Television circuits, facsimile circuits, and pneumatic tubes are shown as possible options in Fig. 4, along with messenger service. Electronic and optical display devices would be equipped with printers to make permanent copies for retention by the user.

Let me repeat that these illustrations are not intended as design recommendations. Their only purpose is to suggest the range of possibilities available with current technology. Numerous questions come to mind at once as these illustrations are examined: Will the quality of cathode-ray-tube displays be acceptable to library users? Will the members of a university community assemble personal information files in microform? What is the optimum technique, in view of cost, quality, and speed of response, for the transmission of information stored in image form? How will the system handle the simultaneous display of text and high-quality continuous-tone illustrations?

These are the questions that the text-access experiment of Project Intrex is intended to answer. Many tests must be made with schemes that provide access in different forms and at different speeds, tested under realistic conditions by different users in different categories.

## Network Integration

My discussion so far has dealt with the information resources stored at a single university. The third experiment of the Intrex core program deals with the problems of extending the reach of the university's information-transfer system to library resources beyond its walls—to the libraries of other universities and to the great national information centers that are coming into existence. In this matter of network integration, the planning conference recommended that the initial efforts of Project Intrex be concentrated on the problem of determining what material is available at such sources. The text-

access problem in the integrated network will be in many respects similar to the local problem and can be tackled as an extension of it after some early results have been accomplished.

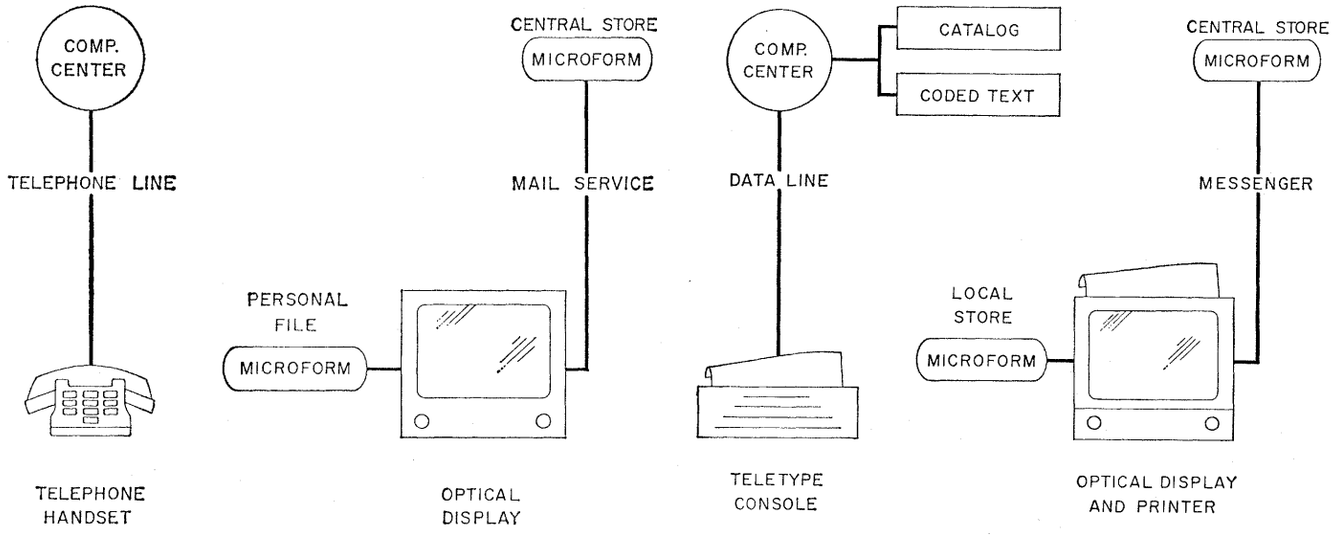
In seeking bibliographic access to outside resources, the user will encounter catalogs organized differently from that of his own university, even after all such catalogs have been converted to machine-readable form. This will mean that the user will not converse directly with the outside catalog. His interrogation will be restricted to his local computation center, which will respond either with catalog data on local resources or with intermediary reference services to a remote information center. The computer may assist the user in utilizing printed index-catalogs of outside sources or in formulating specifications for custom searches at remote information centers.

The planning conference suggested that this investigation first utilize the Medlars (Medical Literature Analysis and Retrieval System) bibliographic capability at the National Library of Medicine and the information system of the National Aeronautics and Space Administration. Medical literature is of increasing interest to M.I.T., and Medlars aims to cover this vast field in great depth and with fast service. The NASA system also covers a broad field of mission- and subject-related literature of exceptional interest to M.I.T. Both have the capability of computer-aided literature-search service in response to user requests, and both issue extensive bibliographies in tape and printed form. These two offer interesting contrasts in types of users, types of literature covered, and types of searches that are possible.

In addition to the use of computer-based national bibliographic services, an effort will be made to tap other research libraries, documentation centers, and information exchanges. This can be accomplished by installing teletypewriters in these facilities. Project Intrex will thus be able to explore various ways of interchanging bibliographic, indexing, and abstracting information and of overcoming divergences of format and convention that might impede cooperation.

### Fact Retrieval

The bibliographic organization involved in the preceding three experiments is essentially document-centered. During the expected life of Project Intrex, continued progress will be made in the rapid processing of data stored in very large files, some ca-



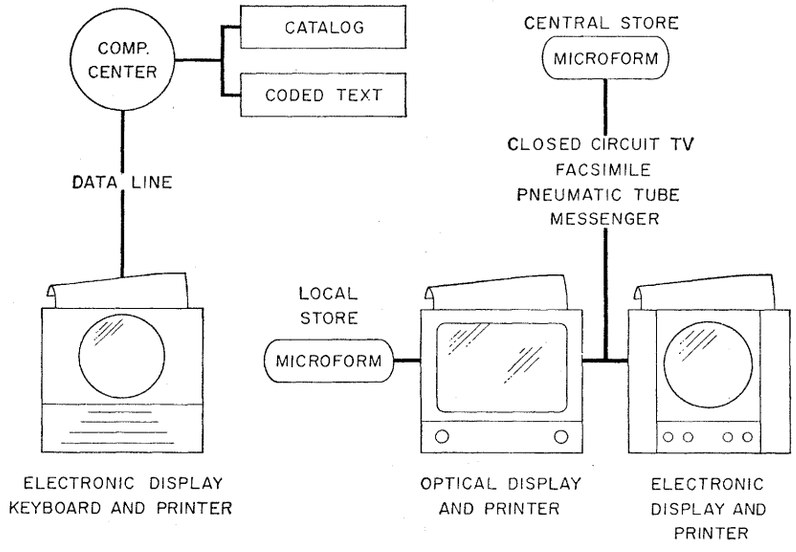




Fig. 2 (top left). Access to text: level 1. Rudimentary information terminal for installation in every office. When interrogated by Touch-Tone dialing, the computation center will provide automatic voice replies to a limited range of directory service requests.

Fig. 3 (top right). Access to text: level 2. Intermediate information terminal. A teletypewriter console will permit the user to consult the digitally encoded union catalog. A local satellite store will contain microform copies of the technical literature appropriate to the location of the terminal.

Fig. 4 (bottom left). Access to text: level 3. Comprehensive information terminal. Electronic and optical displays will provide rapid access to centrally stored information in both digital and image form. Permanent copies of material desired for retention will be available on demand.

pability will be developed for the retrieval and assembly of facts, and many advanced systems for the automatic answering of questions will appear. It is impossible to put a precise timescale on these developments, but it is clear that research on the direct computer manipulation of facts and ideas is an important avenue toward the advanced information-transfer systems described by Licklider (*4*). The planning conference recommended that some effort in pursuit of this longer-term objective be included in the core program of Project Intrex.

A first step toward automatic fact retrieval is a program to assist a user to locate in currently published handbooks the subsection containing facts he desires. An automated merged index of all the available handbooks relevant to a subfield would provide a path on which a user could traverse the bewildering forest of available reference material. Access to this automated index would be provided through consoles placed in information-transfer terminals that also contained book or microfilm copies of the reference handbooks themselves. Many users will come to the console without a clear statement of exactly what facts they are really looking for. A cleverly designed programmed interrogation should be able to extract the proper request from the user. The console will also have a key for a single command, "HELP," which will connect the user to a human reference librarian.

As the next step toward fact-retrieval systems, the contents of a particular handbook, or sections of selected handbooks, will be put into digital form for direct access and manipulation by the computer. A completely computerized data store of this kind has important advantages over a conventional printed handbook:

1) Currency: Updating and editing can be continuously, rapidly, and conveniently performed in the on-line data store.

2) Versatile organization: In an automated handbook, one can easily construct tables for new combinations of variables, different from those that were combined in the original publication. It would be possible to request, for example, a list of melting points of metals with shear strength above a certain level and density between two limits. To extract such a list from a printed handbook by conventional procedures is a slow and laborious task.

3) Computation: Whenever the facts required by a user can be computed from those in the published compendium, the desired information can be promptly generated in the computer-stored data system.

4) Output format control: With a computer-based system, one can easily present to the user a graphic plot of information usually stored in tabular form.

5) Amount of detail: Large quantities of detailed data can be included in the computerized handbook without giving rise to the cost and access problems associated with the inclusion of such material in printed publications.

If we now augment the information stored in the automatic handbook with informal experimental data, we are taking the third step in the fact-retrieval experiment. Perhaps the result might be referred to as an automated notebook. The data-bank project currently under way in the social sciences at M.I.T. in conjunction with Project MAC is an early attempt to establish such a notebook. This experimental system will include data from public-opinion polls, census data, voting data, and life-history data.

For an automated notebook to be effective, people must be able to use it without having precise knowledge of the organizational principles that determined the form of storage of any particular subject of shared data. In particular, a user must be able to have data that are organized in one way presented to him in quite another way. Thus the automated notebook will contain not only data, but programs to manipulate and reshape the data.

### Other Library Functions

The library is traditionally regarded as the center of the intellectual life at a university. The planning conference recognized that changes in the library system are certain to have indirect effects on other activities, some of them quite remote from the libraries themselves. As far as possible, the conference attempted to foresee the indirect implications of moving toward an on-line intellectual community, and its report includes recommendations for studies of these related problems.

For example, the planning conference discussed with considerable enthusiasm the proposition that a large body of factual information, so stored as to be open to interrogation from a variety of users with different interests and degrees of knowledge, might provide one of the most powerful teaching instruments ever conceived. It will be important for Intrex to consider as explicitly as possible what opportunities this new instrument might offer for the educational process at M.I.T.

On a less optimistic note, the possibility was considered that the proposed innovations might impede scholarship as much as they facilitated it. The leisurely perusal of a library's collection is considered by many scholars, particularly those in the humanities, to be an excellent way for students to get a feeling for the structure of a field of knowledge, and even to be an important source of serendipitous discoveries by the more advanced scholar. There is some fear that the proposed changes in library operations would necessarily preclude browsing, thus frustrating many of the library's best customers. The positive view is to try to exploit the new technology to permit a more nimble kind of browsing with greater scope than is possible in the stacks of today's libraries.

A library of the type envisioned by the planning conference can take a much more active role in providing information to its clientele than most libraries have in the past. The availability of a computer system makes it possible to keep a profile of each user's interest and to furnish documents to him even before he requests them. This kind of active library service, aimed at supporting the user's current awareness of developments in his field, is usually called selective dissemination of information (SDI). Programs for SDI are presently operating in many libraries, mostly in industrial or government organizations; they appear to have received little attention from academic institutions. It seems appropriate, therefore, that Project Intrex should explore the extent to which SDI services might be provided in a university community.

In the text-access experiments of Project Intrex, the advantages and disadvantages of producing on-demand copies of items in the library's collection will be studied. A system that operates in this manner is, in a sense, in the publishing business. For new material not yet in the collection, various kinds of limited "publication" would be possible in the information-transfer network. For example, a

newly created manuscript could be made available to other network users either on a selective basis or on a broadcast basis by entry in the public file. The planning conference suggested experimentation that would contribute to the wise planning of the future library's opportunities and responsibilities in this field.

Finally, the conference gave some attention to the possibility of relieving the library's problems, without diminishing its serviceability, by well-conceived rules for acquiring and weeding documents. It is widely held that the amount of good material in any scientific field at any particular time is really rather small; and one of the problems is that this high-quality signal is being drowned in a vast flood of low-quality noise. If there is any truth to this notion, Project Intrex would seem to be in an excellent position to investigate it. The augmented catalog will accumulate comments of users; citations recorded in the catalog will permit analysis of a publication's impact on subsequent authors; mechanized text access will yield data on the actual use of each item in the collection.

Other implications of the Intrex experiments were discussed, but these five—education, browsing, selective dissemination, publishing, selective retention—received the most attention at the planning conference. Although none is essential for getting the Intrex program under way, all of them are important.

### Research and Development

The experimental program that has been outlined is concentrated on a few main problems that the planning conference considered both crucial and soluble. The basic policy suggested to Project Intrex with respect to supportive research and development is to undertake only those tasks that are necessary to ensure successful completion of the main experiments. Perhaps the most significant factor in the situation that Project Intrex is entering is the availability of a powerful new computer technology. The conference was distressed, however, by the primitive state of two critical items, consoles and interaction languages, and recommended that Project Intrex give attention to them.

In surveying the broad area in which Project Intrex will operate—the computer sciences, the library sciences, and parts of other disciplines ranging from psychology to electrical and mechanical engineering—the planning conference observed that there is no dearth of theory in these fields. However, there is not at present a comprehensive and basic theory of information transfer. A major intellectual challenge for Project Intrex is the development of a unifying theory that will lead to coherent design and interpretation of experiments in information-transfer systems.

The immediate effort of Project Intrex is to add details to the recommendations given in the report of the planning conference and to begin the experiments. A grant from the Carnegie Corporation is making it possible to conduct this early part of the experimental program without waiting for the more extensive funding that the complete project will require. The initial experimental work will be performed by the Electronic Systems Laboratory of the Department of Electrical Engineering at M.I.T.

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**NEWS AND COMMENT**

# The Berkeley Scene, 1966 (I): Politics and Potshots

*Berkeley, California.* The University of California at Berkeley has become a kind of year-round long hot summer. What is happening there in the Year One of the post-Free Speech Movement regime is not as dramatic as what happened during last year's student rebellion. Individual events are not as significant. Time is no longer told by in-group references to the dates of various sit-ins, demonstrations, and manifestos. But, if the revolution has left few concrete mementos (Sproul Hall has not, after all, been renamed to honor Mario Savio), it has nonetheless left its marks on campus political activity, on plans for educational reform, on a wide range of internal matters affecting relationships among students, administration, and faculty, and on the university's relations with California's citizens and politicians. It is still too early for a General Theory of Berkeley: the campus is too rich and varied, its 27,000 students and 1500 faculty members are moving in too many directions and responding to too many forces. But, despite the university's seemingly limitless vitality, it is not too much to say that the aroma now coming from the campus is distinctly one of uneasiness. "It takes a boat like this a long time to stop rocking," Berkeley chancellor Roger W. Heyns commented in a recent interview with *Science*, though he added that he believed "every oscillation is getting to be a bit less." "Maybe so," observed one sociologist to whom Heyns's remark was repeated: "The trouble is we're all pretty seasick already."

The sense of uneasiness should not be attributed to paranoid fantasies of the battle-scarred. It is supported by the kind of conventional indices usually cited to prove that an academic institution is in trouble. Freshman applications declined by about 15 percent this year. Some departments—for example, physics and psychology—are admitting to difficulties in getting the graduate students they want. The pace of out-