Facets of

The Technical Information Problem

Charles P. Bourne and Douglas C. Engelbart

STANFORD RESEARCH INSTITUTE

MENLO PARK, CALIFORNIA

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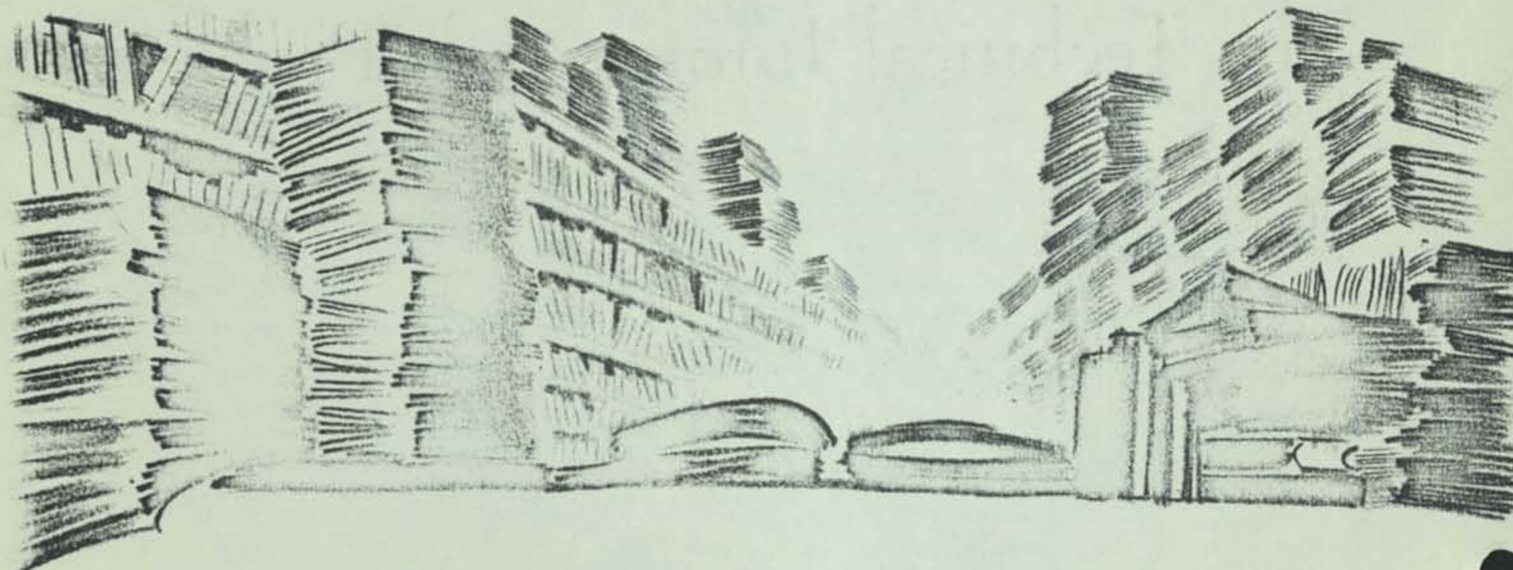


Technology, so adept in solving problems of man and his environment, must be directed to solving a gargantuan problem of its own creation. A mass of technical information has been accumulated and at a rate that has far outstripped means for making it available to those working in science and engineering. But first, the many concepts that must be considered in fashioning such a system and the needs to be served by it must be appraised. The complexities surrounding any approach to an integrated technical information system are suggested by the questions given here.

RECENT world events have catapulted the problem of the presently unmanageable mass of technical information from one that *should* be solved to one that *must* be solved. The question is receiving serious and thoughtful consideration in many places in government, industry, and in the scientific and technical community.

One of the most obvious characteristics of the situation is its complexity. A solution to the problem must serve a diversity of users ranging from academic scientists engaged in fundamental investigations to industrial and governmental executives faced with management decisions that must be based on technical considerations. The solution must accommodate an almost overwhelming quantity of technical and scientific information publicly available in many forms through many kinds of media and in many languages.

Some students of the problem, including men with many years' experience in various aspects of information handling, have viewed this complexity and concluded that the problem cannot be solved in its entirety. These authorities have recommended a piecemeal attack on components of the problem.

Stanford Research Institute believes that the techniques of systems analysis coupled with an understanding of the potentials of machines permit a powerful approach to the solution of this many-faceted problem. In fact, it may very well be that only by grappling with the problem as a single, integrated system can a realistic and lasting solution be attained.

However, to deal with the information system as a whole, it is necessary first to define its complexities with as great detail as possible. As an aid to the preliminary mapping of the system, a study group at SRI polled a portion of the Institute's own professional staff of engineers and scientists for questions they believe must be answered before an effective system can be designed. A representative list of the questions raised in this fashion is given in this article.

The list is impressive, but obviously not exhaustive. It does confirm the multiplicity of points of view that must be appreciated before this problem can be attacked.

Many of the questions require simple factual answers (see "Data Needed About Information Sources and Services," p. 5). They can be answered by straightforward techniques of counting, surveying, sampling, and estimating. A few of the answers are already available, but the fact that most questions of this type cannot be answered from available sources emphasizes the pressing need for a much better quantitative assessment of the size and nature of the information problem before a rational attempt to solve it can be undertaken.

Another group of questions involves essentially matters of national and scientific policy that ultimately must be answered arbitrarily. Data and analysis can give guidance to the answers but the ultimate decision will be based on judgment of relative needs and relative values.

Questions Relating to Policy

What are the specific aims of the program?

Will the system start with only new information? Or will it process back literature, and, if so, how far back?

Will the Service process requests from allied countries? To what extent? Will it coordinate with the Soviet Union?

Can part of the operations be done abroad? What about translation?

Will an international classification, indexing, or retrieval system be adopted or promoted?

Will the system be designed to serve the brilliant, the sophisticated, as well as the more unsophisticated?

Will the Service be financially self-supporting?

Will big business have any better access than small businesses or individuals?

Would a private citizen or scholar afford to use the Service?

How will prices be established for the Service?

What is the range of subject matter to be included?

Will classified information be included?

Will safeguards be established to insure that classified information is kept under proper control?

What type of information should be included? Books (texts, tables)? Technical and trade journals? Conference proceedings and papers presented but not published? Industrial and government interim and final project reports, etc.? Operation and instruction manuals? Patents? Manufacturers' catalogs? Newspapers and general magazines?

Who will be responsible for selecting the material to be included?

What protection will be provided users who want their queries to remain confidential?

Should service be provided outside the technical community? To congressmen? Executives? Businessmen? High-school students?

Who will control the policy in the matter of designing, establishing, and/or operating the Service? An appointed committee, such as for the NACA? A civil servant? A political appointee? A committee elected by scientific organizations?

A Proposal for a National Technical Information Service

Members of Stanford Research Institute have long given thought to the increasing disparity between the accumulation of new knowledge and the means for organizing it for widespread utility. With this problem brought into sharp focus by recent events on the international scene, the Institute believed it appropriate to formalize its views on the magnitude of the problem and to suggest a possible solution. In January, a draft program for a National Technical Information Service was prepared and copies distributed to members of the President's staff, to selected members of Congress, to various agencies within the federal establishment, and to industrial leaders and technical societies, all known to be concerned over the state of technical information affairs.

This document describes a program to solve the nation's technical information problem through the establishment of a national service for the collection, processing, storing, retrieval, and dissemination of scientific and technical information from both foreign and domestic sources. The program comprises five phases, interrelated and partially concurrent:

1—Establish a central organizing and administering, federally constituted Agency.

2—Determine the gross dimensions of the problem.

3—Establish an interim information center using existing services and techniques.

4—Analyze the factors that determine the design and operation of an ultimate National Technical Information Service.

5—Encourage present and initiate additional research and engineering development programs leading to systems and equipment necessary to implement the ultimate National Technical Information Service.

This proposal, and others, for solution of the problem are currently under study by the interested bodies of the nation. Meanwhile, at the Institute study of various phases of the technical information problem, both in the gross, and of specialized aspects of data handling, storage, and retrieval, is continuing.

Would it be feasible to establish legal authority to speed up the standardization and coordination of existing facilities (such as the F.C.C.)?

Who is competent to design, establish, and/or operate the System? Would this be a civil-service organization?

Could the objectives of the Service be achieved by expanding existing government agencies (e.g. Bureau of Standards, the Library of Congress, Armed Services Technical Information Agency)?

If the Service were not directed by some existing government agency, would it not be best handled by some university?

Would it be economically feasible for any sort of commercial enterprise or non-profit corporation organized by the professional community, or by private industry, to establish and run a Service which would assure continued social and technical progress?

If we must look to the federal government for support, what residual responsibilities remain with the professional societies? Should private groups continue to sponsor special collections?

What economic and political limiting factors exist with respect to the freedom one would have in utilizing or changing those organizations already active in the documentation field, and whose existence could be over-shadowed by a national Service?

What about copyrights? Would royalties be forthcoming to the owner of the copyright if the Service distributes the material? What will be the impact on the technical publishing industry?

Should the Service act as a publisher for collections of papers (reprints) in very new and special fields?

How will the priority schedules be fixed for the Service?

How soon could the Service be initiated? With an immediate manual system? With an ultimate mechanized system?

What factors will determine the location? Can strategic dispersal considerations influence the location without adversely affecting efficiency?

Is the proposed Service simply an attempt to copy Russia?

CHARLES P. BOURNE and DOUGLAS C. ENGELBART are research engineers at Stanford Research Institute's computer laboratory. Mr. Bourne gained his first electronics experience in USN schools from 1950-51. From 1952 to 1953 he served as instructor of various aspects of guided missile operation and maintenance with Convair Guided Missile Division and as adult education instructor in electronics at Chaffy Junior College. After receiving his BS degree from the University of California in 1957, he was employed as a research engineer at SRI where he has been engaged in research on mechanization of information retrieval and logical design.

Dr. Engelbart received his BS degree in electrical engineering at Oregon State College in 1948, MEE in 1953, and PhD in 1955 at the University of California. His theses were concerned with design and programming of drum-type computers and special gas-discharge tubes for use in computers. He has worked as professor of electrical engineering at the University of California, as electrical engineer at Ames Aeronautical Laboratories, and as consultant. In October 1957 he joined the SRI staff. Information retrieval is one of his specialties.

Might not an interim solution be to translate and distribute the exhaustive Russian abstracts, thus leaving our interim energies free for other uses?

Might it not be better to reduce the amount of literature produced rather than go to the tremendous expense of providing super-service for all of it? Can a quality filter be applied to this output?

Why not allocate federal money to support more direct interchange between working scientists? Perhaps more meetings, special conventions, seminars, etc., would be more economical than better literature processing? Couldn't the money be better spent on education to achieve a given increase in scientific effectiveness?

Could a substantial portion of the information problem be solved by teaching the users more about present-day documentation techniques?

Questions Requiring Research

Some of the questions posed to the study group will require considerable study and research to produce valid answers. The research will be in many fields—in the social as well as in the natural sciences. Some of the study must be quite profound—even theoretical. Some will be more straightforward. Many of these questions must be answered before the policy decisions implied in the previous group can be made with confidence.

Can we separate apparent need, influenced by present concepts and experience, from real need? Lack of awareness of the potentialities of recently developed methods (or methods not yet developed) can easily result in an unimaginative formulation of the possibilities and opportunities for advantageously using recorded information.

How will users' habits and needs evolve as a good System becomes available?

How are the information needs of a user affected by his age, educational level, profession, type of position held, etc.?

What are the characteristic information needs of the basic (academic) scientist? The applied researcher? The engineer? The decision maker? Are they all equally critical, or is the "applier" of knowledge the one with the biggest problem?

What is the role of information retrieval, storage, etc. in the decision-making process of the research worker, engineer, scholar, administrator, etc.?

How much use does the scientist and engineer make of the facilities that are presently available?

By what processes does the scientist and engineer keep abreast of the advances in the art now? What are the relative importances of each of these processes?

How many scientists and engineers have a definite program of "keeping up with the literature"? How much time

Data Needed About Information Sources and Services

Before the designers of an overall information center can sketch in the outlines of the system problem, a large amount of data about the information input and the existing information services must be collected. Some of the kinds of essential data are suggested by the following.

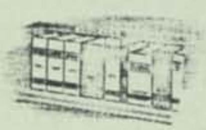
What subject fields are covered by the various journals, books, and reports? And in each case, in what depth?

What are the physical sizes of journals, books, and reports? Page size and number of pages? Frequency of publication? Kind and size of distribution? Cost or subscription price?

In what language(s) do the journals, books and reports appear?

Does each have an index? Are abstracts published, and where? Where is the information indexed?

Who, principally, are the contributors to the technical journals? Who selects or reviews papers for publication? How long, generally, between preparation and publication?



Are microfilm copies of books, journals, and reports available?

Who are the publishers of technical journals, books, and reports? Where is each located? And how long in operation?

How is each publishing operation financed?

What are the policies and objectives of the respective publishers in each field?

What fields of science and technology does each publisher operate in? In what fields does each concentrate or specialize?

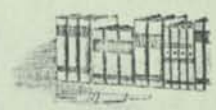
In what language(s) does each publisher produce his journal(s), books, or reports?

Could publishers of journals, books, and reports provide paper tape or other machine-readable copies of their works? At what cost?

How much has been produced to date in the various technical subject categories in journal, book, and report form? What is the physical mass of each? Are back copies available?

What libraries with technical collections, abstracting services, indexing services, and translating services are in existence? Where is each located? What is its organization? How is it financed?

What is the size and training of the staff of the various technical-information handling or processing organizations? In each case is the organization equipped to handle classified material?



In what field(s) does each information handling or processing unit operate?

What classification and indexing systems are in use?

What is the normal time between publication of a document and its appearance in the libraries? When is it abstracted? Indexed? Translated?

What are the types and numbers of scientific and technical people using libraries, and the abstracting, indexing, and translating services? In what ways does the technical community feel it is being adequately or inadequately aided by these services?

Would the various libraries and services be amenable to negotiation of changes or increase in area of coverage, or other changes of service, to fit a reasonable, overall system, if government controlled and subsidized?

What are the charges for service by libraries? Abstractors? Indexes? Translators? Which of these services are self-supporting?

Are special compilations of abstracts, bibliographies, or translations available? And for what fees? How long required to provide such special services?

would they "like to spend"? What keeps them from spending more time?

How much of the literature that would, with reasonably high probability, be useful to a scientist or engineer, is caught by him now by his own regular surveillance of the literature? How far out of his way will the average user go to be sure that he hasn't missed some possible information . . . considering the usual distracting pressures on him, his familiarity with the sources, etc.?

How many pages of literature in various categories relative to the level and interest-area of the user can we expect him to scan or search for his different information needs?

What are the relative merits of the different types of reference information services with regard to the user and his needs, desires, habits, and limitations?

What are the relative importances of the users' various informational needs? On one hand, he needs to know the newsy items such as who is working on what, what his current attack is, who disagrees with whom and basically why, etc.; and on the other hand, he also needs to be able to study in detail the carefully written treatises that may have bearing on his work. Can these different kinds of needs be met by a single system?

What are the special information requirements for different specialty fields?

Does the user, when he goes outside his special field for supporting information, want information in different form or different levels than which he seeks in his own field? For instance, would he be looking more for "cook-book" techniques or for survey-type information?

How valuable would broad, multi-disciplinary searches be if they could be conducted effectively? How great is the problem of differences in nomenclature between fields?

What type of questions now go unanswered at the libraries?

Isn't the main problem of information retrieval one of identification—since people so seldom express satisfactorily their needs to the documentalist?

What are the major limitations in the various methods presently used in classifying and indexing scientific literature?

Is the problem that the information now is just not available at all, or is it that it is just hard to find?

Why aren't the existing services that process technical information satisfactory?

How many places does a user of each discipline have to look for index listings of a given special interest?

How can the processing of recorded information be planned so that it can be effective in spite of human limitations, or of limitations in numbers of human beings?

How much is missed by technical people leaning too heavily on librarians?

What relative gain in efficiency could be achieved by integration, merging, or better managing of existing documentation services?

What increase in efficiency of the scientist or engineer would result from improving the accessibility of recorded information?

What are the probable net benefits, short and long range, of an effective information Service to military, industrial, commercial, scholarly, government groups?

Can dollar costs be derived for reasonably well-proven delays and duplications, and can the total national loss rate due to this problem be realistically estimated? Can it be determined that the expense of delay and duplication now is greater than that of establishing and operating an information Service?

What is the lack of an information Service costing government agencies?

Can the savings in Federal money now spent on other information programs be diverted to a national information Service?

What are the relative costs and characteristics of different reproduction techniques that might be applicable to some of the dissemination and massive processing problems of an information service?

What are the techniques and costs involved in keeping up and in using large mailing lists in taking care of distribution of journals, etc.?

What are relative costs of providing the information in micro form as against making original-size photo copies?

Of the currently-operating abstracting services, how many are operating merely to satisfy an obligation of a professional society that would rather have somebody else do the abstracting?

What services does the Russian All-Union Institute really provide? What is the reaction of a Russian scientist to this information center?

How important is it to know what the rest of the world is doing?

Are any projects or areas of work reported almost exclusively in foreign literature?

What is the expected rate of growth of the system?

What are the potential information processing capabilities of existing mechanical devices?

What are the theoretical capabilities of existing or anticipated machine components which might be applied to the information processing problem?

The Soviet Approach to the Information Problem

The Soviet Union has a comprehensive technical information system in operation. In 1952 the Soviet All Union Institute of Scientific and Technical Information was established in Moscow. By 1957 the Institute had a permanent staff of 2300 translators, abstractors, and publishers. This staff is supplemented by more than 20,000 cooperating professional scientists and engineers throughout the U.S.S.R. who act as part-time translators and abstractors in their specialized fields. The Institute publishes 13 "abstract journals" which annually contain over 400,000 abstracts of technical articles from more than 10,000 journals originating in about 80 countries. It systematically translates, indexes, and abstracts about 1400 of the 1800 scientific journals published in the United States.

To reduce the time between the initial appearance of the more important information in any of the world's journals and its reaching the hands of Soviet scientists and engineers through the normal route of the abstract journals, "Express Information Journals" are also printed. These carry summary information on foreign technological developments within two or three weeks after their receipt. The work done is reported to be not only comprehensive but also of high quality.

The Institute provides numerous other technical information services, such as provision of bibliographies, micro and full size copies of original printed material, technical dictionaries, and foreign-language dictionaries.

The Institute maintains an extensive program aimed to introduce machine methods to information handling. This includes translating machines, and mechanisms for codifying, storing, and retrieving technical information. Significant progress by the Institute towards information mechanization methods and systems is reported.

How often will the system presumably be searched? How definitive will the search have to be? What volume of information should a search produce? How fast should the system respond?

Characteristics of the Information Service

As increasing data become available it will become possible to consider some of the last group of questions—those dealing with the desired or necessary operating characteristics of a comprehensive technical-information processing system. Certainly, the first system implemented would be of an interim nature using existing resources, which unfortunately employ largely manual techniques. However, ultimately it is inevitable, in view of the impressive advances made almost daily in information processing techniques, that a highly mechanized system will be possible.

How soon can an interim system be functioning?

How much can be done just by concentrating on abstract distribution and better dissemination techniques?

Would it be feasible for the abstracting publications to use a standard format and type font, such that mats (or something similar) could easily be distributed to other interested publishers, thus saving printing expenses?

What technical societies could cooperate to publish a single journal instead of numerous splinter journals?

What about the scale of the Service? Does it have to be a big system or nothing?

Does "having a large information Service" necessarily mean the physical collection of all activities at one central location?

Would a group of smaller centers, for specific fields, be of greater utility and more tractable?

Would a collection of special libraries be more useful?

What can a national service provide that is different than what is now available? Is this to be an entirely new type of service, a real advance in the state of the art, or is it to be just more and better of the same thing?

Will the System have a finite capacity? One system might work well with a few million entries, but be hopeless with a hundred million.

As the System grows in size, will it be possible to make changes easily in the classification scheme and bring the old coding into the new scheme?

If a private consultant, with "need to know" established, were to work on a government project, how would he locate and procure pertinent classified material?

Will financial filtering of requests by a uniform fee structure be desirable or effective, or would it be necessary to make non-uniform fee structure so that there is essentially some "priority" given?

What means can be used to pry loose useful information that customarily doesn't get into the published technical information channels?

Will the service include a positive program to declassify material under security restrictions?

What is an acceptable delay in getting information entered into this system?

Will all material in the subject fields be included or will there be an editor or a censor?

Will an attempt be made to standardize the form of the material before it gets into the center? Does the material have to be on standard-size sheets or forms?

What happens when the system becomes overloaded? Should service to users just be late, or should the service just be less complete?

How can we protect against freezing the specifications until enough systems work has been done to make clear what would be optimal?

Will the policy makers make sure that the final methods chosen for a retrieval system are not influenced too heavily by the requirement of compatibility with past systems?

Will abstractions be done? What kind? Descriptive? Critical? Informative? How can we get good-quality abstracts? Should the Service use volunteer abstractors directly or a staff of full-time abstractors? Or should it allow the various technical societies to organize their own volunteer abstracting services?

Will any effort be made to review old documents, and to remove or recode when necessary?

Is a standard (or artificial) vocabulary necessary? How much work will be required to design and institute such a vocabulary?

What techniques and devices can reasonably be developed and applied for facilitating such immediate requirements as printing, reproducing, storing, microfilming, billing, communicating, etc.?

What kind of a data-processing system will the Service need just to keep track of its operation?

Would the information Service keep a collection of the original documents?

What special precautions must be taken to store primary records? Would a duplicate file and collection be maintained to prevent disruption of service due to fires, or other catastrophes? How much would this cost?

What is the useful life of various forms of records? In use? In storage?

What will the information Service physically provide in response to information requests?

Will the output be in English, or a code that must be translated?

Will microform copies be acceptable to the users? If not, what improvements need be made in order to gain user acceptance?

Will the information Service output be in a form that the researcher can determine which of the documents are in a locally accessible collection?

Will the system give answers (e.g., "yes," "no," "5,000 tons in 1945," etc.) as well as references?

Why not periodically publish inventories of research in progress, to indicate what research projects are currently being undertaken in each specialty field, thus helping to eliminate duplication?

Will there be a "special communication network" in which workers in the various specialized fields can easily circulate working papers or "think pieces?" A central agency could maintain printing, listing, (in appropriate subject-interest categories), and mailing facilities for this sort of service.

Will the information Service be able to retain a file of questions to be asked of all new input material, thus providing up-to-the-minute data for standing questions?

Will it be possible to stimulate more writing of "review-the-literature" papers by qualified people in the various fields, in order to provide guides for other workers?

Can a partial search be made? (For example, can 1/10 of the file be searched and the results checked to determine if further searching is justified?)

Could the information Service operate on a "just search ½ the file for me; I don't need a comprehensive search" basis?

What kind of communications network will be needed for the operation of the interim information Service? Will it be accessible to anyone by telephone or other direct device, such that the searcher can interrogate the file directly and at will?

Would the Service be available for browsing?

What technical-manpower drain would the proposed information Service program have on other high-priority scientific programs?

What professional and educational background is needed for the personnel to operate the Service?

Could university science students be used part time and during summers to help with the various processing tasks, as a means of alleviating the shortage of people with adequate technical backgrounds?

Will there be special training for abstractors and translators or for documentation and information specialists, etc.?

How much research is needed? What research budget is reasonable?

If an information Service were established, how soon could present partial services by government agencies be terminated and funds diverted to the Service? Could some special activities in industrial libraries be eliminated?

These questions, by the very nature of their origin, are random and fragmentary. Even the full list from which they have been selected is far from comprehensive. However, we have found them a helpful stimulus as well as a disciplinary aid in viewing the technical-information problem in its broadest dimensions. We hope that others interested in this problem will be similarly served.

*SRI

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Is There a Technical Information Crisis?

The problem of organizing technical information has received more study, particularly at high levels of the governmental and scientific communities, in the past year than in the entire previous era of modern science. Does this attention imply that the nation is suddenly faced with a new situation arising from the Russian satellite program—some new pattern of circumstances that requires an immediate countering action in order to prevent losing the technological race?

Obviously not. Specialists concerned with the organization and dissemination of technical information have been pointing out for many years that the rapid increase in level of technological activities has far exceeded the concept and rate of growth of information processing facilities. Those who have responsibility for organizing and budgeting research and development efforts have been increasingly aware of the rising cost and frustrating inadequacies of the available mechanisms for finding recorded knowledge. The rapidly increasing accumulation of technical information and the lack of adequate organization for its utilization imposes an increasing economic burden on our society and threatens to drown our scientists and engineers in a flood of meaningless paper.

International events have emphasized the time dimension of present-day technology, and particularly the military significance of time. In technical development the major time interval is between the initial scientific discovery and the design of a prototype device. More time is lost—or more time is to be gained—between the laboratory and the drawing board than there is between the drawing board and the production line. In this period, where ideas rather than physical materials are involved, speedup is most feasible. Thus, from a military standpoint, the information system itself has become a "weapon system." It is the weapon system on which all military devices, as well as our peacetime progress, depend.

The problem is an old one. What is new is the general appreciation of its seriousness. Out of this arises hope that major steps toward solution may at last be undertaken. We can no longer afford the piecemeal efforts toward fragmentary solutions, which have been the only kind of efforts this problem has enjoyed in this country until now.

The acute awareness of the need arrives at a time when there is prospect for major help for solution from technology itself. Recent developments in machine systems for information storage and retrieval, although still far from adequate for the job at hand, are definitely encouraging. The technique of "organized invention" for the solution of practical problems has long since proved its efficacy in the applied-research laboratories of the world. The newer techniques of operations research, systems analysis, and applied behavioral sciences, are providing increasing evidence that an organized, systematic approach to very complex problems is effective, economical, and, indeed, may be the only feasible approach.

The cost of inadequate technical information processing facilities in duplication, in delay, in the failure to solve both military and civilian problems in the shortest time is real; it is large; it is constantly growing. The tools for the solution of the problem are available. Failure to use them now can only delay and make more difficult the effort ultimately required to prevent chaos in technical communications.

M. L. KASTENS

STANFORD RESEARCH INSTITUTE

To: Charles Bourne
Douglas Engelbart

Date: May 14, 1958

From: C. A. Scarlott

Location:

Subject: Your paper, "The Technical Information Problem"

Answering:

We're sending you copies of the SRI Journal containing your paper on the Technical Information Problem. This paper is novel in several respects. Because it is based on questions, it is unusual both in its mechanical style and readability. However, I'm convinced now, as I was when we were working with you towards preparation, that it will be read with much interest and will give our audience a new awareness of the technical information problem.

I want to express my own appreciation to you both for your very fine cooperation and patience with us during the preparing of the paper in Journal form.

If you have need of a few extra copies, we'll be glad to provide them.

CAS:bm
Enc.
cc: Jerre Noe
Tom Morrin

Chuck

SRI JOURNAL
STANFORD RESEARCH INSTITUTE

Volume 2 1958 Number One

IN THIS ISSUE

The fourth Western Area Development Conference will be held May 26–27, 1958, in Vancouver, British Columbia. The theme will be "New Products and New Industries Through Research." Besides general area development topics, discussion will be concerned with such expanding industries as electronics, nucleonics and petrochemicals. Particular emphasis will be placed on contribution of research to industrial development.

The Cover—Schematically represented on the cover is the streak camera, one of the simplest of high-speed cameras, yet one of the most useful for photographing explosions. It is used to record an entire event without lost intervals usually encountered when a series of distinct photos are made. It can "draw" a graph by capturing a segment of light from the explosion through a slit. As the mirror revolves, the light moves along film as fast as 4.8 mm per microsecond.

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One of the most obvious characteristics of the situation is its complexity. A solution to the problem must serve a diversity of users ranging from academic scientists engaged in fundamental investigations to industrial and governmental executives faced with management decisions that must be based on technical considerations. The solution must accommodate an almost overwhelming quantity of technical and scientific information publicly available in many forms through many kinds of media and in many languages.

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Stanford Research Institute believes that the techniques of systems analysis coupled with an understanding of the potentials of machines permit a powerful approach to the solution of this many-faceted problem. In fact, it may very well be that only by grappling with the problem as a single, integrated system can a realistic and lasting solution be attained.

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The list is impressive, but obviously not exhaustive. It does confirm the multiplicity of points of view that must be appreciated before this problem can be attacked.

Many of the questions require simple factual answers (see "Data Needed About Information Sources and Services," p. 5). They can be answered by straightforward techniques of counting, surveying, sampling, and estimating. A few of the answers are already available, but the fact that most questions of this type cannot be answered from available sources emphasizes the pressing need for a much better quantitative assessment of the size and nature of the information problem before a rational attempt to solve it can be undertaken.

Another group of questions involves essentially matters of national and scientific policy that ultimately must be answered arbitrarily. Data and analysis can give guidance to the answers but the ultimate decision will be based on judgment of relative needs and relative values.

Questions Relating to Policy

What are the specific aims of the program?

Will the system start with only new information? Or will it process back literature, and, if so, how far back?

Will the Service process requests from allied countries? To what extent? Will it coordinate with the Soviet Union?

Can part of the operations be done abroad? What about translation?

Will an international classification, indexing, or retrieval system be adopted or promoted?

Will the system be designed to serve the brilliant, the sophisticated, as well as the more unsophisticated?

Will the Service be financially self-supporting?

Will big business have any better access than small businesses or individuals?

Would a private citizen or scholar afford to use the Service?

How will prices be established for the Service?

What is the range of subject matter to be included?

Will classified information be included?

Will safeguards be established to insure that classified information is kept under proper control?

What type of information should be included? Books (texts, tables)? Technical and trade journals? Conference proceedings and papers presented but not published? Industrial and government interim and final project reports, etc.? Operation and instruction manuals? Patents? Manufacturers' catalogs? Newspapers and general magazines?

Who will be responsible for selecting the material to be included?

What protection will be provided users who want their queries to remain confidential?

Should service be provided outside the technical community? To congressmen? Executives? Businessmen? High-school students?

Who will control the policy in the matter of designing, establishing, and/or operating the Service? An appointed committee, such as for the NACA? A civil servant? A political appointee? A committee elected by scientific organizations?

A Proposal for a National Technical Information Service

Members of Stanford Research Institute have long given thought to the increasing disparity between the accumulation of new knowledge and the means for organizing it for widespread utility. With this problem brought into sharp focus by recent events on the international scene, the Institute believed it appropriate to formalize its views on the magnitude of the problem and to suggest a possible solution. In January, a draft program for a National Technical Information Service was prepared and copies distributed to members of the President's staff, to selected members of Congress, to various agencies within the federal establishment, and to industrial leaders and technical societies, all known to be concerned over the state of technical information affairs.

This document describes a program to solve the nation's technical information problem through the establishment of a national service for the collection, processing, storing, retrieval, and dissemination of scientific and technical information from both foreign and domestic sources. The program comprises five phases, interrelated and partially concurrent:

1—Establish a central organizing and administering, federally constituted Agency.

2—Determine the gross dimensions of the problem.

3—Establish an interim information center using existing services and techniques.

4—Analyze the factors that determine the design and operation of an ultimate National Technical Information Service.

5—Encourage present and initiate additional research and engineering development programs leading to systems and equipment necessary to implement the ultimate National Technical Information Service.

This proposal, and others, for solution of the problem are currently under study by the interested bodies of the nation. Meanwhile, at the Institute study of various phases of the technical information problem, both in the gross, and of specialized aspects of data handling, storage, and retrieval, is continuing.

Would it be feasible to establish legal authority to speed up the standardization and coordination of existing facilities (such as the F.C.C.)?

Who is competent to design, establish, and/or operate the System? Would this be a civil-service organization?

Could the objectives of the Service be achieved by expanding existing government agencies (e.g. Bureau of Standards, the Library of Congress, Armed Services Technical Information Agency)?

If the Service were not directed by some existing government agency, would it not be best handled by some university?

Would it be economically feasible for any sort of commercial enterprise or non-profit corporation organized by the professional community, or by private industry, to establish and run a Service which would assure continued social and technical progress?

If we must look to the federal government for support, what residual responsibilities remain with the professional societies? Should private groups continue to sponsor special collections?

What economic and political limiting factors exist with respect to the freedom one would have in utilizing or changing those organizations already active in the documentation field, and whose existence could be over-shadowed by a national Service?

What about copyrights? Would royalties be forthcoming to the owner of the copyright if the Service distributes the material? What will be the impact on the technical publishing industry?

Should the Service act as a publisher for collections of papers (reprints) in very new and special fields?

How will the priority schedules be fixed for the Service?

How soon could the Service be initiated? With an immediate manual system? With an ultimate mechanized system?

What factors will determine the location? Can strategic dispersal considerations influence the location without adversely affecting efficiency?

Is the proposed Service simply an attempt to copy Russia?

CHARLES P. BOURNE and DOUGLAS C. ENGELBART are research engineers at Stanford Research Institute's computer laboratory. Mr. Bourne gained his first electronics experience in USN schools from 1950-51. From 1952 to 1953 he served as instructor of various aspects of guided missile operation and maintenance with Convair Guided Missile Division and as adult education instructor in electronics at Chaffy Junior College. After receiving his BS degree from the University of California in 1957, he was employed as a research engineer at SRI where he has been engaged in research on mechanization of information retrieval and logical design.

Dr. Engelbart received his BS degree in electrical engineering at Oregon State College in 1948, MEE in 1953, and PhD in 1955 at the University of California. His theses were concerned with design and programming of drum-type computers and special gas-discharge tubes for use in computers. He has worked as professor of electrical engineering at the University of California, as electrical engineer at Ames Aeronautical Laboratories, and as consultant. In October 1957 he joined the SRI staff. Information retrieval is one of his specialties.

Might not an interim solution be to translate and distribute the exhaustive Russian abstracts, thus leaving our interim energies free for other uses?

Might it not be better to reduce the amount of literature produced rather than go to the tremendous expense of providing super-service for all of it? Can a quality filter be applied to this output?

Why not allocate federal money to support more direct interchange between working scientists? Perhaps more meetings, special conventions, seminars, etc., would be more economical than better literature processing? Couldn't the money be better spent on education to achieve a given increase in scientific effectiveness?

Could a substantial portion of the information problem be solved by teaching the users more about present-day documentation techniques?

Questions Requiring Research

Some of the questions posed to the study group will require considerable study and research to produce valid answers. The research will be in many fields—in the social as well as in the natural sciences. Some of the study must be quite profound—even theoretical. Some will be more straightforward. Many of these questions must be answered before the policy decisions implied in the previous group can be made with confidence.

Can we separate apparent need, influenced by present concepts and experience, from real need? Lack of awareness of the potentialities of recently developed methods (or methods not yet developed) can easily result in an unimaginative formulation of the possibilities and opportunities for advantageously using recorded information.

How will users' habits and needs evolve as a good System becomes available?

How are the information needs of a user affected by his age, educational level, profession, type of position held, etc.?

What are the characteristic information needs of the basic (academic) scientist? The applied researcher? The engineer? The decision maker? Are they all equally critical, or is the "applier" of knowledge the one with the biggest problem?

What is the role of information retrieval, storage, etc. in the decision-making process of the research worker, engineer, scholar, administrator, etc.?

How much use does the scientist and engineer make of the facilities that are presently available?

By what processes does the scientist and engineer keep abreast of the advances in the art now? What are the relative importances of each of these processes?

How many scientists and engineers have a definite program of "keeping up with the literature"? How much time

Data Needed About Information Sources and Services

Before the designers of an overall information center can sketch in the outlines of the system problem, a large amount of data about the information input and the existing information services must be collected. Some of the kinds of essential data are suggested by the following.

What subject fields are covered by the various journals, books, and reports? And in each case, in what depth?

What are the physical sizes of journals, books, and reports? Page size and number of pages? Frequency of publication? Kind and size of distribution? Cost or subscription price?

In what language(s) do the journals, books and reports appear?

Does each have an index? Are abstracts published, and where? Where is the information indexed?

Who, principally, are the contributors to the technical journals? Who selects or reviews papers for publication? How long, generally, between preparation and publication?

Are microfilm copies of books, journals, and reports available?

Who are the publishers of technical journals, books, and reports? Where is each located? And how long in operation?

How is each publishing operation financed?

What are the policies and objectives of the respective publishers in each field?

What fields of science and technology does each publisher operate in? In what fields does each concentrate or specialize?

In what language(s) does each publisher produce his journal(s), books, or reports?

Could publishers of journals, books, and reports provide paper tape or other machine-readable copies of their works? At what cost?

How much has been produced to date in the various technical subject categories in journal, book, and report form? What is the physical mass of each? Are back copies available?

What libraries with technical collections, abstracting services, indexing services, and translating services are in existence? Where is each located? What is its organization? How is it financed?

What is the size and training of the staff of the various technical-information handling or processing organizations? In each case is the organization equipped to handle classified material?

In what field(s) does each information handling or processing unit operate?

What classification and indexing systems are in use?

What is the normal time between publication of a document and its appearance in the libraries? When is it abstracted? Indexed? Translated?

What are the types and numbers of scientific and technical people using libraries, and the abstracting, indexing, and translating services? In what ways does the technical community feel it is being adequately or inadequately aided by these services?

Would the various libraries and services be amenable to negotiation of changes or increase in area of coverage, or other changes of service, to fit a reasonable, overall system, if government controlled and subsidized?

What are the charges for service by libraries? Abstractors? Indexes? Translators? Which of these services are self-supporting?

Are special compilations of abstracts, bibliographies, or translations available? And for what fees? How long required to provide such special services?

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would they "like to spend"? What keeps them from spending more time?

How much of the literature that would, with reasonably high probability, be useful to a scientist or engineer, is caught by him now by his own regular surveillance of the literature? How far out of his way will the average user go to be sure that he hasn't missed some possible information . . . considering the usual distracting pressures on him, his familiarity with the sources, etc.?

How many pages of literature in various categories relative to the level and interest-area of the user can we expect him to scan or search for his different information needs?

What are the relative merits of the different types of reference information services with regard to the user and his needs, desires, habits, and limitations?

What are the relative importances of the users' various informational needs? On one hand, he needs to know the newsy items such as who is working on what, what his current attack is, who disagrees with whom and basically why, etc.; and on the other hand, he also needs to be able to study in detail the carefully written treatises that may have bearing on his work. Can these different kinds of needs be met by a single system?

What are the special information requirements for different specialty fields?

Does the user, when he goes outside his special field for supporting information, want information in different form or different levels than which he seeks in his own field? For instance, would he be looking more for "cook-book" techniques or for survey-type information?

How valuable would broad, multi-disciplinary searches be if they could be conducted effectively? How great is the problem of differences in nomenclature between fields?

What type of questions now go unanswered at the libraries?

Isn't the main problem of information retrieval one of identification—since people so seldom express satisfactorily their needs to the documentalist?

What are the major limitations in the various methods presently used in classifying and indexing scientific literature?

Is the problem that the information now is just not available at all, or is it that it is just hard to find?

Why aren't the existing services that process technical information satisfactory?

How many places does a user of each discipline have to look for index listings of a given special interest?

How can the processing of recorded information be planned so that it can be effective in spite of human limitations, or of limitations in numbers of human beings?

How much is missed by technical people leaning too heavily on librarians?

What relative gain in efficiency could be achieved by integration, merging, or better managing of existing documentation services?

What increase in efficiency of the scientist or engineer would result from improving the accessibility of recorded information?

What are the probable net benefits, short and long range, of an effective information Service to military, industrial, commercial, scholarly, government groups?

Can dollar costs be derived for reasonably well-proven delays and duplications, and can the total national loss rate due to this problem be realistically estimated? Can it be determined that the expense of delay and duplication now is greater than that of establishing and operating an information Service?

What is the lack of an information Service costing government agencies?

Can the savings in Federal money now spent on other information programs be diverted to a national information Service?

What are the relative costs and characteristics of different reproduction techniques that might be applicable to some of the dissemination and massive processing problems of an information service?

What are the techniques and costs involved in keeping up and in using large mailing lists in taking care of distribution of journals, etc.?

What are relative costs of providing the information in micro form as against making original-size photo copies?

Of the currently-operating abstracting services, how many are operating merely to satisfy an obligation of a professional society that would rather have somebody else do the abstracting?

What services does the Russian All-Union Institute really provide? What is the reaction of a Russian scientist to this information center?

How important is it to know what the rest of the world is doing?

Are any projects or areas of work reported almost exclusively in foreign literature?

What is the expected rate of growth of the system?

What are the potential information processing capabilities of existing mechanical devices?

What are the theoretical capabilities of existing or anticipated machine components which might be applied to the information processing problem?

The Soviet Approach to the Information Problem

The Soviet Union has a comprehensive technical information system in operation. In 1952 the Soviet All Union Institute of Scientific and Technical Information was established in Moscow. By 1957 the Institute had a permanent staff of 2300 translators, abstractors, and publishers. This staff is supplemented by more than 20,000 cooperating professional scientists and engineers throughout the U.S.S.R. who act as part-time translators and abstractors in their specialized fields. The Institute publishes 13 "abstract journals" which annually contain over 400,000 abstracts of technical articles from more than 10,000 journals originating in about 80 countries. It systematically translates, indexes, and abstracts about 1400 of the 1800 scientific journals published in the United States.

To reduce the time between the initial appearance of the more important information in any of the world's journals and its reaching the hands of Soviet scientists and engineers through the normal route of the abstract journals, "Express Information Journals" are also printed. These carry summary information on foreign technological developments within two or three weeks after their receipt. The work done is reported to be not only comprehensive but also of high quality.

The Institute provides numerous other technical information services, such as provision of bibliographies, micro and full size copies of original printed material, technical dictionaries, and foreign-language dictionaries.

The Institute maintains an extensive program aimed to introduce machine methods to information handling. This includes translating machines, and mechanisms for codifying, storing, and retrieving technical information. Significant progress by the Institute towards information mechanization methods and systems is reported.

How often will the system presumably be searched? How definitive will the search have to be? What volume of information should a search produce? How fast should the system respond?

Characteristics of the Information Service

As increasing data become available it will become possible to consider some of the last group of questions—those dealing with the desired or necessary operating characteristics of a comprehensive technical-information processing system. Certainly, the first system implemented would be of an interim nature using existing resources, which unfortunately employ largely manual techniques. However, ultimately it is inevitable, in view of the impressive advances made almost daily in information processing techniques, that a highly mechanized system will be possible.

How soon can an interim system be functioning?

How much can be done just by concentrating on abstract distribution and better dissemination techniques?

Would it be feasible for the abstracting publications to use a standard format and type font, such that mats (or something similar) could easily be distributed to other interested publishers, thus saving printing expenses?

What technical societies could cooperate to publish a single journal instead of numerous splinter journals?

What about the scale of the Service? Does it have to be a big system or nothing?

Does "having a large information Service" necessarily mean the physical collection of all activities at one central location?

Would a group of smaller centers, for specific fields, be of greater utility and more tractable?

Would a collection of special libraries be more useful?

What can a national service provide that is different than what is now available? Is this to be an entirely new type of service, a real advance in the state of the art, or is it to be just more and better of the same thing?

Will the System have a finite capacity? One system might work well with a few million entries, but be hopeless with a hundred million.

As the System grows in size, will it be possible to make changes easily in the classification scheme and bring the old coding into the new scheme?

If a private consultant, with "need to know" established, were to work on a government project, how would he locate and procure pertinent classified material?

Will financial filtering of requests by a uniform fee structure be desirable or effective, or would it be necessary to make non-uniform fee structure so that there is essentially some "priority" given?

What means can be used to pry loose useful information that customarily doesn't get into the published technical information channels?

Will the service include a positive program to declassify material under security restrictions?

What is an acceptable delay in getting information entered into this system?

Will all material in the subject fields be included or will there be an editor or a censor?

Will an attempt be made to standardize the form of the material before it gets into the center? Does the material have to be on standard-size sheets or forms?

What happens when the system becomes overloaded? Should service to users just be late, or should the service just be less complete?

How can we protect against freezing the specifications until enough systems work has been done to make clear what would be optimal?

Will the policy makers make sure that the final methods chosen for a retrieval system are not influenced too heavily by the requirement of compatibility with past systems?

Will abstractions be done? What kind? Descriptive? Critical? Informative? How can we get good-quality abstracts? Should the Service use volunteer abstractors directly or a staff of full-time abstractors? Or should it allow the various technical societies to organize their own volunteer abstracting services?

Will any effort be made to review old documents, and to remove or recode when necessary?

Is a standard (or artificial) vocabulary necessary? How much work will be required to design and institute such a vocabulary?

What techniques and devices can reasonably be developed and applied for facilitating such immediate requirements as printing, reproducing, storing, microfilming, billing, communicating, etc.?

What kind of a data-processing system will the Service need just to keep track of its operation?

Would the information Service keep a collection of the original documents?

What special precautions must be taken to store primary records? Would a duplicate file and collection be maintained to prevent disruption of service due to fires, or other catastrophes? How much would this cost?

What is the useful life of various forms of records? In use? In storage?

What will the information Service physically provide in response to information requests?

Will the output be in English, or a code that must be translated?

Will microform copies be acceptable to the users? If not, what improvements need be made in order to gain user acceptance?

Will the information Service output be in a form that the researcher can determine which of the documents are in a locally accessible collection?

Will the system give answers (e.g., "yes," "no," "5,000 tons in 1945," etc.) as well as references?

Why not periodically publish inventories of research in progress, to indicate what research projects are currently being undertaken in each specialty field, thus helping to eliminate duplication?

Will there be a "special communication network" in which workers in the various specialized fields can easily circulate working papers or "think pieces?" A central agency could maintain printing, listing, (in appropriate subject-interest categories), and mailing facilities for this sort of service.

Will the information Service be able to retain a file of questions to be asked of all new input material, thus providing up-to-the-minute data for standing questions?

Will it be possible to stimulate more writing of "review-the-literature" papers by qualified people in the various fields, in order to provide guides for other workers?

Can a partial search be made? (For example, can 1/10 of the file be searched and the results checked to determine if further searching is justified?)

Could the information Service operate on a "just search ½ the file for me; I don't need a comprehensive search" basis?

What kind of communications network will be needed for the operation of the interim information Service? Will it be accessible to anyone by telephone or other direct device, such that the searcher can interrogate the file directly and at will?

Would the Service be available for browsing?

What technical-manpower drain would the proposed information Service program have on other high-priority scientific programs?

What professional and educational background is needed for the personnel to operate the Service?

Could university science students be used part time and during summers to help with the various processing tasks, as a means of alleviating the shortage of people with adequate technical backgrounds?

Will there be special training for abstractors and translators or for documentation and information specialists, etc.?

How much research is needed? What research budget is reasonable?

If an information Service were established, how soon could present partial services by government agencies be terminated and funds diverted to the Service? Could some special activities in industrial libraries be eliminated?

These questions, by the very nature of their origin, are random and fragmentary. Even the full list from which they have been selected is far from comprehensive. However, we have found them a helpful stimulus as well as a disciplinary aid in viewing the technical-information problem in its broadest dimensions. We hope that others interested in this problem will be similarly served.

A Simple Detector of Hazardous Hydrocarbons

MYSTERY surrounds most aircraft crashes. Inasmuch as the causes are difficult to determine, some remain unsolved. Theories are often evolved to explain them, but proof may be impossible. In any event, all possible causes have to be considered, and precautions need to be taken to lessen the possibility of their occurrence.

One possible cause is impure air in the plane cockpit, which may cause a sluggishness of the pilot's reactions. There is a possibility of contaminants, such as hydrocarbons from a leaky fuel system. Hydrocarbons, however, are not only a respiratory danger; mixed with air they form an explosive mixture.

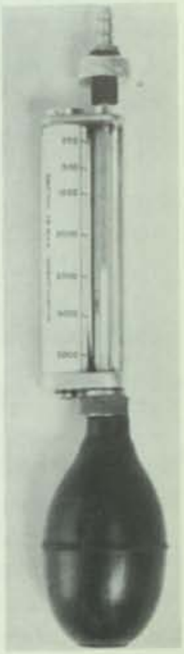
These possibilities suggest that a hydrocarbon detector in the cockpit would be a desirable safety measure. Such a detector should be portable, compact, light in weight, simple to operate, easy to read, and give results quickly.

A detector to fit these specifications has been designed for the Air Force by SRI. The instrument measures the aliphatic hydrocarbon content in air in concentrations from zero to 5000 parts per million and to a maximum error of 20 percent.

It consists of a standard rubber squeeze bulb, and a calibrated glass tube filled with a column of silica gel impregnated with iodine pentoxide and concentrated sulfuric acid. A squeeze of the bulb draws a sample of the atmosphere into the gel. Any aliphatic hydrocarbons present reduce the iodine pentoxide to elemental iodine. The iodine stains the silica gel to a specific length of the column, which is a measure of the aliphatic concentration.

This unit has a uniqueness of selectivity for aliphatic hydrocarbons that has not heretofore been attainable by simple means. Other types of hydrocarbons, detectable by various other methods, do not show up in this test because they oxidize too rapidly.

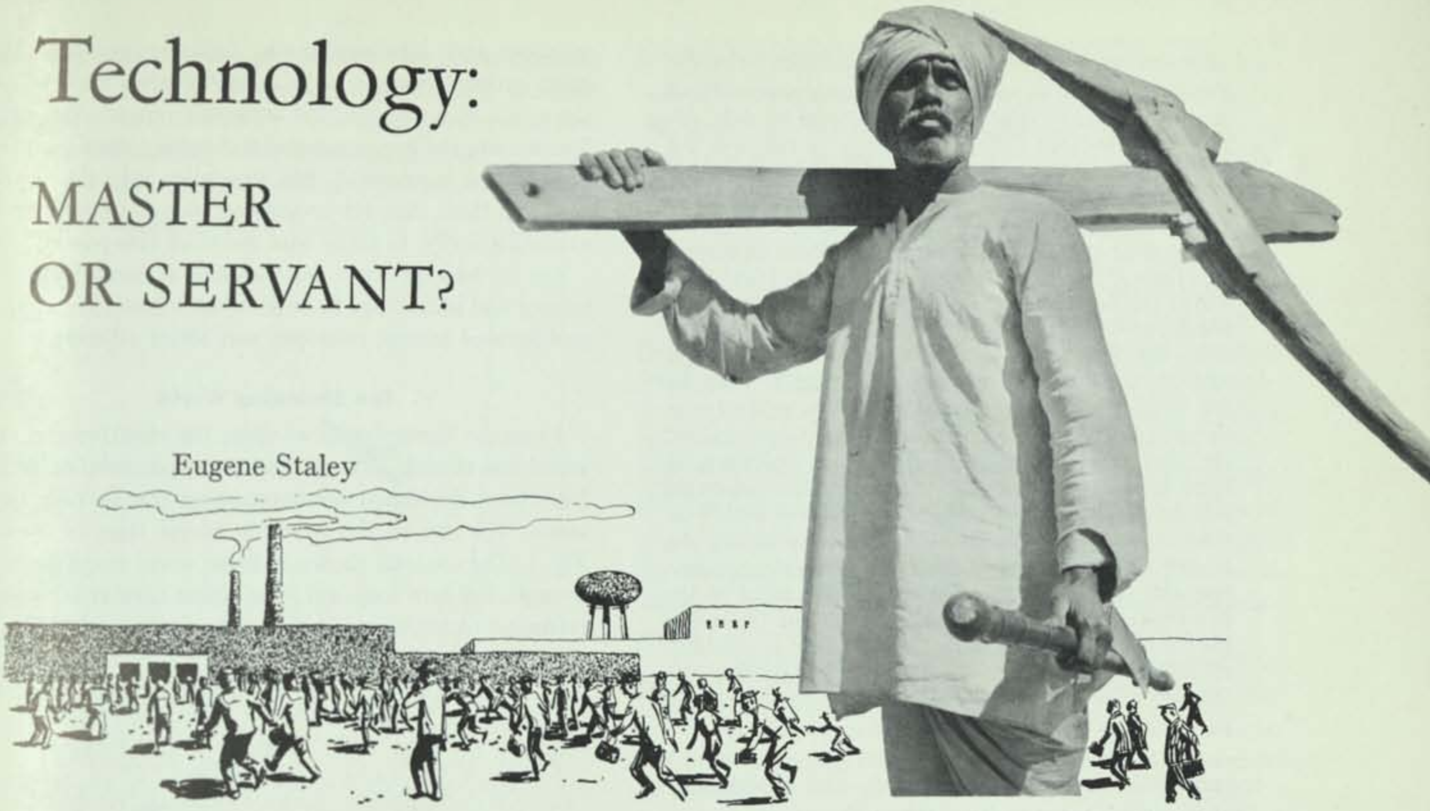
The detector may also be useful for checking fuel-storage areas, for detecting atmospheres in and around refineries, detection of leaks in refrigeration systems, testing the atmosphere of mines and in submarines, and studies of auto exhaust.



Aliphatic hydrocarbon detector

Technology: MASTER OR SERVANT?

Eugene Staley



Research has enabled man to take gigantic strides in understanding and controlling his environment. But what of the impact on man's life? Science and technology create as well as solve problems. For example, the uneven spread of the results of technology among the world's peoples has created a gap between developed and underdeveloped nations which is contributing to world tensions. A new emphasis on the human implications of research is needed.

WHAT is the most significant invention of modern times? Electronic communication? Harnessing nuclear energy? Antibiotics? The ability to create tailor-made materials through chemistry?

My candidate would be none of these. It would be an invention that is responsible for all of them, namely, organized scientific research and development.

Someone has said that in recent times we have "invented the art of systematic invention." Speaking more precisely, it is not just the process of inventing, in the narrow sense, that has been rationalized and systematized. It is the whole interconnected complex of technological development.

We have, in modern techniques of research, development, and product introduction, a powerful engine for systematically producing technological change. We might say that in the twentieth century technology has advanced to the second power—we have a technology for producing new technology.

Toward what ends are we going to use it? By what criteria is it to be guided? Can it be guided? Will it respond only to short-range pressures of the moment, inspired perhaps by no more long-range thinking than is forced by commercial or military competition? Will it perhaps roll ahead with ruthless inhuman momentum like the car of the great god Juggernaut which crushed the faithful devotees in its path? It is imperative nowadays to give some thought to broad questions concerning the human consequences of research and development.

Criterion for Science and Technology

Three and a half centuries ago Sir Francis Bacon laid down a criterion by which to judge the work of science and technology. "The true and lawful goal of science," he wrote about 1603, "is that human life be endowed with new powers and inventions." Bacon was confident that the new powers and inventions to spring from science would, in his words, "be operative to the . . . betterment of man's life."

Modern science and the technological developments built upon it have in many ways—not always, we must admit—bettered man's life. On the favorable side we can point to the easing of daily toil, control of diseases, and the availability to the common man and his family—on a scale that would have been the envy of the rich and noble in earlier ages—of food, clothing, and commodities, as well as

From a talk presented at the SRI Associates Day Meeting, December 1957

Eugene Staley is senior international economist at Stanford Research Institute. He received his A.B. degree from Hastings College, Nebraska, in 1925 and did postgraduate work at the University of Chicago, earning his Ph.D. in 1928. After two successive traveling fellowships, he taught economics at the University of Chicago, followed by professorships of International Economic Relations at the Fletcher School of Law and Diplomacy and at the School of Advanced International Studies in Washington. During World War II and immediately following, Dr. Staley worked on various assignments with the U. S. Government. Joining SRI in 1949, he was chief economist in a mission to Cuba of the International Bank for Reconstruction and Development. Dr. Staley has recently returned from two years in India for SRI as a consultant to The Ford Foundation and the Government of India on problems of India's industrial development. He assisted in establishing the United Nations Relief and Rehabilitation Administration and served as a member of the secretariat of the San Francisco conference which drew up the Charter of the United Nations. In India he also helped to establish an Indian applied economics research organization.

opportunities for education, travel, and entertainment. That is, we can point to these things if we confine our gaze to the dozen or so countries inhabited by about one-sixth of mankind that are technologically and economically most highly developed.

Even in highly developed countries any completely optimistic appraisal of the human consequences of technological development would have to overlook many pockets of underprivilege where the benefits of modern technology, theoretically attainable for all, have not in fact been attained.

In further qualification of the optimistic view, we would have to note that new human problems are often created by the very inventions designed to solve other problems. For example, the new techniques of industrial production, of communication, and of transport were adopted without much attention to the human living aspects of the haphazard city growth which they helped to generate. When we consider the time spent in daily travel between home and work, the problems of air pollution and traffic jams, and the social disorganization and mental stress, of which juvenile crime rates are one symptom, it is clear that technologically based urban living is not an unqualified success.

It is the application of science and technology to weapons of destruction that really gives us pause when we try to apply Sir Francis Bacon's touchstone, "be operative . . . to the betterment of man's life." The same fundamental knowledge and inventive skills which can do so much to *better* man's life are also able to produce even more potent *threats* to life—A-bombs and H-bombs, radiological, chemical, and bacteriological poisons, electronically guided missiles, and intercontinental ballistic missiles. While great nations continue to be ranged against each other on the verge of hostilities, the awesome power over natural forces conferred by science and technology upon man seems like a lethal instrument that has fallen into the hands of children. Have men yet progressed enough morally, as well as intellectually, to make wise use of all this power?

Let us look at some outstanding accomplishments of science and technology in order to note how they raise new problems of human relations and social adjustment.

The Shrinking World

From the human point of view, the effective size of the world has shrunk as more and more powerful techniques have been developed for overcoming the barriers of distance. The size of the world in travel time is shown in Fig. 1. The contrast shown in these world maps is striking enough. But how long will it be before further advances in transport technology will have shrunk the world still more than shown here?

Fig. 1—Size of the world, in travel time. The chart assumes the best travel technology of the stagecoach-sailing ship era, of the railroad-steamship era, and of the aircraft era applied over the whole surface of the earth. The top map represents the world at ten miles per hour on land and sea, the next at 65 miles per hour on land and at 36 miles per hour on the sea, and the third portrays the size of the world in travel time assuming propeller-driven speeds of 300 miles per hour. The tiny figure at the bottom shows the world at passenger aircraft speeds of 500 miles per hour.

The sudden "shrinkage" of the world brought about by technological advance has raised many human problems. In "hands across the sea" speeches, when a new cable or a new transport line is being opened, it is traditional to refer to "bringing people closer together" as a factor making for understanding and peace. This is a fallacy, at least in the short run. The first effect of bringing people closer together is to create new possibilities of conflict. Near neighbors have many opportunities for quarrels that distant peoples do not have. Bolivia has never fought Turkey, but each has fought its neighbors. Peace among peoples in close contact is a positive social achievement; it requires the working out of a host of agreements and procedures and com-

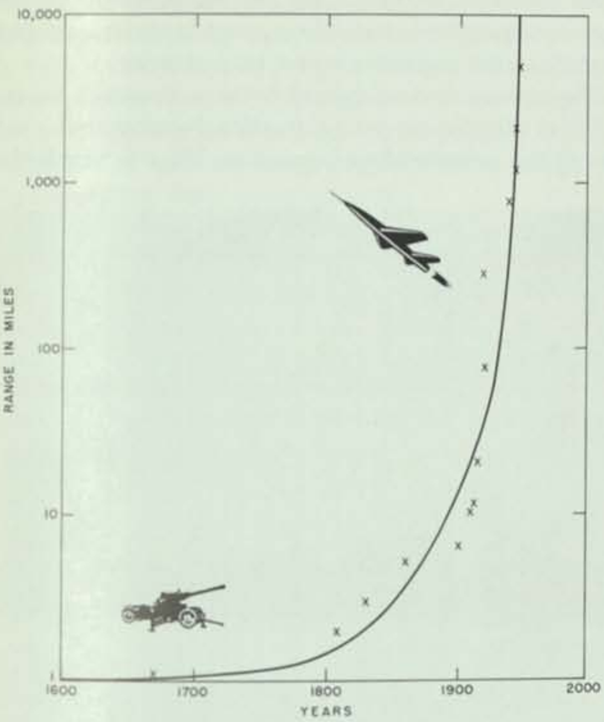


Fig. 2—Increasing range of projectiles—bombs carried by aircraft included. (Source: Hornell Hart, "Technological Acceleration and the Atomic Bomb," *American Sociological Review*, June 1946, p. 289. The curve, fitted by Hart, is of the continuously accelerating loglog or Gompertz type.)

mon institutions to deal jointly with matters of common interest. Under the impact of modern technological change, strange peoples have suddenly become near neighbors and interdependent. This has happened so rapidly that mankind has not yet been able to make adjustments, in ways of thinking and acting, which are required for harmonious existence under the new conditions.

Technological progress in communications has been even more spectacular than in travel and transport. In fact, if we tried to portray the shrinkage of the world in terms of the required time for getting a message from one place to another, the top map of Fig. 1 could roughly represent the situation before the invention of electric methods of signaling, while the present size of the world on the same scale of message-time would be a microscopic dot.

The content of exchanged messages, not the speed, determines whether rapid communication is "operative for the betterment of man's life." The story is told of Thomas Carlyle that a friend rushed up to him in considerable excitement saying, "They've just opened the cable to India. Isn't it wonderful?" And Carlyle replied, "What have we to say to India?"

Physical communication can exist without bringing successful *social* communication. Physical communication is accomplished by a mere exchange of signals, which may or may not be interpreted by the receiver in the sense intended by the sender. Successful social communication puts the emphasis on mutual understanding, a true meeting of minds. Progress in the first without corresponding progress in the second is dangerous. Yet the amount of research effort presently going into improvement of electronic communication and other forms of physical communication must be well over ten times the amount of research currently devoted to improvement in techniques of human understanding. Dr. Lee De Forest, inventor of the three-element electron tube, told an interviewer on his 80th birthday that he was deeply disappointed in the use being made of his brainchild. He hoped that someday those responsible for the programs broadcast by radio and television would do a job worthy of the engineering perfection in the equipment.

Another aspect of technological progress which has had profound social consequences is illustrated in Fig. 2, the increasing range of projectiles. One of man's greatest efforts has been to develop better methods for striking his enemies at a distance.

Human attitudes and social and political institutions have not been able to change rapidly enough to adapt themselves to the new situation created by accelerated technological change in the range and power of weapons and in other aspects of physical technology. In consequence, man faces a crisis of survival. The world today, in terms of travel, communications, and range over which military force can be exerted, is smaller than many of the historic empires. From an objective, rational point of view, a world

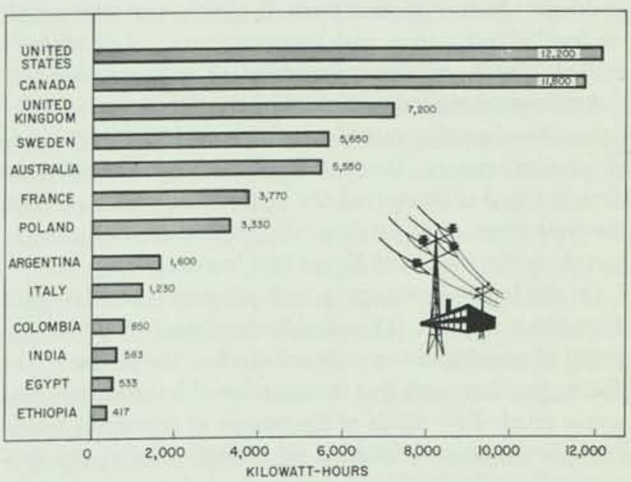


Fig. 3—Per capita consumption of energy from inanimate sources in selected countries, 1949. (Source: United Nations, *World Energy Supplies in Selected Years*, 1929–1950, Statistical Papers, Series J, No. 1, September, 1952, Table 15, pp. 94–96. The coal equivalents have been converted to electricity equivalents at 0.6 metric tons of coal for 100 kilowatt hours, the rate indicated on p. 107, on the basis of efficiencies prevailing in 1949.)

as small as ours requires, for reasonably peaceful human cooperation, some type of world government and world police. Yet this is a political impossibility at present, because of the ways of thinking and the emotional attachments that were formed in men's minds and embedded in social and political institutions when conditions were vastly different.

The uneven diffusion of technological change illustrated in Fig. 3 is another source of present-day human and social problems. Energy consumption is closely correlated with the level of technology, with the productivity of a country's economy, and with the living standard of its people.

A man working at average intensity 40 hours a week for a year develops the equivalent of about 150 kilowatt hours of physical energy. On this basis, we may interpret the data in Fig. 3 to mean that the United States had, in 1949, the equivalent of 81 mechanical-chemical slaves for every person, while India and Egypt had less than four.

On the basis of average income per capita, similar great disparities appear. The highly-developed, high-income group of countries have only one-sixth of the people of the world. Another sixth live in countries of intermediate economic level. Two-thirds of the people of the world live in countries that are classified as technologically and economically underdeveloped, and in which poverty is the rule.

The poverty in underdeveloped countries is shocking, especially since a considerably better level of living is possible with application of known technologies. According to the statistical services of the United Nations, the gap between the highly-developed and underdeveloped countries is not only large but still increasing. The highly-developed countries are still, on the whole, moving ahead more rapidly than the underdeveloped countries. Furthermore, despite the vaunted technological progress of modern times, there are more poverty stricken people in the world today than there were 50 to 100 years ago. This has resulted from the slow or non-existent economic progress in underdeveloped countries while populations have been growing.

The contrast in development between countries has resulted in a tension-producing situation. Poverty itself is not new in the underdeveloped countries. What is new is the awareness of poverty, the realization that it is not the inevitable lot of mankind, and the determination to do something about it. A "revolution of rising expectations" has occurred. This is one of the most important effects of the technological developments that have effectively shrunk the world.

The pottery maker at work on his wheel (above) represents a typical example of village industry as it has existed in India and other countries for centuries. Today, in such countries, can be found a mixture of the old and the developing new technologies. Symbolic of the new is (right) the current expansion of the Tata Iron and Steel Company's installation at Jamshedpur, India. (Pottery photo from The Ford Foundation; steel works photo by Kaiser Engineers.)

Most of the underdeveloped countries are now striving to modernize their technologies and to raise the living levels of their people. In India, for example, a five year program is now in execution which, in terms of India's resources and development problems, is very ambitious. If successful, it will raise the average per capita income from about $59 to about $70 by 1961–62, an increase of 18 percent. This is to be accomplished by a 25 percent rise in national production, which amounts to a per capita rise of 18 percent after allowing for the expected population growth. India is committed to doing this by democratic methods under a political system of representative government responsible to the people in free elections.

It is strongly in the interest of Americans that India should succeed. The future of free political institutions in the world may, indeed, turn on whether India and other countries, similarly attempting technological and economic development within a framework of political freedom, do or do not succeed.

Business Leadership Can Assist

This problem of more adequate diffusion over the world of modern technology and its economic benefits presents to business leadership both opportunities and responsibilities. An inspection of the trends in the underdeveloped, but newly developing countries shows that countries written off heretofore as sales and investment deserts are changing rapidly and deserve a reappraisal.

Concern for economic development in the poorer countries may, in fact, turn out to be just as important for American security as the development of new weapons. It could be that recent Soviet announcements and demonstrations, which have so impressed us with their proficiency in weapons, are a strategic feint. Soviet leaders may count on us, as a result of these demonstrations, to devote vast sums to new weapons programs and to cut the budgets for overseas economic development aid. The real thrust of Soviet expansionism would then reveal itself in non-military seizure of power by playing on economic and social discontents in underdeveloped countries. Khrushchev told an American interviewer recently, "We will beat you in economic and social competition," and this is fully in accord with Soviet doctrine. Dictators have told us the truth about their plans on previous occasions, as Hitler did in *Mein Kampf*, trusting us not to believe them.

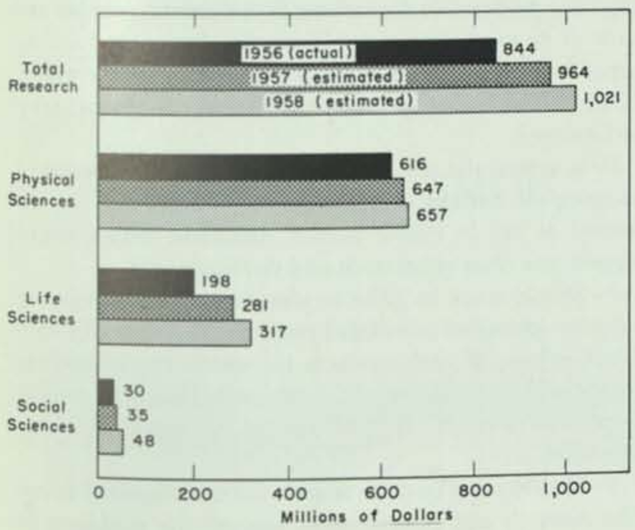


Fig. 4—U. S. Government obligations for research by scientific field. (Source: National Science Foundation).

The Population Problem

It might seem that progress in saving human lives could never create a problem, but in fact it does. The efficacy of modern public-health methods has lowered the death rate in many countries that continue to have high birth rates and are already densely populated. The resulting rapid growth of population—some have called it a "population explosion"—is a most serious obstacle to the betterment of living conditions in such countries. Unless population growth can be brought under control, the outlook for raising living levels in densely populated and poverty-stricken countries is bleak. In India and Communist China this is now officially recognized.

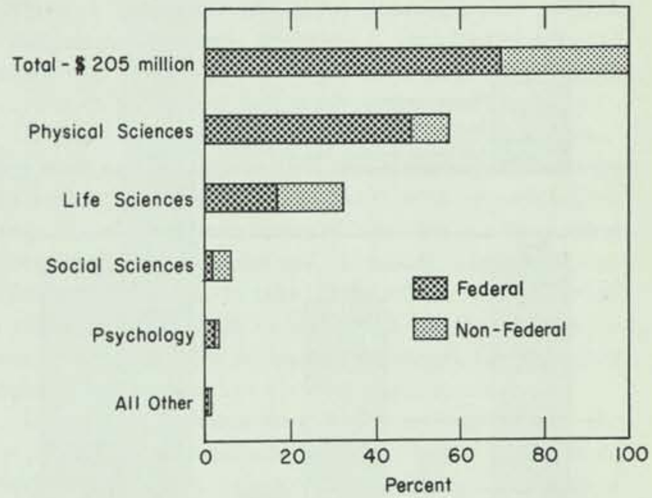


Fig. 5—Separately budgeted research expenditures in colleges and universities, 1953–1954. (Source: National Science Foundation).

Here is a field where research and development is needed. Physiological methods of controlling conception—the often-rumored "pill" that would be safe, reliable, and cheap—would brighten the outlook for betterment of human life in many parts of the world.

Problems Posed by Social Science and Technology

Advances in social science and social technology will not always bring about betterment of man's life, any more than betterment is inevitable as a result of advances in the physical and biological fields. More effective techniques of management, of education, of propaganda, and of group organization can be used for good or for evil purposes. There is no escaping the heavy moral burden placed upon man—the necessity of choosing between good and evil *ends*—by the increasing control over *means* which results from advances in any kind of technology, whether it is physical, biological, or social.

In short, with increasing success in scientific research and development, human and social problems are the crucial problems. Every betterment of man's life resulting from progress in science and technology, and all the hopes of further betterment, can be swept away unless somehow men speed up their progress in the know-how of working together. Modern technology has made us more secure against the hazards of non-human nature, but much more vulnerable to the hazards of human nature, which express themselves in human conflict and disorganization. The majority of the people of the earth still live in poverty, not because techniques for producing enough are unknown, but because of social obstacles to the effective application of these techniques. Progress in meeting other problems of our technological civilization, such as making cities more livable and achieving a better adjustment between the requirements of large-scale organization and the psychic needs of individuals, likewise depends on better understanding of human relations and social organization.

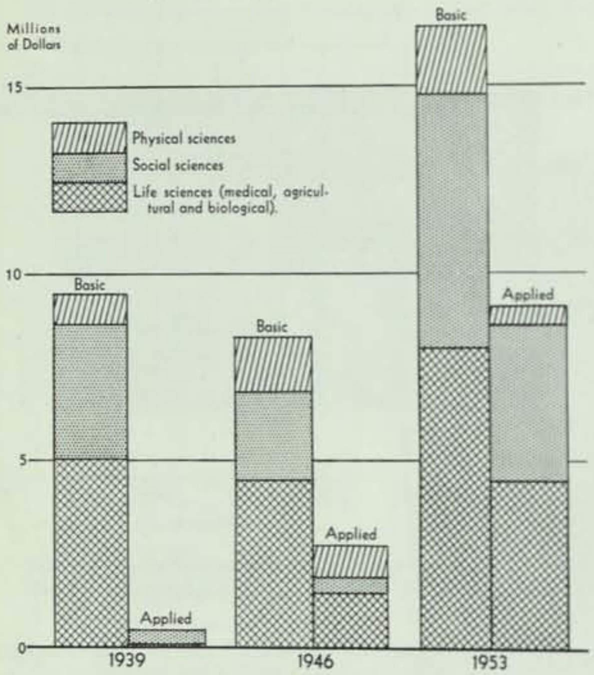


Fig. 6—Support of basic and applied research by 77 larger foundations. (Source: National Science Foundation).

Allocation of Resources for Research

In the face of this situation, how is our society allocating resources for research? Research expenditures in the fields of human behavior and social problems (Figs. 4, 5, and 6) are quite small relative to those in the physical and biological fields. Only in the case of the foundations is there a different emphasis. The shift in this direction in foundation expenditures for research between 1946 and 1953 was largely occasioned by the entry on the scene of The Ford Foundation, which deliberately decided to concentrate on programs in the field of human behavior and social relations.

Unfortunately, we have no reliable information on the allocation of industrial research efforts by major divisions of science. The National Science Foundation's study of industrial research in the United States was limited to the natural sciences and their applications—a revealing fact in itself. If we did have such information, it would very probably reinforce the conclusion that research expenditures are being overwhelmingly directed towards the solution of physical and biological problems, with research on human behavior and social relations a very poor third.

It is not suggested that allocation of larger sums for research in the sciences of human behavior and in their application to pressing human relations problems will bring guaranteed, neat solutions or that it will bring them quickly. Of all the subjects which man has attempted to investigate by scientific methods, human beings and their social relations are the most complex. The behavioral or social sciences probably never can approach the precision or rigor of the physical sciences. But the scientific study of human and social problems has made truly significant advances in recent times. Unquestionably there is both need and opportunity for much more extensive application of the scientific spirit and scientific method to these problems.

For Research Directors to Consider

Many practical questions might well be considered by those responsible for planning and directing industrial research. Only a few can be suggested here. Some will relate to a company's profits, others to a company's community responsibility.

1—Is it a regular part of research and development procedure that as soon as a new technical idea reaches the stage of consideration for serious development, studies are made of its marketing possibilities, the financing requirements for its production, and, if it is a major innovation, the direct and indirect economic and social effects that may be foreseen?

2—Is systematic research undertaken for the purpose of scanning the horizon of human needs, whether or not expressed as yet in visible market demands, which might suggest new lines of research and development?

3—Should more be done to pioneer and encourage, by industry-sponsored or assisted research, those socially constructive uses of new products for which the immediate commercial incentives might not be sufficient? An example is industry support for working out educational uses of television.

4—Should more be done to turn the techniques of scientific research and development toward the problems of human relations and human organization within companies?

5—In view of the shortage of qualified scientists and technologists, has enough attention been given to finding methods for using them more efficiently in industry, and to methods of making more efficient use of science teachers in schools and universities?

6—How would a company's research and development be planned if the profit and loss account were to be calculated on a ten-year period instead of annually?

7—Should companies be doing more, either on their own or by pooling efforts with others, toward the sponsoring of basic and applied research on the social, economic, and other human changes being induced by new technology? In other words, should there be more attention to scientific analysis of the social consequences of research and development?

Companies exist in an economic, social, and political environment that is being profoundly affected by the direct and indirect consequences of technological change. Their achievements in research and development are likely to bring still bigger changes in the future. What is research and development doing to us?—meaning by "us" our nation, our world, the outlook for our children? None of these considerations are too remote to have repercussions on a company's situation. International relations used to seem remote, but if men cannot soon do a better job of matching constructive political and economic thinking to the one world created by modern technology, then there will, sooner or later, be a major war. And business is not good if the customers and the employees and the stockholders are dead.

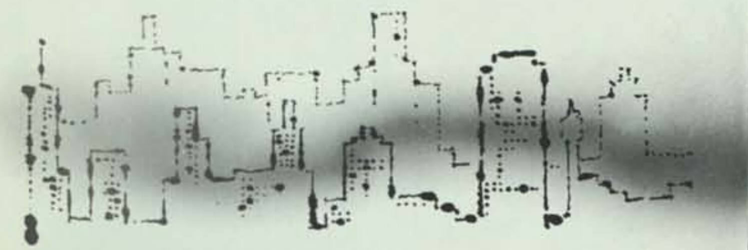
Assuming we avoid international calamity, the powerful influence of technological change on family life, city growth, the problems of urban living, economic development of hitherto retarded areas, and many other aspects of human affairs will have important implications for company planning. In the light of what research can reveal about these social consequences, company planners will need to examine: the long-term aims of the company, changing markets, facilities likely to be needed, new research and development possibilities, kinds of personnel likely to be needed, finance, and methods of providing for follow-through in accordance with needs and opportunities.

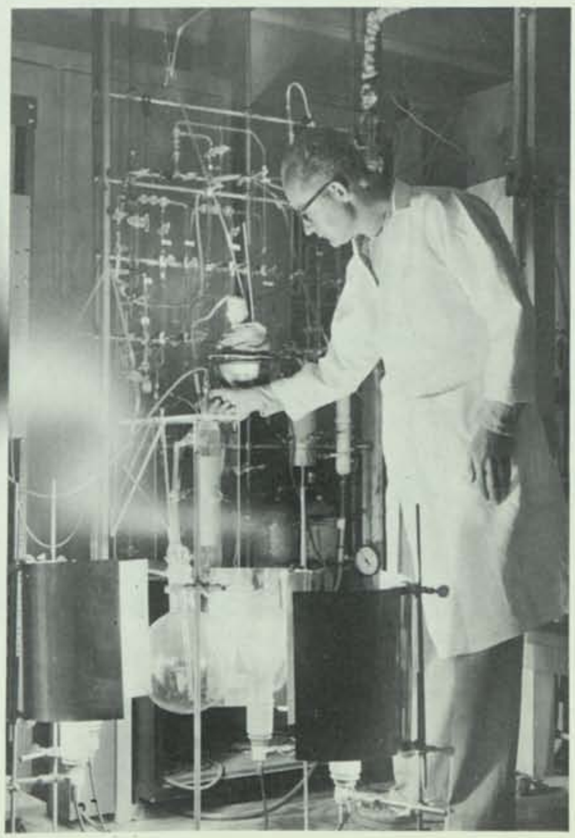
In a world where organized research and development is constantly stepping up the *means* available to man, the wise choice of *ends* and farsighted leadership to gain those ends are crucial problems. For this reason we need, as President Eisenhower said in his Oklahoma City address, "not just engineers and scientists . . . but leaders who can meet intricate human problems with wisdom and courage . . . not only Einsteins but Washingtons and Emersons."

It would be a great mistake if, in our concern for producing more and better scientists and technologists, we were to neglect the need for humanistic thinking and leadership. One of the supreme tasks of education in a free society is to fit citizens to make well-informed, enlightened, discriminating choices—to take the broad view and to see the interrelations of things, to distinguish the better from the worse in many fields of human endeavor. For this they need to know more than their technical specialties.

Unless broad, humanistic understanding directs our technological skills and sensitizes citizens and leaders in all fields to the human values that are the true measures of progress, we shall surely find ourselves being swept along helplessly by a flood of technological developments, and technology will be our master when it should be our servant.

LABORATORY SMOG

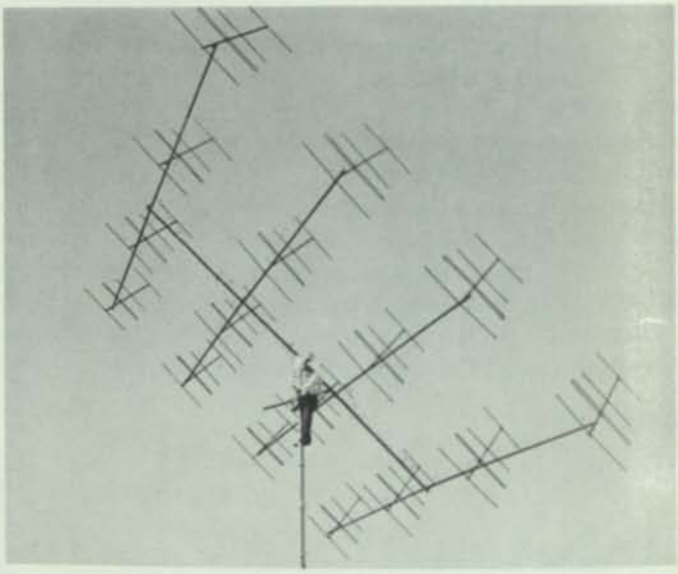




Some types of smog occur when certain atmospheric pollutants are exposed to sunlight. If the materials are known, therefore, it is possible to construct smog synthetically for laboratory examination. The apparatus (right) is used for this purpose. Test pollutants are mixed with air by means of the complex glass system, in the background, at concentrations normally observed in the atmosphere. The mixture flows into the glass vessel surrounded by globes which give off balanced light equivalent to that received from the sun at sea level. After its creation the "smog" can be analyzed to determine its relationship to city smog.

DOORWAYS to the Sky

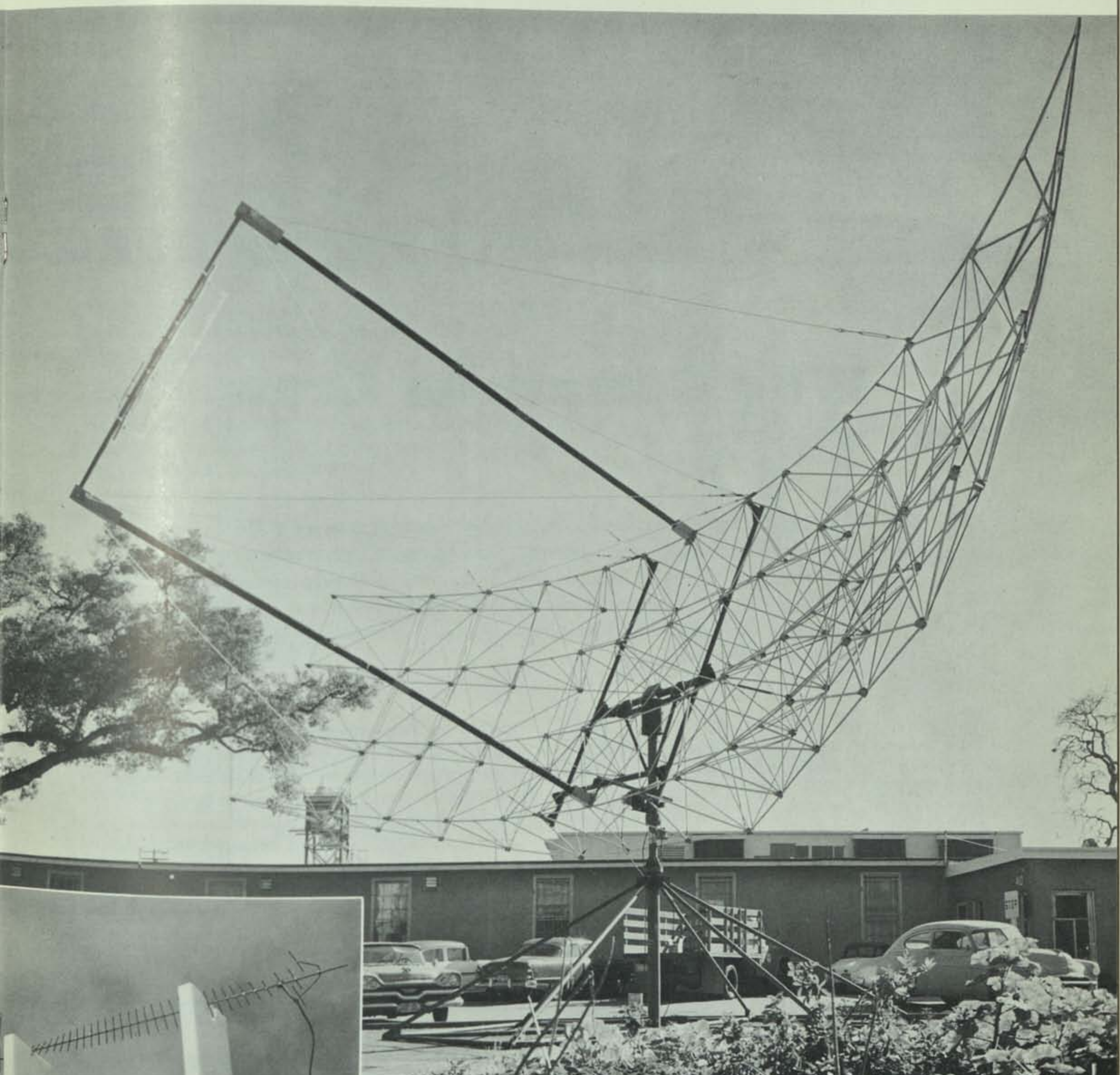
Antennas have been a center of study since 1888 when H. Hertz first experimented with radio waves. Today's extensive use of these electromagnetic waves for communication, navigation, and detection has served to intensify antenna research activity toward greater efficiency, convenience, or economy of construction. Results of the search have been strangely shaped structures that are a far cry from the straight wire aerial.

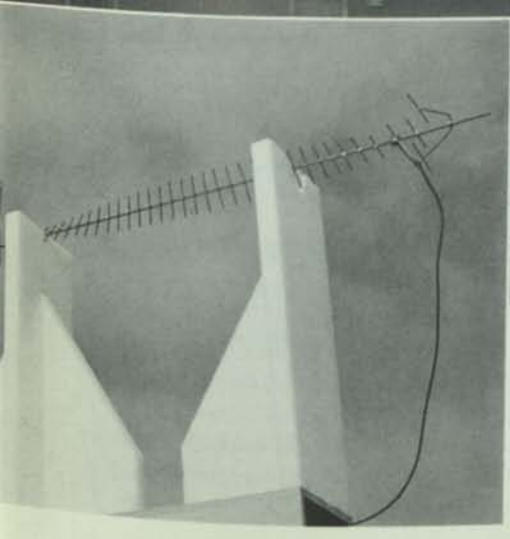


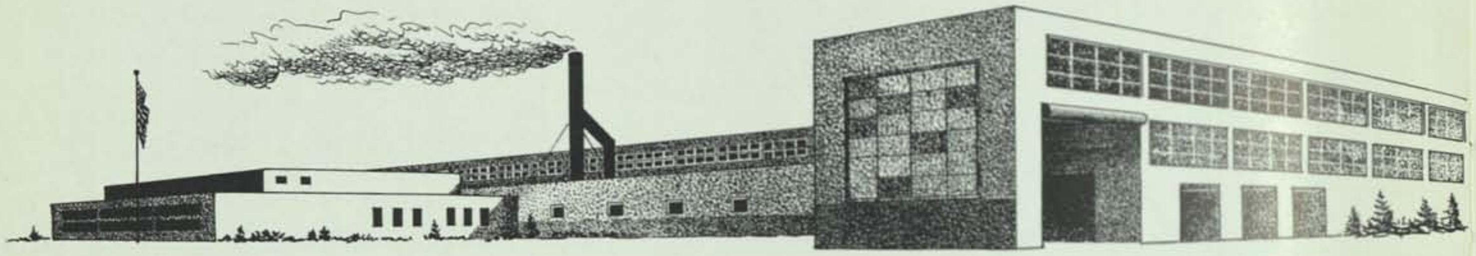
The twist antenna (right), supported on Styrofoam for test, was designed to meet the need for more sensitive point-to-point radio and TV communication in the VHF-UHF (30 to 3000 megacycles) range. A short segment of this antenna is similar to the common parallel rod yagi TV antenna (named after its Japanese inventor). One distinct difference makes its extension beyond the normal yagi length possible: the cross rods are displaced in a spiral around the axis. Extending the length is desirable since the signal-amplifying ability of an antenna normally increases proportionately to its length. In the case of the conventional yagi, however, there is a practical limit beyond which an increase in length yields very little increase in signal strength. The spiral arrangement overcomes this limitation so that it is possible to take full advantage of a long axis. The pictured model is 10 feet long. Expectations are that it can be used advantageously up to many times this length, and can be utilized in installations which would normally require expensive paraboloid antennas.

The parabolic segment antenna (far right) was designed for research use in Alaska in conjunction with a large dish-type antenna to study the aurora. Signals of 400 megacycles are transmitted from the "dish," reflected by the aurora, and received at the parabolic segment located 50 miles away. The signals, modified by the aurora, are being studied by engineers to learn about the characteristics of the aurora.

The broadside yagi array (bottom) mounted on a van (not shown) is used with another large dish antenna at the Radio Propagation Field site of SRI to study moon and meteor "echoes." In this case 100 megacycle signals are beamed to the moon and reflected to the broadside antenna. The returning signals provide information not only about the moon's surface, but also about the upper atmosphere. Other studies are being made of the way signals are reflected from meteors.







Why Companies Grow

N. R. Maines

Companies in ever-shifting competitive industry, much as trees in a forest, display a wide variety of growth patterns. Some maintain high growth rates, while others develop slowly. However, some high-growth companies eventually slow up, and some slow growers accelerate. There must be reasons. A research effort is under way to determine what factors are most influential in the growth patterns of companies.

For several years businessmen have evinced mounting interest in the phenomena associated with company growth. They have wondered why some companies expand sales and profits, while others seemingly stand still. Can growth be deliberate and planned, or is it largely an accident? Are there observable facts to explain successful growth of companies?

In 1955 SRI undertook a study to gain some insight into company growth. The study is not complete—if indeed it ever can be. While we are not fully satisfied with our knowledge of the subject, at least a number of interesting impressions and clues have emerged, sufficient, we believe, to warrant a report of the work done to date, the findings thus far, and the techniques employed.

The study has indicated that companies with high rates of sales growth usually have:

1—An affinity for growth products or fields,

2—Organized programs to seek and promote new business opportunities,

3—Proven competitive abilities in their present lines of business, and

4—Courageous and energetic management, willing to take carefully studied risks.

N. R. Maines is head of Company Planning Research at Stanford Research Institute. After graduating from the University of California in 1938 he worked with trade periodicals and as a trade commissioner until he joined Consolidated Aircraft Corp. in 1942 as an industrial engineer. Nine years later he went to Hughes Aircraft to become supervisor of planning and manager of Management Controls. He first came to the Institute as a Senior Industrial Engineer in 1953 and moved into his present position in 1956. While with SRI he has conducted studies in automation, technical marketing, company resource planning, merger evaluation, and, his latest, on company growth, upon which this article is based.

What Constitutes a Successful Company?

One of the first problems of the study was to establish some yardstick for a "successful company." Now, "success" is a slippery word. Its meaning depends on the standards set. In selecting companies as successful, we place considerable stress on "growth" since most owners and stockholders, particularly of industrial concerns, are looking for increasing earnings and possibilities for capital gains. There can be no question, however, that many companies in stable situations are performing their functions admirably and completely satisfying their owners.

In an examination of a company considered successful by the usual corporate investor several of the following conditions are found:

1—It has grown steadily for years in sales volume and earning power.

2—It operates in markets and product fields that have above-average growth prospects.

3—It withstands periods of adversity because of its size, diversification, financial resources, or other qualities.

4—Its products and services are well regarded by customers and the public at large.

5—Its employees are proud to be associated with it; they have a feeling of personal responsibility for its success and feel that it offers ample opportunity for their development as individuals.

6—It has forward-looking programs to promote its future in such areas as product development, market development, company acquisitions, organization or management development, and operations research.

7—Its management team is highly respected and well rewarded for its capabilities.

8—Its policy is fair in dealing with stockholders, so that

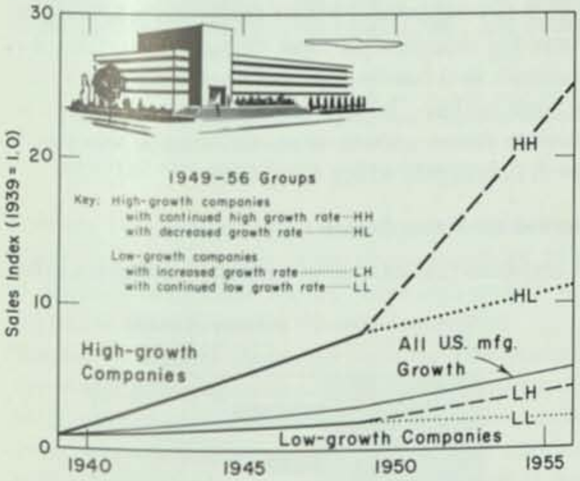


Fig. 1—Sales growth of sample companies. Since the monetary figures are given in current dollars for each year, the chart reflects inflationary trends which are not related to company performance. For comparative purposes, however, this treatment is valid.

the owners realize maximum long-term benefits from their investments.

Method of the Study

Our approach to this problem was similar to the research study, brilliantly executed by the late Dr. Louis M. Terman at Stanford University, of gifted children's careers. He made his first analysis when the children were young, and checked their progress periodically over the years. At each stage he learned something more about these children by observing their successes and failures as they grew and became adults.

The Sample Companies

Manufacturing companies listed in *Moody's Industrials*, that had experienced a growth in sales of at least 400 per-

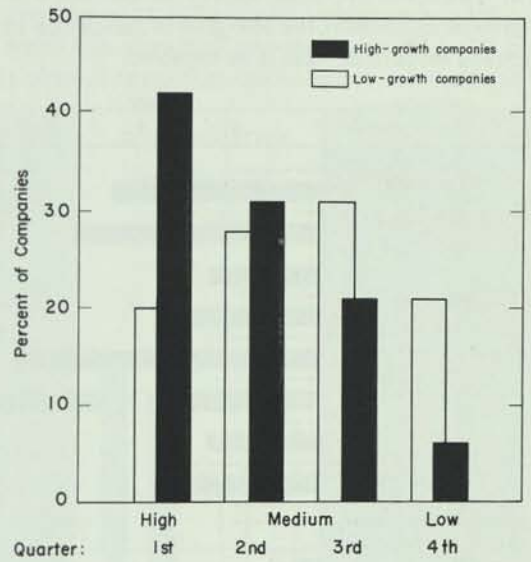


Fig. 2—Growth of high- and low-growth companies, 1939–49. The companies were initially listed in order of growth rate, and then divided into four equal groups. The vertical scale represents the percent of companies in each growth category.

cent from 1939 to 1949, were taken as the apparently "gifted" companies. There were 210 of these. By the same method, the 169 companies whose growth in sales during the same period had no more than doubled were selected as representative of low-growth companies. While the initial portion of the study was for the period of 1939 to 1949, we also have watched the progress of each group in the period since, 1949 to 1956. We intend to look again at these two groups of companies in future years.

These companies have been further classified as to whether the growth of the base decade continued during the following seven-year period, as shown in Fig. 1.

By 1956 the number in the original group of high-growth companies had slipped from 210 to 192, and the original low-growth companies had fallen from 169 to 132. Keeping track of these companies has been a bit difficult, particularly in the case of low-growth companies, which are addicted to going out of business or being bought by someone else. Of the 18 "high-growths" that "disappeared," one became a cooperative, one an investment company, and 16 were sold or merged into other companies. Of the 38 "low-growths" that dropped from the base decade list (22 percent from 1949 to 1956!) one became an investment company and 24 were sold or merged with other organizations.

We haven't sought full details of the remaining 13 but nine are known to be out of business.

Operations in Growth Fields

When the companies comprising the sample are tabulated by industry and arranged in order of industry growth during the period of 1939–1949, Fig. 2, it appears that high-growth companies are most heavily concentrated in the high-growth industries; the low-growth companies in the low-growth industries. This is as expected.

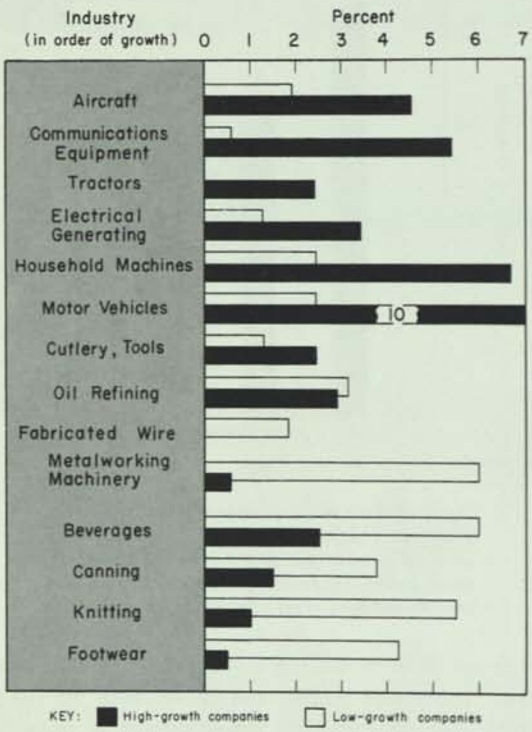


Fig. 3—Company growth vs. industry growth, 1939–49. A selected list of industries—starting with aircraft, which grew 20 percent per year during the test period—was used for the vertical scale.

We find that 75 percent of the high-growth companies are operating in the faster growing industries, only 6 percent in the slowest. Similarly, the same story is shown for the slow-growth companies, with a slight majority of the companies operating in slower growth industries. Clearly many companies operating in growth industries do not share in the general growth, however.

The concentration of companies in industries with corresponding growth rates can be demonstrated from another viewpoint. In Fig. 3 is shown the distribution of high- and low-growth companies with respect to industry growth.

A company may find itself in a growth field by sheer good fortune, but there has always been a company decision, fortuitous or planned, whether recent or in the past, which has determined its field of operations. To improve its chances of growing, then, a company should direct its operations to a growing industry.

The result of radical redirection of company operations into new industries is worthy of consideration. A review of the sample companies shows that nine of the total surviving companies (324) changed a majority of their production from one manufacturing industry to another during the test period. Many others had diversified widely or had changed to non-manufacturing industries, but these were excluded from consideration.

The growth rates from 1947 to 1954 for the industries that each company had left and entered were available, as was the change in sales volume for each company from 1949 to 1956. It was reasoned that if a company had deliberately moved from one industry to another, some measure of its wisdom would be found by comparing the subsequent growth rates of the old and new industries and in the sales performance of the company. This is summed up in Fig. 4.

In the instance of the two companies that experienced sales declines, the change in industry proved to be from a higher growth rate to a lower growth rate. In every other case the switch was to an industry of higher growth rate and was accompanied by a sales increase.

This is a remarkable correspondence between comparative industry growth rates and company success in terms of sales volume but its significance is limited by the small number of companies. Further study of other companies, outside the sample, that have changed industries is contemplated. It is hardly expected that these will all follow the same pattern. In any case, undoubtedly more is required to insure growth than the simple selection of a growth industry in which to operate.

Programs for Future Growth

Companies that have grown rapidly have given evidence

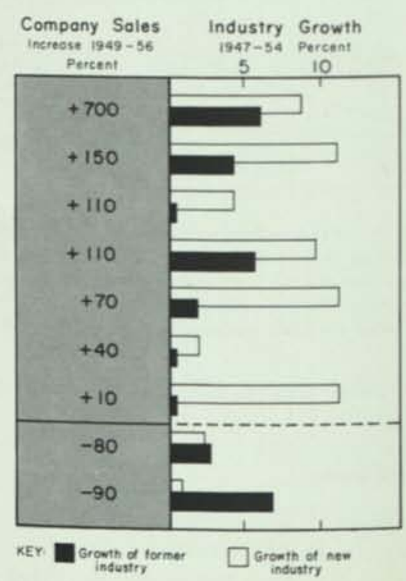


Fig. 4—Comparison of sales growth of a company with sales growth of its previous industry and of its present industry.

of supporting future growth programs such as those for (a) long-range company planning, (b) product research and development, (c) market research, (d) diversification into other product fields and markets, and (e) acquisition of other companies. This cannot be construed to mean that merely following these practices will insure growth. Certainly many low-growth companies have followed approved practices, and just as certainly there has been good planning and bad planning, wise diversification and foolish diversification, profitable acquisitions and ruinous acquisitions, good fortune and bad fortune.

Another statement from the president of a very large, widely diversified manufacturer, whose company was in the group that had a high-growth rate in both periods (i.e., HH) was: ". . . . It would be most difficult for our company to operate without forward planning . . . We view it as a must for successfully-operated growth companies."

A recognition of the need for planning was also apparent in many companies with slow growth. The president of a toy company which had enjoyed high-growth in 1939–1949 but which has slipped in growth (group HL): "It is perfectly obvious to me that our company has not kept pace

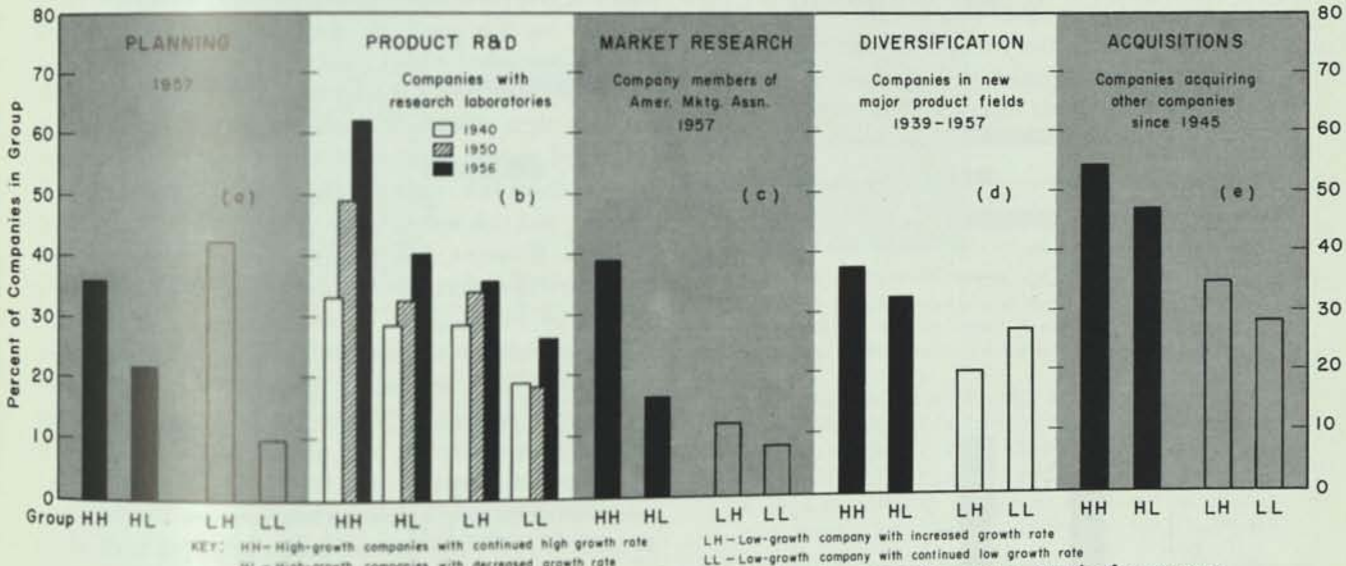


Fig. 5 a-e—Support of growth programs. There are indications that support of various means of promoting growth of a company actually does have some effect on the company's growth. The charts break down the samples into growth groups to compare the percent of each group having various programs.

However, it is interesting to note that what evidence is available (without actually dissecting a company to see what makes it tick) indicates that *more* high-growth companies follow these practices than do low-growth.

Planning—Consider long-range planning. Unfortunately for our study, planning means many things to many men, so that it is extremely difficult to determine whether a formal planning program is in fact being supported in a company. However, correspondence with the companies in each group gave a reasonably valid indication of the status of their planning. Our interpretation of these replies in terms of the percent of companies in each group with formal planning functions is presented in Fig. 5a. In the cases of both high-growth and low-growth companies, those that now support planning programs have shown a superior growth rate in recent years.

Companies with formalized planning programs are enthusiastic about their value. A typical comment is from an optical company, one of the high-growth companies: "We find long-range forecasting absolutely essential to our plans, and we have been able to make our plans with sufficient accuracy to sustain the growth rate we have sought to accomplish."

with the growth of its market and we should be much farther along the road than we are at this time. A little long-range planning done five or six years ago would have, without a doubt, brought us into a much more favorable position today."

Financial planning is one important aspect of long-range planning which was not studied separately. A comment on the value of this practice in aiding company growth is in order. The chairman of the board of an engine company, part of group HH, told us: "The careful job of ten-year forward planning in the financial area, which we completed last year, proved to be extremely helpful in the formulation of present policies with regard to capital investments and 'make' or 'buy' decisions. The amount of new capital required to achieve our goals over the next ten years had a startling impact on the thinking of our whole staff."

Product development and research is another forward-looking practice and one for which reliable data can be obtained—not in terms of expenditures but in terms of actual research laboratories. The percentages of companies in each group which had research labs in 1940, in 1950, and in 1956 are shown in Fig. 5b. The data by years appears especially significant. In 1940—the beginning of the period in which high-growth companies moved ahead of low-growth companies—the combined percent of high-growth companies was substantially higher than that for the combined low-growth companies. In 1950—the beginning of the period in which the HH companies moved ahead of the HL's and the LH's moved ahead of the LL's—the combined HH and LH groups had 60 percent more research labs than did the combined HL and LL groups.

Marketing research is another factor in growth. In the study, support of company memberships in the American Marketing Association was taken as an evidence of market-research programs. Our observations of the habit of marketing men flocking together led us to consider this statistic a good pointer to companies with market-research programs. The results of this aspect of the study are shown in Fig. 5c.

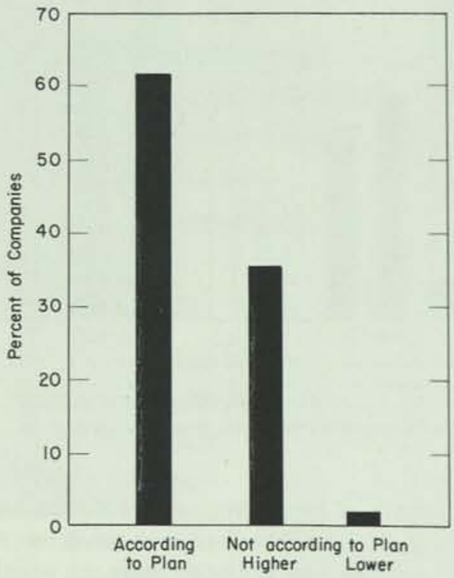


Fig. 6—HH companies experiencing planned and unplanned growth. Some high-growth company executives admitted that luck was an important factor in their company's growth.

Diversification is highly regarded as a growth practice, but, as many authors of articles on business point out, it is no panacea for company ills. A comparison of the percent of companies in each group which moved into one or more new major product fields or markets during the study period is given in Fig. 5d. High-growth companies show substantially greater activity in diversification, but it should also be noted that 25 percent more LL companies diversified than did the higher rated LH companies.

Acquisition of other companies is another popular method for achieving rapid company growth. Actual acquisitions may be considered indicative of organized acquisition programs in companies. A comparison of the percent of companies in each group that acquired other companies since 1945 is set forth in Fig. 5e. No special consideration was given the number of companies acquired although multiple acquisitions were observed to accompany the most spectacular growth rates recorded. As might be expected, the most rapidly growing companies have sought out or attracted acquisition opportunities in more cases than have the slower growth companies.

Unplanned Growth

Growth due to unexpected turns, which perhaps can be termed "luck," is an unquantitative subject if there ever was one, but we have approached its measurement from at least one viewpoint that permits graphic display. In Fig. 6 are given our interpretation of replies from HH companies to questions asked about their growth and planning. In effect, they were asked if they had been able to anticipate and plan their growth or if unforeseen events resulted in unplanned growth. One might expect any successful company to claim full credit for planning whatever growth it achieves, and this was done by the majority of companies, as shown. However, a significantly large percent reported quite candidly that their growth had been drastically affected by unanticipated developments.

A good example of this situation was reported by an official of a large machinery manufacturer, a continued high-growth company: "To be perfectly frank, we must admit that a significant part of the developments in the growth of our company since World War II occurred outside of any planning which our management had been able to make . . . . We feel that we have a large job to do in our company to set planning up as a more conscious effort coordinating various functions of our business. It has only recently been a very live subject in our top management."

And the vice-president for research and development of a chemical company said: "I believe the record would show that unexpected turns of events and unanticipated conditions have had as much or more influence on our growth as our attempts at long-range planning."

So even if you don't follow the recommended practices, there is always luck!

Sales vs Profits

We were curious, of course, about the relationship of sales to profits. Our attempts to correlate percent increase (or decrease) in sales with percent increase (or decrease) in profits yielded poor results. The buckshot pattern of plotted points which resulted was inconclusive. However, one interesting fact was revealed on close analysis: among the companies that recorded sales growth, a reduction in profits was almost as likely as an increase unless a minimum sales increase of 100 percent was attained during either period. This indicated that a critical level of sales improvement was required for profit improvement.

We are reexamining those cases where sales went down and profits increased, or where sales went up and profits decreased.

THE SAMPLE OF COMPANIES was taken without intentional bias. The sole basis of selection was the exceptional rate of sales growth from 1939 to 1949. The samples of both high-growth and low-growth companies contain a representation from the major industries and cover the range of sizes. The distribution does not differ drastically from manufacturing industry as a whole.

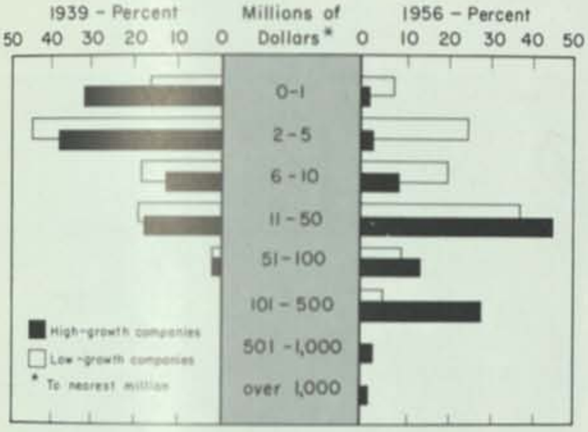


Fig. 7—Companies by range of sales volume, 1939 and 1956.

Except that more high-growth companies started out in the million dollar sales range, the distribution is quite uniform. The majority of both groups in 1939 was less than $5 million annual sales volume. As of 1956 the median low-growth company was under $10 million, and the median high-growth company was under $50 million. However, a heavy cluster of high-growth companies was found in the $101 to $500 million range.

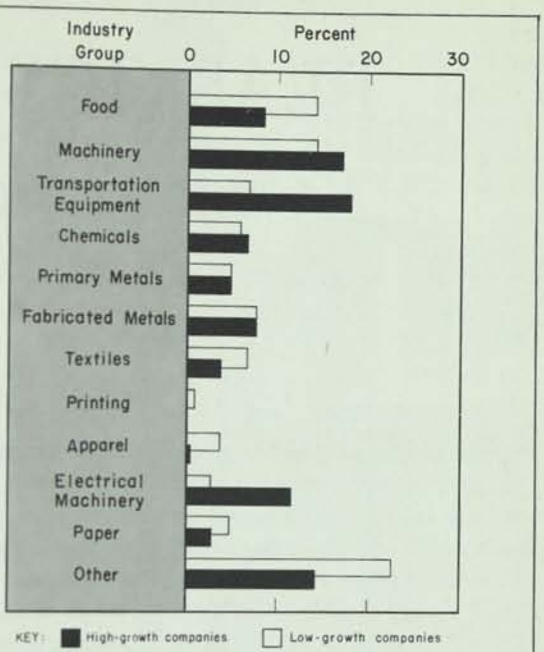


Fig. 8—Companies in each major industry. ("Other" refers to tobacco, lumber, furniture, petroleum, rubber, leather, stone, instruments, and miscellaneous.)

The distribution of the high-growth and low-growth samples by major industries is listed in descending order by "value added" in 1949. The rapid growth of aircraft and electronics companies resulted in some imbalance of the transportation equipment and electrical machinery categories but otherwise an even match is indicated.

Conclusions

A variety of notions, as to factors affecting company growth, can be drawn from the work done thus far, incomplete though it be. Certainly there is evidence that many companies do not have the aggressive, *organized*, forward-looking programs aimed at seeking, developing, and weighing new growth opportunities. Under today's conditions of an accelerating rate of economic, social, and technological change, and an accelerating intensity of business competition, it seems these companies are taking a grave risk.

There is also evidence that many companies remain too long in slowly growing or declining fields and markets before taking steps to explore areas with more attractive futures. The number of companies among our less rapidly growing group who disappeared in the last seven years could support this conclusion. In addition, an even larger number in this category, over the entire 17-year period, have failed to turn in sales and profit performances conducive to growth.

Many remaining questions stand out as needing answers. Some of these are:

1—In the long run, does a company have to grow in order to survive?

2—Does growth in sales volume usually lead to stronger earnings and financial positions?

3—How have the capital requirements of rapidly growing companies been met at stages of their development?

4—What is a sound approach to long-range company planning? What types of goals should be established? What types of strategies and tactics should be considered? What are the mechanisms? How should it be organized?

5—In what ways do organized, forward-looking programs of small, medium-sized, and large companies differ in type, scope, and risk because of their different competitive and economic capacities?

6—How can long-range growth plans be dovetailed with short-term preparedness for unforeseen opportunities?

7—How does management build farsightedness into an entire organization—so that forward-looking programs are not set aside because of day-to-day problems?

Summing-up the findings of the study, we might caution that: the study shows no infallible formula for the achievement of business success, and energetic observance of good management practices does not provide absolute insurance that a company will grow and prosper. Adherence to management practices which have been identified in successful companies, however, should prepare a company to capitalize on future growth opportunities, and should improve the odds for success.

PLASTICS

Creation and Evaluation

The number of possible variations of plastics is nearly infinite. Because of this, chemists have been able to create many different kinds of useful plastics through the years until, today, a sizable backlog of information has built up which can serve as a guide for future formulation. Even with this experience, however, the creation of plastics is still somewhat of an art. Often the results are unexpected.

A new nylon recently synthesized in the SRI laboratories is a good example of the unexpected. The goal was to construct a nylon with improved molding properties. The characteristics sought were a wide melting range above 500 degrees F, good flow properties, low specific gravity, and little, if any, shrinkage on cooling.

Two basic building blocks (monomers) used in the creation of two common nylons looked promising. One of these nylons, nylon 6, is a type used extensively for molding and textiles. Its melting point is low, but it has excellent molding properties. The other, nylon 6T (where T stands for terephthalic acid), is not commercially useful since its melting point is so high that it tends to decompose before melting unless heated under conditions that are not

Fig. 1—The new SRI plastics laboratory is equipped for work with a variety of plastic problems. Besides general development and evaluation as well as studies of the effect of irradiation on plastics, some specific studies have been concerned with development of structural dielectrics for aircrafts, high temperature plastics, and with the effect of radiation on aircraft adhesives. The article and sequence of photos are concerned with a typical project.

Two ingredients (right) go into the construction of nylon x. A mixture of 55 moles of E-Caprolactam and 45 moles of hexamethelene diamonium terephthalate is added to twice their weight of water.

Fig. 2—This mixture is then heated in an autoclave (an air tight kettle) to 572 degrees F while being subjected to a pressure of 200 lb per sq in. A nitrogen atmosphere is introduced in the kettle to exclude oxygen which would weaken and darken the compound. With the temperature constant, the pressure is reduced over a period of several hours until atmospheric pressure is reached. Since water is a by-product of the reaction, the autoclave is then evacuated to remove the last trace of water. Polymerization has been completed.

Fig. 3—After synthesis, the polymer is ground and then molded into test specimens. Nylon x had good molding properties, but low resistance to distortion under pressure at high temperatures.

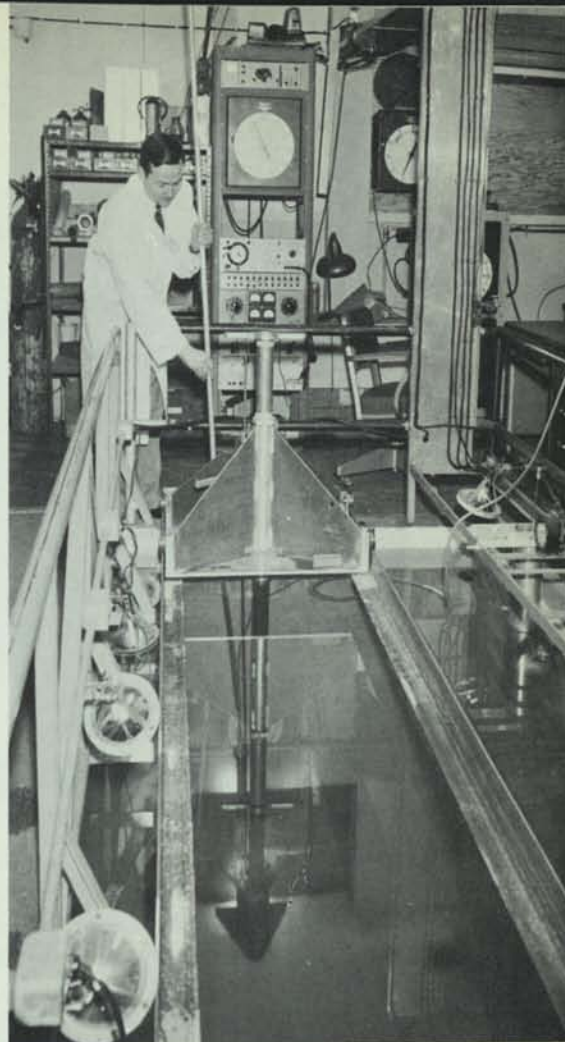


Fig. 4—In an attempt to improve high temperature distortion resistance of nylon x, the material was irradiated by gamma rays from a cobalt-60 source. It was expected that the molecular chains would be induced to cross-link and distortion resistance would improve.

commercially feasible. Despite this drawback, however, it does possess good strength.

It was thought that a new nylon formed by combining nylon 6 and 6T might provide the desirable properties with the undesirable ones less pronounced. The new composite, designated nylon x, did have the desired molding properties, but was poor in resisting distortion under pressure at high temperatures. In an attempt to overcome this deficiency, the material was exposed to gamma radiation. Experience with other plastics indicated that irradiation might cause cross-linking of molecular chains, and cross-linkage sometimes improves distortion properties.

However, another and unexpected modification had taken place. The plastic had changed from white to a deep, bright blue. While color change is not an uncommon result of irradiation, the distinct cleanness and depth of the nylon color in this case was unprecedented.

To discover the reasons for this color change, various compounds containing components of the monomers of nylon x were also irradiated. Some of these turned bright orange or bright red, while others remained unchanged. Comparison of light absorption for nylon x and other nylons revealed that all go through color shifts when exposed to radiation, but only nylon x changed appreciably in the visible color range. When the material was heated the color disappeared rapidly, and it returned to the original white state. At room temperature, however, the color faded very slowly with a "half-life" of several months. Work is continuing toward a better understanding of the mechanism involved and the part played by variations of the polymer structure in bringing about the color change.

Uses

Two uses for nylon x immediately became apparent. As a high-level radiation dosimeter, it can be used to determine the total dosage of an irradiated sample, within which it may be imbedded. It has been found that the amount of color change is proportional to the dose received. It can be used only for high level work, however, since it takes 10,000 roentgens of radiation to make the color first appear.

This special plastic can also be used in the path of a radiation source to map the densities of the beam at various points, as well as the depth of penetration.

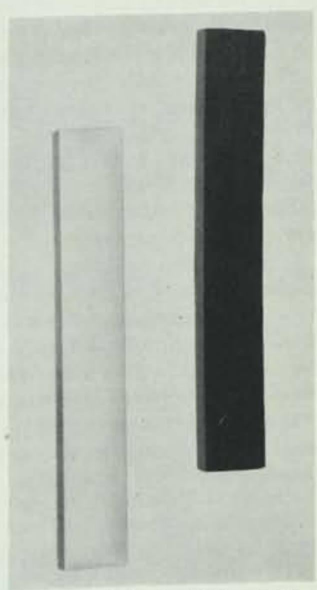


Fig. 5—Under irradiation, nylon x underwent an exceptional color change. Color changes in plastics are not uncommon, but usually the result is a slight yellowing or dirtying due to degradation. Nylon x had changed from a clean white to a deep bright blue.

Traveling the Pacific

In 1956 more than 80 million people, about half the population of the United States, took at least one trip. During the same period the number of American tourists who made a trip to the Hawaiian Islands had risen at an even higher rate—it almost quadrupled.

The Matson Navigation Company in 1954 was faced with the necessity of meeting these exploding demands for ship accommodations by expanding Hawaiian facilities. Such a move would involve expensive ship and hotel construction, however, so going ahead with only hopeful expectations could be risky. A thorough-going preliminary survey seemed indispensable to a decision of establishing strong foundation for planning, and SRI was asked to undertake it.

Hawaiian Tour Potential

Hawaii is a lure for many Americans. Its mild climate, exotic atmosphere, recreational facilities, and superior accommodations are substantial inducements to tourist trade. Matson ships carried over 80 percent of the total passenger traffic from the Pacific Coast to Hawaii during 1930 and the early 1940's. By 1954, however, air carriers accounted for approximately three-fourths of the traffic, with Matson handling most of the remaining quarter by sea passage.

Nevertheless, continued increases in the *total* number of tourists resulted in substantial increases in the number traveling by sea. In fact, Matson's Lurline was operating at capacity on trips to the Islands, and at more than 90 percent capacity homeward.

Investigation indicated that more passengers were available for steamship travel. The question was—how many? Would it be enough to justify another ship on the Hawaiian line? Were additional Island hotels of Matson standards needed? If they were needed, how large should they be and what class accommodations should they have?

Transportation Facilities

Before World War II, Hawaii had a virtual monopoly on tropical-island vacations. Today it is in competition with the Caribbean area, which is closer to the more heavily populated areas of the United States, and therefore is available to a large proportion of the U.S. public at lower cost. Hawaii does offer greater attraction to those states west of the Rockies, however, but indications are that visitors from western states will not exceed 50 percent of this total at any time.

A conservative prediction was made at SRI that by 1975 tourists to Hawaii should number about 382,000 per year, given a degree of peace at that time, and a moderately rising level of disposable consumer income. Of these, it is estimated that about 30 percent would travel by ship if adequate, attractive facilities were available. This indicated that a new ship would be warranted.

To tap this potential, however, ship rates should be attractive. It would be necessary for them to be competitive with first-class air travel plus an additional amount allowing for the luxury and relaxation of a four-day stay on board ship.

The study also showed that the new ship should conform to Matson standards of comfort and prestige, but that it ought to have a larger number of medium-priced rooms. This would be necessary in order to accommodate the growing middle-income travel group.

Under these conditions a new type of ship would be desirable. The one determining factor was whether a ship could be built and operated profitably within these limitations.

Hotel Accommodations

At the time of the study Matson maintained three Waikiki hotels but these and other facilities were unable to meet the peak-season demand. In an attempt to remedy the situation new hotels had been constructed and others were underway. It was expected that these new facilities would increase accommodations enough to meet requirements until about 1965.

In addition, another 400–500 room hotel was contemplated for Waikiki at the time of the study. Thus, for the near future at least, there would be no shortage of visitor facilities. In fact, strong competition was taking shape between hotels. Existing hotels would be concentrating upon attracting tourists during the next ten years, leaving little need for another luxury hotel for some time.

Analysis of the situation, however, showed there was need for hotels in the medium-price class. Extension by Matson in this direction in conjunction with the construction of a passenger liner with medium-priced accommodations, would give them a good competitive position.

The study also pointed up the possibility that the island of Oahu may become overcrowded. Hence it was suggested that resort areas be developed on the neighbor islands as part of a long-range planning campaign.

Meeting the Demand

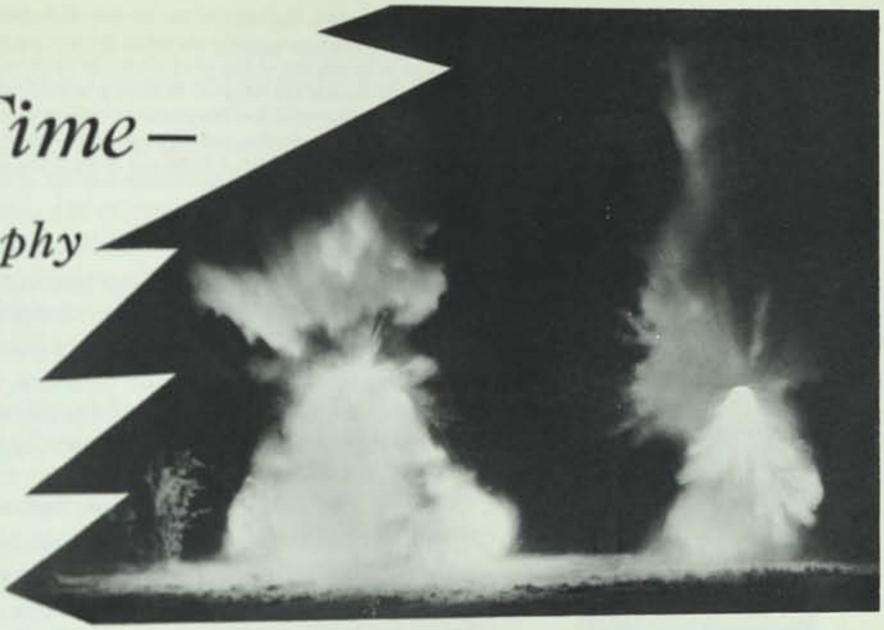
Since the completion of this study, Matson Navigation Company has been active with its plans for the present and the future. More than six months ago the construction of a Hawaii-run ship, the ***Matsonia***, was completed. In addition, two ships, the ***Mariposa*** and the ***Monterey***, have been built for the Australasia route. Each provides first-class accommodations for 365 passengers.

The number of tourists going to Hawaii by 1965 was originally estimated at 280,000 a year. It is now expected that this number will be reached by 1962. New estimates indicate that there will be about 400,000 a year by 1965. To meet the demand, new construction since December of 1954 has increased the hotel capacity by 50 percent. One of the hotels, the Princess Kaiulani, opened in July, 1955. It provides accommodations for 547 guests (290 rooms). This gives Matson four hotels at Waikiki, the other three being the Royal Hawaiian, the Moana, and the Surfrider. In addition, Matson has taken preliminary steps to develop 1500 acres recently acquired at Wailea on the island of Maui with all needed tourist facilities.

Stopping Time—

The Photography of Explosives

Charles H. Bagley



Explosives have served constructive and destructive purposes of mankind for many centuries, but little has been known about what takes place between ignition time and completion of an explosion. Studies of this extremely short time interval have been underway for some 80 years, but only within the last 15 have instruments been available that can adequately resolve these events. The special cameras and techniques of their use in high explosives research are described here.

Black powder was the only useful explosive for many centuries before the invention of dynamite in 1863 by A. B. Nobel. This invention, as well as Nobel's development in 1876 of the mixtures of nitrocellulose and nitroglycerin, known as blasting gelatin and gelatin dynamite, ushered in the era of modern explosives.

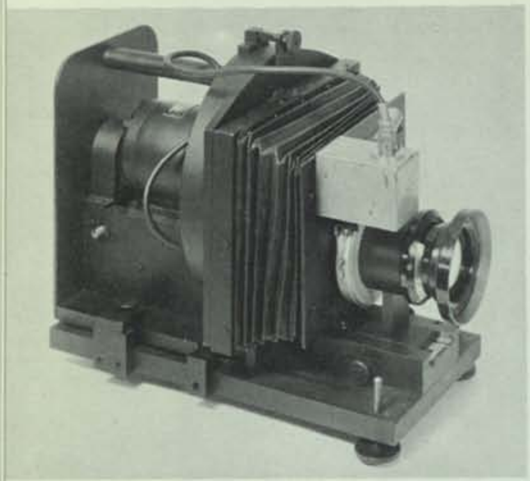
Since the turn of the century studies of detonation and detonation phenomena have been pursued with increasing vigor, leading to the development, in recent years, of improved instruments for making such studies.

An explosive is a material that is stable under ordinary conditions but can be made to undergo very rapid self-propagating decomposition, resulting in the formation of more stable materials, the liberation of heat, and the development of a rapid rise in pressure. This entire reaction is usually completed within a very few millionths of a second. It is the ability of the sudden-pressure effect or shock to do work that is of great importance.

The reaction within an explosive generally travels at speeds of 3 to 8 millimeters per millionth of a second (10,000 to 26,000 feet per second). As this reaction progresses, a shock wave is induced into the surrounding medium, be it gas, liquid, or solid. A great deal of effort has been expended in investigating these shocks and their effects on various materials.

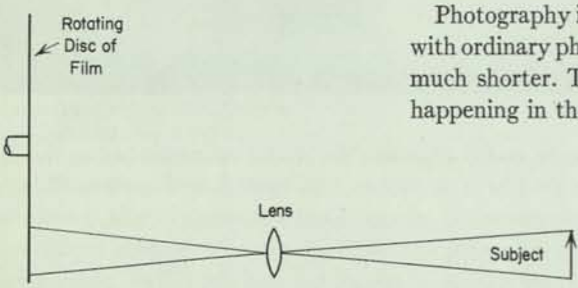
The instruments used in these studies sometimes view the explosives themselves

One of the major problems of taking pictures of explosions is to prevent destruction of the photographic equipment. Accordingly, the cameras are often housed in sturdy bunkers built of reinforced concrete and faced with metal armor plates. The explosion is detonated by remote controls located inside the bunker.



The DISC CAMERA was one of the earliest high-speed cameras. This model consists of a single lens for focusing the image on a 10-inch disc of film, which rotates at 3600 rpm. This kind of camera can be used effectively to study the velocity of luminous metal jets. The photo is of a jet traveling over 60 feet. It appears curved because of the circular motion of the film. The deflection at the end of the streak results from the jet striking a target.

and record both the detonation rate and the shape of the progressing reaction of the charge. In other instances they record the shock and its effect on external objects close to the explosion. Other aspects of this work deal with events at much later times and over greater distances, such as studies of metal jets and the breakup of metal or concrete. Of all the methods used in recording these phenomena, photography, both optical and with x-rays, is the most productive.



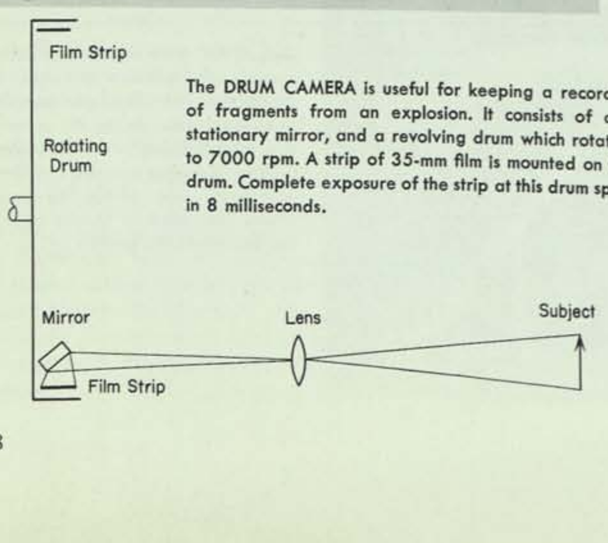
Problems Encountered

Photography in explosive research encounters numerous problems not associated with ordinary photography. The time coverage and exposures necessary are certainly much shorter. The instruments used in this work must be able to record events happening in thousandths of a second to submillionths of a second.

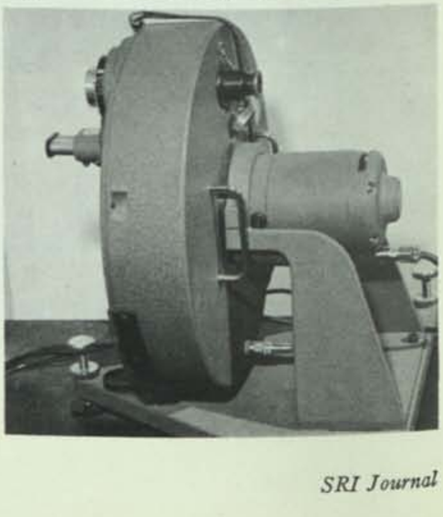
It is also obvious that an explosion does not provide the most favorable circumstances for photography. The camera and related gear are exposed to shock, vibration, and flying particles. The problem is eased by conducting the experiment at some distance from the instruments, since the pressure falls off approximately as the square of the distance, but even then the instruments must be adequately protected. The instruments are generally shielded by steel and concrete bunkers and are sometimes additionally protected by sand bags placed around the charge to stop fragments.

The disadvantage of photographing at a distance can be overcome somewhat with the use of telephoto lenses. Because of the short exposures necessary, high-speed lenses of long focal length and high resolving power are required. These characteristics are not generally compatible in lenses since the manufacture of high-aperture lenses of long focal length is difficult and expensive. One of the reasons for this is that the glass elements must be large and flaw-free. Furthermore, the required precision grinding and polishing are accomplished only as a result of very careful workman-

Charles H. Bagley is manager of the Calaveras explosive test site of SRI's Poulter Laboratories. After spending his youth in Arizona and the Philippines, he earned his BS degree in Mining Engineering at the University of California in Berkeley, followed by a year of graduate work in Civil Engineering at the University of Tennessee. In 1942 he entered the Navy Department in San Francisco as a metals physical and chemical property inspector. In the Army from 1943 to 1946 he worked on explosives. After discharge he went to Los Alamos for the University of California where he supervised development, research, and production testing of explosives. Mr. Bagley joined SRI in 1954 and has since been responsible for the design, construction, and installation of ultra-high-speed cameras, and bomb-proof shelters to house them. He also supervises the development and research of explosives, particularly explosives to produce special wave shapes.



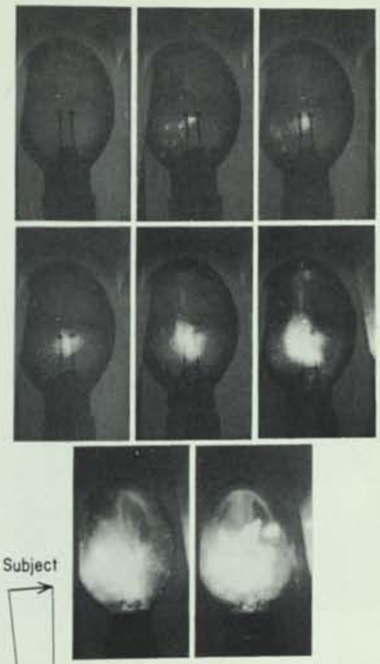
The DRUM CAMERA is useful for keeping a record of the velocity of fragments from an explosion. It consists of a single lens, a stationary mirror, and a revolving drum which rotates at speeds up to 7000 rpm. A strip of 35-mm film is mounted on the inside of the drum. Complete exposure of the strip at this drum speed takes place in 8 milliseconds.



ship, which also makes the lenses costly. However, compromises are possible. Objective lenses in use for high-speed photography of explosives vary from 10 to 50 inches in focal length and from $f5$ to $f14$ in apertures and are usually achromatic, that is, a two-element lens that has been color corrected. Although such lenses have a small angle of view, they are widely used in instrument design. Lenses with small viewing angles are undesirable in all but specialized cameras.

Another problem is that of obtaining the extremely short exposures necessary to freeze the action resulting from a detonation. For accurate analysis, sharp pictures are necessary. The exposures needed vary with the speed of the event. When studying the reaction of explosives themselves, much shorter exposures are required than are necessary when the effects of explosives in demolition work are under observation.

If an exploding charge is viewed so that the image is as large as the object, the image of the detonation moves on the film eight millimeters (1/3 inch) in a millionth of a second (microsecond). Thus, an exposure of a few hundredths of a microsecond is necessary to reduce the motion during exposure to a few tenths of a millimeter. Acceptable exposures can often be as long as one-tenth of a microsecond, but longer exposures may render the pictures much too blurred for accurate measurement.

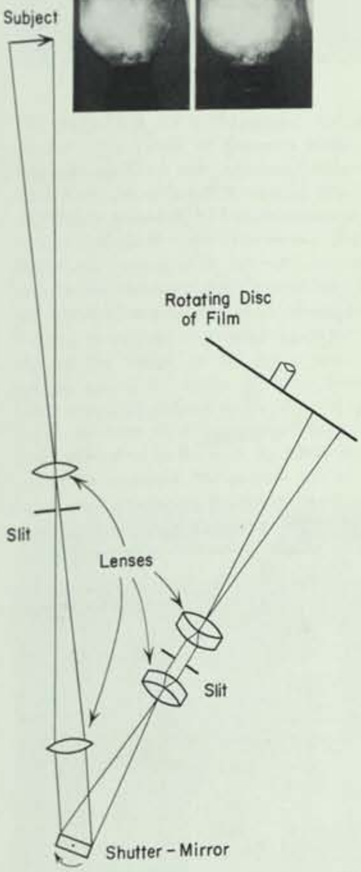


Light Sources

Such short exposures introduce the problem of obtaining sufficient illumination. The difficulty of adequate exposures has been somewhat alleviated, however, with recent advances in film emulsion and developer speeds. Black and white films are now available with American Standards Association emulsion ratings of 200, and special developers can yield equivalent emulsion speeds of 2000 to 4000. For comparison, an average amateur black and white film has a speed rating of 80. Such speeds were unobtainable ten years ago without undue and troublesome grain effects on the emulsion.

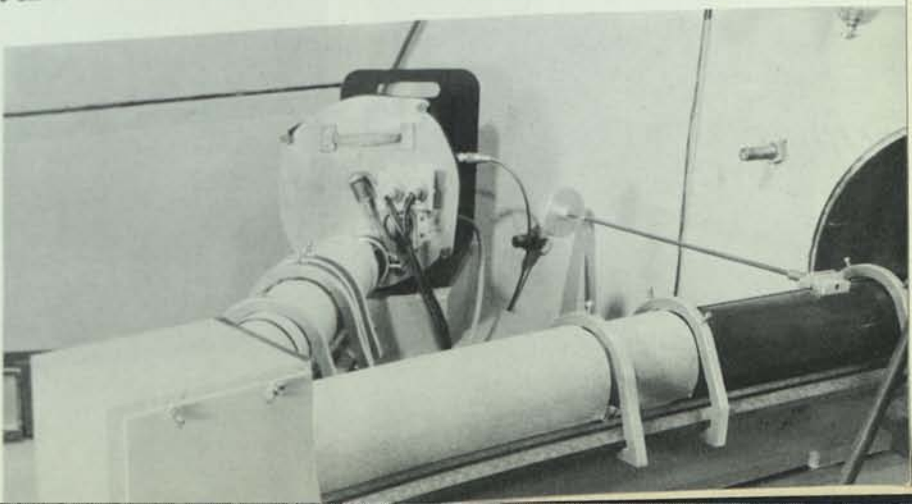
Color film has been substantially improved to make it an important aid in separating the components of a test. Equivalent ratings of 200 to 400 are now available as compared with conventional Kodachrome 8 to 12 rating.

Even with improved film, however, light sources must still be many times more intense than the artificial or natural lighting ordinarily used in photography. Because of this, the light emitted during the explosion or special artificial lighting can be utilized.



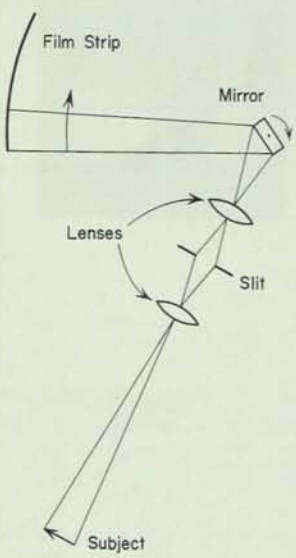
Self Luminosity

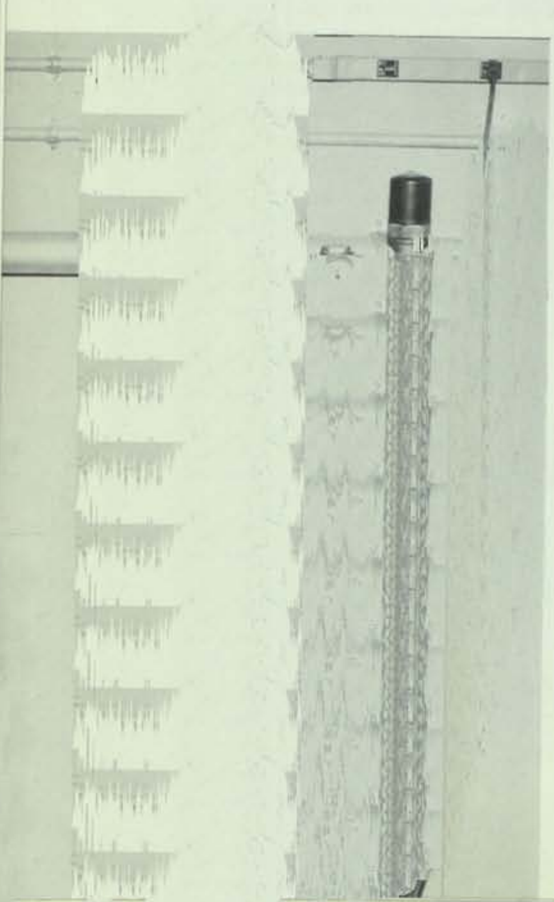
Shock waves from explosions in some gases produce light that has been estimated as having a peak luminosity of 80 million lumens (one lumen per square foot is equal to the illumination from a standard candle one foot away). By comparison, the light from the most powerful commercial flash bulb or the sun amounts to approximately 5 million lumens. Because the light persists such a short time, camera exposures are based on experience and not on direct measurements.



The FRAMING DISC CAMERA is useful for short exposures of a "long-term" event. It takes 60 pictures at the rate of 15,000 frames a second with exposures from 0.3 to 0.14 microseconds. Although each exposure is very short, the time from first to last picture is 5 or more milliseconds. The camera consists of a rotating disc of film and a rotating mirror which serves as a shutter. The film is exposed once each mirror rotation. The series of flash-bulb photos vividly demonstrates how slow the flash bulb is compared to high-speed techniques used in explosives studies.

The STREAK CAMERA (depicted on the cover of this issue), although an extremely simple high-speed camera, is unexcelled as a constant-writer, time-resolving instrument. It is ideally suited for direct studies of explosions, and of the immediate effects of their detonation. In this camera, a slit allows only a segment of light from an explosive event to reach a revolving mirror which reflects it to a strip of 35-mm film. The result is a graph with a time scale. The writing speed can be varied from 0.48 to 4.8 mm per microsecond. The photo shows the rate at which the detonation front of an explosive moves. The straight diagonal line indicates that in this case the rate is constant.





A better idea of the exposure problem can be given by an example. An adequate exposure with the explosive light source described above can be obtained on a photograph using standard plus-X film with an American Standards Association emulsion rating of 80, a lens with an $f14$ aperture ratio, and a light-duration time of a quarter of a microsecond.

Artificial Illumination

Two methods of producing short-duration, high-intensity light are the electrical spark discharge and the vaporization of metal wire by electrical energy. In the latter case, a path is formed for the discharge of the stored electrical energy by placing a small wire across the spark gap. The source of illumination is still the spark formed by the electrical discharge, but it is more easily controlled. Both techniques are old but are still commonly used.

Light sources using these techniques that produce light pulses of about one microsecond duration are commercially available and experimental laboratory sparks of one tenth microsecond duration have been achieved.

The high-intensity light that results when a gas is subjected to an explosive-induced shock is sometimes used as a light source. Air and argon are generally used. Xenon yields the most intense light but is expensive and is used only when the extra cost can be justified

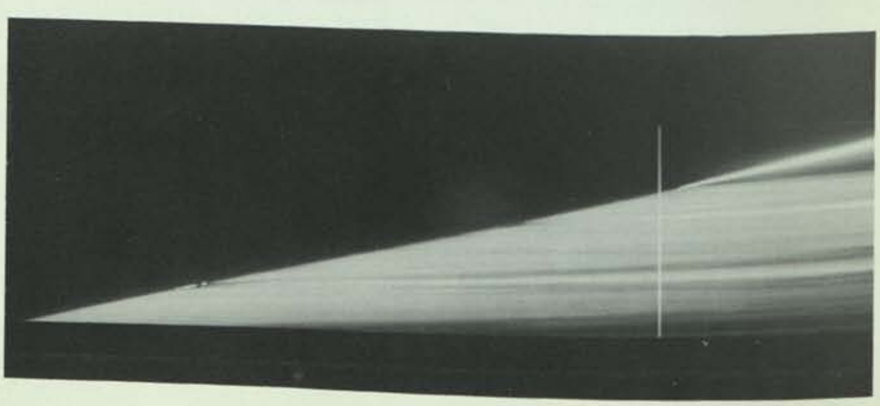
If any of these gases occupies a narrow space between an explosive surface and a lucite cover, a brilliant short-duration light flash is produced as the shock travels through the gas. When the shock wave reaches the lucite cover, the light-transmission properties change so the light is diffused, probably as a result of compression of the plastic by the pressure wave. This light diffusion greatly reduces the light reaching the camera and hence effectively stops the exposure. The diffusion lasts long enough for the slower acting mechanical shutter to operate.

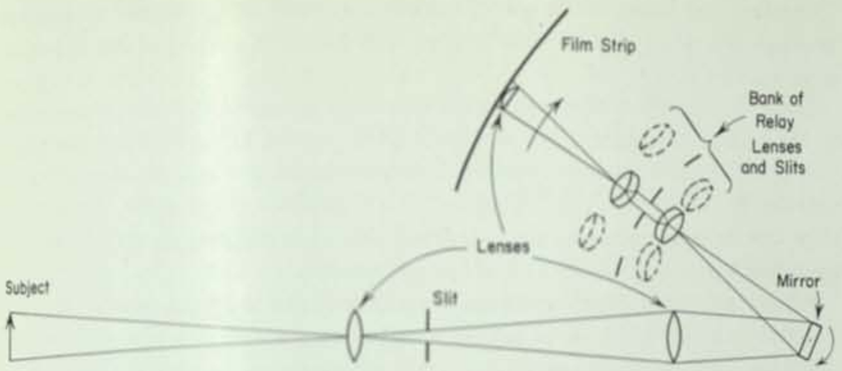
Using this method of illumination and shuttering, pictures have been taken with exposures as short as three hundredths of a microsecond.

The duration of light can be easily extended to 100 or more microseconds for longer-term events. A modification of the circuit in the spark-discharge technique or of the wire in the vaporization method can produce longer illuminations. The explosive-induced shock can be allowed to travel the length of a gas-filled tube instead of across a narrow gap, thus lengthening illumination duration.

Fast Shutters

Another approach to short exposures is the fast shutter. If the shutter is fast enough it is unnecessary to have a short-duration light source. The Kerr Cell is one of the most successful ways of producing such a shutter. It uses a liquid (usually nitrobenzine) that allows light waves moving in only one direction (i.e. polarization) to pass through when an electromagnetic field is applied to the cell. To use the Kerr Cell as a shutter, a set of filters that polarizes the light in the other





direction and the Kerr Cell are placed in series between the light source and the film. Except when an exposure is to be made, the light is blocked from the film because the optical system blocks one half the light; the Kerr Cell, with applied field, the other half. When exposure is desired, the magnetic field is removed from the cell, allowing light to pass through to the film. The "shutter speed" thus becomes the speed with which the electromagnetic field can be switched off and on. Some fairly large-aperture (two-inch diameter) Kerr cells have recently been made which permit exposures of a few hundredths of a microsecond.

After instruments have recorded the pertinent portion of the test it is often desirable to shutter the system from the light produced by the shocks and gases associated with the explosion. This would require a shutter that was somewhat slower than the Kerr Cell but one that would still block or interrupt the light beam in 10-40 microseconds. One method that has been used with slower instruments, covering the millisecond range, makes use of a small explosive charge and any fine powder, such as flour. The detonation of the charge blows the powder across the optical path and thus obscures the light until the comparatively slow-moving mechanical shutter in the camera can be closed.

A variation of this technique is to use the smoke from a detonating fuse. The viewing window may be effectively darkened, in a few microseconds, by the smoke which is propelled very rapidly across the opening, after the event has been recorded on film.

Another simple method is to interpose a mirror in the optical path. This mirror is destroyed by a small explosive charge at the conclusion of the exposure.

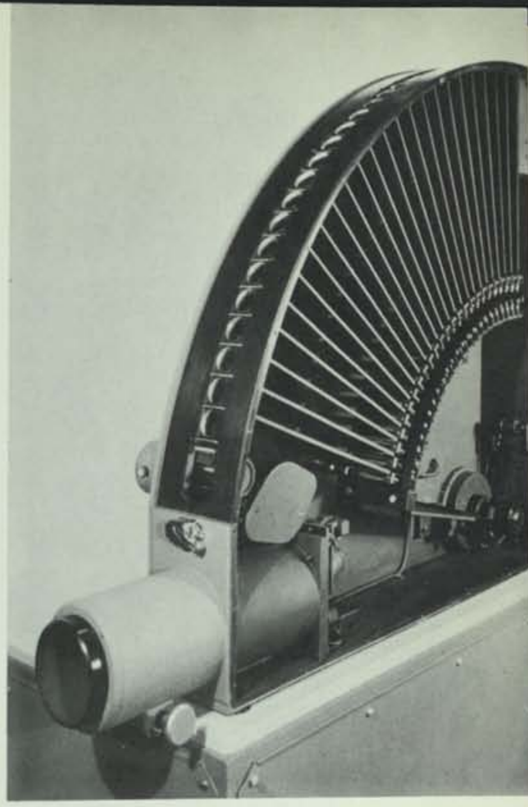
One of the most effective fast shutters is achieved by sending a strong explosive-induced shock through a piece of glass through which the camera looks at the test. As the shock progresses through the glass, the glass fractures into very fine particles but does not shatter. The resulting crazed pattern diffuses the light, forming a permanent light barrier.

Spanning Time With Cameras

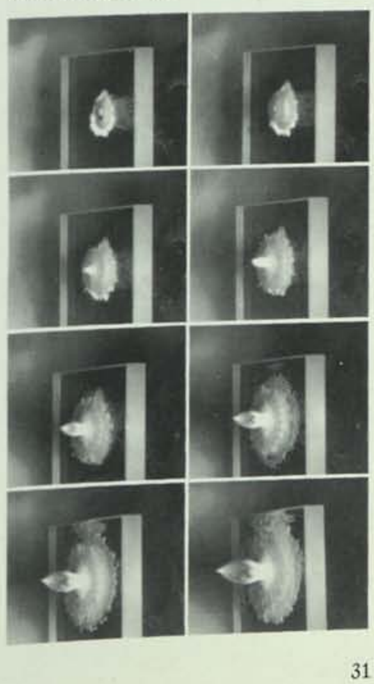
The techniques discussed thus far can be used to produce one or two pictures on stationary film. To record more pictures (i.e. motion pictures) of the same event, some method of transporting either the film or the image must be devised. Film or image transporting has become a research problem by itself. Because of inertia of the film and film mechanism, it is not practical to start, move, and stop the film for each exposure as is done with ordinary motion-picture cameras.

The most direct method of film transport is to move a strip of film continuously from one reel onto another reel. This is the method used in high-speed motion picture cameras employing rotating prisms to switch the image. This scheme is limited to about 15,000 frames a second with exposures of about 30 microseconds.

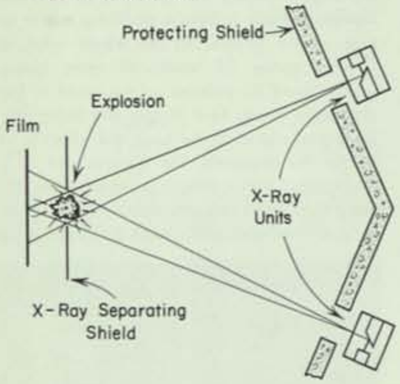
The disc camera is an older method of film transport. A circular sheet of film is mounted on a metal disc and then rotated by an electric motor.

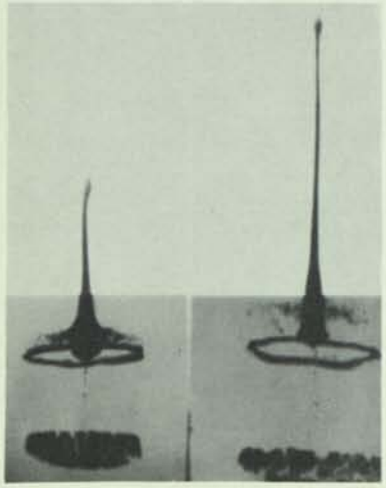


The **FRAMING CAMERA** yields discrete pictures of a range of exposure times. It takes 25 pictures with exposures ranging from 5 microseconds and a framing rate of 60,000 per second to 0.14 microseconds at a rate of 2,400,000 frames per second. Since the streak camera does not take discrete pictures, the framing camera is often used to aid with the interpretation of its photos. The framing camera utilizes a revolving mirror to pick up the image. As the mirror spins, it sweeps across 25 banks of relay lenses which record 25 pictures on the inside of the stationary drum. As it leaves one relay lens bank and moves to the next, the effect is to shutter the exposure. The pictures are of a jet of metal penetrating a block of glass. Exposures a half microsecond long were made at a rate of 600,000 frames per second.



FLASH X-RAY units are useful for recording phenomena obscured visually by smoke or other opaque materials. They produce flashes of about 0.2 microseconds in duration. Only one shadowgraph can be taken at a time with a unit, but they can be effectively used in pairs. They are so arranged that when the explosion occurs, the x-ray units flash in sequence and record the event at different times on separate parts of a single film. The x-ray tubes and the film must be close to the explosion, so special protective measures must be taken to prevent their destruction. The photo is of a cup-shaped explosive, the base of which forms a jet on exploding.





Another, and faster, method is the drum camera which uses film mounted on the inside of a drum. The image is relayed to the moving film by means of a mirror or prism.

These three methods of mounting the film have an upper limit of speed governed by the tensile strengths of the materials used. In the first two cases the tensile strength of the film must be considered and, in the latter case, the strength of the material in the drum. A drum, 16 inches in diameter, and made of aluminum alloy, can be safely operated at 7000 revolutions per minute. At this drum speed the velocity of the film is about 485 feet per second.

When the limit of rotational drum speed is reached, the most obvious approach is to move the image at a high rate of speed along a stationary film. Considerable effort has been expended in recent years in constructing rotating mirrors and prisms capable of greater and greater rates of revolution. The limiting speed of the recently developed assemblies of rotating mirrors driven by air turbines is the tensile strength of the materials in the mirror. The writing speed, or speed with which the image travels along the film is, of course, a function of the distance from the film to the rotating mirror.

The streak or slit camera can serve as an example in understanding these velocities. A ¾-inch wide mirror traveling at 2000 revolutions a second provides an image motion along the film of 12,000 feet per second—but, in the case of the streak camera, there are no discrete or separate pictures. This camera is depicted on the cover of this issue.

These high-speed rotating mirrors are the most important components in framing cameras where they serve to shutter the image as well as to transport it along the stationary film.

Penetrating With X Rays

Techniques involving x rays may, at first glance, not appear to belong to this discussion of optical instruments, but if one considers the x-ray source as a point source of radiation and the x-ray film as a recorder, the principles of shadow photography and x-radiography are closely related.

The fundamental difference between the two is that the wavelengths of visible light are a thousand or more times greater than those of the x rays employed. This feature makes use of x rays more difficult. Unlike visible radiation, x rays can be focused or reflected only to a slight degree. Further, for maximum resolution, the film must be close to the explosive charge since the edges of the image on the x radiograph become fuzzy as the distance between object and film is increased. The film is enclosed in an armored cassette which is blown away by the explosion. It is subsequently recovered, usually intact.

X-ray techniques are employed when the phenomenon to be observed is obscured by smoke, detonation gases, or shock waves, rendering optical methods useless. Presently a technique of taking two successive x-ray pictures with 0.15-microsecond exposures is proving extremely useful in studies of explosives.

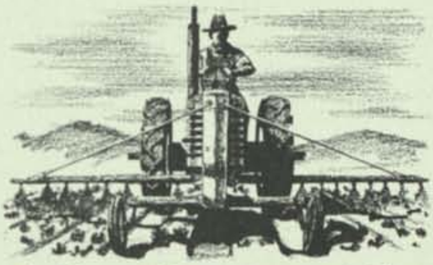
Studies Continue

The problems of ultra-high-speed photography are under constant study and advances are being made. The need for shorter and shorter exposures as well as for instruments with greater time resolution will continue.

Besides advances made in optical and x-ray instruments described herein, devices using the principle of the image-converter tube show promise. The image-converter tube utilizes an electronic-optical combination whereby the image is converted to a pattern of electrons. Several advantages exist with such a device, the main one being the large amplification that is possible. Such instruments may eventually produce more information than any present method used for high-speed shock-wave research.

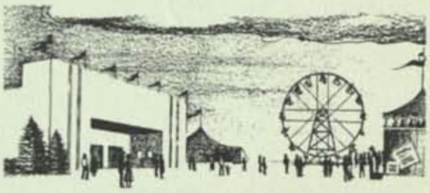
. . . In Brief

Taking Kinks Out of Laundry—the All-American Research Foundation of commercial laundry owners has taken a forward-looking step by initiating research on commercial laundry automation in order to reduce costs to the customer. A new system, conceived as a production line rather than the presently used "batch" method of laundering, could accomplish this aim. Hand processing would be reduced, and sorting would be eliminated entirely. The first problem encountered in devising such a system is washing time. Under present methods, all the items in a batch are washed for 20 to 30 minutes. Since clothing, linens, and other articles handled on a production-line basis will need to be washed individually, this time must be reduced to about a minute per item in order to meet the desired time schedule.



Leafy Vegetables—The remarkable productivity of postwar agriculture has been due largely to new insecticides, such as DDT and parthion, which serve to protect plants from the appearance of their first buds until they are full grown. For effective use, however, these pesticides must have exactly known "residence time" on crops, so that only negligible and harmless residues are left at the time of harvest. Detailed methods for safe use of these valuable tools have resulted from field research by the Department of Agriculture, Food and Drug Administration, industry, and universities. To learn more about residues on leafy green vegetables at harvest time, SRI is developing new and rapid methods for determining what and how much residues are present. This is of vital importance to growers, shippers, and buyers. The John A. Hartford Foundation has made a grant to support the study. The new methods will make extensive use of chromatography for separation and identification as well as using modification of known physical, chemical, biological and enzymic techniques for quantitative determination.

The Erratic Potentiometer—Potentiometers, used to control voltage in many electric circuits, must often be discarded by industrial organizations even though they still have a long life expectancy. Reason: after 100,000 revolutions of the contacts along the windings, not a long life for industrial use, the normally dependable characteristics become increasingly erratic, making the potentiometer useless. Utilizing a background of data collected during research on similar instrument failures, investigation is being made of the causes of variation.



Fair Weather—Holding a world fair is an expensive and financially risky undertaking. To reduce the possibilities of financial difficulties, the Washington State World Fair Commission has asked SRI to apprize various aspects of a fair being planned for 1961 or 1962. Some questions being asked are: What space should be allotted to different exhibit categories, and how should they be operated financially? Should the fair operate all year or seasonally? What will be the impact of air travel in 1961–62 on attendance? What will be the financial return on attendance in relation to cost?

Keeping Redwood Red—Timber from ancient redwoods has been used for construction since the days of early California. It has been favored because it is so durable that, even when exposed to weather, it can be used without protective coating. Its principal disadvantage is that it loses its characteristic red color and turns gray when exposed to rain and sunlight. A study is being made to find a way to treat board siding so that the compounds which impart the distinctive color to redwood are made insoluble.

"AMERICA can never again live in isolation. Either we march into the future, together with the other free nations, into a world of peace and prosperity, or we decline into obscurity and failure, as a people who had not the vision to see the world as it is, or who had not the courage to face up to duty."

RICHARD M. NIXON, *Vice President of the United States, speaking at the International Industrial Development Conference held in San Francisco, October 14–18, 1957.*

The Magazine of
DATAMATION
58
September/October

Research & Engineering

page 6 THE TECHNICAL INFORMATION PROBLEM

DATAMATION 58

the automatic handling of information

volume 4, number **5**

EDITORIAL

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DEPARTMENTS

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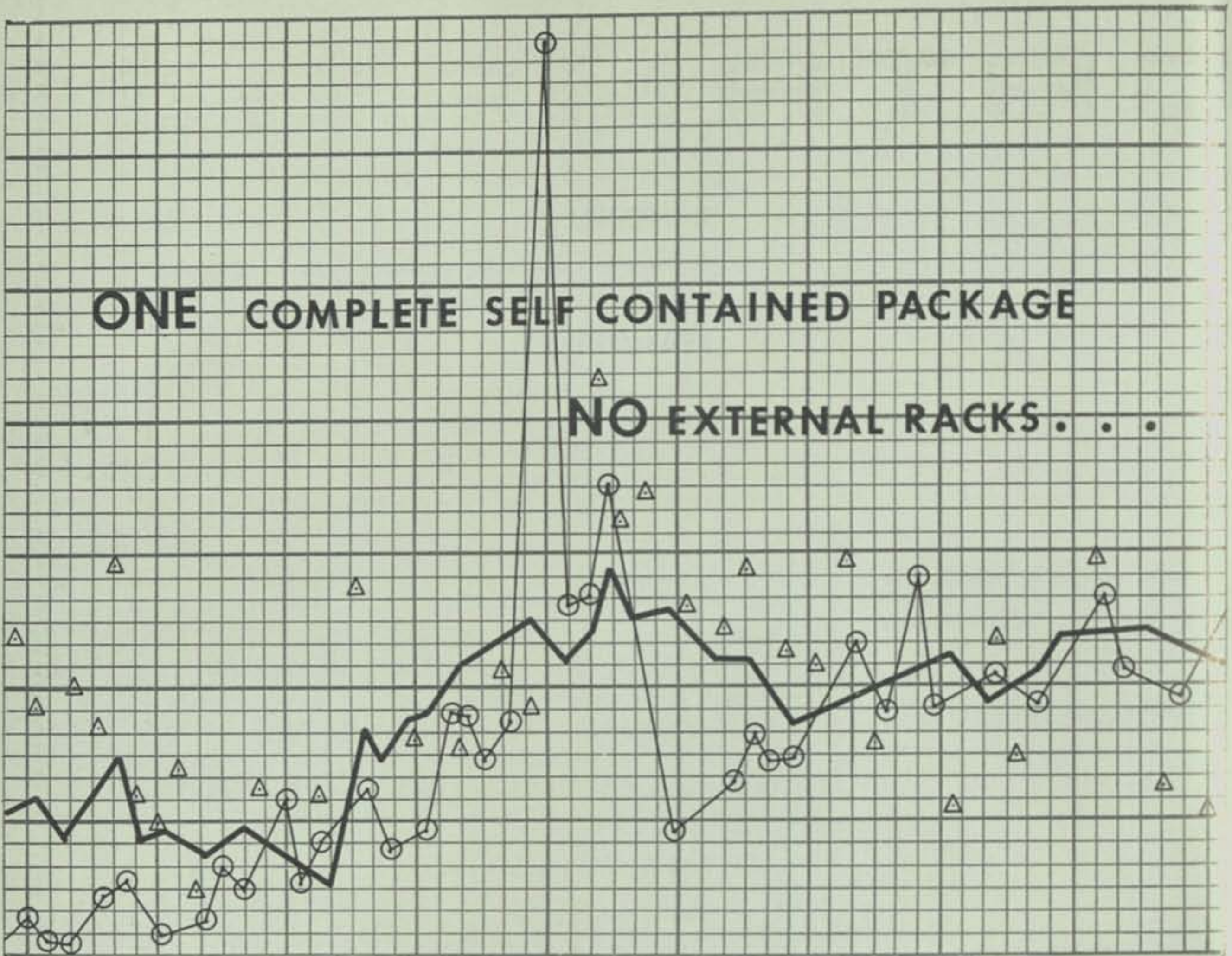

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UNIVAC 1105 SET FOR BUREAU OF CENSUS

Construction of a Univac Scientific 1105 computer has been completed by Remington Rand and the first unit is being delivered to the Bureau of Census in Washington for 1960 census use. The Bureau will eventually use two 1105's in its Washington headquarters and several others are to be placed in U. S. universities for collaborative census use. . . . Philco Corp. and the Uptime Corp. of Rawlins, Wyo., will develop and market a new high speed punched card reader, the Speedreader 2000. Equipment was invented by Raymond B. Larsen, Uptime president.

HAPPENINGS, RECENT AND NOTABLE

Computer Equipment Corp., is the new name for the company formerly known as Digitron, Inc. The name change was effected "in order to clarify the nature of the business in which our growing electronic firm is engaged," according to A. C. Bellanca, president of the Los Angeles firm. . . . Reese Engineering, Inc., Philadelphia, has formed a Digital Systems Engineering department. It will provide a complete service from consultation to systems assembly with particular emphasis on special data handling equipment. Lowell S. Bensky heads the department . . . Servomechanisms Inc., Hawthorne, Calif., has received an order amounting to nearly a half-million dollars from Lockheed Aircraft for production of true airspeed computers.

SUBSTITUTE 'BANKING' FOR 'RETRIEVAL?'

The area of datamation now referred to as "data retrieval" is predicted to grow to major proportions during the next decade, according to Bernard S. Benson, Benson-Lehner Corp., president. In a recent talk to leading members in the data processing field, Benson pointed out that a misnomer is being created in the use of this phrase because the retrieval of information is only one part of an overall process. He suggested that this particular operation be renamed "data banking" which covers investment, internal organization and withdrawal.

U. S. NAVY'S OVERALL COMPUTER PICTURE

Navy Management REVIEW has released a table showing the growth of electronic digital computer installations in the United States Navy. Figures for 1958 and 1959 are estimated. Dollar amounts exclude cost of supporting punched card installations. This table is reprinted by courtesy of the REVIEW.

END FISCAL YEAR	Number of Systems Installed			Number of People			Dollars (Thousands)		
	Total	Bus.	Sci.	Total	Bus.	Sci.	Total	Bus.	Sci.
1954	5	1	4	102	49	53	$ 849	$ 234	$ 615
1955	10	2	8	166	64	102	4720	605	4115
1956	20	8	12	262	94	168	3891	1160	2731
1957	29	13	16	586	368	218	9184	4234	4950
1958	48	26	22	988	718	270	12299	7272	5027
1959	72	46	26	1242	930	312	23057	15961	7096

editorial

IS THERE A TECHNICAL INFORMATION CRISIS?

Merritt L. Kastens is an assistant director of Stanford Research Institute, Menlo Park, California. He has responsibility for certain special program developments as well as the Institute's research service departments.

A native of Chicago, Kastens received a B.S. degree in chemistry in 1944 from Roosevelt College in Chicago. Later he took graduate studies on inorganic physical chemistry at the University of Chicago.

During 1944-45 Kastens was a research chemist with the Armour Research Foundation in Chicago. His wartime service as an ensign in the U.S. Navy included duty as engineering officer on board an attack transport in the Pacific.

From 1946 to 1952 he was associate editor of *Chemical & Engineering News* and *Industrial and Engineering Chemistry*, working in San Francisco, Chicago and New York. He is the author of several articles on chemical production techniques, the chemical industry, and research management. He joined SRI in 1952.

The problem of organizing technical information has received more study, particularly at high levels of the governmental and scientific communities, in the past year than in the entire previous era of modern science. Does this attention imply that the nation is suddenly faced with a new situation arising from the Russian satellite program—some new pattern of circumstances that requires an immediate countering action in order to prevent losing the technological race?

Obviously not. Specialists concerned with the organization and dissemination of technical information have been pointing out for many years that the rapid increase in level of technological activities has far exceeded the concept and rate of growth of information processing facilities. Those who have responsibility for organizing and budgeting research and development efforts have been increasingly aware of the rising cost and frustrating inadequacies of the available mechanisms for finding recorded knowledge. The rapidly increasing accumulation of technical information and the lack of adequate organization for its utilization imposes an increasing economic burden on our society and threatens to drown our scientists and engineers in a flood of paper.

International events have emphasized the time dimension of present-day technology, and particularly the military significance of time. In technical development the major time interval is between the initial scientific discovery and the design of a prototype device. More time is lost—or more time is to be gained—between the laboratory and the drawing board than there is between the drawing board and the production line. In this period, where ideas rather than physical materials are involved, speedup is most feasible. Thus, from a military standpoint, the information system itself has become a "weapon system." It is the weapon system on which all military devices, as well as our peacetime progress, depend.

The problem is an old one. What is new is the general appreciation of its seriousness. Out of this arises hope that major steps toward solution may at last be undertaken. We can no longer afford the piecemeal efforts toward fragmentary solutions, which have been the only kind of efforts this problem has enjoyed in this country until now.

The acute awareness of the need arrives at a time when there is prospect for major help for solution from technology itself. Recent developments in machine systems for information storage and retrieval, although still far from adequate for the job at hand, are definitely encouraging. The technique of "organized invention" for the solution of practical problems has long since proved its efficacy in the applied-research laboratories of the world. The newer techniques of operations research, systems analysis, and applied behavioral sciences, are providing increasing evidence that an organized, systematic approach to very complex problems is effective, economical, and, indeed, may be the only feasible approach.

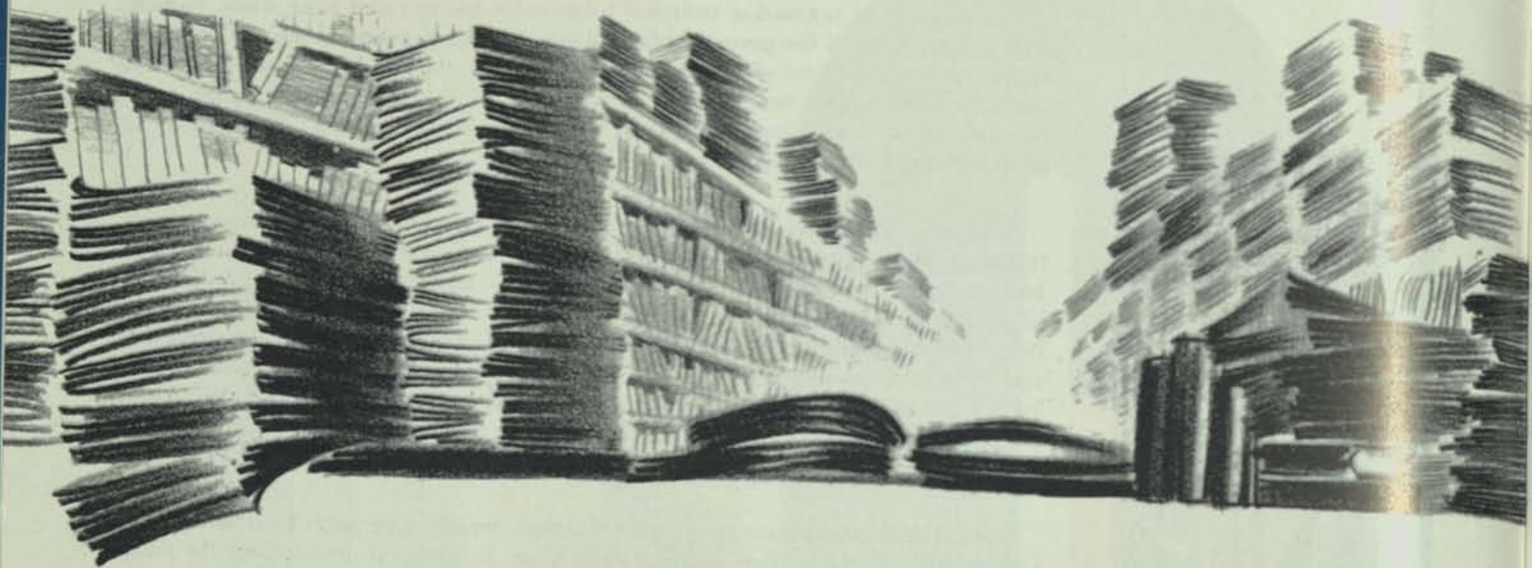
The cost of inadequate technical information processing facilities in duplication, in delay, in the failure to solve both military and civilian problems in the shortest time is real; it is large; it is constantly growing. The tools for the solution of the problem are available. Failure to use them now can only delay and make more difficult the effort ultimately required to prevent chaos in technical communications.

M. L. KASTENS

Reprinted from STANFORD RESEARCH INSTITUTE JOURNAL, Number One, 1958.

FACETS OF THE

TECHNICAL INFORMATION PROBLEM



Technology, so adept in solving problems of man and his environment, must be directed to solving a gargantuan problem of its own creation. A mass of technical information has been accumulated and at a rate that has far outstripped means for making it available to those working in science and engineering. But first, the many concepts that must be considered in fashioning such a system and the needs to be served by it must be appraised. The complexities in any approach to an integrated information system are suggested by the following questions.

by CHARLES P. BOURNE and DOUGLAS C. ENGELBART

Recent world events have catapulted the problem of the presently unmanageable mass of technical information from one that **should** be solved to one that **must** be solved. The question is receiving serious and thoughtful consideration in many places in government, industry, and in the scientific and technical community.

One of the most obvious characteristics of the situation is its complexity. A solution to the problem must serve a diversity of users ranging from academic scientists engaged in fundamental investigations to industrial and governmental executives faced with management decisions that must be based on technical considerations. The solution must accommodate an almost overwhelming quantity of technical and scientific information publicly available in many forms through many kinds of media and in many languages.

Some students of the problem, including men with many years' experience in various aspects of information handling, have viewed this complexity and concluded that the problem cannot be solved in its entirety. These authorities have recommended a piecemeal attack on components of the problem.

Stanford Research Institute believes that the techniques of systems analysis coupled with an understanding of the potentials of machines permit a powerful approach to the solution of this many-faceted problem. In fact, it may very well be that only by grappling with the problem as a single, integrated system can a realistic and lasting solution be attained.

However, to deal with the information system as a whole, it is necessary first to define its complexities with as great detail as possible. As an aid to the preliminary mapping of the system, a study group at SRI polled a portion of the Institute's own professional staff of engineers and scientists for questions they believe must be answered before an effective system can be designed. A representative list of the questions raised in this fashion is given in this article.

The list is impressive, but obviously not exhaustive. It does confirm the multiplicity of points of view that must be appreciated before this problem can be attacked.

Many of the questions require simple factual answers (see "Data Needed About Information Sources and Services," p. 9) They can be answered by straightforward techniques of counting, surveying, sampling, and estimat-

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i A few of the answers are already available, but the that most questions of this type cannot be answered ı available sources emphasizes the pressing need for a h better quantitative assessment of the size and nature he information problem before a rational attempt to e it can be undertaken.

nother group of questions involves essentially matters national and scientific policy that ultimately must be wered arbitrarily. Data and analysis can give guidance the answers but the ultimate decision will be based on dgment of relative needs and relative values.

uestions relating to policy

hat are the specific aims of the program?

ll the system start with only new information? Or will it process back literature, and, if so, how far back?

ll the Service process requests from allied countries? To what extent? Will it coordinate with the Soviet Union?

n part of the operations be done abroad? What about translations?

l an international classification, indexing, or retrieval system be adopted or promoted?

ll the system be designed to serve the brilliant, the sophisticated, as well as the more unsophisticated?

ll the Service be financially self-supporting?

ll big business have any better access than small businesses or individuals?

Could a private citizen or scholar afford to use the Service?

How will prices be established for the Service?

What is the range of subject matter to be included?

Will classified information be included?

Will safeguards be established to insure that classified information is kept under proper control?

What type of information should be included? Books (texts, tables)? Technical and trade journals? Conference proceedings and papers presented but not published? Industrial and government interim and final project reports, etc.? Operation and instruction manuals? Patents? Manufacturers' catalogs? Newspapers and general magazines?

Who will be responsible for selecting the material to be included?

What protection will be provided users who want their queries to remain confidential?

Should service be provided outside the technical community? To congressmen? Executives? Businessmen? High-school students?

a proposal for a national technical information service

Members of Stanford Research Institute have long given thought to the increasing disparity between the accumulation of new knowledge and the means for organizing it for widespread utility. With this problem brought into sharp focus by recent events on the international scene, the Institute believed it appropriate to formalize its views on the magnitude of the problem and to suggest a possible solution. In January, a draft program for a National Technical Information Service was prepared and copies distributed to members of the President's staff, to selected members of Congress, to various agencies within the federal establishment, and to industrial leaders and technical societies, all known to be concerned over the state of technical information affairs.

This document describes a program to solve the nation's technical information problem through the establishment of a national service for the collection, processing, storing, retrieval, and dissemination of scientific and technical information from both foreign and domestic sources. The program comprises five phases, interrelated and partially concurrent:

1—Establish a central organizing and administering, federally constituted Agency.

2—Determine the gross dimensions of the problem.

3—Establish an interim information center using existing services and techniques.

4—Analyze the factors that determine the design and operation of an ultimate National Technical Information Service.

5—Encourage present and initiate additional research and engineering development programs leading to systems and equipment necessary to implement the ultimate National Technical Information Service.

This proposal, and others, for solution of the problem are currently under study by the interested bodies of the nation. Meanwhile, at the Institute, study of various phases of the technical information problem, both in the gross, and of specialized aspects of data handling, storage, and retrieval, is continuing.

Who will control the policy in the matter of designing, establishing, and/or operating the Service? An appointed committee, such as for the NACA? A civil servant? A political appointee? A committee elected by scientific organizations?

Would it be feasible to establish legal authority to speed up the standardization and coordination of existing facilities (such as the F.C.C.)?

Who is competent to design, establish, and/or operate the System? Would this be a civil-service organization?

Could the objectives of the Service be achieved by expanding existing government agencies (e.g. Bureau of Standards, the Library of Congress, Armed Services Technical Information Agency)?

If the Service were not directed by some existing government agency, would it not be best handled by some university?

Would it be economically feasible for any sort of commercial enterprise or non-profit corporation organized by the professional community, or by private industry, to establish and run a Service which would assure continued social and technical progress?

If we must look to the federal government for support, what residual responsibilities remain with the professional societies? Should private groups continue to sponsor special collections?

What economic and political limiting factors exist with respect to the freedom one would have in utilizing or changing those organizations already active in the documentation field, and whose existence could be over-shadowed by a national Service?

What about copyrights? Would royalties be forthcoming to the owner of the copyright if the Service distributes the material? What will be the impact on the technical publishing industry?

Charles P. Bourne and **Douglas C. Engelbart** are research engineers at Stanford Research Institute's computer laboratory. Mr. Bourne gained his first electronics experience in USN schools from 1950-51. From 1952 to 1953 he served as instructor of various aspects of guided missile operation and maintenance with Convair Guided Missile Division and as adult education instructor in electronics at Chaffy Junior College. After receiving his BS degree from the University of California in 1957, he was employed as a research engineer at SRI where he has been engaged in research on mechanization of information retrieval and logical design.

Dr. Engelbart received his BS degree in electrical engineering at Oregon State College in 1948, MEE in 1953, and PhD in 1955 at the University of California His theses were concerned with design and programming of drum-type computers and special gas-discharge tubes for use in computers. He has worked as professor of electrical engineering at the University of California, as electrical engineer at Ames Aeronautical Laboratories, and as consultant. In October 1957 he joined the SRI staff. Information retrieval is one of his specialties.

Should the Service act as a publisher for collections of papers (reprints) in very new and special fields?

How will the priority schedules be fixed for the Service?

How soon could the Service be initiated? With an immediate manual system? With an ultimate mechanized system?

What factors will determine the location? Can strategic dispersal considerations influence the location without adversely affecting efficiency?

Is the proposed Service simply an attempt to copy Russia?

Might not an interim solution be to translate and distribute the exhaustive Russian abstracts, thus leaving our interim energies free for other uses?

Might it not be better to reduce the amount of literature produced rather than go to the tremendous expense of providing super-service for all of it? Can a quality filter be applied to this output?

Why not allocate federal money to support more direct interchange between working scientists? Perhaps more meetings, special conventions, seminars, etc., would be more economical than better literature processing? Couldn't the money be better spent on education to achieve a given increase in scientific effectiveness?

Could a substantial portion of the information problem be solved by teaching the users more about present-day documentation techniques?

questions requiring research

Some of the questions posed to the study group will require considerable study and research to produce valid answers. The research will be in many fields—in the social as well as in the natural sciences. Some of the study must be quite profound—even theoretical. Some will be more straightforward. Many of these questions must be answered before the policy decisions implied in the previous group can be made with confidence.

Can we separate apparent need, influenced by present concepts and experience, from real need? Lack of awareness of the potentialities of recently developed methods (or methods not yet developed) can easily result in an unimaginative formulation of the possibilities and opportunities for advantageously using recorded information.

How will users' habits and needs evolve as a good System becomes available?

How are the information needs of a user affected by his age, educational level, profession, type of position held, etc.?

What are the characteristic information needs of the basic (academic) scientist? The applied researcher? The en-

data needed about information sources and services

Before the designers of an overall information center can sketch in the outlines of the System problem, a large amount of data about the information input and the existing information services must be collected. Some of the kinds of essential data are suggested by the following.

What subject fields are covered by the various journals, books, and reports? And in each case, in what depth?

What are the physical sizes of journals, books, and reports? Page size and number of pages? Frequency of publication? Kind and size of distribution? Cost or subscription price?

In what language(s) do the journals, books and reports appear?

Does each have an index? Are abstracts published, and where? Where is the information indexed?

Who, principally, are the contributors to the technical journals? Who selects or reviews papers for publication? How long, generally, between preparation and publication?

Are microfilm copies of books, journals, and reports available?

Who are the publishers of technical journals, books, and reports? Where is each located? And how long in operation?

How is each publishing operation financed?

What are the policies and objectives of the respective publishers in each field?

What fields of science and technology does each publisher operate in? In what fields does each concentrate or specialize?

In what language(s) does each publisher produce his journal(s), books, or reports?

Could publishers of journals, books, and reports provide paper tape or other machine-readable copies of their works? At what cost?

How much has been produced to date in the various technical subject categories in journal, book, and report form? What is the physical mass of each? Are back copies available?

What libraries with technical collections, abstracting services, indexing services, and translating services âre in existence? Where is each located? What is its organization? How is it financed?

What is the size and training of the staff of the various technical-information handling or processing organizations? In each case is the organization equipped to handle classified material?

In what field(s) does each information handling or processing unit operate?

What classification and indexing systems are in use?

What is the normal time between publication of a document and its appearance in the libraries? When is it abstracted? Indexed? Translated?

What are the types and numbers of scientific and technical people using libraries, and the abstracting, indexing, and translating services? In what ways does the technical community feel it is being adequately or inadequately aided by these services?

Would the various libraries and services be amenable to negotiation of changes or increase in area of coverage, or other changes of service, to fit a reasonable, overall system, if government controlled and subsidized?

What are the charges for service by libraries? Abstractors? Indexes? Translators? Which of these services are self-supporting?

Are special compilations of abstracts, bibliographies, or translations available? And for what fees? How long required to provide such special services?

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gineer? The decision maker? Are they all equally critical, or is the "applier" of knowledge the one with the biggest problem?

What is the role of information retrieval, storage, etc. in the decision-making process of the research worker, engineer, scholar, administrator, etc?

How much use does the scientist and engineer make of the facilities that are presently available?

By what processes does the scientist and engineer keep abreast of the advances in the art now? What are the relative importances of each of these processes?

How many scientists and engineers have a definite program of "keeping up with the literature"? How much time would they "like to spend?" What keeps them from spending more time?

How much of the literature that would, with reasonably high probability, be useful to a scientist or engineer, is caught by him now by his own regular surveillance of the literature? How far out of his way will the average user go to be sure that he hasn't missed some possible information . . . considering the usual distracting pressures on him, his familiarity with the sources, etc?

How many pages of literature in various categories relative to the level and interest-area of the user can we expect him to scan or search for his different information needs?

What are the relative merits of the different types of reference information services with regard to the user and his needs, desires, habits, and limitations?

What are the relative importances of the users' various informational needs? On one hand, he needs to know the newsy items such as who is working on what, what his current attack is, who disagrees with whom and basically why, etc.; and on the other hand, he also needs to be able to study in detail the carefully written treatises that may have bearing on his work Can these different kinds of needs be met by a single system?

What are the special information requirements for different specialty fields?

Does the user, when he goes outside his special field for supporting information, want information in different form or different levels than which he seeks in his own field? For instance, would he be looking more for "cook-book" techniques or for survey-type information?

How valuable would broad, multi-disciplinary searches be if they could be conducted effectively? How great is the problem of differences in nomenclature between fields?

What type of questions now go unanswered at the libraries?

Isn't the main problem of information retrieval one of identification—since people so seldom express satisfactorily their needs to the documentalist?

What are the major limitations in the various methods presently used in classifying and inaexing scientific literature?

Is the problem that the information now is just not available at all, or is it that it is just hard to find?

Why aren't the existing services that process technical information satisfactory?

How many places does a user of each discipline have to look for index listings of a given special interest?

How can the processing of recorded information be planned so that it can be effective in spite of human limitations, or of limitations in numbers of human beings?

How much is missed by technical people leaning too heavily on librarians?

What relative gain in efficiency could be achieved by integration, merging, or better managing of existing documentation services?

the soviet approach to the information problem

The Soviet Union has a comprehensive technical information system in operation. In 1952 the Soviet All Union Institute of Scientific and Technical Information was established in Moscow. By 1957 the Institute had a permanent staff of 2300 translators, abstractors, and publishers. This staff is supplemented by more than 20,000 cooperating professional scientists and engineers throughout the U.S.S.R. who offer their services as part time translators and abstractors in their specialized fields.

The Institute publishes 13 "abstract journals" which annually contain over 400,000 abstracts of technical articles from more than 10,000 journals originating in about 80 countries. It systematically translates, indexes, and abstracts about 1400 of the 1800 scientific journals published in the United States.

To reduce the time between the initial appearance of the more important information in any of the world's journals and its reaching the hands of Soviet scientists and engineers through the normal route of the abstract journals, "Express Information Journals" are also printed. These carry summary information on foreign technological developments within two or three weeks after their receipt. Reports made on the work done indicate that it is not only comprehensive but also of high quality.

The Institute provides numerous other technical information services, such as provision of bibliographies, micro and full size copies of original printed material, technical dictionaries, foreign-language dictionaries, and other varied source material.

The Institute maintains an extensive program aimed to introduce machine methods to information handling. This includes translating machines, and mechanisms for codifying, storing, and retrieving technical information. Significant progress by the Soviet All Union Institute towards information mechanization methods and systems is reported.

What increase in efficiency of the scientist or engineer would result from improving the accessibility of recorded information?

What are the probable net benefits, short and long range, of an effective information Service to military, industrial, commercial, scholarly, government groups?

Can dollar costs be derived for reasonably well-proven delays and duplications, and can the total national loss rate due to this problem be realistically estimated? Can it be determined that the expense of delay and duplication now is greater than that of establishing and operating an information Service?

What is the lack of an information Service costing government agencies?

Can the savings in Federal money now spent on other information programs be diverted to a national information Service?

What are the relative costs and characteristics of different reproduction techniques that might be applicable to some of the dissemination and massive processing problems of an information service?

What are the techniques and costs involved in keeping up and in using large mailing lists in taking care of distribution of journals, etc.?

What are relative costs of providing the information in micro form as against making original-size photo copies?

Of the currently-operating abstracting services, how many are operating merely to satisfy an obligation of a professional society that would rather have somebody else do the abstracting?

What services does the Russian All-Union Institute really provide? What is the reaction of a Russian scientist to this information center?

How important is it to know what the rest of the world is doing?

Are any projects or areas of work reported almost exclusively in foreign literature?

What is the expected rate of growth of the system?

What are the potential information processing capabilities of existing mechanical devices?

What are the theoretical capabilities of existing or anticipated machine components which might be applied to the information processing problem?

How often will the system presumably be searched? How definitive will the search have to be? What volume of information should a search produce? How fast should the system respond?

characteristics of the information service

As increasing data becomes available it will become possible to consider some of the last group of questions—those dealing with the desired or necessary operating characteristics of a comprehensive technical-information processing system. Certainly, the first system implemented would be of an interim nature using existing resources, which unfortunately employ largely manual techniques. However, ultimately it is inevitable, in view of the impressive advances made almost daily in information processing techniques, that a highly mechanized system will be possible.

How soon can an interim system be functioning?

How much can be done just by concentrating on abstract distribution and better dissemination techniques?

Would it be feasible for the abstracting publications to use a standard format and type font, such that mats (or something similar) could easily be distributed to other interested publishers, thus saving printing expenses?

What technical societies could cooperate to publish a single journal instead of numerous splinter journals?

What about the scale of the Service? Does it have to be a big system or nothing?

Does "having a large information Service" necessarily mean the physical collection of all activities at one central location?

Would a group of smaller centers, for specific fields, be of greater utility and more tractable?

Would a collection of special libraries be more useful?

What can a national service provide that is different than what is now available? Is this to be an entirely new type of service, a real advance in the state of the art, or is it to be just more and better of the same thing?

Will the System have a finite capacity? One system might work well with a few million entries, but be hopeless with a hundred million.

As the System grows in size, will it be possible to make changes easily in the classification scheme and bring the old coding into the new scheme?

If a private consultant, with "need to know" established, were to work on a government project, how would he locate and procure pertinent classified material?

Will financial filtering of requests by a uniform fee structure be desirable or effective, or would it be necessary to make non-uniform fee structure so that there is essentially some "priority" given?

What means can be used to pry loose useful information that customarily doesn't get into the published technical information channels?

Will the service include a positive program to declassify material under security restrictions?

What is an acceptable delay in getting information entered into this system?

Will all material in the subject fields be included or will there be an editor or a censor?

Will an attempt be made to standardize the form of the material before it gets into the center? Does the material have to be on standard-size sheets or forms?

What happens when the system becomes overloaded?

Should service to users just be late, or should the service just be less complete?

How can we protect against freezing the specifications until enough systems work has been done to make clear what would be optimal?

Will the policy makers make sure that the final methods chosen for a retrieval system are not influenced too heavily by the requirement of compatibility with past systems?

Will abstractions be done? What kind? Descriptive? Critical? Informative? How can we get good-quality abstracts? Should the Service use volunteer abstractors directly or a staff of full-time abstractors? Or should it allow the various technical societies to organize their own volunteer abstracting services?

Will any effort be made to review old documents, and to remove or recode when necessary?

Is a standard (or artificial) vocabulary necessary? How much work will be required to design and institute such a vocabulary?

What techniques and devices can reasonably be developed and applied for facilitating such immediate requirements as printing, reproducing, storing, microfilming, billing, communicating, etc.?

What kind of data-processing system will the Service need just to keep track of its operation?

Would the information Service keep a collection of the original documents?

What special precautions must be taken to store primary records? Would a duplicate file and collection be maintained to prevent disruption of service due to fires, or other catastrophes? How much would this cost?

What is the useful life of various forms of records? In use? In storage?

What will the information Service physically provide in response to information requests?

Will the output be in English, or a code that must be translated?

Will microform copies be acceptable to the users? If not, what improvements need be made in order to gain user acceptance?

Will the information Service output be in a form that the researcher can determine which of the documents are in a locally accessible collection?

Will the system give answers (e.g., "yes," "no," "5,000 tons in 1945," etc.) as well as references?

Why not periodically publish inventories of research in progress, to indicate what research projects are currently being undertaken in each specialty field, thus helping to eliminate duplication?

Will there be a "special communication network" in which workers in the various specialized fields can readily circulate working papers or "think pieces?" A central agency could maintain printing, listing, (in appropriate subject-interest categories), and mailing facilities for this sort of service.

Will the information Service be able to retain a set of questions to be asked of all new input material, thus providing up-to-the-minute data for standing questions?

Will it be possible to stimulate more writing of "review-the-literature" papers by qualified people in the various fields, in order to provide guides for other workers?

Can a partial search be made? (For example, can 1[illegible] of the file be searched and the results checked to determine if further searching is justified?)

Could the information Service operate on a "just search ½ the file for me; I don't need a comprehensive search" basis?

What kind of communications network will be needed for the operation of the interim information Service? Will it be accessible to anyone by telephone or other direct device, such that the searcher can interrogate the file directly and at will?

Would the Service be available for browsing?

What technical-manpower drain would the proposed information Service program have on other high-priority scientific programs?

What professional and educational background is needed for the personnel to operate the Service?

Could university science students be used part time and during summers to help with the various processing tasks, as a means of alleviating the shortage of people with adequate technical backgrounds?

Will there be special training for abstractors and translators or for documentation and information specialists, etc.?

How much research is needed? What research budget is reasonable?

If an information Service were established, how soon could present partial services by government agencies be terminated and funds diverted to the Service? Could some special activities in industrial libraries be eliminated?

These questions, by the very nature of their origin, are random and fragmentary. Even the full list from which they have been selected is far from comprehensive However, we have found them a helpful stimulus as well as a disciplinary aid in viewing the technical-information problem in its broadest dimensions. We hope that others interested in this problem will be similarly served.

INTERNATIONAL CONFERENCE ON INFORMATION PROCESSING

R... entatives of at least twelve countries will be at-te... g the International Conference on Scientific Infor-m... n, November 16 - 21, 1958, to be held at The May-fl... Hotel, Washington, D. C. The opening session a... s, Sunday, November 16, at 8 p.m., will be made ... Lindor Brown of England, Secretary for Biological ... es (The Royal Society) followed by a reception. ... e five day conference will be divided into seven ... morning and afternoon sessions, during which the ... rs of scientists of various countries and of this coun-... ill be presented and discussed.

... onsors of the conference are, National Academy of ... nces, National Research Council, National Science ... dation, and the American Documentation Institute. ... is scientific information conference is expected to ... t more than usual interest because of the participa-... of the U.S.S.R. and Czechoslovakia.

... a one

... ginning the morning of November 17, area one pro-... s the knowledge now available and the methods of ... taining scientist's requirements for scientific literature ... reference services. Discussion panel leader is Dr. ... p Morse, Department of Physics, Massachusetts In-... te of Technology. Among the thirteen papers to be ... nted will be one from Czechoslovakia entitled, "Sys-... atically Ascertaining Requirements of Scientists for ... rmation," by Jiri Spirit and Ladislav Kofnovec of the ... gue Research Institute for Materials and Technology.

... a two

... eading the discussion on area two's topic is Dr. Elmer ... tchisson, American Institute of Physics. Subject matter ... function and effectiveness of abstracting and indexing services for storage and retrieval of scientific information. The fifteen papers to be presented include a contribution from Russia: "On the Functioning of the All-Union Institute of Scientific and Technical Information of the Academy of Sciences of the U.S.S.R.," by A. I. Mikhailov of the Moscow academy of which he writes.

area three

Subject for area three is the effectiveness of scientific monographs, compendia, and specialized information centers in meeting the needs of scientists. Present trends and new and proposed techniques and types services will be elaborated. The panel leader is Dr. Alexander King, European Productivity Agency. Five papers are scheduled and include one entitled, "Recent Trends in Scientific Documentation in South Asia: Problems of Speed and Coverage," by P. Sheel of Insdoc National Physical Laboratory, New Delhi, India.

area four

Organization of information for storage and search . . . comparative characteristics of existing systems, will be dealt with in area four and discussion is led by Dr. Eric de Grolier, Centre Francois D'Exchanges et de Documentation Techniques. Among the seven papers to be presented is, "Experience in Developing Information Retrieval Systems on Large Electronic Computers." This paper has been submitted by Ascher Opler and Norma Baird of The Dow Chemical Company in New York.

area five

Area five will review the organization of knowledge for storage and retrospective search: Intellectual problems and equipment consideration in the design of new systems. Dr. Gilbert W. King of the I.B.M. Research Center will be the discussion panel leader. Twenty papers are to be reviewed and countries represented in this area are—the U.S.S.R., Netherlands, France, Great Britain and the U S. One paper is entitled, "On the Coding of Geometrical shapes and Other Representations, with Reference to Archaeological Documents." This has been submitted by Jean-Claude Gardin of Centre Nationale de la Recherche Scientifique in Paris.

area six

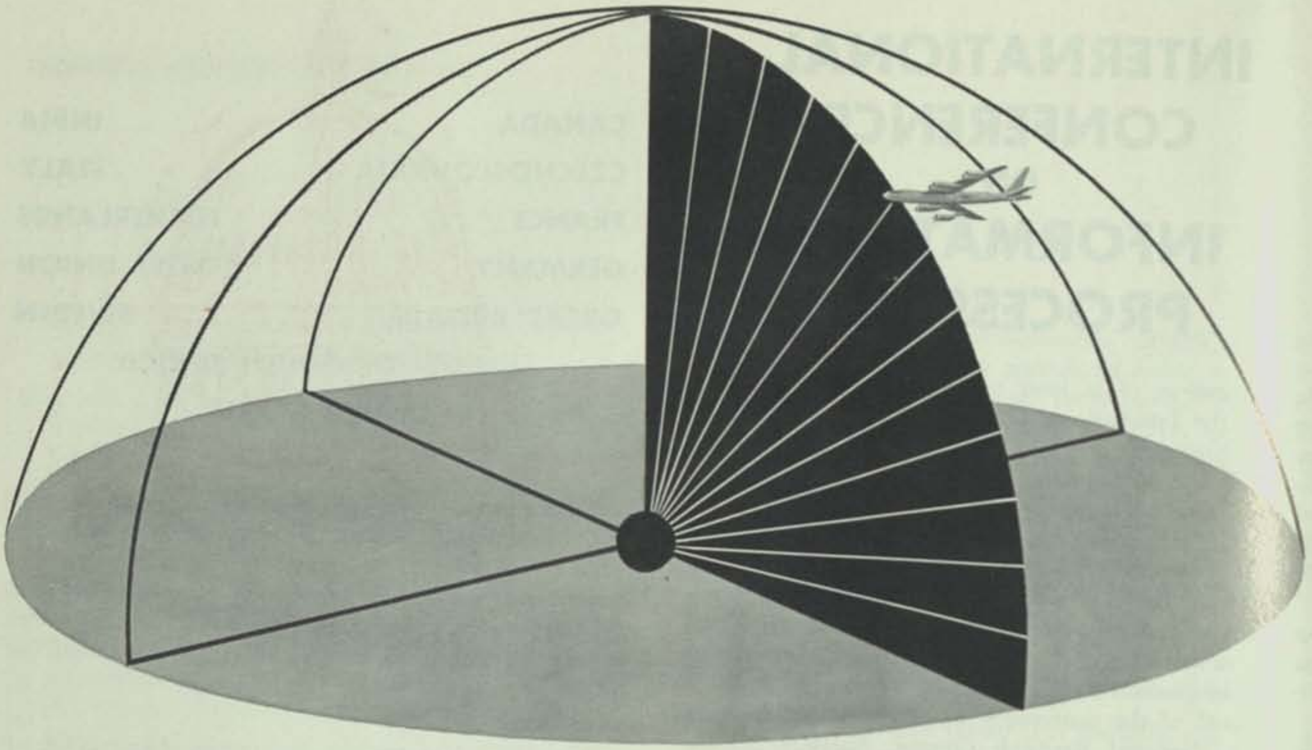
The topic for area six is the organization of information for storage and retrospective search: possibility for a general theory of storage and search. Leading the discussion will be Dr. John Tukey, Department of Mathematics, Princeton University. Among the six papers to be presented will be, "The Structure of Information Retrieval Systems," by B. C. Vickery, Imperial Chemical Industries, Ltd., Welwyn, England.

area seven

On Friday morning, November 21, the concluding area seven is devoted to a subject that is surely of universal interest. To be discussed – the responsibilities of governmental bodies, professional societies, and other groups, to provide improved information services and promote research in documentation. Mr. Verner Clapp, Council on Library Resources, Inc., will be heading the panel. Nine papers will be reviewed and include contributions from France, England, the United States and one from the Union of South Africa entitled, the "Responsibility for the Development of Scientific Information as a National Resource, by Hazel Mews, Department of Librarianship, University of Witwatersrand, Johannesburg.

There will be exhibitors at this conference from manufacturers of equipment utilized in the field of data storage and data retrieval.

For conference contact, see Important Dates in Datamation, page 35.



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Fullerton, Orange County, California

Circle 4 on Reader Service Card.

DATAMATION *abroad*

IN LONDON:
LOG ANALYZER DEVELOPED

Based on development work carried out at the Imperial College of Science, London, on a transformer analog system devised by C. L. Blackburn, an advanced transformer analog analyzer has been recently built and installed at the Witton Works of General Electric Co., England. The new analyzer is called the WINA (Witton Network Analyzer) and operates on 50 cycles supply. It has a "very high" inherent accuracy of 0.1%, according to the manufacturer. The equipment is arranged in 4 sections, each consisting of a central plugboard with 52 standard analyzer units arranged in racks.

COMPUTER
INSTALLATIONS ABROAD

ElectroData division of Burroughs Corp. has shipped a 205 electronic computing system to the South African National Life Assurance Co., Capetown. The insurance firm became the first in South Africa to employ datamation for policy handling . . . Italy and Germany have displayed keen interest in computing equipment that can provide shortcuts to problems in aircraft and guided missile programs, according to Paul Dennis of Bendix Computer. Dennis said his firm will install a unit at the University of Rome for the Italian Air Ministry to be used in an Italian missile program. He said major West German industrial plants such as Dornier, Zeiss and Zahnradfrabrik are vitally interested in this work . . . an IBM 650 and auxiliary equipment has been installed by the National University of Mexico in its electronic computing center.

IDP GROUP
ORGANIZED IN SWEDEN

Data processing equipment users in Stockholm, Sweden, have formed an IDP Group, composed of about 40 members. Secretary is Peter Hansen of the Swedish Commerce Bank. Exchange of ideas, visits to installations, keeping up with latest changes, and exploring technical data, are some of the targets which this group has set for itself. The IDP group idea is making huge strides and certainly its future is very promising, according to our Swedish correspondent.

IBM SUISSE
OPENS CENTER IN ZURICH

At the end of May, IBM, Extension Suisse, opened a data processing center in Zurich. Officiating at the opening ceremony was H. R. Luthy, director of IBM's Swiss subsidiary. Leading Swiss personalities and the president of IBM World Trade Corporation, A. K. Watson, were in attendance. The center has a 650 and a staff of 12 scientists and engineers under the supervision of Dr. Jakob Haller.

JAPANESE
MARKET COMPUTERS IN '59

Word comes from Japan that at least three companies are expected to be producing computers commercially next year. The Musasino One (see page 31) will be on exhibit by its commercial maker at a data processing conference in Europe next year.

REVIEW OF IN-LINE INDICATORS

In two previous issues of DATAMATION we have surveyed two forms of data display devices. In the January-February issue we presented graphic display devices, and in the July-August issue — high-speed printers.

This month we offer a survey of in-line visual display devices which are used when the human observation of data is required. These in-line displays can be used in applications varying from single decades for indicating a particular channel number, etc., to complex tote board type displays used by such groups as the North American Defense Command and the Strategic Air Command in their operations control centers.

TALLY REGISTER in-line indicator

This in-line indicator is intended to serve as an input link – primarily for conversion from serial input to parallel output with simultaneous translation from one code to another (BCD to decimal, etc.) Model 274 data control unit is a tape-fed, shift register with parallel readout. Information is serially read at 60 characters per second and is shifted through the control unit. When the final position has been loaded, a signal is generated to control the output program. Controls are provided to preset the word length from two to seven characters. Additional controls are provided to permit one-character-at-a-time or one-word-at-a-time operational modes. (Tally Register Corp., 5707-37th S. W., Seattle 6, Washington.)

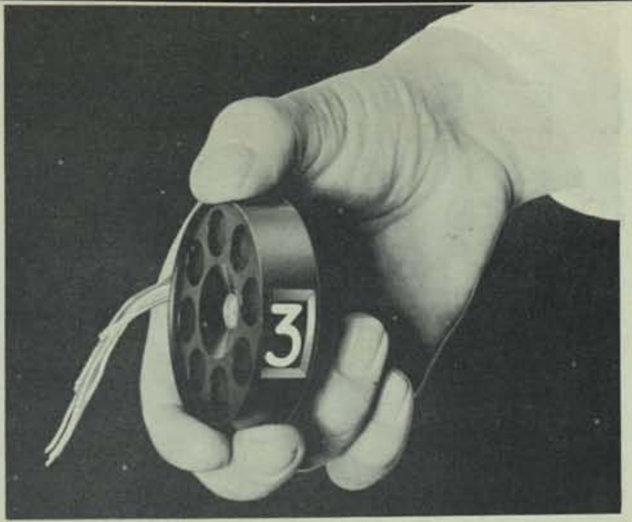
Circle 101 on Reader Service Card.

KIN TEL, COHU digital readout

Model 471 digital readout presents numbers on a single plane, with no overlapping characters. It employs a projection system . . . providing 7,000 to 8,000 hours of lamp life. Display provided by the 471 consists of four digits (decimal and 0 through 9) plus a symbol readout with symbols +, −, AC, NN, ohm, kilohm, megohm, A/B, AC/B, AC/AC, X. Individual digits are 1⅛ in. high. The total display area is 2 in. high by 7½ in. long. Power requirements are ¼ amp at 6.3 volts AC for each symbol or digit that is lit. Vertical space of 3½ in. is required in the standard 19 in. rack mount. Special models are available with up to nine individual readouts consisting of any combination of digits or symbols required. These digital readouts are designed for use with all types of digital converters and encoders. (Kin Tel, a division of Cohu Electronics, Inc., 5725 Kearny Villa Road, San Diego 12, California.)

Circle 102 on Reader Service Card.

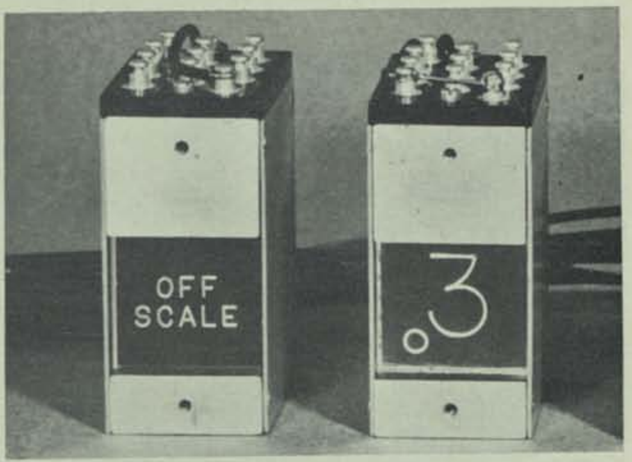
PATWIN
mag indicator



Numbers or symbols are displayed on this electro-magnetic indicator at a rate of two per second. Only .028 amperes are required for the duration of signal pulse and the display holds its position, without power, until the next pulse. One moving part, weighing ⅕ oz. and mounted on a miniature precision bearing, insures long life and high reliability. Digits or symbols are large enough to be read at distances up to 25 feet and are free from parallax and glare, the manufacturer contends. Interlocking construction facilitates stacking. An external dc pulse of approximately one watt is required to actuate the indicator. Indicators are available with nominal voltages of 12, 24 or 36 volts. Average response time varies between .5 and .6 seconds for maximum rotation. (Patwin Division, Patent Button Company, Waterbury 20, Connecticut.)

Circle 103 on Reader Service Card.

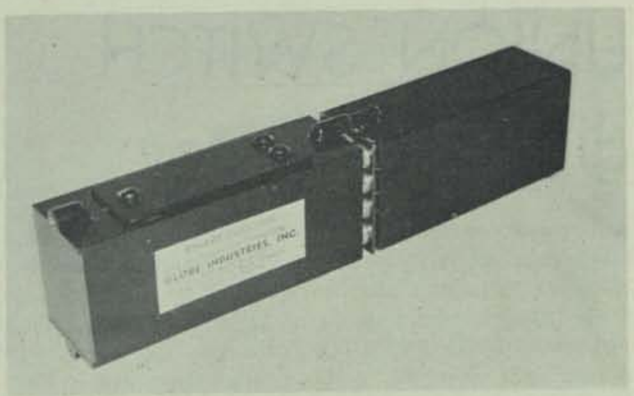
MILMAN
digital readout



Presented on this digital readout are the lighted digits 0 through 9 and decimal point, plus other information such as [illegible]ty signs or special symbols. Modular design of the [illegible] allows side-by-side mounting for in-line presentation of information. Message readout will display, separately [illegible]e panel area, up to three different color-coded pr[illegible] messages, greatly increasing the accuracy of visual observations, states the manufacturer. Message and color combinations are made up to suit individual requirements. The superpositioning of messages in the readout reduces the amount of panel area required to present a given amount of information and eliminates panel art work and engraving. The units are designed for operation on 6, 14, or 28 volts. (Milman Engineering Co., 1831 Pontius Avenue, Los Angeles 25, California.)

Circle 104 on Reader Service Card.

GLOBE
binary decoder

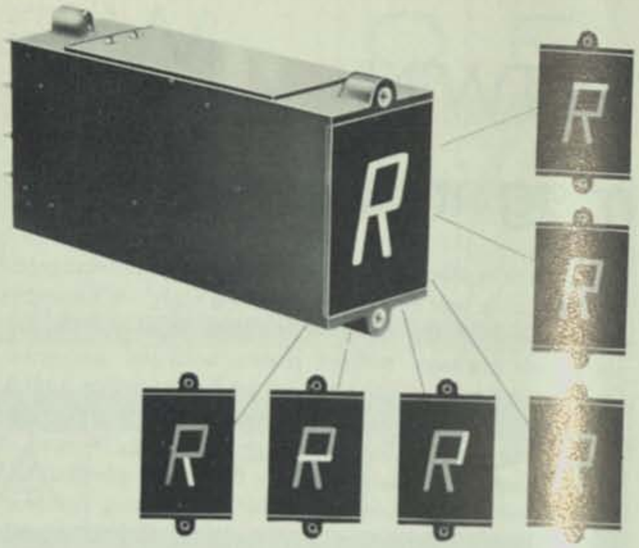


A completely self-contained unit operating from pulsed input signals on four wires, this binary decoder is a high speed relay controlled decoding matrix operating into a single plane illuminated digital readout. Operating speeds are compatible with modern tape punch and printing equipment. Various input circuits are possible. These include a parallel input containing signal and no signal conditions to indicate coded information, or a pulsed system in which power or ground pulses are fed to the input terminals. The inputs may be scanned serially from a mechanical or electronic multiplexing device. It has been found that a high speed relay at the input to a multiplexer will provide power and ground pulses to operate a bank of these decoders. This unit is particularly suitable for use in low cost remote readout or telemetering systems which require serial transmission of information, according to the manufacturer. Mechanical synchronization of scanning switches on a start-stop system has proven successful in many installations. (Globe Industries, Inc., 525 Main Street, Belleville 9, New Jersey).

Circle 105 on Reader Service Card.

I. E. E.
in-line display

This is a new unit which will display any letter A through Z, any number 0 through 9 and + or − symbols. Designed primarily for use with electronic data handling and processing systems the alphanumeric display unit features one-plane presentation. Characters are of uniform size and intensity and readability is insured from any angle of viewing, it is claimed. The unit utilizes a 12-bar matrix, each bar having a miniature projection lamp behind it. By projecting each bar through its own lens system onto a single-plane screen, and by the selection of the proper combination of any of the 12 bars, any desired letter, number, or symbol may be formed. The size of the character displayed is approximately ⅞ in. high x ⅝ in. wide. Size of the viewing screen is 1-15/16 in. wide. This firm also manufactures a 90 degree inline display and a standard in-line display line. (Industrial Electronic Engineers, 3973 Lankershim Boulevard, North Hollywood, California.)



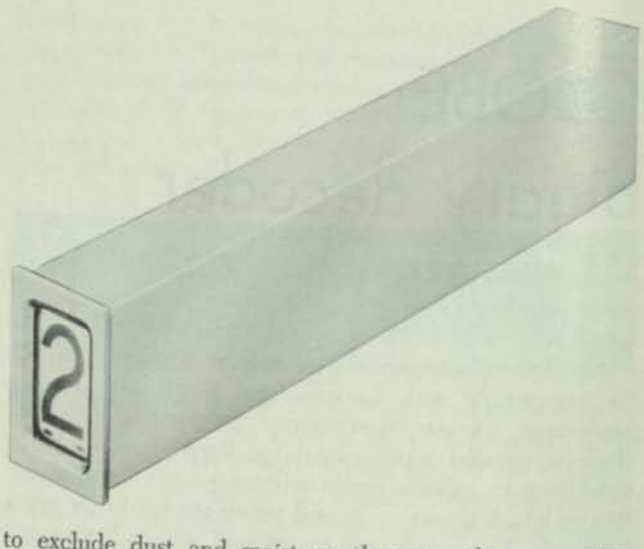
Circle 106 on Reader Service Card.

BECKMAN
in-line indicator

Model 5916 in-line indicator displays up to six red digits 1¼ in. high. Each digit is formed by a pattern of segments, each segment evenly illuminated by a grain-of-wheat lamp operated at reduced voltage for long life. This display differs from indicators using stacked lucite plates or stacked figure wires in that all digits are formed on the same surface plane. The surface image was employed in order to create an unobscured display which could be read from wide angles. Red color is used to permit readings in high ambient light. The indicator operates in response to a 1-2-2-4 binary code supplied by the manufacturer's counting instrument or some other source. The in-line indication does not change while the counter is actively scaling, but changes only at the end of a counting interval, at which time it displays the new total. Maximum display rate is 15 presentations per second. (Beckman/Berkeley Division, Beckman Instruments, Inc., 2200 Wright Avenue, Richmond 3, California.)

Circle 107 on Reader Service Card.

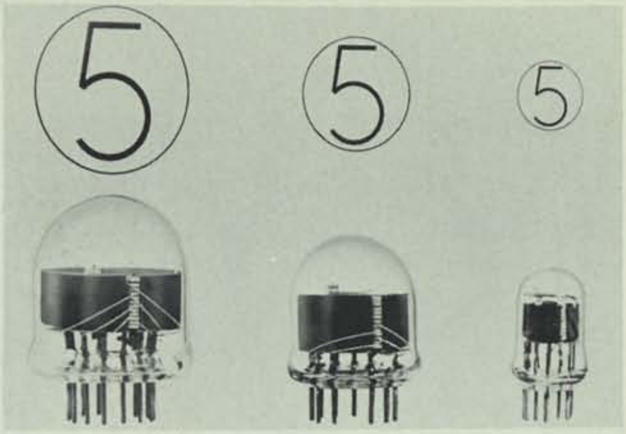
UNION SWITCH
digital indicator



A motor driven digital indicator operates on a direct drive basis, does not rely on the use of intermittent drive mechanisms to position the characters. Numbers 0 through 9 and two blanks are displayed in sequence, in response to four bit binary coded decimal input. Operating on an open circuit principle, complete code agreement of both binary ones and binary zeros is checked to assure positive and correct positioning of the indicator. The one inch character indicator utilizes the major portion of its frontal area for display. Its ability to operate as a nonvolatile binary readout, in conjunction with its inherent capabilities of storing binary data, is claimed to be its most desirable feature. The indicator is mounted in a gasket sealed case to exclude dust and moisture, thus providing operation under widely varying environmental conditions. (Union Switch and Signal, Division of Westinghouse Air Brake Company, Swissvale, Penna.)

Circle 108 on Reader Service Card.

BURROUGHS indicator tubes



Nixie Indicator Tubes are completely electronic devices which display numerals or alphabetical characters in a common viewing surface. Due to this fact, a number of Nixies, when placed side by side, form an "in-line" presentation which reduces operator fatigue and makes for an easily read display. The Tubes consist of 10 metal cathodes formed in the shape of numerals or other characters and a common anode which provides a uniform electrical field. These elements are enclosed in a glass envelope which is filled with neon gas. By applying a potential between one of the cathodes and the common anode, a bright neon glow is caused to form around the selected element, thus causing it to appear clearly and distinctly at the single viewing surface. The presentation can be caused to change at a 50 KC rate. There are four basic types available: BD-200-S miniature, 6844-A standard, 7153 super, and BD-307 jumbo. (Electronic Tube Division, Burroughs Corporation, Plainfield, New Jersey.)

Circle 109 on Reader Service Card.

FISCHER/PORTER digital indicator

Featured in this direct-reading digital indicator, designed primarily for use with this company's turbine flowmeters, is a completely digital system, operating from the frequency output of the turbine meter, which takes full advantage of the linearity and repeatability inherent in the turbine meter primary. Some features: in-line, illuminated, digital indication. Inch-high numbers providing digital reading up to 25 feet away. Direct reading of flow, with manual correction for specific gravity as an optional feature. True integrated flow rate – integration is performed during the sampling interval and the indication is corrected immediately following each sampling period. An octupler provides information at many times the output frequency of the primary. Automatic, frequency-controlled range switching is virtually instantaneous even at maximum accelerations. Customized time base is also featured along with manual specific gravity adjustment. (Fischer and Porter Company, 758 Jacksonville Rd., Hatboro, Pa.)

Circle 110 on Reader Service Card.

Non-Linear Systems digital ohmmeter

Series 20 digital volt-ohmmeter has been designed specifically for missile and weapons system check-out. It automatically and continuously measures and displays dc voltage, voltage ratio and resistance. The unit is available in four and five digit models. It makes three readings per second with accuracy to .01%. It is the first combination volt-ohm ratio meter having functions selected by a panel switch or remotely by means of electrical signals. Among exclusive features claimed by the manufacturer are interchangeable plug-in circuit boards, illuminated numerical read-out that snaps out for bulb inspection (with removable non-glare hood), a Wolff-Poggendorf potentiometer using precision stabilized wired-wound resistors and controlled by mercury relays. Series 20 has high input impedence, 10 megohms to 1000 megohms, operates card punches, electric typewriters and other printing devices. (Non-Linear Systems, Inc., Del Mar, California.)

Circle 111 on Reader Service Card.

Significant data from airborne vehicles . . . missile and aircraft structures . . . power plants . . . complex weapons and control systems . . . are being gathered by Consolidated Systems designed to produce useful information in a minimum of flights or firings. These are systems of proven design, based on unmatched experience in recording, converting, and reproducing selected in-flight data. Read the complete story in BULLETIN CEC 3014-X5.

systems division **Consolidated Electrodynamics**

300 N. Sierra Madre Villa, Pasadena, California / Offices in Principal Cities Throughout the World

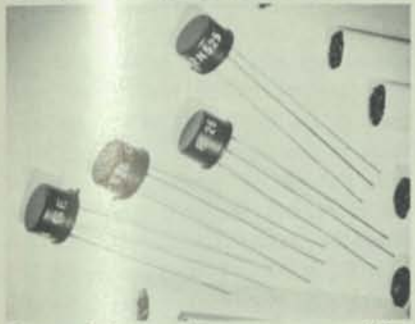
Telemetered and recorded data are made available in the form of analog or digital magnetic tapes, punched paper cards or tapes, visual displays, and direct-readout oscillograms.

Circle 5 on Reader Service Card.

new products in DATAMATION

transistors

A new line of 30-volt, one-half ampere PNP germanium transistors for use in data processing equipment has been



designed for medium power amplifier and low frequency, high current switching applications. The four models available: 2N524, 2N525, 2N526 and 2N527. They have a triangular lead arrangement and are housed in JETEC TO-5 package. With a collector current of 20-milliamperes and a voltage of 1-volt in a common emitter circuit, the 2N524 has a typical forward current gain of 35, the 2N525–52, the 2N526–73 and the 2N527–91. Beta holdup on all models is typically 75% of the 20-milliampere value at 200-milliamperes. For information write GENERAL ELECTRIC, Semiconductor Products Dept., Syracuse, N. Y.

Circle 150 on Reader Service Card.

analog computer

Model 200 is enclosed in a console unit equivalent in size to three standard racks. Included in the console are

the patchbay assembly, a .01% reference voltage divider, a precision panel mounted vacuum tube voltmeter, and all the indicating lights, switches, internal wiring, power and logic controls essential to the operation of an analog computer system. A writing shelf, at desk height, extends across the console unit. Occupying the center of the shelf is a raised turret supporting the control panel which places all the computer control and monitoring switches within reach of the operator. All indicators are centralized and readily visible. For information write COLORADO RESEARCH CORP., Broomfield Heights, Colorado or use reader service card.

Circle 151 on Reader Service Card.

voltage-to-digital converters

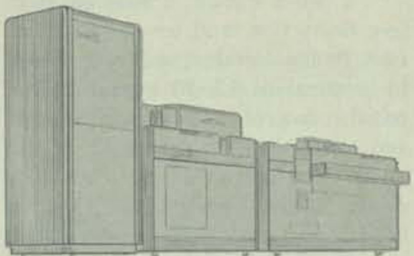
This four-decimal digit unit, model V16-AD, utilizes 17 printed circuit cards and comes in a standard hous-

ing. Eight printed circuit card positions are left vacant for auxiliary equipment. For additional flexibility auxiliary equipment may be integrated within the housing for precision potentiometer testing or analog computer readout. Inputs are full scale, 1, 10 and 100 volts. Input impedances are 1K, 10K, and 100K respectively. A high impedance input amplifier can be incorporated for 100 megohms input impedance. The unit occupies 5¼" of panel space. It is capable of up to 1000 independent conversions per second. For information write ADAGE, INC., Dept. P, 292 Main St., Cambridge 42, Mass. or use card.

Circle 152 on Reader Service Card.

accessory ca-2

Versatility and rapidity of input-output operation for the G15 computer is increased by this unit. The acces-

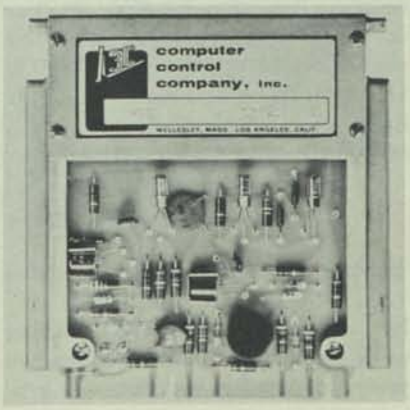


sory permits standard 80 column cards, punched in conventional numeric or alphanumeric codes, to be processed at high speed. It also handles high speed tabulation of numeric or alphanumeric printed copy. Information may be read or punched at the rate of 100 cards per minute by summary punches such as the IBM 514 or 523 (pictured at right). Output information may be tabulated at the rate of 100 lines per minute by the IBM 402 or 403. Three IBM units – one for input, one for output, and a third for either input or output – may be simultaneously connected to the CA-2. Cards may be read or punched in standard code and alphanumeric and numeric characters may be mixed. Special characters, indicated by multiple holes in card columns may be read or punched. For information write BENDIX COMPUTER, 5630 Arbor Vitae Street, Los Angeles 45, California or use reader service card.

Circle 153 on Reader Service Card.

digital module

Model SM-10 is a delay unit with amplifiers which does not incorporate any logic. It has three basic sections

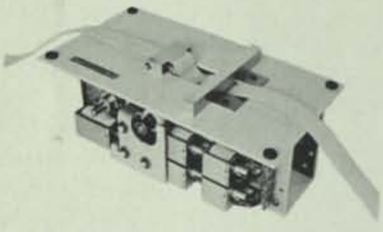


. . . a driver circuit, a magneto-strictive delay line, and an amplifier circuit. Its input is designed to be driven by a standard LE-10 logical T-PAC or other logical circuitry with right-in and erase control exercised at this point. The output of the SM-10 is similar in low driving capability to an LE-10 package. Both assertion and negation outputs are provided. Delays up to 560 microseconds are available. For information write COMPUTER CONTROL CO., INC., 92 Broad St., Wellesly 57, Mass. or use reader card.

Circle 154 on Reader Service Card.

tape punch

This punch features .046 in. diameter feedhole, .072 in. diameter codehole and is spaced .100 in. in both



directions. The standard punch is supplied with the feedholes in line with the codeholes. The standard location of the feedhole is .394 in. from the guide edge of the tape. The punch operates on a single cycle basis by demand and can be operated at any speed up to twenty seven cycles per second, depending upon the external requirements of the equipment feeding it. The punch requires one electrical input for each codehole connection. Two cam-actuated auxiliary contacts are provided on the drive shaft. For information write PRECISION SPECIALTIES, INC., 1342 East 58th Street, Kansas City, Missouri or use reader service card.

Circle 155 on Reader Service Card.

bobbin cores

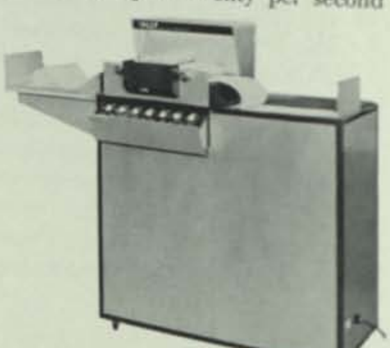
New "Poly Cap" tape wound bobbin cores are capped with a glass polyester which offers complete core pro-

tection, according to the manufacturer. The rigid structure of the cap, which will not distort with temperature changes, allows complete freedom of handling of the assembly line without the necessity of tweezers or special tools. Another claim—the permanent sealed protection of the cap lowers production costs for users. The fitted cap, which covers the bobbin flanges, adds nothing to the bobbin width or window area. Less wire is required for windings. The caps are unbreakable in normal use and handling. For information write MAGNETICS, INC., Box 391, Butler, Penna. or use card.

Circle 156 on Reader Service Card.

digital plotter

Model 201 plots visibly at speeds up to eight points per second with four symbols or up to twenty per second



with random symbols. Results of computers can be plotted immediately. The plotted result is a series of mechanically generated printed impressions on paper or vellum. The act of plotting is a complex of mechanical actions performed by a series of subsystems. The selection of symbol, plotting value, paper position, etcetera, all are performed along the principles of a digital servo. Values and instructions are entered into the secondary buffer. Upon receipt of an instruction signal the mechanical systems are motivated until their positions is in agreement with the contents of the secondary buffer. After this, the act of printing occurs and the secondary buffer is reset. For information write TALLY REGISTER CORP., 5300 – 14th Avenue, N. W., Seattle 7, Washington or use card.

Circle 157 on Reader Service Card.

shaft encoder

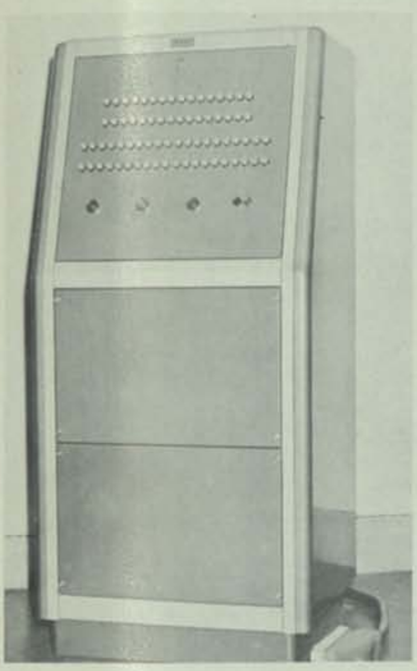
Special logic used in these airborne binary shaft encoders automatically performs brush selection within the

encoder eliminating electronics otherwise required for double brush V-scan systems. Digit and complement are simultaneously available in natural binary. Design provides noise-free life by preventing commutation of load currents on the disc, yet allowing continuous or pulse reading at up to 200 RPM. An error detecting scheme provides a means of detecting and rejecting erroneous readings. For information write NORDEN DIVISION, United Aircraft Corp., Wiley St., Milford, Conn. or use reader service card.

Circle 158 on Reader Service Card.

wroc 452

This unit is designed to increase the co selector, pilot selector and digit selector capacity of the IBM 407

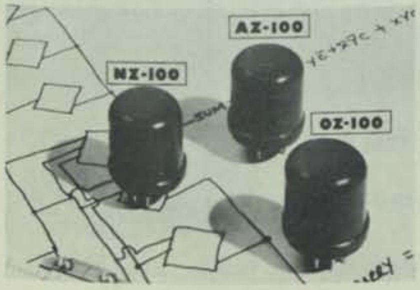


printing tabulator. The WROC 452, as pictured, consists of a flexible type control panel containing 32 selectors, each one of which may, by control panel wiring, be made to operate in the manner of an IBM type pilot or co selector. It is also equipped with four multitransfer selectors consisting of 10 transfer rows and one common row, each row having 10 positions. Other features include an alpha numeric emitter, 100 position – two column digit selector and converter units. For information write MANAGEMENT ASSISTANCE, INC., 40 Exchange Place, New York, N. Y.

Circle 159 on Reader Service Card.

miniature modules

Development of a new approach to the design of digital logic called the "Manalog System" has been an-



nounced. The system consists of three basic seven-pin miniature plug-in modules, which are energized by a 100 KC R. F. power supply. The first of the three modules, type NZ100, is a "not" plug-in. It is comprised of a series-type pulse magnetic amplifier. The second module in the system is the OZ100. It consists of three silicon double anode, zener diodes with appropriate zener breakdown voltages. The third module–AZ100–contains three zener diodes of different breakdown voltage from the OZ100. For information write HOFFMAN ELECTRONICS CORP., Semiconductor Div., 930 Pitner Ave., Evanston, Ill.

Circle 160 on Reader Service Card.

tape converter

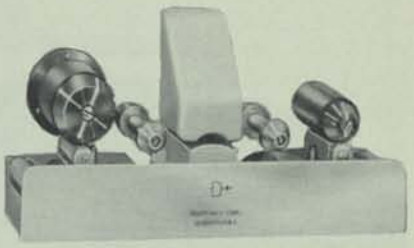
The Kinetape Converter, 768H-1 (left below), when used with the TE-206 Kineplex Data System (right below)

provides high speed transmission of digital data from magnetic tape over voice quality telephone circuits. Data rate is 300 characters per second and is adaptable to either IBM or Univac tapes. Both the 768H-1 and TE-206 are completely transistorized and employ etched circuit cards to provide high reliability. New signaling techniques allow signal-to-noise performance and spectrum utilization. Error detection and correction is automatically accomplished by error coding and data transmission techniques. For information write COLLINS RADIO CO., 2700 W. Olive, Burbank, Calif.

Circle 161 on Reader Service Card.

tape reader

Model C301 is a photoelectric perforated tape reader. It is available in versions to handle any one of the



standard punched tape widths. Reading speeds range from 100 characters per second to 750 characters per second. The start-stop feature of this tape transport permits intermittent reading of tapes at slower rates. The reading head has been successfully operated at temperatures to 60° C. This model uses short strips requiring six inch leaders or loops of tape. Reel feed units are also available. After a stop command, 1.8 milliseconds is required for tape to come to rest. For information write DIGITRONICS CORP., Albertson Ave., Albertson, L. I., N. Y. or use reader service card.

Circle 162 on Reader Service Card.

stepping motors

Translating pulses into incremental shaft positions, these stepping motors may be used to rotate control me-

chanisms, potentiometers, counters, and rotary switches on computers and other electronic devices. With an angular increment of 36 degrees per pulse it gives 10 indexing positions

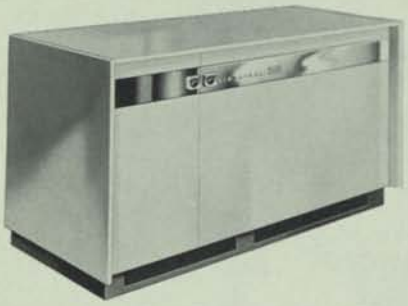

TAPES YOU CAN

with ±½° detent accuracy at a maximum stepping rate of 15 per second. Motors need all applicable environmental tests of MIL-E-5272A. Mounting is either servo or stud and models are available for wide range of operating voltages. For information write G. H. LELAND, INC., 123 Webster Street, Dayton 2, Ohio or use card.

Circle 163 on Reader Service Card.

control system

LIBRATROL — 500 system is developed around a rapid-response digital computer. The unusual aspect of this

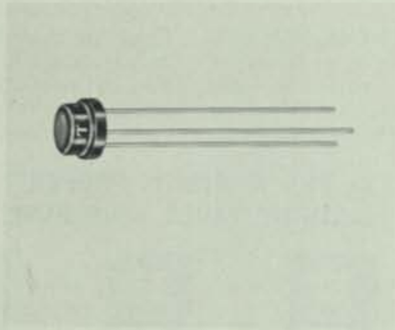


system is the provision for a full range of process control — from accurately processing data that provides understandable information to a human operator, to complete automatic control of the entire process. Such a building block concept offers the user a single system with the capacity to accommodate expanding functions. A gradual change-over from manual process control to a completely automatic computer-controlled plant may be made without replacing this system. It has been designed for connection to existing equipment in any processing plant for a wide variety of industries. For information write LIBRASCOPE, INC., 808 Western Avenue, Glendale, California or use card.

Circle 164 on Reader Service Card.

input transistor

A new silicon transistor operates at low current and d.c. amplifier input stages. Recommended for operation

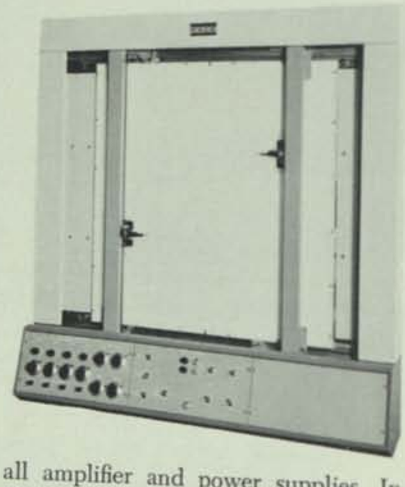


in the range 2-200 micro amps, the ST1026 features drift of only .05 milli-microamps per degree C and .5 milli-microamps per day. This low drift makes the transistor useful in circuits with high impedence sources. Many new low current applications are opened up by the high beta (typically 25 at 5 ua to 70 at 100 ua). For information write TRANSITRON ELECTRONIC CORPORATION, Wakefield, Mass. or use reader card.

Circle 165 on Reader Service Card.

x-y plotter

New design feature of this transistorized variplotter models 205S and T includes complete transistorization of

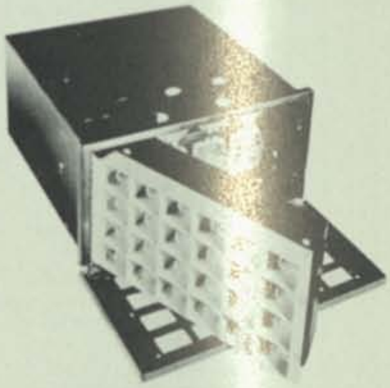


all amplifier and power supplies. In this way vacuum tube failures from burnout or shock damage is no longer a problem, the manufacturer claims. Other announced features — instant warmup, greater speed, large 30 in. by 30 in. plotting surface and high reliability. The announced weight is 250 pounds. Servo motors operating at 400 cps provide increased speed. It will operate in any position from horizontal to vertical. For information write ELECTRONIC ASSOCIATES, INC., Long Branch, New Jersey or use reader service card.

Circle 166 on Reader Service Card.

annunciator

This annunciator has flashing sequence alarm, no drain circuit and has been designed for monitoring



complex automatic equipment from 24 to 96 points in the utility and continuous process industries. Series 61 annunciator is a completely integrated unit with all plug-in relays hermetically sealed. No power is used by series 61 and all signals are normal. Instant operator attention is directed to off normal conditions by flashing sequence and audible alarm. For monitoring more than 96 points, annunciator systems may be connected to operate in parallel. For information write PANNELIT, INC., 7401 North Hamlin Ave., Skokie, Illinois or use reader service card.

Circle 167 on Reader Service Card.

printing machine

Providing a printed copy or a printed copy and a punched tape, this machine is equipped with its own con-

trolling circuits and power supply. The user needs to provide external contacts for data entry and start, in order to operate the unit. Dependent upon the external control circuitry and functions required, the maximum speed of complete machine cycling, 10 digits per cycle, is from 180 per minute printing only, to 64 per minute printing, accumulating and punching. The entry of a number of digits simultaneously, either printing or printing and punching in groups of digits, reduces readout control circuit complexity and greatly adds to the reliability of the system by reducing the number of operations required of the system control components. For information write MONROE CALCULATING MACHINE CO., INC., Electronic Components Div., 60 Main St., San Francisco, Calif. or use card.

Circle 168 on Reader Service Card.

tape-to-card converter

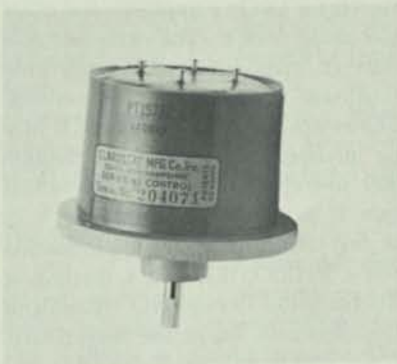
Featured in this unit is a removable plugboard which can be programmed to handle many applications, control

automatic card punching and provide the new converter, model C749, with flexibility. A second plugboard or coding matrix equips the unit to convert tape which has been punched with any type code – 5, 6, 7 or 8-channel. The converter operates in conjunction with any standard IBM 024 or 026 card punch, but in no way hinders normal manual operation of the card punch. If the card punch is equipped with the IBM self checking number device then certain selective indication data is automatically verified. For information write SYSTEMATICS, INC., 60 East 42nd Street, New York 17, N. Y. or use reader card.

Circle 169 on Reader Service Card.

potentiometer

A new sign/cosign potentiometer for use in computer assembly has a standard conformity plus/minus 1% peak-



to-peak, or a special conformity of plus/minus ½% peak-to-peak. The unit employs oil-impregnated bronze bearings for a recommended maximum speed of 30 rpm. Precision windings, plus a low wear wiper design, produces a guaranteed life of 500,000 cycles, the manufacturer claims. The unit has a flange mount with a diameter of 2.050 in. and 1.925 in. diameter beyond. Shaft torque is 1.0 oz. in. For information write CLAROSTAT MANUFACTURING CO. INC., Dover, New Hampshire or use reader service card.

Circle 170 on Reader Service Card.

sampling switch

A new three-pole sampling switch for use in high speed aircraft instrumentations and data reduction systems features collector rings for each of the three poles, provided in a separate hermetic connector. The switch is comprised of three poles with thirty BBM contacts per pole operating at 5 rps. Two of the poles scan differential thermo couple and strain gauge output signals while the third pole provides the timing function. Special metal brushes are driven through a suitable gear reduction system by a 115 volt a.c. 400 cps single phase 15 watt motor. Noise levels in the order of 20 to 30 microvolts are maintained in this switch throughout its 1,000 hour operating life. For information write INSTRUMENT DEVELOPMENT LABORATORIES, INC., 67 Mechanic Street, Attleboro, Mass. or use reader service card.

Circle 171 on Reader Service Card.

mag tape dataplotter

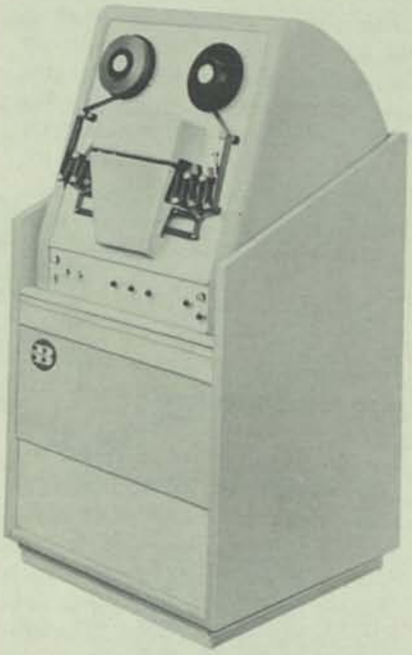
This unit is capable of accepting tape codes written on IBM, Remington Rand, Electrodata, and other digital

computing equipment. X-Y graphs of data recordered in digital form on magnetic tape is accomplished at high speeds. Used with any of the manufacturer's plotting boards, data can be presented in points, symbols, or continuous lines. Statistical charts of all types and many forms of mechanical drawings are drawn. For applications

other than plotting, analog voltages are readily available. For information write ELECTRONIC ASSOCIATES, INC., Long Branch, N. J. or use card.
Circle 172 on Reader Service Card.

photoreader

This unit, according to the manufacturer, reads 1000 characters per second. It is adaptable to standard



width tape, from five to eight level code. Plastic reels are available in two sizes, for tapes of 350 or 700 feet (40,000 or 80,000 characters). Features include automatic rewind and end-of-tape sensing, true straight-line loading and drift-free design. The photoreader is available as a component for mounting in any standard 19" cabinetry. For information write ELECTRODATA DIVISION, Burroughs Corporation, 450 Sierra-Madre Villa, Pasadena, Calif. Or use card.
Circle 173 on Reader Service Card.

photojunction cell

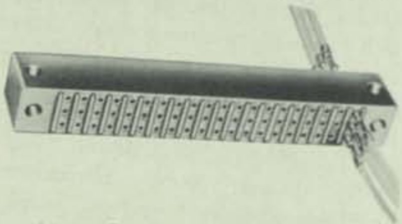
A new light sensitive cell for use in computers weighs approximately 1 gram. In computers, the RCA-7224 can be employed to translate information from punched cards and punched tape. In actual operation a beam of light passes through the whole of the card or tape and activates the tiny cell which will trigger the computer memory. The cell employs a germanium pn alloy junction and features fast rise and fall characteristics.
For information write RADIO CORPORATION OF AMERICA, Electron Tube Division, 415 South 5th Street, Harrison, New Jersey or use card.
Circle 174 on Reader Service Card.

miniature switch

A new mercury switch that weighs 1.8 grams with leads attached is designed for use in computers and other electronic devices. The extremely low shift of mass involved in actuation facilitates gang-mounted assemblies. The switch, designated AS419A1, may be mounted in any position through 360 degrees around its longitudinal axis. It may be actuated by slow, snap or fast-tilting action. For information write MICROSWITCH, a division of Minneapolis - Honeywell Regulator Co., Freeport, Ill. or use reader card.
Circle 175 on Reader Service Card.

terminal blocks

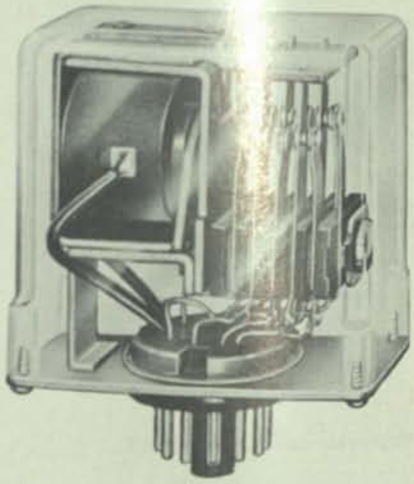
These terminal blocks have been designed for various computer applications and printed circuitry. They ac-



cept standard "AMP 53" solderless taper pins and are available in any combination of feedthru individual or shorting terminals. External wiring has been eliminated by completely protected, mold-in internal buss connections between any combination of terminals. Holes are provided for convenient stacking or right angle and perpendicular mounting. Taper receptacles are brass gold plated over silver for low contact resistance and freedom from corrosion. A variety of molding materials are available including Melamine, Diallyl Phthalate, Alkyd and Phenolic Mica. For information write DEJUR-AMSCO CORPORATION, Electronic Sales Div., 45-01 Northern Boulevard, Long Island City, N. Y. Or use reader card.
Circle 176 on Reader Service Card.

relay

Model 219 relays are designed for performance on the order of twenty million operations. They are mechani-



cally protected by plastic covers and are designed with plug-in construction for servicing. Accepted standards of insulation include spacings of ⅛ in. through air, ¼ in. over surface and a minimum of 1500 volts AC dielectric test. Contacts have 10 ampere current carrying capacity. Plug and socket combinations are limiting factors on ratings. Stock contact arrangements are DPDT on octal plugs and DPDT plus two normally open contacts on 12-pin octal style plugs. Operating coils may be AC or DC. For information write STRUTHERS-DUNN, INC., Pitman, New Jersey. or use reader service card.
Circle 177 on Reader Service Card.

people moving up in DATAMATION

Clair C. Lasher is the new general manager of General Electric's Computer Department in Phoenix. Joining the company in 19[illegible]9, he became manager of marketing at the inception of the department in 1956. He supersedes **H. R. Oldfield, Jr.**, who has been appointed general manager of a new component division, unnamed as yet . . . Philco has announced promotion of **Sol Zechter** to manager of Transistorized Devices Laboratory in Philadelphia. Since joining the company he has handled development of equipment under government contracts in transistorized communications, telemetering—holds two patents on the latter, five pending on electronic devices . . . **Jack Cudahy** will head the new west coast office of Technitrol Engineering Co. Philadelphia. This office will provide manufacturers with technical assistance on problems of complex design.

Newly appointed member of Control Data Corporation's mechanical engineering group, **Dean M. Roush,** will have specific responsibilities associated with design of Minneapolis company's new CDC 1604 scientific computer. The initial order on a $600,000 Navy contract was announced recently. Roush was formerly mechanical engineer with Remington Rand Univac's Military Division. Other Control Data appointments: to computer engineering staff, **James D. Harris** as senior administrative assistant, **Carl E. Koehler** as systems logical designer, **James E. Thornton** as senior electrical engineer. Also, **Dr. Robert E. Smith** named senior mathmatician on professional staff.

Joseph A. Resca is now the New York district sales manager for Burroughs' ElectroData Division. He will be in charge of sales and service of company's E101, 205 and 220 computers, and EDP systems in that area. Lately manager of the division's Dallas district he was formerly with Telecomputing Corporation. ElectroData has also established two new district sales offices. **Claggett A. Jones** will head the Atlanta, Ga., office and **Charles V. Hoge** is in charge of Denver, Colo., branch . . . **William E. Brugman** has been appointed to the newly created position of components sales manager at Telemeter Magnetics, Inc.

Expansion of DATAmatic, data-processing division of Minneapolis-Honeywell Regulator Co., resulted in the opening of a Washington sales office. **Robert F. Anderson** has been appointed manager, **Fillmore Dobbs** is assistant. . . . **Gerard Q. Decker** was elected vice president of Servomechanisms, Inc., by board of directors. He was promoted from division manager of the company's Subsystems Division . . . Computer Engineering Associates, Inc., appointed **Dr. Richard H. MacNeal** as manager of their Engineering Service Division. . . . **Philip Balaban** has been named director of research for Mid-Century Instrumatic Corp., in New York.

Samuel Ochlis is the new sales manager of Instrument and Equipment Division, Epsco, Inc., Boston. The division designs, manufactures, building blocks in large data handling systems. **Wallace E. Rianda** is vice-president and general manager of Epsco-West, newly established west coast division. He was formerly marketing manager of Beckman Instruments, Inc. **William F. Gunning,** technical director, **Ralph McCurdy,** in charge of production—were also associated with Beckman.

Taft B. Russell is now manager of systems sales and research and development contracts of General Devices, Inc., Princeton, N. J. . . . . Consolidated Electrodynamics Corp. has established an International Department within the Marketing Division and appointed **Rodney W. Meyer,** as director.

Computer Services Division of the Corporation for Economic and Industrial Research has announced appointment of **Robert L. Patrick** deputy director. . . . appointed manager of Sylvania's newly formed Needham, Mass., data processing facility is **Frank M. Thomas. Richard R. Fidler** will head advanced development-data conversion department. . . . **John B. Olson** is named chief engineer of Computer Measurements Corp. . . . Stromberg-Carlson has appointed **William G. Alexander** assistant general manager.

Homer M. Sarasohn is named director of engineering planning on corporate staff of IBM. He will exercise staff supervision of all product development, engineering activities and provide liaison among IBM's operating divisions. **Dr. Morton M. Astrahan** is appointed functional manager, responsible for research on data processing needs of small business. **Richard W. Porter** is appointed program manager for a large government contract.

CLAIR C. LASHER
GE's Computer Department

DEAN M. ROUSH
Control Data Corporation

JOSEPH A. RESCA
Burrough's ElectroData Division

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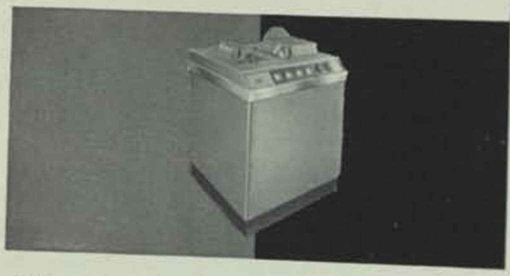

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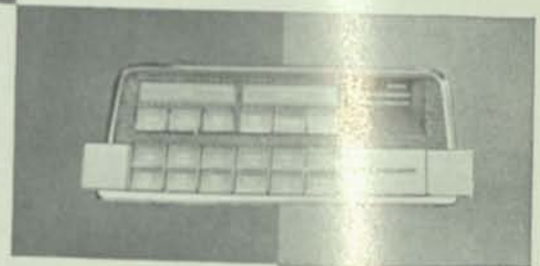

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ELEMENTARY PRINCIPLE OF PARAMETRON AND ITS APPLICATION TO DIGITAL COMPUTERS

by SABURO MUROGA
Senior Researcher, Electrical Communication Laboratory
Nippon Telegraph and Telephone Public Corporation

The idea of the parametron was born in Tokyo and is so named because its working principle makes use of "a parametrically excited oscillation." Its principle is quite common in our daily lives. Examples range from a swing and a yoyo which children like, to a parasitic oscillation of a speaker cone which is an engineer's problem.

Take the first example in Fig. 1 (page 32). As a child moves his body up and down repeatedly, the swing starts to oscillate. Suppose in this case that the vertical change of the gravity center of his body has a frequency "2f". Then the movement of the swing has a frequency "f". An important fact in this case is the relation between an initial state of the swing and a phase of its final oscillation. The final oscillation of the swing can take one of two possible phases, even though their amplitudes and frequencies are the same, and which one of them is to be taken actually depends on which side of the rest point the swing was placed initially, as shown in Fig. 1.

In principle, however small this initial displacement of the swing, left or right of the point of perfect rest, it determines a phase of the final oscillation with a large amplitude. In the terminology of radio engineers, a small signal which takes one of two possible phases has been amplified into one with much larger amplitude which retains the original phase. And it is interesting to note that these two possible phases are different from each other by pi radian; that is, the voltage of one oscillation is equal to the minus of the other.

SABURO MUROGA was born in Shizuoka-ken, south of Tokyo, in 1925. In 1947 he graduated from Tokyo University with a degree in Electrical Engineering, and last year received a Ph.D. for his thesis, "Information Theory." Before coming to Nippon Telegraph and Telephone Laboratory in 1950, he was with the laboratory of the National Railways and then the Radio Regulatory Commission. In 1953 he was a participant in the Foreign Student Summer Project at Massachusetts Institute of Technology. He stayed on at M.I.T. for another six months, and then went to the University of Illinois for a half year. He holds ten patents and has fifteen papers published on information theory and digital computers, including material in the IRE Proceedings.

Parametron is the very realization of this by electronic means, that is, simply a pair of magnetic cores, a resistor, and a condenser, as shown in Fig. 2. A resonant circuit with a variable inductance is constructed with these components. Then an alternating current with a frequency 2f and a direct current superposed on that are applied on the primary windings of the inductance. But nevertheless the secondary windings are made to cancel an induced output to the primary input, and an alternating current with a frequency f starts to oscillate as the swing did from a vertical movement of the human body. This induced oscillation can take one of the binary phases, and if a signal with a small amplitude and a frequency f is given initially in the circuit, it will be amplified. These two are essential points of parametrons. Here the resonant frequency of the circuit, in other words, the proper frequency of the swing, should be nearly equal to half of the excitation frequency 2f.

The idea of applying this principle to switching circuits was discovered by E. Goto of Professor H. Takahashi's laboratory at Tokyo University in 1954. He made its application possible by devising a three-beat excitation and a majority decision logical operation.

Any number of parametrons can be assembled to realize a switching circuit with application of three-beat excitation as follows: Connect parametrons serially, bridging their terminals with resistances and transformers as shown in Fig. 3, and apply the excitation currents on their primary windings sequentially from the left. Then the oscillation of the parametron P1 will be coupled into the second parametron P2 as an initial small signal input to it, so that a phase of the former will be conveyed to the second. Similarly, P2 will supply the initial signal to the third parametron P3. Repeating this process over any number of parametrons, a phase of the first parametron will be correctly conveyed to the last parametron. This is a kind of shift register which is important in switching circuits. For its physical realization, it is economically impossible to prepare a source of excitation current for each parametron. The whole set of parametrons is divided

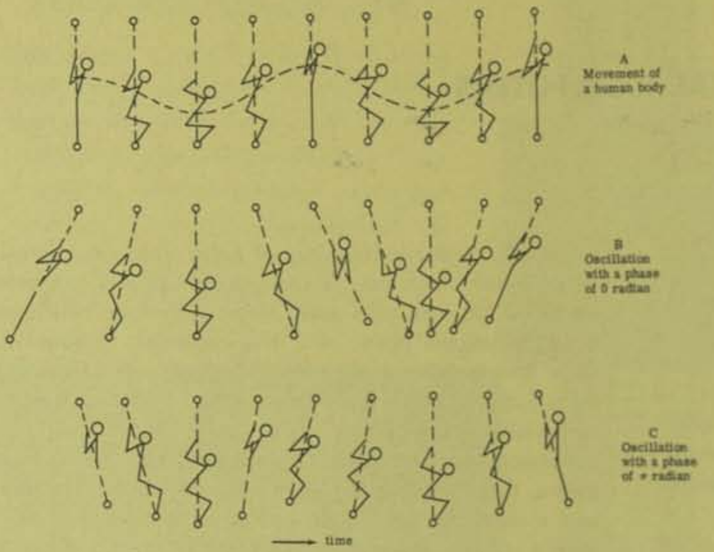

Figure 1. Parametron principle in a swing.

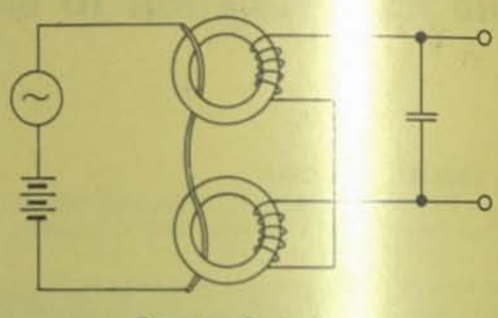

Figure 2. Parametron

into three groups so that every adjacent three parametrons belong to the groups I, II, and III, respectively.

For each of these groups, only three sources feed currents i_I, i_{II}, and i_{III}, the tails of whose envelopes overlap each other, respectively, as shown in Fig. 4. For example, the tail of i_I overlaps the head of i_{II}, but no part of i_{III}. During this overlap, phases of the oscillations in a set of parametrons belonging to group I are conveyed to those of group II, but not to those of group III. Thus, with three-beat excitation the transmission of binary signals in a single direction could be realized in a whole network of parametrons.

majority decision principle

Another important principle is the application of majority decision to logical operations of parametrons, which are indispensable for switching circuits. As widely known from Boolean Algebra, the logical operations "and", "or", and "not" are sufficient for switching circuits to perform any digital functions. For this purpose outputs of all the parametrons are coupled to inputs of the next parametrons with equal resistances. Here in Fig. 5 where a circle indicates a parametron, all the amplitudes of oscillated voltages in three parametrons are assumed to be equal. Then a phase of the parametron which is coupled from these three parametrons is obviously determined from an algebraic sum of input voltages from these parametrons of the majority decision.

Now assume the phase of the first parametron to keep O radian and the other two to be variables. If the first variable takes a phase of pi radian and the second O radian, the two voltages of the constant and the first variable cancel, leaving simply the voltage of the second variable with a phase of O radian. Thus the coupled parametron will oscillate a voltage of O radian for this input. Similarly, if the first and second both take O radian, a voltage of O radian with triple amplitude will become the input to the coupled parametron. The output phases for other combinations of the variables may be seen from

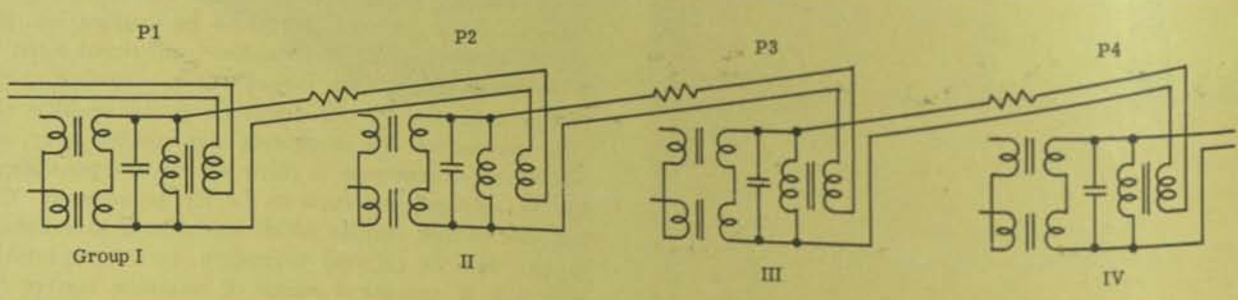

Figure 3. A shift register with parametrons

Table I which shows this circuit of parametrons to be "and" circuit if the phases of O and pi radians are regarded as binary digits "O" and "1", respectively. Also it will be clearly understood that a circuit of parametrons will work as "or" if the first parametron takes a constant phase pi radian and the other two are regarded as variables. See Table II. The remaining "not" can be realized quite easily by reversing the polarity of the coupling transformer between the parametrons.

It is interesting to see that the majority decision principle of logical operations of parametrons is quite similar to that of neurons in living organisms. In general, logical elements standing on the majority decision principle which have been studied by the author have some interesting, unique properties as performers of the Boolean Algebraic operations and will be discussed elsewhere.

Fig. 6 shows some examples which might be encountered in switching circuits like digital computers, where a circle indicates a parametron, a coupling line with a crossing "not" and + or − inside a circle the constant 1 or 0. In these circuits the number of inputs into a parametron is limited to a maximum of three, but could be increased to five, seven or more.

The original type of parametron uses a pair of ferrite cores with an outer diameter of about 4 mm. and a single turn primary winding for excitation and a ten turn secondary winding for the resonant circuit. Its resonant frequency was chosen at 1 2 mc. The condenser and resistor are of normal type. As easily seen from this structure, low cost and almost limitless life are expected. This type of parametron was used for our computer "M-1". Parametron consumes less than 80 mw on average. This power consumption characteristic has been much improved by efforts of Z. Kiyasu and others in our laboratory which backed

Table I— "and" circuit for constant with 0 radian

1st variable	2nd variable	Output
0	0	0
0	pi	0
pi	0	0
pi	pi	pi

Table II — "or" circuit for constant with pi radian

1st variable	2nd variable	Output
0	0	0
0	pi	pi
pi	0	pi
pi	pi	pi

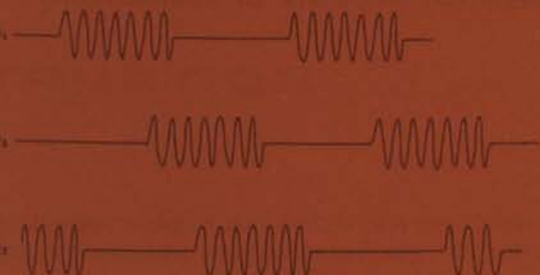

Figure 4. Excitation currents in three beats

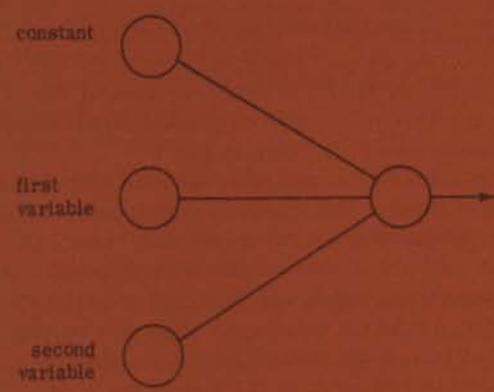

Figure 5. Majority decision principle

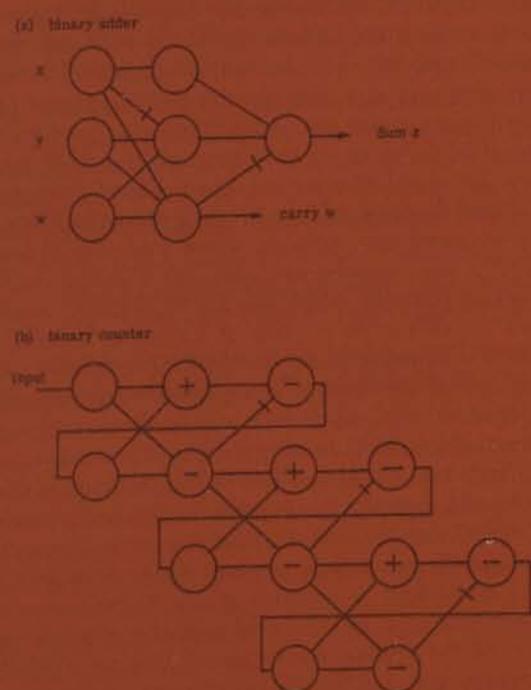

Figure 6. Examples of the parametron circuits

the development of an electronic telephone exchange and construction of a digital computer with parametrons. It was improved by three to five times.

musasino 1

Our large scale digital computer which has been constructed by the laboratory people including the author primarily for scientific problems was named "Musasino 1" after its location. It was completed in March 1957 with a small magnetic core memory capacity and had been used to calculate tables of elementary functions. In March of this year its memory was enlarged to 256 words, making its debut in public as ready for general use in our laboratory. This is the first large scale digital computer with parametrons. It is shown in Fig. 7.

The panels on the right are the source of excitation currents of 2.4 mc. The sixteen square panels in the center contain the parametrons, six upper panels being the control unit and the lower ten the arithmetic unit. Above these parametron panels are neon indicators for the accumulator, a quotient register, an order pair register, and various alarms, while manual control switches are to the left. At the rear of the room is the electrical power source.

The M-1 is a program-stored binary computer with fixed point in a parallel system. The word structure and instructions are modeled after the Illiac at the University of Illinois. Consequently, a single word represents forty binary digits as a number or a pair of orders. About 130 different instructions are available, including ones for handling magnetic tapes, for performing three different Boolean Algebraic operations, for controlling brightness of the beam spot of a cathode ray tube display and others.

The M-1 uses 5356 parametrons, of which 2800 are used for the arithmetic unit, 1600 for the control unit and 1456 for the magnetic memory, and 519 vacuum tubes for the source of high frequency excitation currents, high power drivers, the neon indicators and others. The M-1 consumes a stabilized dc power of 5 kc for the primary ac 9 kva.

The magnetic core memory, where a number of ferrite cores of 2 mm diameter are used, has a unique feature. Its working principle, which was also Goto's idea, depends entirely on alternating currents. A current of a frequency f/2 with a constant phase for selecting a desired word among the whole memory is superposed on information currents of a frequency f, each of whose phases is specified by each of the forty binary digits of a number to be stored and then it is flowed into the magnetic cores of the desired word, writing the number on these. For reading out a stored number from the magnetic cores, a current of the frequency f/2 with a constant phase flows into the desired cores from a selection matrix to induce second harmonic currents, each of whose phases depends on a polarity of the residual magnetism of the core. The selection matrix, too, consists of parametrons, of which only one is placed at a crosspoint of the vertical and horizontal

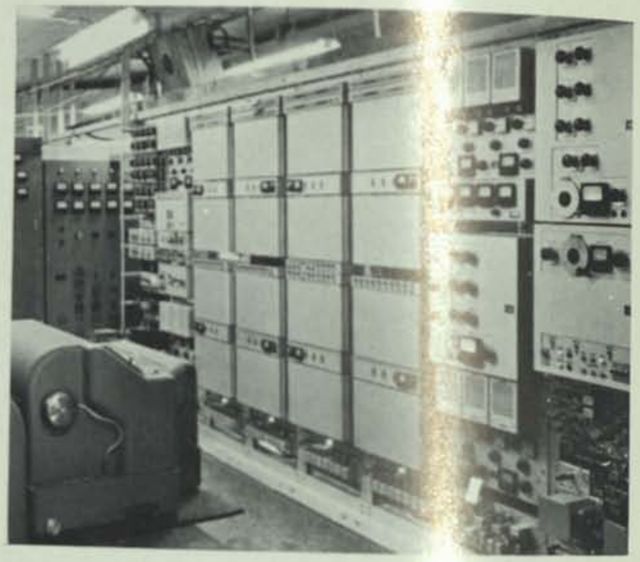

Figure 7. The M-1

wires of excitation. Ferrite cores with non-rectangular hysteresis curve are satisfactory for this memory principle.

A paper tape with six holes for a Japanese standard teletype is used for input and output. One of these holes is for odd parity check and when the tape is read by a photoelectric reader, the computer stops for failures of the check. A teletype punch is used for the output.

A number of features for speedup and easy use are included in the machine's design. A carry detector and a high speed multiplier, for example, are incorporated. The former is to sense an end of carries in addition or subtraction and consequently average times for addition and division are greatly reduced. Many alarms for incorrect orders, misoperations of the input, changes of source voltages and others are provided.

The life of a parametron is almost infinite because of its simple structure. There has been no replacement of parametrons during the 4000 hour run of the M-1. The only troubles have been bad soldering connections, but once these are fixed, that is the end of the trouble. The cost of the magnetic core memory is low because the required characteristics of the core are not rigid. The M-1 has worked very stably for these four months without any failures and with almost no maintenance. Every day, ten minutes after electricity is applied, it is available for computations.

Only relatively low speed of operation might be considered a defect of parametrons, but the M-1's speed is almost comparable with vacuum tube computers in a serial system. Its speed is linearly proportional to the repetition frequency and orders for addition and multiplication take 2 and 10 milliseconds on average, respectively, for 10 kc repetition which may be at least doubled by further adjustment in the near future.

Important dates in DATAMATION

Oct. 9-11: Information Storage and Retrieval Systems Conference, Graduate School of Library Science, University of Texas. Contact Dr. R. R. Douglass, Graduate School of Library Science, University of Texas, Austin, Texas.

Oct. 13-15: International Systems Meeting, Systems and Procedures Association, Hotel Penn-Sheraton, Pittsburgh, Penna. Contact A. M. Motter, Jones and Laughlin Steel Corp., #3 Gateway Center, Pittsburgh 30, Penna.

Oct. 16-18: The Institute of Management Sciences Annual Meeting, Philadelphia, Pennsylvania.

Oct. 20-21: Remington Rand Univac Users Conference, John Hancock Mutual Life Insurance Company, Boston, Mass. Contact R. M. Petersen, Secretary, Univac Users Conference, General Electric Company, Appliance Park, AP 1-109, Louisville, Kentucky.

Oct. 20-24: National Business Show, Coliseum, N. Y. C. Contact Rudolph Lang, Managing Director, 530 5th Ave., New York 36, N. Y.

Oct. 22-25: The National Businessmen's Exposition, Great Western Exhibit Center, Los Angeles, Calif. Sponsored by NMA. Contact Robert W. Caldwell, NMA Show Chairman, National Businessmen's Exposition, 2807 Sunset Boulevard, Los Angeles 26, Calif.

Oct. 23-24: Operations Research Society of America National Meeting, Statler Hotel, St. Louis, Missouri.

Oct. 23-25: The National Society of Professional Engineers – fall meeting, St. Francis Hotel, San Francisco, Calif. Contact Kenneth E. Trombley, National Society of Professional Engineers, 2029 K St., N. W., Washington 6, D. C.

Oct. 23-25: 1958 National Simulation Conference, Statler-Hilton Hotel, Dallas, Texas. Sponsored by IRE-PGEC. Contact J. E. Howard, 2100 Menefee Dr., Arlington, Tex.

Oct. 25: American Mathematical Society Meeting, Princeton University, Princeton, New Jersey.

Oct. 27-28: Fifth Annual East Coast Conference on Aeronautical and Navigational Electronics, Lord Baltimore Hotel, Baltimore. Sponsored by IRE. Contact Harry Rutstein, Publicity Chairman, Lord Baltimore Hotel, Baltimore, Maryland.

Oct. 29-30: Fifth Annual Computer Applications Symposium, Morrison Hotel, Chicago. Sponsored by the Armour Research Foundation, Illinois Institute of Technology. Contact the Foundation at 35 W. 33rd St., Technology Center, Chicago 16, Illinois. (See page 41.)

Oct. 30-31: Fourth Electronic Business Systems Conference, Olympic Hotel, Seattle. Sponsored by the western division of the NMAA. Contact E. B. S. Conference, NMAA, P. O. Box 134, Seattle 11, Washington.

Nov. 3-7: Fifth Institute on Electronics in Management, The American University, Washington, D. C. Contact Lowell H. Hattery, Fifth Institute on Electronics in Management, The American University, 1901 F Street, N. W., Washington 6, D. C.

Nov. 16-21: International Conference on Scientific Information, Mayflower Hotel, Washington, D. C. Sponsored by NAS, NRC, NSF and ADI. Contact Secretariat, International Conference on Scientific Information, National Academy of Sciences, 2101 Constitution Avenue, N. W., Washington 25, D. C. (See page 13.)

Nov. 17-18: Federal Govt. Accountants Association's 8th Annual Symposium. Theme: "Management and Electronic Data Processing." Contact Martin C. Powers, 1523 L St., N. W., Washington 5, D. C.

Nov. 17-20: Fourth Annual Conference on Magnetism and Magnetic Materials, Sheraton Hotel, Philadelphia, Penna. Sponsored by AIEE. Contact John Leslie Whitlock Associates, Exhibition Managers, 6044 Ninth St., North, Arlington 5, Virginia.

Nov. 19-20: Northeast Electronics Research and Engineering Meeting, Mechanics Hall, Boston, Mass. Sponsored by IRE. Contact J. J. Faran, General Radio Company, 22 Baker Avenue, West Concord, Mass.

Nov. 20-21: Conference on Electronic Computation, Kansas City, Missouri. Sponsored by the Kansas City Section and the Committee on Electronic Computation of the Structural Division, ASCE. Contact Secretary, Steven J. Fenves, 203 Civil Engineering Hall, University of Illinois, Urbana, Illinois.

Nov. 20-21: American Mathematical Society Meetings; Pomona, Calif.; and Nov. 28-29: Northwestern University, Evanston, Illinois; and Durham, North Carolina.

Nov. 28-Dec. 4: National Physical Laboratory Symposium and Electronic Computer Exhibition, London, England. Contact C. V. Wattenbach, Deputy Managing Director, Dictograph Telephones, Ltd., London, England.

Dec. 3-5: Eastern Joint Computer Conference, Bellevue-Stratford Hotel, Philadelphia, Penna. Contact John M. Broomal, Burroughs Corp., Paoli, Pa. (publicity information) or Dr. F. M. Verzuh, MIT Computation Center, Cambridge 39, Mass. (program information). (See p. 40.)

Dec. 9-10: Mid-America Electronics Convention, Municipal Auditorium, Kansas City, Missouri. Contact Wilbert O'Neal, The Vendo Co., 7400 E. 12th, Kansas City. Mo.

Jan. 20-22, 1959: American Mathematical Society – 65th Annual Meeting, U. of Penn., Philadelphia, Pa.

Feb. 12-13: Transistor and Solid State Circuits Conference, University of Pennsylvania, Philadephia, Pa. Sponsored by the PGCT, the AIEE and the University of Pennsylvania. Contact Arthur B. Stern, General Electric Co., Building 3, Syracuse, N. Y.

Mar. 2-6: Western Joint Computer Conference, Fairmont Hotel, San Francisco, Calif. Sponsored by PGEC; AIEE; and ACM. Contact M. L. Lesser, IBM Research Laboratory, San Jose, Calif.

June 15-20: International Conference on Information Processing, Paris, France.

Engineer L. Maiboroda at the controls of SESM, Russian calculator.

COMPUTING IN THE USSR

trial work started on sesm

Trial work on SESM, a Russian electronic calculator, has been initiated at Kiev, in the calculating center of the Ukrainian Academy of Sciences. This specialized computing machine is capable of solving linear algebraic equations having up to 400 unknown factors and is the first of its kind to be produced in the USSR or anywhere in Europe, according to Soviet scientists. It is being used to reckon complex hydro-technical building and machine building designs and to solve the problems in geodesy and mathematical physics.

Extensive use of both vacuum tubes and solid state devices are featured in SESM's construction. The machine occupies 86 sq. ft.

Systems engineering was accomplished under the supervision of S. A. Lebedev and Z. L. Rabinovich at the Ukrainian Academy of Sciences.

WJCC COMMITTEEMEN NAMED

Committee heads have been named for the 1959 Western Joint Computer Conference to be held in San Francisco, March 3-5, 1959.

Joint sponsors are the Institute of Radio Engineers, the American Institute of Electrical Engineers and the Association for Computing Machinery. Headquarters and meeting place will be the Fairmont Hotel.

Robert R. Johnson of the General Electric Computer Laboratory, Palo Alto, Calif., is general chairman and has announced the composition of the steering committee for the conference, all Californians, as follows:

Richard W. Melville of Stanford Research Institute, Menlo Park, vice-chairman and chairman of the technical program; Charles Asmus of General Electric Computer Laboratory, Palo Alto, conference secretary-treasurer; Byron J. Bennett of IBM Product Development Laboratories, San Jose, publications; George A. Barnard, III of Ampex Corporation, Redwood City, publicity; Harry K. Farrar of Pacific Telephone & Telegraph Co., San Francisco, exhibits.

Also, Kenneth F. Tiede of University of California Radiation Laboratory, Livermore, field trips; Robert M. Bennett, Jr., of IBM Research Laboratory, San Jose, registration; L. D Krider of University of California Radiation Laboratory, Livermore, printing; Mrs. Joanne Teasdale of General Electric Computer Laboratory, Palo Alto, women's activities; Earl T. Lincoln of Stanford Research Institute, Menlo Park, mailing; and Robert C. Douthitt of Remington Rand, El Cerrito, local arrangements.

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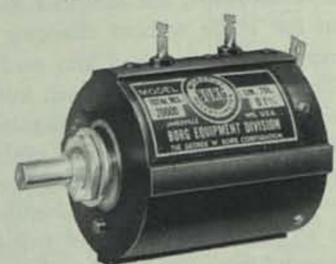

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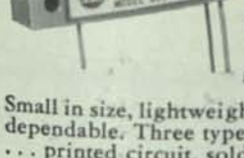

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IBM ANNOUNCES TRANSISTORIZED 7070

Details have been released on IBM's newest computer, the 7070, billed as "a completely transistorized computer in the intermediate price field."

By using transistors (manufactured by Texas Instruments, Inc.) one third is cut from installation and environmental control costs, IBM claims. Another claim: computer time is saved by overlapping machine operations. By using two tape channels, the 7070, while computing, reads or writes magnetic tapes at the rate of up to 125,000 characters per second. IBM says the system can handle simultaneously "several" 400-card-a-minute readers and 250-card-a-minute punches.

In order to permit in-line data processing, four files of 50 magnetic disks can be included in the system, providing for the random access storage of 24 million digits. Also available—an immediate access memory of 50,000 to 100,000 digits held magnetically in miniature ferrite cores.

As an installation aid, IBM has developed a series of general-purpose, automatic programs for the 7070.

One of the assembly routines available for the 7070 is similar to the Autocoder program, which serves as a simplifield system of program writing for the 705.

Although the language used is not Autocoder language, it resembles it somewhat. Operation codes are in mnemonic notation (a memory-aiding device) and the programmer can refer to the field to be processed in a manner that has a definite meaning to him such as "Grosspay," "FICA" and other familiar terms. Comments such as "Compute Exemption Amount" on the first instruction of a sub-routine can be written to assist the programmer in keeping track of blocks of instructions. Not only is the task of writing the program made easier, but additions, deletions, and corrections can be made without changing addresses written.

Instructions are punched into cards and fed into the 7070. The program converts each instruction into a machine-language program step, assigning locations for the instructions and for the data used in the program. An output card is punched for each instruction, and these cards comprise the program deck. Assembling of the program and the record-keeping phase of writing the program are performed by the 7070 itself.

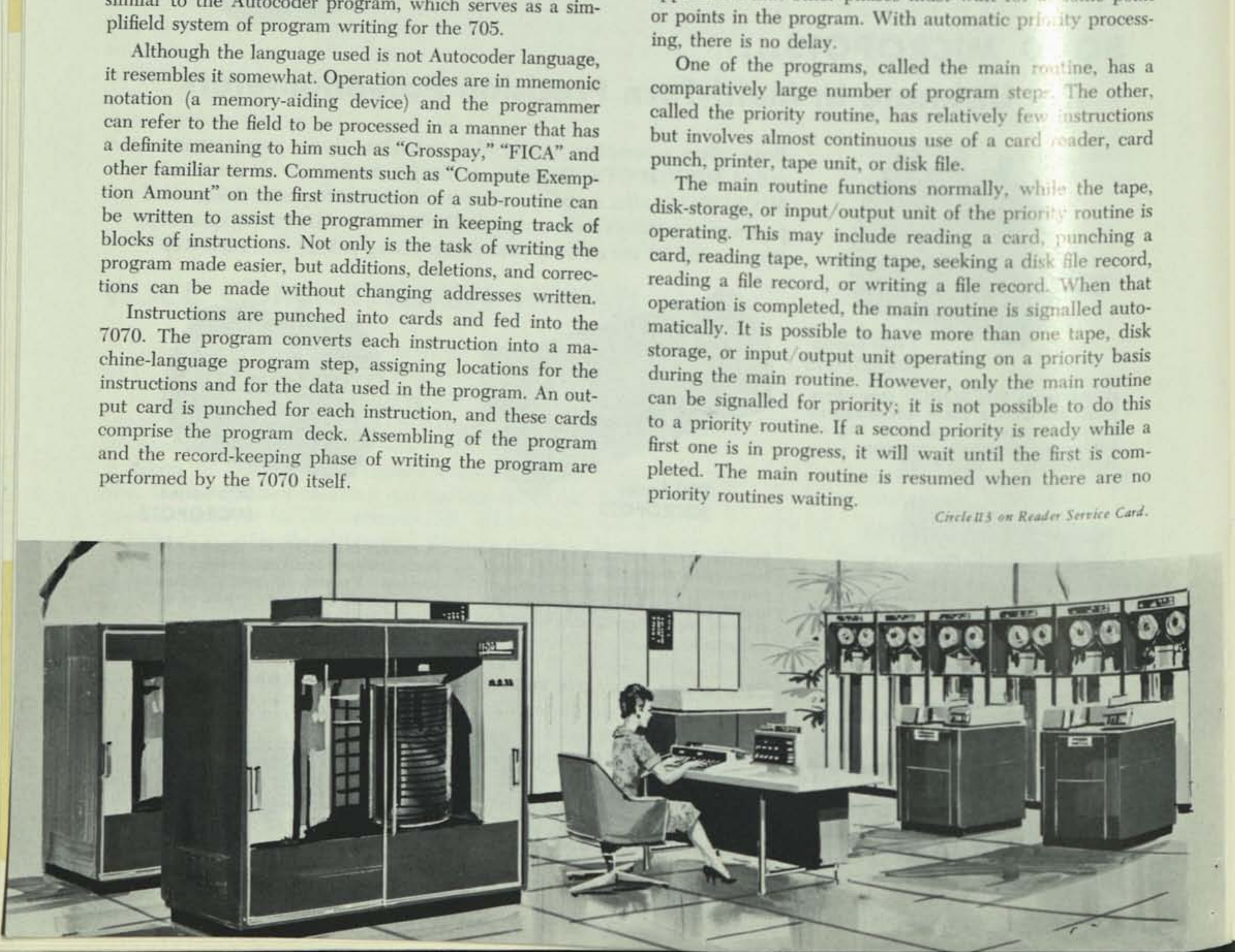
Company officials pointed out that the 7070 will also be able to compile Fortran language, the same as used by IBM 650 and 700-series systems. The term Fortran stands for formula translation and is a means of expressing mathematical processes in a manner that the machine can read and translate into a group of program steps. The programmer writes the formula in a manner quite similar to normal mathematical notation, and the machine creates its own program to carry out the operation. For example, the formula (a+b)* c/d means: add a to b, multiply the sum by c, and divide this product by d.

A tape sorting and merging routine will be available for the 7070. In addition, there will be utility routines for clearing core storage between limits, moving disk storage to output, load routines, tracing routines, and so on.

Another feature of the 7070 is Automatic Priority Processing which makes it possible to combine two programs and virtually eliminate any lost time waiting for an operation to be completed. Often programs are said to be "input-bound," "seek-bound," etc., referring to parts of the application that other phases must wait for at some point or points in the program. With automatic priority processing, there is no delay.

One of the programs, called the main routine, has a comparatively large number of program steps. The other, called the priority routine, has relatively few instructions but involves almost continuous use of a card reader, card punch, printer, tape unit, or disk file.

The main routine functions normally, while the tape, disk-storage, or input/output unit of the priority routine is operating. This may include reading a card, punching a card, reading tape, writing tape, seeking a disk file record, reading a file record, or writing a file record. When that operation is completed, the main routine is signalled automatically. It is possible to have more than one tape, disk storage, or input/output unit operating on a priority basis during the main routine. However, only the main routine can be signalled for priority; it is not possible to do this to a priority routine. If a second priority is ready while a first one is in progress, it will wait until the first is completed. The main routine is resumed when there are no priority routines waiting.



DATAMATION *book capsules*

CENTRALIZED INFORMATION SERVICES:—OPPORTUNITIES AND PROBLEMS by Allen Kent and James W. Perry, 1958, Interscience Publishers, Inc., 250 Fifth Avenue, New York, N. Y., 156 pp., $5.00.

This book presents an introductory analysis and summary of studies directed to the investigation of advantages and feasibility of centralized, cooperative information services.

The results of eight studies and surveys carried out over the past three years by the Center for Documentation and Communication Research at Western Reserve University have been analyzed, systematized and summarized. The purpose of the authors is to clarify the goals and indicate the practibility of future developments. Some contents of this study: Questionnaire on Special Classifications and Information Systems; Information Processing by Professional Societies; High Speed Telecommunication in Centralized Information Services.

SCIENTIFIC PROGRAMMING IN BUSINESS AND INDUSTRY by Andrew Vazsonyi, 1958, John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 474 pp., $13.50.

An attempt to develop a mathematical language understandable to businessmen using scientific techniques to solve managerial problems in terms of business, rather than in terms of mathematics, is presented. These techniques are clarified and mathematical programming and its applications are defined.

The book contains descriptions of the use of linear programming in transportation allocation; the use of statistical methods in production and inventory control. This approach has been applied with successful results, claims author Vazsonyi, in programs discussed with business people and case histories have been included.

NONDESTRUCTIVE READOUT OF MULTILEVEL MAGNETIC MEMORY by R. L. Van Allen and C. B. House, 1958, Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., Order PB 131475, 26 pp., .75 cents.

This is a report on a new method developed for nondestructive readout of memory cores as a result of Armed Forces-sponsored research and development in electronics. The method, an infinite-resolution of reading the flux level in a magnetic core without destroying this flux level, uses solid-state devices, requires less than ten milliwatts supply during nondestructive interrogation, while standby power drain is in the microwatt range.

Output information is in the form of an alternating waveform whose frequency is a function of the flux level of the storage core. Frequency ratios of 30:1 were obtained. Also developed — a circuit for clearing and resetting a core in preparation for further information storage.

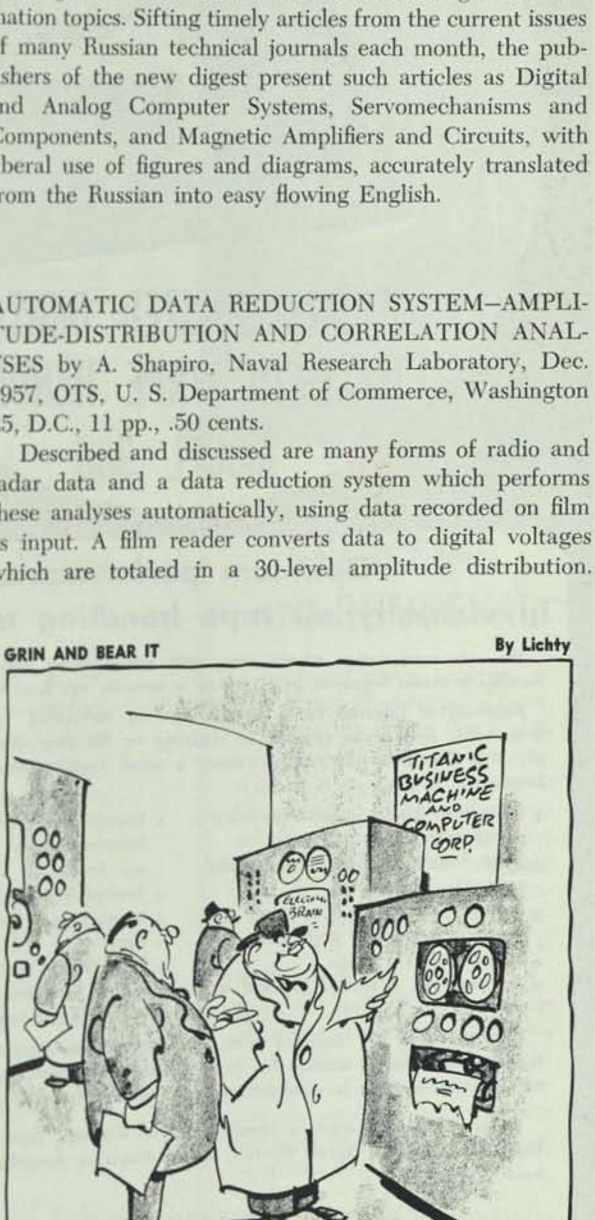
AUTOMATION EXPRESS, International Physical Index, Inc., 1909 Park Avenue, New York 35, N. Y., $57.50 for one year.

Volume one, number one, published in May of this year, is the initial 40-page offering of a comprehensive digest of current Russian literature dealing with automation topics. Sifting timely articles from the current issues of many Russian technical journals each month, the publishers of the new digest present such articles as Digital and Analog Computer Systems, Servomechanisms and Components, and Magnetic Amplifiers and Circuits, with liberal use of figures and diagrams, accurately translated from the Russian into easy flowing English.

AUTOMATIC DATA REDUCTION SYSTEM—AMPLITUDE-DISTRIBUTION AND CORRELATION ANALYSES by A. Shapiro, Naval Research Laboratory, Dec. 1957, OTS, U. S. Department of Commerce, Washington 25, D.C., 11 pp., .50 cents.

Described and discussed are many forms of radio and radar data and a data reduction system which performs these analyses automatically, using data recorded on film as input. A film reader converts data to digital voltages which are totaled in a 30-level amplitude distribution.

GRIN AND BEAR IT **By Lichty**



"This eliminates guess work in medicine, doctor! Feed it symptoms and it diagnoses the case, writes a prescription and indicates the size bill the patient can pay!"

EJCC SITE—PHILADELPHIA

Over 3,000 delegates are expected to attend the Eighth Annual Eastern Joint Computer Conference which will be held on December 3, 4 and 5 in Philadelphia—at the Bellevue Stratford Hotel.

Included in the conference program are technical sessions, exhibits, a party – reception and a luncheon.

"Modern Computers – Objectives, Designs and Applications" is the theme of this year's EJCC which is sponsored by the Institute of Radio Engineers, the American Institute of Electrical Engineers and the Association for Computing Machinery. Conference Chairman is Peter E. Raffa of Technitrol Engr. Co., Philadelphia.

"This industry is in a transition period—going from huge expenditures for research and development to a marketing program which will induce commercial sales and applications," an EJCC spokesman noted, adding, "this trend will be reflected both in the sessions and the exhibits."

Technical papers, dealing with a wide range of data processing subjects, will be presented by individuals prominent in the industry. Exhibits will cover equipment, components and services related to all phases of computer and data processing systems.

Installation of exhibits will begin on Dec. 2. They will be open from 9:30 a.m. to 9 p.m. on Dec. 3, and from 9:30 a.m. to 6 p.m. on Dec. 4 and 5. Handling all exhibit arrangements is John Leslie Whitlock and Assoc., 6044 Ninth St., Arlington 5, Va.

Vice Chairman for Registration is William E. Bradley, Philco Corp., G and I Division, Philadelphia.

In the November/December issue, DATAMATION will feature complete and detailed coverage of the Eastern Joint Computer Conference with pictures, complete program details and exhibitor information. This is in keeping with our policy of providing full coverage for every Eastern and Western Joint Computer Conference.

COMPUTER SYMPOSIUM

armour sponsors for fifth year

With the purpose of providing an effective medium of communication for persons and organizations concerned with the broad field of computers, Armour Research Foundation is again sponsoring—for the fifth year in succession—a Computer Applications Symposium. The 1958 meeting will be held at the Morrison Hotel, Chicago, on October 29 and 30.

Symposium committee chairmen, F. C. Bock, R. B. Wise and M. J. Jans, have stated that the sessions will stress the use of new computers and accessories, new techniques of computer programming, organization and operation of computer installations . . . and new applications. (This year Armour Research Foundation of Illinois Institute of Technology, have announced the expansion of their computing facility.)

Reservations can be made for one or both days by writing to Mr. M. J. Jans, Conference Secretary, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill. Fee is $20 for one, $30 for two days, luncheon included.

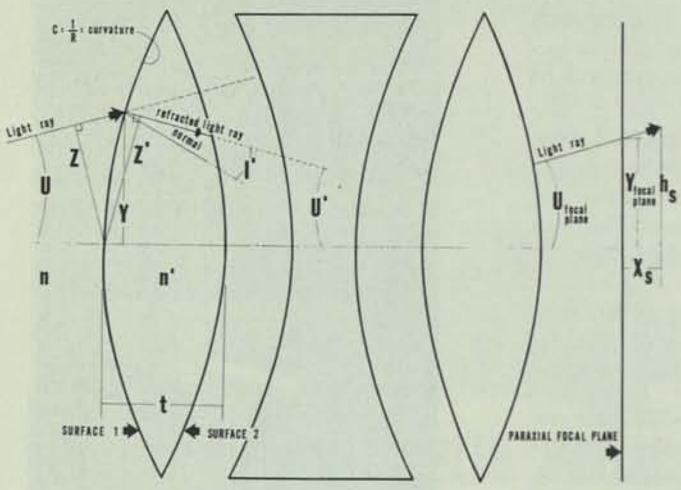
Monday morning, October 29: 8:00—Registration. 9:00—Welcome address by Mr. H. A. Leedy, Director, Armour Research Foundation. 9:10—"Operations Research and the Automation of Banking Procedures," R. A. Byerly, Director of Research, National Association of Bank Auditors and Comptrollers. 9:50—"Information Systems Modernization in the Air Material Command (Univac 1105, IBM 709)," D. E. Ellett, Colonel, USAF, Chief of Data Development Division, Air Materiel Command. 11:00—"Utilization of Computers in Information Retrieval," Ascher Opler, Consultant with Computer Usage Company.

Monday afternoon: 12:20—"Problems and Prospects of Data Processing for Defense," A. Phillips, Director of Data Systems Research Staff, Office of the Assistant Secretary of Defense (Comptroller). 1:50—"An Integrated Data-Processing System with Remote Input and Output (NCR 304)," R. D. Whisler, Systems and Audit Manager, S. C. Johnson & Sons, Inc. 2:30—"The Role of Character Recognition Devices in Data-Processing Systems," R. L. Howell, Director of Electronics Processing, The Reader's Digest Association. 3:40—"Input-Output, Key or Bottleneck?" R. D. Elbourn, Chief of Components and Techniques Section, Data Processing Systems Division, U. S. Department of Commerce. 4:20—Panel discussion between session chairmen and speakers.

Tuesday morning, October 30: 8:00—Registration. 9:00—Welcome address by V. H. Disney, Manager of Electrical Engineering Research Department, Armour Research Foundation. 9:10—"Scientific Uses of a Medium-Scale Computer with Extensive Accessory Features (IBM 650)." Richard A. Haertle, Supervisor, Engineering Mathematics Group, AC Spark Plug Division, General Motors Corporation. 9:50—"Optimizing Designs with Computers," D. D. McCracken, Associate Research Scientist, Institute of Mathematical Sciences, New York University. 11:00—"Computer Applications in the Numerical Control of Machine Tools," R. B. Clegg, Engineer, Servo Machine Tool Division, Kearney and Trecker Corporation.

Tuesday afternoon: 12:20—"Frontiers in Computer Technology," R. W. Hamming, Member of the Technical Staff, Bell Telephone Laboratories. 1:50—"Computer Sharing by a Group of Consulting Engineering Firms, (Bendix G-15D)," E. M. Chastain, president, and J. McCall, general manager, Midwest Computer Service, Inc. 2:30—"Current Developments in Computer Programming Techniques (IBM 650, Univac 1)," Frederick Way, III, Assistant Director, Computing Center Case Institute of Technology. 3:40—"The Future of Automatic Programming (Univac 1103A, IBM 704)," Walter F. Bauer, Director, Computation and Data Reduction Center, Space Technology Laboratories. 4:20—Panel discussion.

DIGITAL COMPUTER AIDS IN OPTICAL SYSTEMS DESIGN



by EUGENE THORBURN
Optical Engineer
Pacific Optical Corporation

Common to the successful solving of practically all design problems in the development of today's highly complex physical systems is the mass of computations that must be continually processed as the work progresses.

How well this load of computation is managed may well be the determining factor in the profit or loss aspects of a new development; at the least, it strongly influences the degree of precision attained in the final product.

The formulation of the basic approach, the selection of the appropriate theories and concepts, the garnering of the necessary data, and the establishment of the correct design procedures, these are all matters within the technical control of the design engineer.

But the rapid and accurate evaluation of mathematics that represent the system's performance is not. For this, the design engineer today is dependent on the extent and appropriateness of the computing and calculating equipment that is available to service him at the right time and at the right place for maximum speed in the handling of this mathematical load.

Mathematical evaluations on what any system will accomplish when it is built is called "proving out" the design philosophy. And unless continuation of the design approach can be maintained by frequent mathematical evaluations accomplished quickly, it will either delay final production of the system or waste a great deal of the design group's time — a serious cost penalty in today's era of "profit-squeezing." Design complexity, with its associated volume of mathematical problem solving and performance prediction, is especially prevalent in the field of advanced optics.

In optical system development, the mathematics employed actually predict the performance of the lenses and lens systems in terms of the deviations of light rays passing through the system from those optical paths that would give the desired object-image relationship.

These actual deviations from the theoretically required paths are imposed by the physical limitations of optical materials. Also, there exists always some finite difference between the nature of the point-source world and physical reality.

This relationship frequently imposes severe problems and involved calculations in optical design because the product of these deviations is the difference between the object as considered by the optical system and the image actually produced by the system.

The difference between the image and the object are grouped under such nomenclature as focus, resolution, depth of field, and other representative optical performance parameters.

No one has ever constructed a perfect lens system. This is a physical impossibility. Fortunately though, it is possible to accurately predict what degree of imperfection any given system will have.

But this process of predicting lens system performance is highly complex, and its solutions require not only long but also tedious mathematical calculations. The extent of the mathematical labor borders on the fantastic and can frequently price a system right out of the realm of practicality, certainly remove it from a competitive cost range.

The length and complexity of the mathematics required can rapidly be appreciated by considering that, prior to the advent of electronic computing methods, a competent lens designer often spent two or more years developing and perfecting a lens system of average complexity. Now, with the rapid advances in the field of optics, manual calculations by a designer could take a lifetime.

The majority of the designer's calculating time is not necessarily spent in formulating the basic system design. In most instances, he has to crank through the arithmetic involved in determining the effects of various adjustments in the component characteristics of the overall system. This means that, whenever he substitutes one component for a more suitable lens part, he has to recalculate these changes and how they effect the overall system.

optical firms and computers

Before electro-mechanical desk calculators first came along, the designer would spend years calculating any given project. The new calculators reduced the figure to months of computing time. But even this considerable

Diagram (above) illustrates parameters involved in mathematical representation of path of light ray through optical systems. System performance is measured in terms of aberrations which are deviations of actual image from image derived assuming perfect lenses.

reduction left the overall cost in time too heavily balanced in favor of essential computing time.

Although the later developed electronic computers are now frequently applied in the more complex segments of general industry, their use by optical firms has been relatively rare.

This lack of utilization might possibly be explained by the fact that, although optical manufacturers have had very definite need for their own computers, the initial cost of computing systems in relation to the potential sales volume of optical systems was difficult to justify by cost-conscious management.

On the other hand, a management team in the optical industry, aware of all contributing phases of their industry's problems, needs to balance a considerable first financial outlay against direct savings in design labor costs and indirect saving resulting from more rapid completion of final deliveries of the systems.

In a great many cases it has been proven that the introduction of fully electronic computers greatly reduced the amount of time spent in optical system development and changed the status of optical designers from arithmetical monitors to creative engineers.

Under the regime of the electronic computer, calculations as well as evaluations of the complex mathematical representations of optical system performance requires not months, but minutes, and more often seconds.

To the casual observer the mathematics predicting the performance of a single lens or the composite of lenses in a multi-lens optical system might seem rather elementary in comparison to the highly complex forms in use in today's technology. And, no optical designer would take issue with this observation. However, it is not the degree of mathematical sophistication involved, but the sheer weight of the computational burden that has turned the optical designer to the use of digital computers.

This mass of mathematical labor is the result of optical design being more of an art than science. While the relationships between the behavior of light rays and the characteristics of various media are exactly bound by unequivocal equations, the utilization of these relationships to produce high performance optical systems depends to a major degree on the judgement, experience and patience of the optical designer.

The various optical aberrations that constitute the deviation of the actual image produced from that produced by a theoretically perfect lens system cannot be singled out one by one and corrected without certain penalties in other aspects of system performance. This interaction between the several forms of aberrations require that optical designers operate in a constant state of compromise to arrive at the 'optimum' design.

This necessity for compromising advantages and weighing disadvantages sets the requirements for the ability of the designer to follow very carefully the performance trends of the system as shown by the computations. On the basis of the calculations, complemented by his experience and design judgement, the designer must make those interacting changes and adjustments in lens configuration, material, and system concept that will eventually result in satisfactory system performance.

This cut-and-try procedure is as old as optical system design, but at least relief from the drudgery of the computations has been provided by the digital computer.

optical mathematics

The figure on page 42 is a functional diagram of the relationship between light rays and optical surfaces that form the basis of optical system design. This interaction and its associated mathematics must be investigated at each optical surface of the system and for a large enough assortment of light rays from various portions of the object to give a proper evaluation of the system performance. Opening and surface equations would express the relationships at the first surface. Transfer equations would relate the results of the first surface effects of the second surface where the surface equations must be applied again. Closing equations would establish the coordinates of the light ray as it reaches its focal point at the end of the system in terms of height above the optical axis and distance from the theoretical focal plane.

The final coordinates of the ray and the intermediate orientations are exact traces of the ray's path through the system. The deviations of this path from the path predicted by assuming perfect lens performance are a measure of the optical system's performance.

The final design of a lens system requires the thorough investigation of system performance by means of this

Royal McBee's LGP-30 desk-sized digital computer is now operating in the design department of Pacific Optical Corporation. The computer's flexibility and memory capacity make it well suited for the field of optical systems design, according to Pacific officials.

exact ray trace method. As many as thirty rays testing the performance of various portions of the lens surfaces must be carried surface-by-surface through the system. The lens designer observes the system performance in terms of the ray orientation and distribution, and makes adjustments and modifications required to optimize the system.

Fortunately, the nature of optical aberrations is such that they may be pitted against each other to achieve overall improvements. That is, carefully chosen use of certain aberrations in some lenses may result in a countering of the aberrations resulting from other lenses to the end that the final overall system aberration is much smaller than the individual lens contributions.

This portion of the design procedure places the greater portion of responsibility for success on the designer's mastery of the "art." His ability to recognize the nature of the aberration, his knowledge of the most efficient corrective action, and his appreciation of the effect of the corrective action on various other system parameters, marks the difference between success and failure of the design. It is in this area of the design effort that the digital computer, by furnishing the designer with rapid evaluations of the effects of his design judgement, proves most valuable.

two design aids

To permit rough estimates of system performance during the preliminary design stages, optical designers employ approximations to the ray trace equations which provide reasonable evaluation of the third order aberrations and overall system performance. The usual procedure is for the designer to prepare, on the basis of past experience and theoretical performance calculations, the complex of lenses and optical surfaces he deems necessary to perform the required optical task.

Once the basic system has been established the third order aberrations are computed. At Pacific Optical, the LGP-30, purchased from the Royal McBee Corp , has been programmed to perform this series of computations. The capability of the program is such that systems consisting of as many as forty optical surfaces may be analyzed.

To use the computer, the designer feeds in the curvature, thickness, and index of refraction associated with each surface of the system. The output of the computer consists of the following aberrations: spherical, coma, astigmatism, distortion, transverse longitudinal color, transverse oblique color, and Petzval curvature.

These values are printed out in terms of the contributions of each surface, and the total value of each form of aberration is also printed. Plotting these values permits the designer to re-evaluate the performance of the system and begin the series of modifications that will lead to the final design.

Previously, the majority of design work was done using the third order aberrations, except for the very final system modifications, since the amount of computation was drastically reduced in comparison to the exact ray trace procedure. However, the utilization of the LGP-30 has permitted more frequent application of the ray trace technique. The entire ray trace procedure has been programmed on the LGP-30.

As in the programming of the third order aberrations, forty optical surfaces may be considered, and the inputs of curvature, thickness, and index of refraction associated with the several surfaces are all that are required. Computer output consists of Y, sin I, and sin U, at each surface plus values of Y, U, h_s, and X_s, at the focal plane.

Consideration of the capabilities of digital computers in optical design problems have led to the concept of utilizing the computer as a means of accelerating the optimization process. Under the proposed system the basic optical system would be established and the corresponding surface data fed to the computer. A suitable criterion for optimal system performance would be established as the computer objectives. A program would be proposed permitting the computer to make adjustments in the characteristics of the surfaces on the basis of systematic trial and error operations.

Pacific Optical Corporation is devoting considerable effort in the development of such a computerized design program. In fact, the anticipation of the long range necessity for and advantages of such a program had considerable weight in making the choice of computers to be purchased. The flexibility and storage capabilities of the LGP-30 make it suited for application to these computer concepts, according to Pacific Optical officials.

In considering any segment of our rapidly advancing technology, no part can be isolated from the whole. Every science today is being buffeted and shaped by the needs and demands of other sciences.

Our recent leap into space with missiles and satellites has loosed a flood of demands for more precise and elaborate optical systems for visual tracking, astranavigation.

The streamlining of industrial manufacturing is opening a broad market for optical measuring techniques yielding increased resolution in process control systems.

Television is impatiently awaiting improved camera lenses, motion pictures are desparately searching for better depth dimension effects, and the progress of aerial photo reconnaissance and mapping in three dimensions is hungry for improved equipment.

Nor is the matter entirely one of merely broadening and refining the product Along with expanding applications has come a compacting of the time with which these new demands for optical equipment must be satisfied.

On both of these counts, broadened application and sharply constricted delivery schedules, the in-plant, readily available computer has become inevitable if optical systems manufacturers are to meet their responsibilities in the years ahead.

Circle 114 on Reader Service Card.

new DATAMATION *literature*

TRANSISTOR MANUAL: This is the third edition of this transistor manual first introduced in 1957. Fully covering circuits of various types, a completely revised section on applications and giving specifications, it tells in its 168 pages how to build almost everything using transistors. Describing basic semiconductor theory, the meaning of transistor parameter symbols, how to read a transistor specification sheet, the company contends it is of interest to expert and student. Copies are priced at $1.00. For copy write GENERAL ELECTRIC COMPANY, Semiconductor Products Department, Syracuse, N. Y. or use reader service card.

Circle 200 on Reader Service Card.

DIGITAL CONTROL COMPUTER: Four-page reference bulletin describes the RW-300 Digital Control Computer. Process control, data logging, pilot plant, and test facility applications for computer control systems are discussed and detailed specifications are listed. The computer incorporates analog-digital conversion equipment, handles up to 1,000 analog inputs, up to 128 analog outputs. Operates with wide range of digital input and output equipment: automatic typewriters paper tape and punched card readers, paper tape and card punches, and on-off devices. For copy write THE THOMPSON-RAMO-WOOLDRIDGE PRODUCTS CO. P. O. Box 45067, Airport Station, Los Angeles 45, Calif. or use reader service card.

Circle 201 on Reader Service Card.

DIGITAL MODULES: An eight-page supplement to this manufacturer's Catalog T describes the six new additions to the Series T group of transistorized digital modules. Illustrations and prices for each model are included along with a concise description of the unit and its applications. The models incorporated in this catalog supplement are: T-Pac Serial Memory model SM-10; T-Pac Static Flip-Flop model FS-10; T-Pac Thyratron Driver model TO-10; Indicator Panel model TI-10; Thirty Unit Delay Chassis model DU-10; Plugboard Panel model PB-10. For copy write COMPUTER CONTROL COMPANY, INC., 92 Broad Street, Wellesly 57, Massachussetts or use reader card.

Circle 202 on Reader Service Card.

FLIGHT DATA SYSTEM: Twenty-three page brochure on this manufacturer's Victor System 272 has fifteen diagrams and photographs illustrating the FM Flight Test Data System designed to record and process data aboard flight test aircraft with high accuracy. Automatic correction occurs by mechanical and electronic means when data is processed through reduction equipment at ground station. For copy write VICTOR ADDING MACHINE COMPANY, Government Contract Office, 3900 North Rockwell Street, Chicago 18, Illinois or use reader service card.

Circle 203 on Reader Service Card.

PORTABLE OSCILLOGRAPH: New portable two-channel oscillograph package with built-in amplifiers, Brush Mark II, is fully described in this four-page, two-color bulletin Designed for applications considered impractical for direct writing recording of electrical and physical phenomena this recording unit requires no additional equipment for operation, features pushbutton selection of our chart speeds. Low inertia, frictionless, the Mark II records directly onto ink paper. For copy write BRUSH INSTRUMENTS, Division of Clevite Corporation, 3405 Perkins Avenue, Cleveland 14, Ohio or use reader card.

Circle 204 on Reader Service Cord.

ANALOG COMPUTER TRANSISTOR: A six-page booklet deals with one phase of the transistor production cycle. Titled, "An Analog Computer Study of the Stability of a Molten Zone Refining Process used in the Production of Transistors," it describes and illustrates by diagrams technique of simulating on the analog computer, conditions experienced by a germanium rod under various conditions of temperature, rod diameter, and length of molten zone. Explained is how the analog computer can quickly, accurately solve non-liner problems for conditions impossible to observe accurately in their true state. For copy write ELECTRONIC ASSOCIATES, INC., Long Branch, New Jersey or use reader service card.

Circle 205 on Reader Service Card.

TAPE RECORDER: The new Model C-100 series of instrumentation tape recorders is fully described and illustrated in this four-page bulletin, available free to qualified members in the field. Characteristics, operating features and complete engineering specifications of the new transistorized recording system are given. Simplicity, compactness and dependability of the C-100 series is stressed. For copy write MINCOM DIVISION, Minnesota Mining and Manufacturing Company, 2049 South Barrington Avenue, Los Angeles, California or use card.

Circle 206 on Reader Service Card.

FILE-COMPUTER SYSTEM: Booklet U 1562 describes company's Model 1 File-Computer Data Automation System. Features described include: concept of building block construction, random access to the magnetic storage drums, advantages of combined internal and external programming, variety of input-output equipment. Also discussed: the parity check, automatic character and blockette counters, checking of computations by reverse arithmetic process. For copy write REMINGTON RAND Division of Sperry Rand Corporation, 315 Fourth Avenue, New York 10, N. Y. or use reader service card.

Circle 207 on Reader Service Card.

PROGRAMMING THE FILE-COMPUTER: A 249-page manual, prepared for trained programmers and computer operators, explains how to program the Univac file-computer. The book is divided into eight principal topics to facilitate study of specific areas of programming and incorporates over 175 illustrations and block diagrams. Of value to businessmen considering using this company's file-computer for data processing. For copy write REMINGTON RAND DIVISION, Sperry Rand Corporation, 315 Fourth Avenue, New York 10, N. Y. or use reader service card.

Circle 208 on Reader Service Card.

DC POWER SUPPLIES: A six-page folder describes manufacturer's custom built DC power supplies for computers, aircraft, military and special applications. Photographs and diagrams, plus chart of relative characteristics of different types of power supplies are included. For copy write GENERAL ELECTRIC COMPANY, Rectifier Department, Lynchburg, Virginia or use reader service card.

Circle 209 on Reader Service Card.

CLUTCHES AND BRAKES: Electromagnetic clutches and brakes of a new miniature line are outlined with specifications in company's twenty-six page booklet. Schematic diagrams, dimensional data and minimum performance curves are provided for ten models. Characteristics and general data is given on last page. These units feature high torque rating, rapid response, zero backlash, – are light weight and moderately priced, according to the manufacturer. For copy write AUTOTRONICS, INC., Dept. #16, Rt. 1, Box #812, Florissant, Missouri or use reader service card.

Circle 210 on Reader Service Card.

ANALOG-PUNCHED TAPE SYSTEM: This manufacturer's Model ZA-750 Analog-Punched Tape Data System is described in a four-page brochure. Principles of operation, output format, technical specifications and construction are given. Designed to meet requirements for a rugged, economical, low speed data processing system, model ZA-750 contains plug patch-board permitting quick and easy changing of program format. For copy write ELECTRONIC ENGINEERING COMPANY OF CALIFORNIA, Sales Department, 1601 E. Chestnut, Santa Ana, California.

Circle 211 on Reader Service Card.

TRANSICON DATRAC: Six-page folder illustrates the company's modularized, transistorized, reversible analog-to-digital and digital-to-analog converters, and alarm limit monitors. Line drawings and a description of the models is given. Folder contains ten pictures of Transicon Datrac plug-in building blocks and specifications on analog-to-digital, digital-to-analog converters and alarm limit monitors. For copy write EPSCO, INC., Equipment Division, 5[illegible] Commonwealth Avenue, Boston 15, Mass. or use card.

Circle 212 on Reader Service Card.

BASIC SWITCHES: A revised thirty-two-page edition of Basic Switch Catalog 62c, with illustrations and diagrams, gives details of over 200 catalog listings of basic switches and related devices. Page twenty-seven contains technical information on installation, mounting and proper selection. Switches detailed include the new high-precision roller lever switch; the adjustable actuator switch for fine adjustment; the "pulse" switch for securing electrical impulses without complicated actuating mechanisms. For copy write MICRO SWITCH, A Division of Minneapolis-Honeywell Regulator Company, Freeport, Illinois or use reader service card.

Circle 213 on Reader Service Card.

DATA ACCUMULATOR: New automatic inspection data accumulator for tinplate, model GE 302, is covered in this four page booklet. Designed specifically for an industrial environment, maker contends this new magnetic drum system reduces accustomed number of electronic circuits; increases system reliability by reducing complexity. Booklet contains illustrations, diagrams and specifications. For copy write GENERAL ELECTRIC COMPANY, Computer Department, 1103 North Central Avenue, Phoenix, Arizona or use card.

Circle 214 on Reader Service Card.

TAPE RECORDER/REPRODUCER: Model FR-100A, modular magnetic tape recorder/reproducer for instrumentation, is fully described in this fourteen-page, four-color booklet. Photographs and information explain how this latest equipment is being used and back page lists company equipment specialists where specifications may be obtained. For copy write AMPEX CORPORATION, Instrumentation Division, 860 Charter Street, Redwood City, California or use reader service card.

Circle 215 on Reader Service Card.

ANALOG COMPUTER: A fully illustrated 18-page brochure and folder describes MC-5800 analog computer. Fourteen pages of specifications and descriptions are included in a four-page folder. The folder is a photographic model of the MC-5800 computer clearly illustrating the unique packaging wherein the computer may be instantly "unzippered" from the confines of its cabinet for unobstructed access during maintenance. Other features of the computer are described including circuit logic required for building-block flexibility, adaptability for high speed repetitive operation, bivariable function generation, complete automatic problem check. For copy write MID-CENTURY INSTRUMATIC CORP., 611 Broadway, New York 12, New York.

Circle 216 on Reader Service Card.

INTEGRATED DATA SYSTEM: Systems for gaining instrumentation computed data in rapid time is detailed in this two-page folder. The manufacturer's Automatic Data Re-

Circle 14 on Reader Service Card.

Circle 15 on Reader Service Card.

cording Monitoring System designed for acquisition and processing of data from rocket or jet engines, is outlined with a system block diagram illustrating data flow and typical components. A small, general-purpose digital computer is an integral part of the system. For copy write CONSOLIDATED ELECTRODYNAMICS CORPORATION, Systems Division, 300 North Sierra Madre Villa, Pasadena, Calif. or use reader service card.

Circle 217 on Reader Service Card.

ANALOG, DIGITAL UNITS: In an eight-page General Electric booklet, computers and computing systems, analog and digital, are described. Covered are such subjects as, "GE 100 Electronic Data Processor for Banking Applications," "GE Transistorized Magnetic Ink Character Reader," "GE 310 Data Acquisition System for Process Monitoring," "GE 302 Automatic Inspection Data Accumulator for Tinplate," "GE 309 Gage Logging System," "GE 307 Miniaturized AC Network Analyzer," "GE 306 Analog Computer," "GE 308 Economic Dispatch Computer," "GE 301 Heat Rate Computer," "GE Industrial Card Reader." For copy write GENERAL ELECTRIC COMPUTER DEPARTMENT, 1103 North Central Avenue, Phoenix, Ariz. or use card.

Circle 218 on Reader Service Card.

MINIATURE CLUTCH AND BRAKE: Four page leaflet on manufacturer's new line of miniature clutches and brakes. Applications include drive for tape reader; position type servo for analog and digital computer. Leaflet gives dimensional data, specifications and minimum performance curves for electro-magnetic brake model BF-125; clutch model C-125 and brake-clutch model MC-125. For copy write AUTOTRONICS, INC., Dept. #16, Rt. 1 Box #812, Florissant, Missouri or use card.

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cording Monitoring System, design... for acquisition and processing of d... from rocket or jet engines, is o... lined with a system block diagram il... lustrating data flow and typical co... ponents. A small, general-purpose di... ital computer is an integral part ... the system. For copy write CONSO... LIDATED ELECTRODYNAMIC... CORPORATION, Systems Division, 300 North Sierra Madre Villa, Pasadena, Calif. or use reader service card.

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ANALOG, DIGITAL UNITS: In an eight-page General Electric booklet computers and computing systems analog and digital, are described. Covered are such subjects as, "GE 100 Electronic Data Processor fo... Banking Applications," "GE Transis... torized Magnetic Ink Characte...

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...pator. Leaflet gives dimensional data, specifications and minimum performance curves for electro-magnetic brake model BF-125; clutch model C-125 and brake-clutch model MC-125. For copy write AUTOTRONICS, INC., Dept. #16, Rt. 1 Box #812, Florissant, Missouri or use card.

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fil 1958

DIALOG

INFORMATION SERVICES, INC.
3460 Hillview Avenue
Palo Alto, CA 94304
(415) 858-2700 TELEX 334499

November 13, 1987

Madeline M. Henderson
5021 Alta Vista Road
Bethesda, MD 20814

Dear Madeline:

Here is a copy of a paper that I've chosen for consideration for your Pioneers compilation. It was a Sputnik reaction paper that characterized some of the national planning issues in 1958 that are still valid today.

I've not sought the necessary clearance from the publisher (SRI, 333 Ravenswood Avenue, Menlo Park, CA 94025). I'd rather have you do it because you could give a better description of the circumstances of your proposed use.

It was good to see you again.

Best regards,

Charles P. Bourne
Director
General Information Division

CPB:kir
87317DIS0008

Enclosure - Reprint, "Facets of the Technical Information Problem"
SRI Journal No. 1, 1958

asis

AMERICAN SOCIETY FOR INFORMATION SCIENCE • 1424 16TH ST., N.W., SUITE 404 • WASHINGTON, D.C. 20036 • 202/462-1000

August 28, 1987

Mr. Charles Bourne
1619 Santa Cruz Avenue
Menlo Park, CA 94025

Dear Charlie,

You have been invited, as an ASIS Pioneer of Information Science, to participate in a luncheon at the 50th Anniversary Conference in Boston. We envision stimulating discussions between Pioneers and the attendees on the topics of the Pioneers' contributions to the mainstream of information science. You were also told that a monograph has been proposed, "featuring the Pioneers and the luncheon discussions." As editors for that commemorative volume, we would like to start on the process of compilation.

We have suggested that the volume contain (1) a short biographical sketch and photo of each Pioneer; (2) a short paper by each Pioneer, chosen by the Pioneer as his/her favorite work, or most-cited work, or work which typifies the contribution(s) he/she wants to have discussed; and (3) a summary of the discussion between the Pioneer and those sharing the luncheon period with him/her. We would like to have items (1) and (2) for all Pioneers, even those who cannot attend the luncheon.

You have already supplied the biography and photo to ASIS headquarters. What we need now is to have you select the material you want to have included, and if necessary obtain clearance from the copyright holder. If we can help with the latter task, we'd be happy to try but expect that you can more effectively make the necessary contact directly. For the discussion records we will undertake some editing, for consistency perhaps, but ask you to approve final copy.

Will you please contact either one of us, by mail or phone, with your reactions, an idea of what paper(s) you are examining for possible inclusion, and whether you foresee problems in obtaining clearance. We will keep you informed, "and we thank you for your support!"

Lea M. B.

Lea M. Bohnert (401) 294-2093
4 Cavanaugh Court
Rd #1, Box 28
Saunderstown, RI 02874

Madeline H.

Madeline M. Henderson
(301) 530-6478
5021 Alta Vista Rd.
Bethesda, MD 20814

INFORMATION: The Transformation of Society

ASIS 50th Anniversary Conference October 4-8, 1987, Boston

July 8, 1987

Mr. Charles Bourne
1619 Santa Cruz Avenue
Menlo Park, CA 94025

Dear Charlie:

Plans for the ASIS 50th Anniversary Conference and special activities for our Pioneers of Information Science are now firm.

As Linda Resnik mentioned in her letter to you, we have scheduled a Luncheon with the Pioneers of Information Science on Tuesday, October 6, in Boston. This informal, but substantive, event will feature each Pioneer in attendance as the special guest at a designated table. With hosts presiding and recorders summarizing discussions, attendees will select the tables of the Pioneers with whom they will enjoy the lunch discussions. Bob Chartrand and Madeline Henderson, coordinators of the Luncheon activities, expect a free-wheeling and stimulating experience for all involved.

For the dinner party on October 7, your involvement is less rigorous. We ask only that you be in attendance and allow ASIS to acknowledge your accomplishments in the field once again.

Since several publications are being considered in conjunction with the Pioneers activities, may I encourage you, please, if you have not already done so, to send a current biography and black and white photo to Linda Resnik at ASIS Headquarters. In addition, Madeline asks that you begin considering which of your short papers you would like included in a proposed monograph featuring the Pioneers and the luncheon discussions. ?

If you have questions about the conference activities, please contact Madeline (301/530-6478) or Bob (202/287-7056). In the meantime, please help us make final luncheon plans by informing Linda Resnik immediately of your attendance plans.

I look forward to seeing you in Boston in October.

Sincerely,

Toni

Toni Carbo Bearman
Conference Chair

STANFORD RESEARCH INSTITUTE

MENLO PARK, CALIFORNIA

January 1958

A DRAFT PROGRAM FOR A NATIONAL TECHNICAL INFORMATION CENTER

A DRAFT PROGRAM FOR A
NATIONAL TECHNICAL INFORMATION CENTER

THE PROBLEM

The preeminent position of the United States as a world power is dependent upon continued leadership in science and technology. Of vital importance to technical progress is the ready availability and applicability of discoveries, concepts, and data from all sources--past and present, foreign, and domestic.

Existing mechanisms for processing technical information are unable to cope with the present deluge of publications. The result has been enormous duplication of effort and expense, serious delay of technological progress, and failure to realize the full potential of a rapidly expanding military and civilian research effort.

THE PROGRAM

This document describes a program to solve the nation's technical information problem through the establishment of a national center for the collection, processing, storing, retrieval, and dissemination of scientific and technical information from both foreign and domestic sources. The program comprises the following actions:

1. Establish a central organizing and administering Agency.
2. Determine the gross dimensions of the problem.
3. Establish an interim information center using existing services and techniques.
4. Analyze the factors which determine the design and operation of an ultimate National Technical Information Center.
5. Encourage present and initiate additional research and engineering development programs leading to systems and equipment necessary to implement the ultimate National Technical Information Center.

NATIONAL TECHNICAL INFORMATION CENTER

Because of the size and nature of the National Technical Information Center, it should be administered by a federally constituted Agency.

It is strongly recommended that the resources and services of the Center be equally accessible to all research, industrial, academic, and government organizations throughout the country, consistent with security requirements.

In view of the breadth of service anticipated and the demonstrable economic value of these services, the Center should be at least partially supported through service fees from its various users.

There is no inherent limitation on the scope of subject matter which can be processed by an operation such as described here. However, in order to develop an integrated system in a reasonable time, it is desirable to place arbitrary boundaries on the information to be included. At present the most highly organized and easily defined body of information is the literature of the physical and biological sciences. There are compelling practical incentives to include the slightly less well organized literature of the various fields of engineering and medicine. It is recommended that the initial planning of the system be limited to not more than these categories. Once the Center is in operation, a well-conceived system can be extended to encompass the literature of law, the behavioral sciences, and other fields of importance, but which are presently less easily organized for systematic processing. This expansion should be undertaken at the earliest possible time.

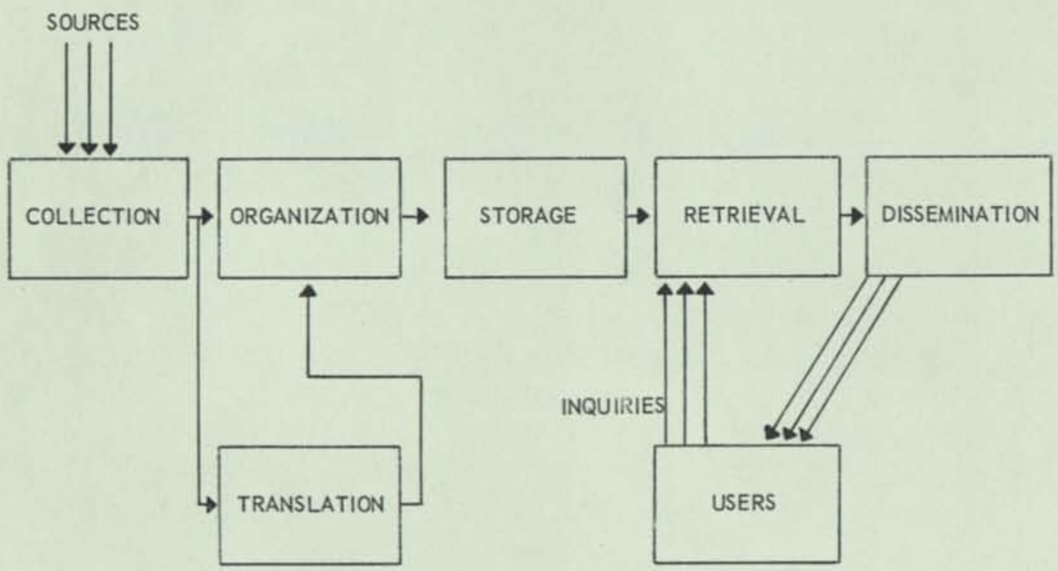
An inherent function of the central organizing and administering body is to establish a strong program of research. This research effort must probe into the origins, transmittal, and use of information. It must also develop the principles and mechanics of new devices for use by the Center. It is not intended that the Center itself conduct all or even a major part of such research and development programs, but rather that the Agency contract for and coordinate such efforts wherever they can be carried out most effectively.

The Center is expected to function as a coordinating and communications focus in its information processing operations rather than as a completely self-contained mechanism. Undoubtedly, a large volume of the operation will be conducted at a single location, but modern communication facilities make it unneccessary for the entire operation to be physically centralized. Furthermore, dispersed operation will permit exploitation of already existing capacities and thus make possible earlier and more economical operation.

The Center in its interim form will utilize large numbers of specialized personnel employing manual techniques similar to those presently employed by large technical abstracting services, such as that of the American Chemical Society and the Soviet Technical Information Institute. However, as the system evolves and as mechanized equipment is developed and becomes available, the operation should become increasingly mechanized. With this evolution the service should become speedier, more comprehensive, and more creative.

INFORMATION FLOW

The functions of the National Technical Information Center, in both its initial manual form and its ultimate highly mechanized development, can be represented by the following flow diagram:



A DRAFT PROGRAM FOR A
NATIONAL TECHNICAL INFORMATION CENTER

BACKGROUND

Man's most persistent medium for recording his progress and for communicating his ideas and discoveries to others is the written word. In the world of science this communication is formalized in periodicals, reports, and books. In recent years the rapidly growing volume of such publications threatens technical communications with a paralyzing glut and ultimate collapse. Inability to deal with the rising flood of technical publications has already seriously handicapped this country's industrial and scientific development.

Furthermore, increasing concern has been felt over the time for new products--particularly new military devices--to reach the manufacturing stage. History of any technical development from conception to the finished product shows that the major time interval lies between discovery of the basic principle and demonstration of its practical usefulness in the laboratory. This period may extend for decades. On the other hand, even the most involved development engineering seldom requires more than five or ten years. More time is lost--or more time is to be gained--between idea and demonstration than between demonstration and production. It is in this period, where ideas rather than physical materials are involved, that speedup is most feasible. Information has no inertia; it can be accelerated infinitely--subject only to the limits of our skill and facilities for transmission and correlation.

Existing information handling processes and library services are based largely on techniques developed more than fifty years ago. Recent research and development efforts have produced fragments of solutions at best. The continued vitality of scientific progress in this country demands a generalized solution to the information problem. In an era in which scientific and technological accomplishment is the measure of a nation's international stature, the problem is of compelling urgency.

MAGNITUDE OF REQUIRED EFFORT

The magnitude of an undertaking designed to process a major part of the world's technical information cannot be measured by any single parameter. However, certain figures emphasize the massive nature of the required effort. Informed estimates provide the following data on the world's ouptut of technical literature:

	Total	Annual Growth percent
Responsible technical journals	30,000 to 50,000	
Articles published annually	500,000 to 2,000,000	10 to 15
Technical books published annually	60,000	
Documents issued annually (U.S. Government only)	100,000 to 150,000	30 to 40

The heaviest users of technical literature in the country are the 200,000 professional research specialists who spend from 5 to 25 percent of their time seeking useful published information. The engineering profession makes much less use of such information by reason of its difficulty of access. The resulting duplication of development effort increases costs and injects unwarranted delays in product availability. Several thousand research libraries representing millions of dollars of annual operating costs and tens of millions of reference items utilize some 500 abstracting and indexing services in a valiant but futile effort to meet these informational needs. Coordination and integration of these services and operations would reduce the waste of money and scientific manpower.

In addition to struggling with the sheer volume of the literature, the American scientific community encounters an increasing complication in dealing with the technical information published in languages other than English. There is a serious lack of awareness in the United States of the growing significance of foreign technical publications. Limited data indicate that "pure" scientists refer to foreign sources (including those published in English) about 30% of the time; "applied" scientists 10%; and engineers even less. Apparently the information extracted from foreign language literature by U.S. scientists and engineers is very small, yet this literature as a whole is probably expanding much more rapidly than that in English. Furthermore, the number of languages in which technical information is being generated is increasing.

No complete information processing facility exists in this country or abroad. However, beginnings toward this objective have been made by the Soviet Union through the Soviet All-Union Institute of Scientific and Technical Information founded in 1952. Its function is to accumulate the published technical literature of the world, process it and distribute abstracts, reviews, and compendia as quickly as possible. The full-time staff of 2,300 specialists is supplemented by 20,000 scientists and engineers who serve as abstractors and translators on a part-time basis.* The relative effectiveness of this Institute is attested to by prominent American scientists who have said that the best way to determine what American science is doing is to read the Russian abstract literature.

Soviet scientists have undoubtedly found their technical information Institute an important factor in the scientific race with the West. Only a few months intervene between publication of Western research information and when it is placed in the hands of a Soviet worker in his own language. Duplication of research and library effort is reduced, thereby permitting more effective use of the scarce and valuable trained manpower, and all investigators enjoy the stimulation resulting from access to the thinking of colleagues throughout the world.

The Soviet Institute does not appear to provide extensive facilities for systematic searching of the literature. It is known to have a strong and far-advanced research and development program aimed at creating mechanized search and retrieval devices. It is reported that the Soviet Institute has an operational English-Russian electronic translator. Furthermore, the Russian operation seems to limit its scope to the physical sciences, biology, and some branches of engineering; excluding medicine, [illegible]

* An operation of this size in the U.S. would require an annual operating budget of about $60 million, excluding cost of journals and books; printing and distribution; and part-time abstractors and translators.

law, economics, civil engineering, and other valuable areas of information. However, having developed the procedures to handle some categories of technical information, presumably the Institute will ultimately extend its activities into additional subject fields.

METHOD OF APPROACH

The actions proposed below have two prime objectives, which must be pursued simultaneously. First, to meet the nation's most immediate needs, it is considered necessary that an interim technical information center be brought into being as quickly as possible to collect, process, and disseminate technical information. Second, to establish, following analysis and research, an ultimate National Technical Information Center, utilizing maximum mechanization for accelerating the flow of technical information from all parts of the world into the laboratories of the United States.

The success of the program depends inherently upon the coordination and continuity of the five actions outlined below:

1. Establish a central organizing and administering Agency.
   An Agency of the United States should be established with the responsibility and authority to make arrangements for the conduct of research, development, and operations relating to the interim and ultimate National Technical Information Center. The Agency will employ directly a small staff consistent with its policy making, contracting, and administrative functions.

   An extensive and continuing systems analysis of the nation's technical information problems and programs will provide the basis upon which the Agency will contract for new research and development projects. Privately supported research and development efforts will be encouraged when they are consistent with the Agency's long-range goals. Existing and new technical information projects conducted by other government agencies will be subject to the review and concurrence of this Agency. In this way all aspects of the national technical information problem will be dealt with in an expeditious, systematic, and well-integrated manner.

   Operation of the National Technical Information Center may be conducted under contract to the Agency. Such an operation will involve the coordinated participation of many supporting services, in conjunction with a central information processing and storage facility.

   Program details would be formulated by the Agency as the requirements develop.

2. Determine the gross dimensions of the problem.
   Before any steps can be taken to establish even an interim technical information center, it will be necessary to achieve a quantitative appreciation of the size and detail of the

work to be done and the service to be rendered. A survey to this end should be initiated promptly. The study would utilize known techniques, and would provide reliable estimates of the magnitude of various factors critical to entering into the interim operation. Among these are the volume of technical publications produced in various subject categories; the distribution of technical information sources by country and language; the general nature, frequency, and number of user inquiries; the numbers and types of personnel required to staff an interim center; the size of facility and types of equipment required.

Many organizations have already recognized the importance of the information problem and have undertaken studies of several of these factors. (See Appendix A.) These studies can contribute much valuable information for the design of the interim operation.

A large reservoir of facilities and experience in individual components of the information center's program is already in operation. Extensive but uncoordinated abstracting services exist. (See Appendix B.) In addition, an estimated 500-700 industrial research groups maintain abstracting services in their own limited fields of interest. Translating services are less fully developed, but some are in operation and probably could be expanded. (See Appendix C.) These and similar existing services will be inventoried and factored into the interim system to assure maximum economy and earliest possible operation.

These surveys can be completed in about six months if maximum practical concentration of effort is applied.

3. <u>Establish an interim information center using existing services and techniques.</u>

The nation need not await completion of extensive analyses or development programs before taking positive action to meet the immediate needs for better access to technical information. Immediate steps can be taken to establish an interim operation to perform at least part of the desired information processing functions using available techniques. The interim operation can provide at least translating, abstracting, and conventional indexing operations following procedures already developed by the major abstracting journals.

Unfortunately, the readily available techniques are largely manual. Fully developed machines are available only for small segments of the total operations. The available machines should be used in standard or modified form wherever possible. However, the interim operation will unavoidably require large numbers of specialized personnel. The supply of trained information specialists is small. Hence recruiting and training must be given careful thought in devising a plan for the immediate center if the plan is to be practicable.

The surveys outlined under action 2 will provide the basic parameters for the design of the interim center. Other studies of organization, operational analysis, machine feasibility, and short-term machine development programs will be undertaken as the interim center is brought into being.

The interim center will suffer from many inadequacies and inefficiencies, but an immediate partial solution to the nation's information problem will have been provided. Better organization and dissemination of technical information will significantly reduce the volume of literature which the individual scientist or engineer must use. Our research and engineering laboratories will have improved access to the findings of colleagues in foreign lands, particularly those lands which are beginning to contribute important technical and scientific discoveries. Furthermore, existence of a center in operation will provide an insight into the systems problem that would be difficult, if not impossible, to gain completely through theoretical analysis.

Fortuitously, we are assured that this interim approach is feasible. The initial operation of the Soviet Technical Information Institute was undertaken on a similar basis--in fact, Russian spokesmen have said that it was a conscious extension of the methods of the American Chemical Abstracts. The Soviet Institute is in operation and seems to be effective. Its research program of the past five years is reportedly now beginning to produce unique advanced equipment for the refinement and extension of the Institute's services.

An aggressively and realistically pursued program in the United States could result in a similar operating center within two years.

4. Analyze the factors which determine the design and operation of an ultimate National Technical Information Center.
There is a critical need to identify and evaluate the importance of the many factors pertinent to the design and operation of an ultimate National Technical Information Center. These include organizational and operational considerations. The organizational factor is particularly important for the encouragement of research necessary to implement successfully an ultimate information center, and it will be discussed separately later.

Human factors and machine factors constitute the two major operational considerations that must be systematically examined, and which will lead to a host of research problems. It is anticipated that systematic study of user needs and characteristics as well as research on the logic of information systems will have to be undertaken. Methods of classifying, abstracting, indexing, storing, retrieving and disseminating increasingly formidable amounts of information will have to be studied in detail. No scheme for accomplishing these operations adequate to the needs of the scientific community is yet at hand.

It will be necessary to consider many machine factors and potential advances in the state of the art. No present machine is equal to the task of storing the immense quantities of information available. Even further from solution is the problem of achieving rapid access to a specific small fraction of a very large body of stored information. The complexity of the situation is further increased by the need for machine translation and organization. Partial solutions exist. Printed matter can be read by machines to a limited extent; machine translation from one language to another has been demonstrated on a small scale; high-speed handling of printed documents and turning of book pages are under development; high-speed printing mechanisms are now in operation. Major improvement in these machine capabilities is certain. When current machine performance is considered in the course of the system analysis, improvements will be identified which can be pursued in the research program.

Certain of the boundaries of the system analysis will be determined by policy decisions to be made by the governing Agency. Who will pay for the service and on what basis? What kinds of information will be handled? Who will have access to the information?

The systems analysis will provide a basis for an objective design of an information retrieval structure that can meet the nation's information needs with least time, money, and effort.

Experience gained from the interim technical information center will also contribute to the programming of specific research and development projects and to the design of the ultimate Center.

5. Encourage present and initiate additional research and engineering development programs leading to systems and equipment necessary to implement an ultimate National Technical Information Center.

The Agency will guide the total research effort. It will encourage and support necessary research and development programs, prevent duplication of effort, and integrate and coordinate pertinent activities being undertaken throughout the country. It should have control over the rate of development of the Center, primarily through its control of funding for research and development work.

This Agency will be responsible for aggressively thinking through and supporting an extensive and uninterrupted long-term research and development effort. The magnitude of this effort will determine the rate at which the ultimate Center is designed and becomes operational. The Agency will be responsible for obtaining the services of individuals and laboratories possessing both capabilities and facilities for effectively contributing to the total program. Only through such an arrangement can an ultimate National Technical Information Center be established which will, in time, contribute markedly to the scientific and technical world leadership of this country.

BUDGETARY CONSIDERATIONS

This presentation provides only the broad outlines of a suggested program. Many refinements will have to be injected. Many details are ignored and many remain to be uncovered.

The intent here is primarily to indicate the magnitude of the program, something of the state of the art, and to suggest an approach to the solution of the compelling national need for better use of technical information. However, from these broad outlines and what is known about implementing programs of this size, order-of-magnitude estimates of immediate budget requirements can be made.

The compelling nature of the information problem suggests that funds be authorized immediately to pursue the initial investigation of the gross dimensions of the problem and to initiate the establishment of an interim center. Subsequent authorization of funds should also be sought to ensure an aggressive and continuing program. In addition, it may be assumed that private enterprise will continue to invest large sums in research and development, particularly on equipment necessary to mechanize information processes.

For the remainder of fiscal year 1958 a supplemental authorization of $2.0 million would meet the estimated needs of the governing body to support $500,000 for surveys and initial investigations, and $1.5 million to begin procurement of equipment and facilities to accommodate the interim technical information center.

It is too early to provide a definitive estimate for the fiscal year 1959 budget, but obligational authority should be sought for $50 million. Included in this figure are support of short-range research and engineering development necessary for the equipping and operation of the interim facility and for the beginning of the long-range systems analysis, initial staffing and operation of the interim center. Support of certain long-range research and development programs of obvious pertinence to any system for the ultimate National Technical Information Center should be initiated during this period. It is questionable whether an optimum long-range research program could be attained within the figure given here, but a valid estimate is impossible at this time.

For the fiscal year 1960 and subsequent years the annual budget can be expected to exceed $100 million. The upper limit will be determined by the aggressiveness with which the research and development effort is pursued. It will also be affected by the extent to which the operation of the National Technical Information Center will be made self-supporting through charges for services. Such income can be substantial in view of the large present expenditures of government and industrial organizations for individual services which may be relieved by the operation of the Center.

CONCLUSION

The technical information needs of the nation can be met by an intelligently conceived and earnestly pursued research, development, and operational program. Such a program will be difficult--it will be costly. However, it is neither more difficult nor more costly than other systems development programs which the United States has undertaken and completed to achieve and retain our internal and international status. The cost in lost prestige and technical stagnation which may result from failure to solve this problem might well prove catastrophic.

Stanford Research Institute has prepared the Draft Program for a National Technical Information Center as a public contribution to the solution of a national problem which it believes to be of critical importance.

The Institute's experience in systems design; operations research; information organization; and in the conception and development of information processing devices, we believe, provides a unique perspective into the complex scope of this problem.

The Institute maintains an active and expanding program of research in all phases of the information processing problem. The Institute invites consideration for a role in planning and coordinating, as well as execution of appropriate research phases of any national technical information program, such as the one outlined herein.

APPENDIX A

A PARTIAL LIST OF ORGANIZATIONS CONDUCTING RESEARCH AND DEVELOPMENT IN INFORMATION PROCESSING

All-Union Institute of Scientific and Technical Information (USSR)
Association of Special Libraries and Information Bureaux (England)
Battelle Memorial Institute
Birkbeck College (England)
Burroughs Corporation
California Institute of Technology
Cambridge Language Research Unit (England)
Case Institute of Technology
Chemical Abstracts Service
Columbia University
Documentation, Inc.
Dow Chemical Company
Eastman Kodak Company
Federal Telecommunications Laboratories
Eugene Garfield Associates
Georgetown University
Computation Laboratory of Harvard University
Herner, Meyer and Company
International Business Machines Co.
International Telemeter Corporation
Lehigh University Library
Librascape
Arthur D. Little, Inc.
Low Temperature Research Station (England)
Magnavox Co.
Massachusetts Institute of Technology
National Academy of Sciences-National Research Council
National Bureau of Standards
National Cash Register Co.
North American Aviation Inc.
Ramo-Wooldridge Corporation
RAND Corporation
Rutgers University
Sperry Rand Corp.
Stanford Research Institute
Teleregister Corporation
U. S. Patent Office
University of Michigan
University of Pennsylvania
University of Virginia
University of Washington
Western Reserve University
Zator Company

APPENDIX B

A PARTIAL LIST OF TECHNICAL ABSTRACTING PUBLICATIONS*

Accountant's Index
Acoustical Society of America
Acoustical Society Contemporary
  Papers, Journal
Aeronautical Engineers Index and
  Review Abstracts
Aeronautics, Index
Agricultural Index
Agriculture, Bibliography of
  Agronomy Abstracts
Air Pollution
Air University Periodical Index
Allergy and Applied Immunology,
  Quarterly Review
Alloy Digest
Aluminum Abstracts Bulletin
American Concrete Inst. Proc.
American Documentation
American Journal of Nursing
American News of Books
Analytical Abstracts
Analyticus Cancer, Index
Anco
Anesthesia and Analgesia Current Index
Animal Breeding
Annotated Bibliography of Economic
  Geology
API Technical Abstracts
Applied Chemical Abstracts, Journal
Applied Entomology, Review of
Applied Mechanical Review
Applied Physics, Journal of
Applied Spectroscopy
Art Index
Asian Studies, Journal of
ASTIA Card Service
ASTIA Unclassified Reports
Astronomical Newsletter
Atomic Energy Reporter

Battelle Technical Review
B.C.U.R.A. Bulletin
Best's Bulletin Service
Bibliographic Index
Biography Index
Biological Abstracts
Biological Science, International
  Abstracts of
Book Review, International
British Abstracts
B.S.E.A. Abstracts
Building Science Index
Business Service Checklist
Buttersworth Card System

Canada, Bibliography of
Canadian Index
Canadian Patent Office Record
Cancer Current Literature
Card Service, Advance Abstracts
Ceramic Abstracts
Ceramic Abstracts, British
Chemical Abstracts
Chemical Abstracts, Analytical
Chemical Abstracts, British
Chemical Engineering News
Chemical Literature
Chemical Market Abstracts
Chemical and Physics Abstracts,
  British
Chemical Spotlight
Chemisches Zentrablatt
Child Development Abstracts
Cinnotalid Bibliography of North
  American Geology
Classified Reports (ABC),
  Abstracts of
Computers and Automation
Corrosion Abstracts

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* From a survey by Western Reserve University

Corrosion et anti-Corrosion Abstracts
Corrosion Engineers Abstracts, National Society of
Crerar Metal Abstracts
Crippled Children Bulletin of Current Literature, National Society for
Cumulative Book Index
Current Chemical Papers
Current Technical Literature, Index to

Dairy Science Abstracts
Data
Dental Abstracts
Dental Literature, Index to
Dirivent Patent Service Dissertation Abstracts
Distillation Literature and Abstracts
Document Index
Dyers and Colourists, Journal Society

Eastman Kodak
Eastman Kodak Library Reports
Education Index
Electrical Engineering Abstracts
Electronics Abstracts
Engineering Index
Engineer's Digest
EPA Technical Digest
Essay and General Literature Index
European Technical Digest
Excerpta Medica

Fats, Oils, Detergents Abstracts
Field Crop
Files Coping the Technical News
Fisheries, Commercial, Abstracts
Fisheries Abstracts, F.A.O. World
Food, Current Abstracts
Food Science Abstracts (British)
Food, Index and the Literature Journal of Food
Forestry Abstracts
Fuel Abstracts

Gas Abstracts
Gaylor's Technical Service
General Electric Internal Bulletins and Reports
Geological Abstracts
Geographical Publications, Current
Geophysical Abstracts
Glass Technical Abstracts, Journal Society
Government Classification Cards
Great Britain Dept. of Science and Industries Research, Translation of Russian

Herbage Abstracts
Highway Research Abstracts
Historical Abstracts
Horticultural Abstracts
Hosiery Abstracts
Hospital Abstract Service
Hospital Literature, Cumulated List of
Hospital Literature, Index to Current
Hygiene, Bulletin of

IGT Abstracts
IMM Abstracts
Industrial Arts Index
Industrial Diamond Bibliography
Industrial Health, Achives of
Industrial Hygiene Digest
Industrial Labs
Information Service Bulletin
Ink Maker
Instrument Society of America
International Index
International Institute for the Conservation of Museum Objects
Interplanetary, British
Iodine Abstracts and Reviews
IPC Library Notes
IRE Abstracts
Iron and Steel Institute Abstracts, Journal

Labor--Personnel Index
Lectrodex
Leukemia Abstracts
Library Bulletin of Abstracts
Library of Congress Air Pollution
Library of Congress Bibliography of Translation from Russian
Library of Congress, Books; Subjects

Library of Congress Central Europe Accession
Library Literature
Light Metals Bulletin
Literary Notes

Magnesium Review and Abstracts
Management Abstracts
Market Abstracts
Material Construction, Review of
Mathematical Abstracts
Medical Abstracts
Medical Digest, International
Medical Literature, Current List
Medical Science, International Abstracts of
Medical and Veterinarian Mycology Review of
Medical and Veterinarian Zoology, Index-Catalogue of
Medicus, Index
Medicine, Modern
Metal Finishing
Metal Literature, ASM Review
Metals Journal, Institute of
Metallurgical Abstracts
Metallurgical Abstracts (British)
Metals Review
Meteorological Abstracts
Military Affairs
Milk and Milk Products, Abstracts of Literature
Mond Nickel Bulletin
Monitor

National Defense
NACA Research Abstracts (Card File)
Natural and Synthetic Fibers
Naval Research Laboratories
Neurology and Psychology, Digest of
New Testament Abstracts
New York Times Index
Non-Destructive Testing
Non-Ferrous Metals, British
Nuclear Science Abstracts
Nutrition Abstracts
Nutrition Reviews
NYSEM Bibliography of Electr. Micr.

Obstetrics and Gynecology Survey
Official Gazette of U.S. Patent Office
Olin Mathieson Chemical Corp.
Opthamalic Abstracts and Research

Packaging Abstracts
Paint, Colour, Review of Current Literature Relating to
Paint, Varnish and Lacquer Assoc., British
Paint, Varnish and Lacquer Assoc. National
P.A.I.S.
Paper Chemists, Bulletin of the Institute
Paper Making and U.S. Patents, Bibliography of
Pasteur, Bulletin Institute
Patent Journal (Union of S. Africa)
Patent Research Office Patent Lists, International
Patents Abstract Journal (British)
Pediatric Current Literature, Abstracts from
P. B. Reports, Index to
Personnel Administration
Personnel--Management Abstracts
Pesticides Abstracts
Petroleum, Journal of the Institute (Abstract section)
Petroleum Technology
Philips Technical Review
Philippine Periodicals, Index to
Photographic Abstracts
Physics Abstracts
Plant Breeding Abstracts
Plant Disease Reporter
Plastics Fed, Abstracts, British
Plastics Technology
Poliomyelitis Current Literature
Prevention of Deterioration Abstracts
Printing and Lithographic Abstracts
Psychological Abstracts
Public Affairs Information Service Bulletin
Public Health Engineering Abstracts
Publisher's Weekly

Quality Control and Applied Statistics
Quality Control and Industrial Statistics Abstracts
Quarterly Cumulative Index Medicus

Radio Engineers, Institute of
Reader's Guide
Refrigeration Abstracts
Rehabilitation Literature
Report of NRL Progress
Research Information Service
Resins, Rubbers, Plastics
Revue d'Aluminum
Road Abstracts
Rubber Abstracts
Rubber Formulary
Russian Accessions, Monthly Accessions

Schnelidienst--Literature
Science Abstracts
Science Instr. Research Assoc., British
Science and Technical Papers, Abstracts of
Science and Technical Reports, Bibliography of
Semiconductor Electronics
SIPRE Bibliography
Sociological Abstracts
Soil Science, Bibliography
Soils and Fertilizers
Solid Propellants
Special Library Consultants
Specifications and Rel. Pub. Air Force, Index of
Specifications and Standards, U.S. Army
Specifications and Standards, U.S. Navy
Spectrographic
Stanford Handbook
Statistical Methods in Industry, International Journal of
Subject Index to Periodicals
Subject Index to Periodicals, British
Sugar Industries Abstracts
Surgery, International Abstracts of
Surgical Digest, International
Surgery and Gynecology, Quarterly Review
Synthetic Liquid Fuel Abstracts
Synthetic Methods of Organic Chemistry (Theilheimer)

Tappi
Technical Abstracts
Technical Book Review Index
Technical Digest Service (new)
Technical Journals
Technical and Electrical Industries-File
Technical Reports
Technical Survey
Textile Industry, Journal of the
Textile Technical Digest
Textracts
Tobacco Abstracts
Toilet Goods Association
Translated Contents List of Russian Periodicals
Translation Monthly
Tropical Disease Bulletin
Tuberculosis Index and Abstracts

United Nations Documents Index
Uniterm Index of Chemical Patents
Universal Oil Products Abstracts
Unlisted Drugs
U.S. Bureau of Census Cataloguing
U.S. Dept. of Commerce (Office of Technical Service)
U.S. Government Monthly Publication Catalogue
U.S. Government Research Reports
U.S.D.A. Medical and Veterinarian Zoology
U.S.D.A. Soil-Water Conservation
U.S.D.A. Fish and Wildlife

Vacuum Abstracts
Veterinary Bulletin
Veterinarius Index
Vide
Vitamin Abstracts

Water Pollution Abstracts
Weed Investigation, Bibliography of
Welding, Bibliographical Bulletin for
Welding Journal, British
Welding and Metal Fabrication
Wilson Indexes

Wireless Engineer's Abstracts
Wistar Institute
World Medicine, Abstracts of
World Veterinary Abstracts Journal

Z.D.A. Abstracts
Zoological Record

APPENDIX C

A REPRESENTATIVE LIST OF PUBLIC AND COMMERCIAL TECHNICAL TRANSLATING SERVICES

American Institute of Biological Sciences - Publishes four Russian biology journals in complete English translation.

American Institute of Physics - Publishes eight Russian physics journals in complete English translation.

American Mathematical Society - Publishes annual volumes of Russian mathematical papers.

Associated Technical Services - A technical translating service providing material in 25 languages. Also issues periodic lists of articles translated in chemistry, physics, electronics, medicine, etc., predominantly Russian, but including many languages especially among Soviet countries.

Berlitz Translation Service

Columbia Technical Translations - Publishes Physics Series of the Bulletin of the Academy of Sciences of the USSR.

Consultants Bureau, Inc. - Publishes 19 journals in the fields of chemistry, physics, electronics, geology, biology. Also issues translated tables of contents free and from time to time publishes collections of important papers on subjects of current interest.

Engineering Societies Library

Far Eastern and Russian Institute

Henry Brutcher, Technical Translations--Issues monthly list of translated articles available, with abstracts, from Russian, Polish, Japanese, German, and occasionally other languages.

Institute of the Aeronautical Sciences

International Physical Index Inc. - Translates, abstracts, and indexes over 60 leading Russian electronics and automation journals monthly. Complete bibliographic and translation services covering Russian language publications of the physical sciences also available.

Morris D. Friedman, Russian Translations - Issues frequent lists of translated articles.

Pergamon Institute - Publishes an English translation of the Russian journal "Elektrichestvo," and translates three leading Russian journals in the fields of radio engineering, communications, and electronics. Also translates and publishes Russian books in English. (Pergamon Press)

Primary Sources - Translates and publishes selected Russian technical papers from four Soviet journals dealing with research in metallurgy--to be published quarterly beginning with first issue (Quarterly Review) March, 1958.

THE NATIONAL TECHNICAL INFORMATION PROBLEM

Merritt L. Kastens, Assistant Director
Stanford Research Institute

Presented before the Subcommittee on Reorganization of the Senate Committee on Government Operations

GENTLEMEN: In accepting your generous invitation to appear before this body to discuss the problem of the use of technical and scientific information in this country, I appear not in the role of a specialist on information processing, but rather as a representative of those who need and use such information in their daily work. More particularly, I will presume to speak for the some 275,000 scientists and engineers in the applied research and development laboratories of American industry and of the U. S. Government agencies, as well as an equal number of their professional colleagues in production, sales, market research, and executive functions who depend upon technical information for the fulfillment of their professional duties.

I would call your attention particularly to the fact that I am speaking of the applied research and development community and its related activities. It has been my observation that the smaller community, estimated at some 24,000 by the National Science Foundation, of basic scientists has been amply represented before this and other groups interested in the subject by a number of spokesmen in government, notably those of the National Science Foundation; by speakers from some of the national professional societies and by prominent individuals.

It is not my intention to compare the relative worth of basic investigations versus the practical application of science and technology either on the basis of number of practitioners or any other basis. I do wish to call your attention to the nature and magnitude of the technical information needs of perhaps a half million highly-trained scientists and engineers who for various reasons have not been effectively articulate on this and other questions of national science policy, and who have a large interest both professionally and economically in the technical information problem.

I might add that by implication I also speak for the managements in both industry and in the Government agencies, which must pay the bills for the present inadequate and cumbersome information processing facilities -- a bill which SRI estimates presently exceeds one billion dollars a year. Ultimately, of course, this cost must be borne by the United States economy as a whole. I submit, gentlemen, that the United States economy is not getting its money's worth for this expenditure. I submit further that a rational and adequate system for fulfilling this national function is unlikely to cost a great deal more, and may very well ultimately cost a great deal less. The possible economic savings through the elimination of duplication of research and development effort and through the acceleration of the rate of technological progress which an adequate technical information system would make possible is extremely difficult to estimate quantitatively. However, they undoubtedly are large.

A very recent survey of a group of industrial laboratories engaged primarily in contract work for the Department of Defense produced the estimate that 30 to 85% of the research and development effort unwittingly duplicated work already completed elsewhere because of the lack of effective channels of technical communication. This in spite of the fact that this same group of investigators was already spending nearly 10 percent of its time in seeking information from existing technical communications media. An experienced government research administrator has stated that because of the difficulty of adequately searching the past record of science and technology for previous related work, it is no longer economic to attempt a literature search for any research problem in which the experimental cost will be less than $100,000. When smaller experimental programs are involved, it is cheaper to go into the laboratory and repeat the research. Most research administrators and most practical researchers have come to approximately this same decision, although they probably have not determined a specific dollar cut-off point.

However, there are other cases in which there is no economic alternative to using the existing record of scientific and technological accomplishment. I know of at least one military research program in which more than one million dollars was spent on the preliminary literature search before the experimental program could be outlined. I know of other military areas where budgets of several million dollars a year are dedicated to the continuing surveillance of limited areas of technology. Similar examples could be drawn from industry.

These examples, I would emphasize again, are from the field of applied research. Programmed research work directed at the ultimate solution of specific military and civilian technological problems not only accounts for more than 90% of the scientific and engineering effort in the United States but it makes greater and more explicit demands on the technical information system. Applied research is always done against a specific or an implied deadline. Time is of the essence in this kind of work. It may mean money; it may mean increased military potential; it may mean enhanced commercial competitive position, but it is always important. Therefore, the applied researcher whether in industry or in the government needs his information promptly. When operating decisions must be made based on technological factors, the data which may be of critical importance today may quite literally be useless a few months from now. It is readily understandable therefore that these kind of scientific specialists are extremely frustrated by retrieval systems, such as those offered by some existing abstract services which only permit location of needed information from three to five years after the experimental work has been completed and the results released for publication. It is small wonder that such applied research specialists spend so much of their time and of their organizations' money in traveling across the country or across the world to attend technical meetings to attempt to find out what is happening <u>now</u>. I know one West Coast company which has budgeted as much as 10 percent of its total research budget to send members of its professional research staff to technical meetings in an attempt to insure that it had the <u>latest</u> technical information.

The basic investigator, usually found in the academic laboratory, is under no such time pressure. The ultimate value of his completed work is by definition independent of the time at which the discovery is made. Furthermore, action decisions are seldom made directly as a result of a theoretical discovery.

The applied research specialist uses a much broader spectrum of information sources than the basic research man. The academic investigator is free to define his own problem and his own goal.

He tends to make this definition within the classical categories of science. Since the theoretical journals are in general obligingly organized along these same categories, the possible places where significant literature might appear are relatively few. The objectives set for the applied research men, unfortunately, do not come neatly packaged -- as problems in chemistry, or biology, or solid-state physics, or even electrical engineering. He is asked to devise a nose cone for a missile, or a practical treatment for a specific disease, or a production unit to accomplish a particular process. He therefore can expect to find useful information in the publications of a dozen or more disciplines at levels ranging from the most theoretical to the trade literature and perhaps even advertisements.

By the same token, in an advanced area of basic theory there often are only a few dozen productive workers in the entire world. Such a group can, and usually does, maintain more or less direct communications. They are reasonably assured that no important discovery relating to their interests will arise very far outside of this circle. The specialist with a practical problem knows that he must call directly or indirectly on the talents and knowledge of a broad range of specialists for the information he needs. He must turn to the formal literature to seek the help of those outside of his own organization and his own circle of acquaintances.

Finally, applied research tends to be episodic. A problem is presented; a workable solution is attained; another problem is presented. The applied research specialist is presented at periodic intervals with the need to acquaint himself with a new body of knowledge related to, but different from, that which he has used in the past. The fundamental investigator tends to devote his professional career either to one specific area of investigation or to a closely connected and regularly evolving series of subjects which are naturally related one to another. He seldom is faced with the need to locate and digest a large body of new knowledge in which he had previously had relatively little interest.

I have emphasized in some detail these differences between the activities of the applied research and development community and the basic research community in order to indicate the differences in both size and nature of their respective information needs. I think this differentiation is particularly significant in that it does much to explain why certain government agencies, notably the National Science Foundation, and some of the professional societies, and scientific information services have tended to appear complacent about the technical information problem. These organizations and their spokesmen either are part of, or are primarily influenced by, the academic scientist and engineer and the basic research specialist generally. Keeping in mind the relatively small size of the academic and basic research communities and, therefore, the relative simplicity of their information problems, and then, further, the nature of the need for and use of scientific information by this group, there may be strong justification for the statements by the groups' spokesmen that their problem is not large. They often seem to say, "Perhaps a little more money please, so that we can do a little more of what we are doing now; but for Heaven's sakes, let's keep the government out of the situation."

In marked contrast to this attitude is the sentiment which predominates in the industrial community and is strongly echoed by the technical agencies of the Defense Department. Here we find the belief that the cost of finding and using technological information is already oppressively large; that the present system for many practical purposes has already broken down; that the existing facilities are cumbersome, unreliable, and in some instances so thoroughly useless, that they must be duplicated again and again in individual laboratory organizations.

Both these positions can be justifiable. It may be that the basic scientific community does not have a serious technical information problem one that can be met by orderly improvement of the existing organizations and practices. It is certainly true that the much larger applied research community has a tremendous and critical problem in obtaining the scientific and technical information it needs and that this problem requires prompt, massive, and original action for its solution. I urge that this committee keep the distinction between these problems in mind in attempting to determine the proper role of the federal government in this field. Let me emphasize once more that these statements do not reflect any evaluation of the relative importance to our society of basic or applied research. They relate only to the characteristics of the technical information problem. They should by no means be interpreted to mean that the needs and interests of the basic research community should be ignored in this matter, nor do they imply that the proper solution to the information problems of the applied researcher would be of no use to the fundamental investigator. I believe that any system which would provide an adequate solution to the problems of the applied research community will automatically present considerable benefits to basic science and would almost certainly advance the rate of fundamental discovery.

If we agree that there is a real, national problem in processing technical information, what are the specific characteristics of the problem and what sort of mechanism is suitable for its solution? First of all, there is no question but that it is a large problem. Publishing, processing, and storing scientific and technical information is probably accounting for expenditures of about one billion dollars a year. The users of the informatiom must spend many additional millions of dollars to use this information. We have made some very rough estimates at Stanford Research Institute and believe that nearly 25 percent of our entire research budget is devoted to acquiring, processing, storing, and disseminating information. A major part of this expense of course is in the time of our professional staff spent in reading, searching the literature, attending seminars, etc. If our estimates are right and our experience is at all typical, then the various public and private organizations which during 1958 are expected to spend between $9 and $10 billion on research and development activities will be paying between $2 and $2½ billion for the use of existing technical and scientific knowledge. There is considerable overlap between these two figures but it may very well be that we are dedicating more than one-half percent of our gross national product to this problem of technical information systems. I do not mean to imply that this amount of money is in any sense wasted or that a <u>large</u> percentage of it could be saved through the development and use of an ideally operating, highly efficient information processing system. I <u>do</u> submit that it is a tremendous expenditure for a service which is not satisfying the vast majority of its users. Furthermore, there is ample evidence of duplication and inefficiency to show that the efficiency of the present system could be markedly improved and even a small percentage increase could return an impressive number of dollars.

Now, as large as these numbers are at the present time, the most disconcerting aspect of the situation is that most of the factors involved are increasing exponentially, i.e., they do not simply add a regular increment every year, but rather increase by the multiplication of some factor so that each year the added amount is greater than the year before. Total research expenditures in the United States are increasing on a pretty steady trend line of about 10 percent per year. Obviously, the more research we do, the more information we organize, the more material there is to be published, processed, and searched through, the more chance there is of finding something useful.

Unfortunately, superimposed on this growth curve is an unfortunate characteristic of present information processing systems. Indexes and catalogs tend to grow at a faster rate than the information they provide a key to. The cost of maintaining the same quality of service in a library goes up faster than the number of books in the library. You can see this in your own experience -- if you have a small library at home, you can find what you want with no system of organization. If your library is a little larger, perhaps you put in a crude system by shelving the books by subject or alphabetically, If you have a large personal library, you may need a simple card catalog, which will require the attention of a secretary or a clerk. Eventually you will need file cabinets, special desks, and all sorts of costly paraphernalia to make your library useful to you. Without having the figures, I would be willing to wager that the history of the budget of the Library of Congress would show some such exponential relationship between the size of the collection and the cost of servicing it. As a practical matter, however, libraries often allow the level of their service to deteriorate as they become larger rather than to support the oppressive additional cost of handling larger volume.

Finally, there is a factor in the growth pattern which is the most explosive of all and perhaps particularly significant especially in terms of the differentiation I have been emphasizing between the volume of research done in universities and that done in applied research laboratories. Just as there has been a marked trend during the past 25 years for the center of gravity of research efforts to move off the campus and into non-academic laboratories, there has been an even sharper tendency for the center of research library work to follow this same route. In 1940 there were about 200 so-called Special Libraries, mostly private industrial libraries, in the United States. In 1953 there were over 2500 such libraries. By 1955 there were nearly 4000. Today there are undoubtedly over 5000. The budgets of these special libraries vary widely, and it is extremely difficult to make a reasonable estimate of their total expenditures; but it is quite probable that their total expenditures now are approaching those of the combined university libraries of the country and their present trend line will take them well beyond the university library total within the next few years.

There is considerable difficulty in assessing the actual total size of the technical information problem, or, more pertinently, the probable size of the activity that would be required to pull the present services into a system. However, there is even less known about the qualitative nature of this problem. It is obvious that many kinds of people use technical information for a vast variety of purposes. They ask their questions in many forms. They need their answers in at least as great a diversity of forms. The relative importance, both quantitative and qualitative, of the various kinds of users and the relative needs for different kinds of answers is almost a wholly unexplored field. However, these questions must be understood and at least partially answered before an effective solution can be sought for the overall problem.

This lack of definitive information on the nature of the technical information problem has seriously hampered constructive thinking on the possible solution to the problem. The literature, including the testimony before this and several other legislative committees, records many opinions, guesses, ideas, speculations, and generalities. However, it is very difficult to come to grips with the problem or to consider the relative merits of various proposals put forward without having for comparison some ideas of the specific dimensions of the problem. As you know, Stanford Research Institute early this year recommended that the first operational step toward the solution of the problem must be a measuring, a survey, of just what has to be done, and what is being done. Subsequently, the Council for Documentation Research at a special meeting in February arrived at the same conclusion and petitioned the National Academy of Sciences to seek mechanisms to have such a survey made. The data from such a survey are even required to consider such questions of who should be responsible for the technical information system in the country, as well as what that system will be. Stanford Research Institute has stated that we believe this is a problem which requires coordination on a national level, and that the problem is of such magnitude and complexity that the planning and coordination function can only be accomplished by an instrument of the federal government. Now I am sure that we at SRI are no more inclined than other people who have considered this problem to impose a new responsibility on the federal government, nor are we anxious to introduce a new federal agency into either our professional or our operational program if it can be avoided. We arrived at our conclusion, perhaps reluctantly, as a result of a crude estimate of the size and complexion of the national function involved. We believe that the matter is too big to be handled by voluntary cooperation between separate activities, independent development by commercial interests of propriety devices and procedures, or as a separate private enterprise, either commercial or non-profit. It is significant that others who have suggested various non-governmental organizational schemes have without exception assumed that the problem was substantially smaller and simpler than we have.

It should also be pointed out that even our most generous estimate of the magnitude of this problem does not approach the size of the billion dollar budgets involved in the development and implementation, for instance of some of the missile weapons systems problems of recent years. We are still talking here in the range well below the cost of the development of a nuclear submarine, or for that matter the planning and construction of a large hydroelectric installation.

A further direct implication of our estimate of the nature of the problem is our belief that a solution must be sought through a single, planned, integrated,program of development which attacks all of the complex facets of the problem as they occur in relation to the problem as a whole. The same line of reasoning leads us to expect that the ultimate solution will be found in a single, integrated system operating as a coordinated network of activities, rather than as a multitude of independent activities somehow or other combining to meet a single need.

Now I must admit that our approach to this problem has undoubtedly been affected substantially by our experience with large "systems" such as the national banking system and particularly, weapons systems developments. Without wishing to emphasize unduly the military implications of timely, comprehensive technical information and its relationship to the speed of development and production of military hardware, it is not unwarranted in our present technological era to consider the technical information capabilities of this country as, in its own way, a weapons system. It is perhaps even more pertinent to observe that both the conceptual and mechanical complexity of the technical information function taken in its entirely is paralleled only in some of the larger modern weapons systems. In developing and making operational these complex capabilities, it was discovered some years ago that fragmentary, "cooperative," independent development and planning of individual components was cripplingly inefficient and too often a complete failure. We submit that the technical information problem is of similar complexity and requires similar techniques. Our experience in the systems approach to complex problems leads us to have profound respect for the power and efficiency of these techniques. With these techniques at our disposal we feel confident that a problem can be attacked in its entirety and that a workable and economical solution can be found. With this confidence, we see no need to attack the problem piecemeal, with some blind faith that somehow or another it will all work together in the end. It is also probably this experience with complex systems problems that makes us impatient with those who have counseled extreme caution, procrastination, or despair when confronted with this problem in all its complexity.

I would like to make one closing remark in regard to cost, particularly operating cost. The objection is frequently raised that any centrally administered program, particularly one run by the federal government, would attain monstrous proportions and would be too costly. A further argument contends that the cost of a machine system for storage and retrieval of information would be excessive because of high capital investment and would "freeze out the little fellow."

I have tried to point out earlier that the present costs of information processing are indeed monstrous, and it would seem to me to be contrary to our entire principle of our American economy to contend that by centralizing and standardizing an operation, eliminating manual effort and duplication, that our overall costs would be increased. Why in this particular kind of operation there should be the contention that hand-crafting and custom design of systems is less costly than what amounts to "mass production" is difficult for me to follow, but this argument is essentially presented. A more reasonable argument is that such a procedure would introduce some of the shortcomings of mass production--that the service would be less personalized, and less closely fitted to the specific needs of the user. This argument may very well be valid, but it too must ultimately be considered on economic grounds. We may then find that we will prefer a Chevrolet which will provide adequate transportation to a custom-made vehicle exactly adapted to each particular requirement or idiosyncracy which costs ten times as much.

The second argument, I believe, is also based on lack of knowledge or understanding of the economics of the present situation. Remember now that I am talking here only about the area in which the knowledge of science and engineering is applied to the practical problems of the world. Thus, the university scholar is excepted from this discussion for the present. From this special point of view, the "little fellow" has been long since frozen out. Adequate searching of the technical literature for the solution of any kind of complex technological problem under the primitive conditions existing today requires special talents and facilities as well as an expenditure of money well beyond the resources of the "little fellow," whether he be a scholar, inventor, or a small to medium-sized businessman. Granting our "little man" has the appropriate technical competence, he must gain access to a special library. The public research libraries adapted to the needs of applied research men in this country can virtually be counted on the fingers of one hand. The university libraries do not generally serve this purpose. They function largely as a depository in which the information may very well be available but can be reasonably located only by literature specialists or individual scholars with the profound knowledge of the literature of their field. Larger organizations have their own libraries and staff them with special librarians and literature subject specialists in order to be able to locate and obtain the technical information they feel their organization needs. Such facilities and staffs are expensive. Companies which support them do not do it for prestige reasons, but because it is the only practical way for them to make use of the existing hodge podge of literature services. The individual, or small organization, cannot afford such facilities. Even with facilities available labor and material costs for such a literature search of a problem of any complexity will run between $1000 and $100,000. In exceptional cases such as the military one I mentioned earlier, they may run substantially more than that.

Gentlemen, the "little man" is out of this business already. His only hope lies in a generalized facility where he can pay only for his pro rata share of the use of the facility and not be forced to maintain an entire independent facility of his own. In an information processing system which will give the information he needs at less than the present prohibitive cost.

If we go beyond the simple economic considerations to questions of social equity, a single, central system would make it feasible to effect policies whereby certain groups may be subsidized in their use of the technical information. Certainly, special privileges could be extended to outstanding scholars. Perhaps workers in certain fields such as medical research could be granted cost advantages. If it were deemed to be in the national interest, special provisions could be made to serve small businessmen at something less than actual cost. Under the present circumstances, such policies cannot be practically implemented. Some private information services do make their publications available at less than cost to universities and other selected groups. Many such services are subsidized through one medium or another by industry or even by government. But this is a hit or miss approach, which does not actually get to the major items of cost, nor does it permit very precise application to attain the greatest national good.

I thank you for your attention and will close by merely reminding you once more that we are dealing here with a problem which is already costing our economy a great many millions of dollars. It's cost in duplication of effort, in the delay of technological development, and in its detrimental effect on progress towards greater public health, and other social objectives is incalculable. It is a situation that is presently critical and is becoming worse at an alarming rate. It is a problem which must some day be solved for the United States and ultimately must be faced on a world-wide basis. I commend you for your interest and wish you success in your efforts to assure that a positive and rational national program is initiated.

A NATIONAL TECHNICAL INFORMATION CENTER

Introduction

The apparent ability of the USSR to effect technological innovations, particularly in the military area, with significantly shorter "lead" time than the United States has concerned our strategists, intelligence experts, and technical men since the end of World War II. The superiority of the Soviet performance in this respect was implicit in the development time-tables of the intercontinental bomber, the jet transport, the fission bomb, and other instances. It was demonstrated with disconcerting finality in the cases of the thermonuclear weapons; long-range ballistic missiles; and, most recently, satellite development.

Many theses have been put forward to explain this superior performance: tighter administration, better coordination, concentration of effort, more effective technical education, greater national prestige afforded scientists and technologists. All of these factors undoubtedly have a bearing on the problem, but they are largely intangible; they relate to differences in philosophy and attitudes--they are extremely difficult to compensate directly or quickly.

There is, however, one major tangible facility which serves all Soviet science and technology to increase the rate of flow of research and development effort. Such a facility could be created in the United States by direct effort in reasonable time. In 1952 the Soviet All Union Institute of Scientific and Technical Information was founded. Now staffed by more than 2,300 specialists, supplemented by 20,000 scientists and engineers who act as part-time abstractors and translators, its function is to accumulate the published technical literature of the world (10,000 journals, 80 countries), process it, and make available the information it contains in the most useful form possible. This Institute has proven its effectiveness to the extent that prominent American scientists have said that the best way to find out what American science is doing is to read the Russian literature. It is painfully apparent that no such facility exists in the Western world.

The operation of this Technical Information Center has undoubtedly been an important factor in aiding the Soviets in their race to overtake the West in science and technology. Through the operations of this Institute, Soviet scientists and engineers in even the remotest laboratories can have available to them abstracts, summaries, and translations of Western technical articles of direct interest to their field of activity within a very few months after the original material was published. There is no need to repeat work which has been done by other nations, and which may be had for the asking through their scientific and technical publications.

Examination of the history of any technical development from the theoretical discovery or unique concept through to finished hardware immediately shows that the major time interval is between the initial discovery and the design of a prototype device. In historical fact, this period may be as long as 50 to 100 years. Even the most involved production engineering seldom requires more than five or ten years. There is more time lost--or there is more time to be gained--between the laboratory and the drawing board than there is between the drawing board and the production line. And it is in this period, where ideas rather than physical materials are involved, that speedup is most feasible. Ideas have no inertia; they can be accelerated infinitely--subject only to the limits of our skill and facilities for information processing.

A Proposal

The technical community has suspected for some time that it is drowning in the flood of information and literature it is producing. The continued vitality of scientific progress may demand an organized solution to the information problem. However, in an era in which international competition is increasingly determined on the basis of technological accomplishment, the problem takes on compelling urgency. We can no longer afford the piecemeal efforts toward fragmentary solutions, which have been the only kind of efforts this problem has enjoyed in this country until now. The information system itself has become a "weapon system." It is the weapon system on which all military devices, as well as our peacetime progress, depend.

In the present world environment the solution to the technical information problem requires two steps. First, we must build an immediate interim facility to counterbalance an existing foreign military potential which has already proven its ability to work to our disadvantage in the present power struggle. Having this interim capacity in hand, we must work with all urgency to seek an ultimate, efficient solution to the problem of full and rapid utilization of the knowledge mankind has gained, and is gaining, through thought and experiment. We know our competitor in the great struggle has long since mounted his attack on this ultimate problem. We do not know how far behind we are, but there is ample evidence, both direct and indirect, that he has made substantial progress.

The course to the interim solution is clear. Conventional survey techniques can define the magnitude and the scope of present U. S. technical information processing activity. For this phase, there is neither time nor need for a profound systems-analysis of information processing operations, much less an intensive exploration of the mechanism of information transmittal. A valid statement of the size and general nature of the requirement will satisfy this preliminary phase.

With survey data in hand on the amount and kind of demand that exists for collection, translation, abstracting, codification, storage, and dissemination, the first national technical information center can be designed and established. In order to attain operation quickly, it must employ the best of available techniques and equipment. These techniques are essentially manual. It must utilize established information operations which have achieved partial solutions to the general problem, but which have not been previously coordinated. The initial operation will be awkward; it will be inefficient; above all, it will require many people. But it will be an operation. It will provide an American center where the knowledge of the world can be marshalled and made available to American scientists and engineers, managers, and planners. The inadequacies of this stop-gap system must be anticipated and accepted. The major goal in the design of the system must be to make it sufficiently general and flexible that it can be evolved into a more rational and efficient system as new techniques are conceived and new equipment developed.

Once steps are underway to meet the immediate challenge, the more profound campaign for a true understanding and solution of the ultimate problem can be begun. This campaign must enlist the skills of many branches of modern science. Many are now applied to the information problem, but usually in isolation or without generalized coordination.

Before the systems problem can be tackled, we must ascertain the state of development of the components. Psychology will contribute its knowledge of the learning process and problem-solving mechanisms. Library science has data about information patterns and inquiry characteristics and their interrelation. Linguists, semanticists, and lexicographers must provide the understanding of language structure necessary for machine translation and codification. The dramatic new discoveries in electronics--memory and storage devices, data-processing systems, remote reading and printing equipment--must be exploited and adapted to provide the mechanisms which will make a true information-processing system possible. Information theorists and statisticians have techniques which may be adapted to coding and searching information. Finally, the powerful techniques of systems analysis and operations research may be used to correlate these various factors and to define the characteristics of the complete system.

To coordinate the contributions of these varied fields to this problem and determine to relative states of their varied arts will be a demanding task, but one critical to the proper planning of a program to develop the ultimate information system. The development of that ultimate system is undoubtedly beyond the capacity of any one organization anywhere. It will require the participation of many teams from industry, universities, research institutes, and government laboratories. However, as has been learned in the development of other weapon systems, these various teams will contribute most effectively if their activities are coordinated and their general orientation planned by a central group.

Of course, the optimal system will never be developed. This is an open-ended job which will continue to achieve refinements for all foreseeable time. However, properly integrated with an operating information center, the development program can test and then install its equipment and benefit from continual feedback, which, in turn, will stimulate further discoveries.

The Goal

The true value to the nation's economy of a comprehensive and effective technical information center using high-speed automatic equipment is difficult to calculate, but it is of large magnitude. It has been estimated that such a facility would have the effect of increasing by at least 25 percent the effective supply of creative scientists and engineers by saving time now spent in laborious literature searching, and from the recovery of time now wasted in repeating work already done and reported but inaccessible in the present chaotic mass of technical literature.

Beyond these savings would be the elimination of much of the effort and expenditure now put into collecting and maintaining libraries by traditional methods--expenditures that are duplicated thousands of times throughout the country to perform nearly identical operations.

These savings--both the dollar recovery from the elimination of duplication of effort and the time gain in speeding the rate of technical innovation--apply not only to military activities but will accrue to an equal or greater extent to our entire civil economy.

Finally, there are the benefits which can be foreseen only generally. It is exciting to contemplate the stimulation and innovation that may be achieved through a facility which can bring to bear on a specific problem virtually all recorded thought and data, cheaply and quickly. There is a justifiable analogy with the introduction of high-capacity computers during the past decade. These devices have made possible entry into areas of research, and even areas of thought, that were inaccessible or inconceivable before these far-reaching extensions of human capacities were available. Similar new potentialities can be anticipated from high-capacity information processing equipment.

A well conceived and progressively operated information center will not be merely a highly inventoried warehouse of knowledge. It will be a creative tool for analyzing and correlating knowledge as it is reported in order to channel it quickly to the areas which have greatest need for it. It can be the constructive instrument with which to organize all that man has learned into a meaningful pattern, by which he can not only solve problems of practical technology, but perhaps gain greater understanding of himself and his institutions.

The rewards for the successful solution to the information processing problem, both economic and intellectual, are great. The political and military incentives for seeking this solution immediately, with high concentration of effort, are also great. Failure to grasp the information problem in its entirety and to seek a general and positive solution will increasingly entangle our technological society with unread literature and unused knowledge until we cannot fail to lose our present position of technological advantage. In a period in which both military might and international prestige are heavily dependent upon scientific and technical achievement, we cannot afford to fail to meet this challenge.

December 12, 1957

TECHNICAL INFORMATION PROGRAM

THE NEED

To cope with the avalanche of new technical data

To assure maximum utilization of all discoveries and developments made either in the United States or throughout the world

To permit correlation of discoveries in all fields of human endeavor to provide inter-stimulation and the opportunity for generalization

THE SYSTEM

- Collection
  - Selection
  - Extraction
  - Translation
- Codification
  - Abstracting
  - Coding
    - Synthetic language
    - Word frequency probability
    - Synthetic semantic code
  - Logic
    - Linear
    - Coordinate
    - Semantic
- Storage
  - Encyclopedic
  - Verbatim
  - Access (Index)
    - Storage of original information

Retrieval

- Form of question
- Programming
- Precision
- Form of answer
- Question storage

Dissemination

- References
- Original copy
  - Microfilm
  - Tape
  - Hard copy
  - Telefacsimile
  - Television
- Compendia
  - Abstract journals
  - Reviews
  - Data volumes
  - Analyses
  - Handbooks

THE RESULTS

Saving of time of engineers and scientists now spent in information seeking (as high as 35 percent in some fields)

Saving of time spent in duplicating research already reported but inaccessible with present facilities (percentage unknown, but substantial magnitude)

Saving of time spent in maintaining thousands of largely duplicated libraries (many millions of dollars per year)

Shortening of "lead time" between initial concept and production device (probably 2 to 10 years savings in many cases)

Quicker and more accurate appraisal of "state of art" in any field in this country and abroad.

January, 1958

A DRAFT PROGRAM FOR A NATIONAL TECHNICAL INFORMATION CENTER

THE PROBLEM

The preeminent position of the United States as a world power is dependent upon continued leadership in science and technology. Of vital importance to technical progress is the ready availability and applicability of discoveries, concepts, and data from all sources--past and present, foreign, and domestic.

Existing mechanisms for processing technical information are unable to cope with the present deluge of publications. The result has been enormous duplication of effort and expense, serious delay of technological progress, and failure to realize the full potential of a rapidly expanding military and civilian research effort.

THE PROGRAM

This document describes a program to solve the nation's technical information problem through the establishment of a national center for the collection, processing, storing, retrieval, and dissemination of scientific and technical information from both foreign and domestic sources. The program comprises the following actions:

1. Establish a central organizing and administering Agency.
2. Determine the gross dimensions of the problem.
3. Establish an interim information center using existing services and techniques.
4. Analyze the factors which determine the design and operation of an ultimate National Technical Information Center.
5. Encourage present and initiate additional research and engineering development programs leading to systems and equipment necessary to implement the ultimate National Technical Information Center.

NATIONAL TECHNICAL INFORMATION CENTER

Because of the size and nature of the National Technical Information Center, it should be administered by a federally constituted Agency.

It is strongly recommended that the resources and services of the Center be equally accessible to all research, industrial, academic, and government organizations throughout the country, consistent with security requirements.

In view of the breadth of service anticipated and the demonstrable economic value of these services, the Center should be at least partially supported through service fees from its various users.

There is no inherent limitation on the scope of subject matter which can be processed by an operation such as described here. However, in order to develop an integrated system in a reasonable time, it is desirable to place arbitrary boundaries on the information to be included. At present the most highly organized and easily defined body of information is the literature of the physical and biological sciences. There are compelling practical incentives to include the slightly less well organized literature of the various fields of engineering and medicine. It is recommended that the initial planning of the system be limited to not more than these categories. Once the Center is in operation, a well-conceived system can be extended to encompass the literature of law, the behavioral sciences, and other fields of importance, but which are presently less easily organized for systematic processing. This expansion should be undertaken at the earliest possible time.

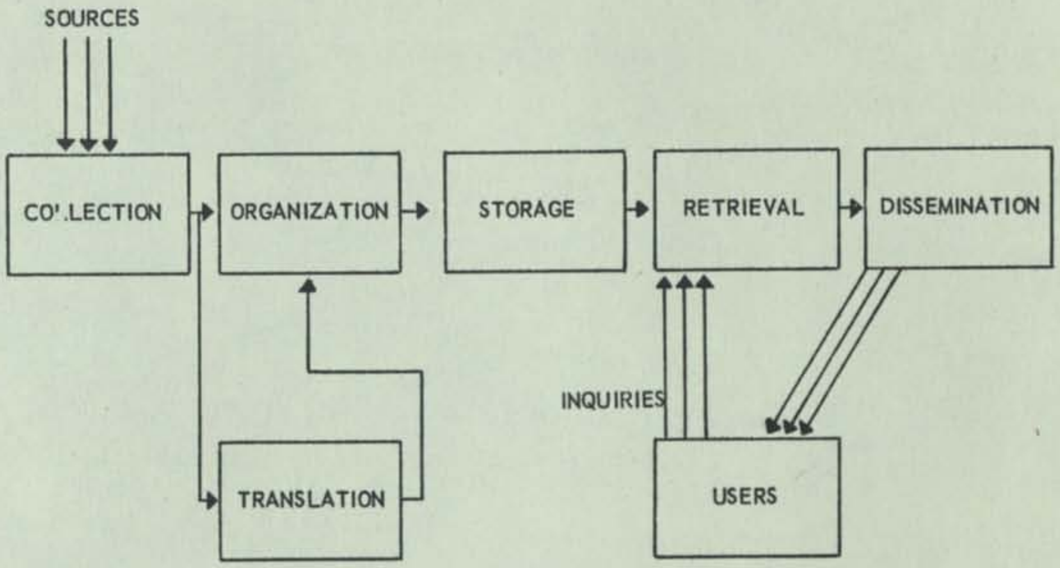
An inherent function of the central organizing and administering body is to establish a strong program of research. This research effort must probe into the origins, transmittal, and use of information. It must also develop the principles and mechanics of new devices for use by the Center. It is not intended that the Center itself conduct all or even a major part of such research and development programs, but rather that the Agency contract for and coordinate such efforts wherever they can be carried out most effectively.

The Center is expected to function as a coordinating and communications focus in its information processing operations rather than as a completely self-contained mechanism. Undoubtedly, a large volume of the operation will be conducted at a single location, but modern communication facilities make it unneccessary for the entire operation to be physically centralized. Furthermore, dispersed operation will permit exploitation of already existing capacities and thus make possible earlier and more economical operation.

The Center in its interim form will utilize large numbers of specialized personnel employing manual techniques similar to those presently employed by large technical abstracting services, such as that of the American Chemical Society and the Soviet Technical Information Institute. However, as the system evolves and as mechanized equipment is developed and becomes available, the operation should become increasingly mechanized. With this evolution the service should become speedier, more comprehensive, and more creative.

INFORMATION FLOW

The functions of the National Technical Information Center, in both its initial manual form and its ultimate highly mechanized development, can be represented by the following flow diagram:



A DRAFT PROGRAM FOR A
NATIONAL TECHNICAL INFORMATION CENTER

BACKGROUND

Man's most persistent medium for recording his progress and for communicating his ideas and discoveries to others is the written word. In the world of science this communication is formalized in periodicals, reports, and books. In recent years the rapidly growing volume of such publications threatens technical communications with a paralyzing glut and ultimate collapse. Inability to deal with the rising flood of technical publications has already seriously handicapped this country's industrial and scientific development.

Furthermore, increasing concern has been felt over the time for new products--particularly new military devices--to reach the manufacturing stage. History of any technical development from conception to the finished product shows that the major time interval lies between discovery of the basic principle and demonstration of its practical usefulness in the laboratory. This period may extend for decades. On the other hand, even the most involved development engineering seldom requires more than five or ten years. More time is lost--or more time is to be gained--between idea and demonstration than between demonstration and production. It is in this period, where ideas rather than physical materials are involved, that speedup is most feasible. Information has no inertia; it can be accelerated infinitely--subject only to the limits of our skill and facilities for transmission and correlation.

Existing information handling processes and library services are based largely on techniques developed more than fifty years ago. Recent research and development efforts have produced fragments of solutions at best. The continued vitality of scientific progress in this country demands a generalized solution to the information problem. In an era in which scientific and technological accomplishment is the measure of a nation's international stature, the problem is of compelling urgency.

MAGNITUDE OF REQUIRED EFFORT

The magnitude of an undertaking designed to process a major part of the world's technical information cannot be measured by any single parameter. However, certain figures emphasize the massive nature of the required effort. Informed estimates provide the following data on the world's ouptut of technical literature:

	Total	Annual Growth percent
Responsible technical journals	30,000 to 50,000	
Articles published annually	500,000 to 2,000,000	10 to 15
Technical books published annually	60,000	
Documents issued annually (U.S. Government only)	100,000 to 150,000	30 to 40

The heaviest users of technical literature in the country are the 200,000 professional research specialists who spend from 5 to 25 percent of their time seeking useful published information. The engineering profession makes much less use of such information by reason of its difficulty of access. The resulting duplication of development effort increases costs and injects unwarranted delays in product availability. Several thousand research libraries representing millions of dollars of annual operating costs and tens of millions of reference items utilize some 500 abstracting and indexing services in a valiant but futile effort to meet these informational needs. Coordination and integration of these services and operations would reduce the waste of money and scientific manpower.

In addition to struggling with the sheer volume of the literature, the American scientific community encounters an increasing complication in dealing with the technical information published in languages other than English. There is a serious lack of awareness in the United States of the growing significance of foreign technical publications. Limited data indicate that "pure" scientists refer to foreign sources (including those published in English) about 30% of the time; "applied" scientists 10%; and engineers even less. Apparently the information extracted from foreign language literature by U.S. scientists and engineers is very small, yet this literature as a whole is probably expanding much more rapidly than that in English. Furthermore, the number of languages in which technical information is being generated is increasing.

No complete information processing facility exists in this country or abroad. However, beginnings toward this objective have been made by the Soviet Union through the Soviet All-Union Institute of Scientific and Technical Information founded in 1952. Its function is to accumulate the published technical literature of the world, process it and distribute abstracts, reviews, and compendia as quickly as possible. The full-time staff of 2,300 specialists is supplemented by 20,000 scientists and engineers who serve as abstractors and translators on a part-time basis.* The relative effectiveness of this Institute is attested to by prominent American scientists who have said that the best way to determine what American science is doing is to read the Russian abstract literature.

Soviet scientists have undoubtedly found their technical information Institute an important factor in the scientific race with the West. Only a few months intervene between publication of Western research information and when it is placed in the hands of a Soviet worker in his own language. Duplication of research and library effort is reduced, thereby permitting more effective use of the scarce and valuable trained manpower, and all investigators enjoy the stimulation resulting from access to the thinking of colleagues throughout the world.

The Soviet Institute does not appear to provide extensive facilities for systematic searching of the literature. It is known to have a strong and far-advanced research and development program aimed at creating mechanized search and retrieval devices. It is reported that the Soviet Institute has an operational English-Russian electronic translator. Furthermore, the Russian operation seems to limit its scope to the physical sciences, biology, and some branches of engineering; excluding medicine,

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* An operation of this size in the U.S. would require an annual operating budget of about $60 million, excluding cost of journals and books; printing and distribution; and part-time abstractors and translators.

law, economics, civil engineering, and other valuable areas of information. However, having developed the procedures to handle some categories of technical information, presumably the Institute will ultimately extend its activities into additional subject fields.

METHOD OF APPROACH

The actions proposed below have two prime objectives, which must be pursued simultaneously. First, to meet the nation's most immediate needs, it is considered necessary that an interim technical information center be brought into being as quickly as possible to collect, process, and disseminate technical information. Second, to establish, following analysis and research, an ultimate National Technical Information Center, utilizing maximum mechanization for accelerating the flow of technical information from all parts of the world into the laboratories of the United States.

The success of the program depends inherently upon the coordination and continuity of the five actions outlined below:

1. Establish a central organizing and administering Agency.
   An Agency of the United States should be established with the responsibility and authority to make arrangements for the conduct of research, development, and operations relating to the interim and ultimate National Technical Information Center. The Agency will employ directly a small staff consistent with its policy making, contracting, and administrative functions.

   An extensive and continuing systems analysis of the nation's technical information problems and programs will provide the basis upon which the Agency will contract for new research and development projects. Privately supported research and development efforts will be encouraged when they are consistent with the Agency's long-range goals. Existing and new technical information projects conducted by other government agencies will be subject to the review and concurrence of this Agency. In this way all aspects of the national technical information problem will be dealt with in an expeditious, systematic, and well-integrated manner.

   Operation of the National Technical Information Center may be conducted under contract to the Agency. Such an operation will involve the coordinated participation of many supporting services, in conjunction with a central information processing and storage facility.

   Program details would be formulated by the Agency as the requirements develop.

2. Determine the gross dimensions of the problem.
   Before any steps can be taken to establish even an interim technical information center, it will be necessary to achieve a quantitative appreciation of the size and detail of the

work to be done and the service to be rendered. A survey to this end should be initiated promptly. The study would utilize known techniques, and would provide reliable estimates of the magnitude of various factors critical to entering into the interim operation. Among these are the volume of technical publications produced in various subject categories; the distribution of technical information sources by country and language; the general nature, frequency, and number of user inquiries; the numbers and types of personnel required to staff an interim center; the size of facility and types of equipment required.

Many organizations have already recognized the importance of the information problem and have undertaken studies of several of these factors. (See Appendix A.) These studies can contribute much valuable information for the design of the interim operation.

A large reservoir of facilities and experience in individual components of the information center's program is already in operation. Extensive but uncoordinated abstracting services exist. (See Appendix B.) In addition, an estimated 500-700 industrial research groups maintain abstracting services in their own limited fields of interest. Translating services are less fully developed, but some are in operation and probably could be expanded. (See Appendix C.) These and similar existing services will be inventoried and factored into the interim system to assure maximum economy and earliest possible operation.

These surveys can be completed in about six months if maximum practical concentration of effort is applied.

3. <u>Establish an interim information center using existing services and techniques.</u>

The nation need not await completion of extensive analyses or development programs before taking positive action to meet the immediate needs for better access to technical information. Immediate steps can be taken to establish an interim operation to perform at least part of the desired information processing functions using available techniques. The interim operation can provide at least translating, abstracting, and conventional indexing operations following procedures already developed by the major abstracting journals.

Unfortunately, the readily available techniques are largely manual. Fully developed machines are available only for small segments of the total operations. The available machines should be used in standard or modified form wherever possible. However, the interim operation will unavoidably require large numbers of specialized personnel. The supply of trained information specialists is small. Hence recruiting and training must be given careful thought in devising a plan for the immediate center if the plan is to be practicable.

The surveys outlined under action 2 will provide the basic parameters for the design of the interim center. Other studies of organization, operational analysis, machine feasibility, and short-term machine development programs will be undertaken as the interim center is brought into being.

The interim center will suffer from many inadequacies and inefficiencies, but an immediate partial solution to the nation's information problem will have been provided. Better organization and dissemination of technical information will significantly reduce the volume of literature which the individual scientist or engineer must use. Our research and engineering laboratories will have improved access to the findings of colleagues in foreign lands, particularly those lands which are beginning to contribute important technical and scientific discoveries. Furthermore, existence of a center in operation will provide an insight into the systems problem that would be difficult, if not impossible, to gain completely through theoretical analysis.

Fortuitously, we are assured that this interim approach is feasible. The initial operation of the Soviet Technical Information Institute was undertaken on a similar basis--in fact, Russian spokesmen have said that it was a conscious extension of the methods of the American Chemical Abstracts. The Soviet Institute is in operation and seems to be effective. Its research program of the past five years is reportedly now beginning to produce unique advanced equipment for the refinement and extension of the Institute's services.

An aggressively and realistically pursued program in the United States could result in a similar operating center within two years.

4. Analyze the factors which determine the design and operation of an ultimate National Technical Information Center.
There is a critical need to identify and evaluate the importance of the many factors pertinent to the design and operation of an ultimate National Technical Information Center. These include organizational and operational considerations. The organizational factor is particularly important for the encouragement of research necessary to implement successfully an ultimate information center, and it will be discussed separately later.

Human factors and machine factors constitute the two major operational considerations that must be systematically examined, and which will lead to a host of research problems. It is anticipated that systematic study of user needs and characteristics as well as research on the logic of information systems will have to be undertaken. Methods of classifying, abstracting, indexing, storing, retrieving and disseminating increasingly formidable amounts of information will have to be studied in detail. No scheme for accomplishing these operations adequate to the needs of the scientific community is yet at hand.

It will be necessary to consider many machine factors and potential advances in the state of the art. No present machine is equal to the task of storing the immense quantities of information available. Even further from solution is the problem of achieving rapid access to a specific small fraction of a very large body of stored information. The complexity of the situation is further increased by the need for machine translation and organization. Partial solutions exist. Printed matter can be read by machines to a limited extent; machine translation from one language to another has been demonstrated on a small scale; high-speed handling of printed documents and turning of book pages are under development; high-speed printing mechanisms are now in operation. Major improvement in these machine capabilities is certain. When current machine performance is considered in the course of the system analysis, improvements will be identified which can be pursued in the research program.

Certain of the boundaries of the system analysis will be determined by policy decisions to be made by the governing Agency. Who will pay for the service and on what basis? What kinds of information will be handled? Who will have access to the information?

The systems analysis will provide a basis for an objective design of an information retrieval structure that can meet the nation's information needs with least time, money, and effort.

Experience gained from the interim technical information center will also contribute to the programming of specific research and development projects and to the design of the ultimate Center.

5. Encourage present and initiate additional research and engineering development programs leading to systems and equipment necessary to implement an ultimate National Technical Information Center.

The Agency will guide the total research effort. It will encourage and support necessary research and development programs, prevent duplication of effort, and integrate and coordinate pertinent activities being undertaken throughout the country. It should have control over the rate of development of the Center, primarily through its control of funding for research and development work.

This Agency will be responsible for aggressively thinking through and supporting an extensive and uninterrupted long-term research and development effort. The magnitude of this effort will determine the rate at which the ultimate Center is designed and becomes operational. The Agency will be responsible for obtaining the services of individuals and laboratories possessing both capabilities and facilities for effectively contributing to the total program. Only through such an arrangement can an ultimate National Technical Information Center be established which will, in time, contribute markedly to the scientific and technical world leadership of this country.

BUDGETARY CONSIDERATIONS

This presentation provides only the broad outlines of a suggested program. Many refinements will have to be injected. Many details are ignored and many remain to be uncovered.

The intent here is primarily to indicate the magnitude of the program, something of the state of the art, and to suggest an approach to the solution of the compelling national need for better use of technical information. However, from these broad outlines and what is known about implementing programs of this size, order-of-magnitude estimates of immediate budget requirements can be made.

The compelling nature of the information problem suggests that funds be authorized immediately to pursue the initial investigation of the gross dimensions of the problem and to initiate the establishment of an interim center. Subsequent authorization of funds should also be sought to ensure an aggressive and continuing program. In addition, it may be assumed that private enterprise will continue to invest large sums in research and development, particularly on equipment necessary to mechanize information processes.

For the remainder of fiscal year 1958 a supplemental authorization of $2.0 million would meet the estimated needs of the governing body to support $500,000 for surveys and initial investigations, and $1.5 million to begin procurement of equipment and facilities to accommodate the interim technical information center.

It is too early to provide a definitive estimate for the fiscal year 1959 budget, but obligational authority should be sought for $50 million. Included in this figure are support of short-range research and engineering development necessary for the equipping and operation of the interim facility and for the beginning of the long-range systems analysis, initial staffing and operation of the interim center. Support of certain long-range research and development programs of obvious pertinence to any system for the ultimate National Technical Information Center should be initiated during this period. It is questionable whether an optimum long-range research program could be attained within the figure given here, but a valid estimate is impossible at this time.

For the fiscal year 1960 and subsequent years the annual budget can be expected to exceed $100 million. The upper limit will be determined by the aggressiveness with which the research and development effort is pursued. It will also be affected by the extent to which the operation of the National Technical Information Center will be made self-supporting through charges for services. Such income can be substantial in view of the large present expenditures of government and industrial organizations for individual services which may be relieved by the operation of the Center.

CONCLUSION

The technical information needs of the nation can be met by an intelligently conceived and earnestly pursued research, development, and operational program. Such a program will be difficult--it will be costly. However, it is neither more difficult nor more costly than other systems development programs which the United States has undertaken and completed to achieve and retain our internal and international status. The cost in lost prestige and technical stagnation which may result from failure to solve this problem might well prove catastrophic.

Stanford Research Institute has prepared the Draft Program for a National Technical Information Center as a public contribution to the solution of a national problem which it believes to be of critical importance.

The Institute's experience in systems design; operations research; information organization; and in the conception and development of information processing devices, we believe, provides a unique perspective into the complex scope of this problem.

The Institute maintains an active and expanding program of research in all phases of the information processing problem. The Institute invites consideration for a role in planning and coordinating, as well as execution of appropriate research phases of any national technical information program, such as the one outlined herein.

APPENDIX A

A PARTIAL LIST OF ORGANIZATIONS CONDUCTING RESEARCH AND DEVELOPMENT IN INFORMATION PROCESSING

All-Union Institute of Scientific and Technical Information (USSR)
Association of Special Libraries and Information Bureaux (England)
Battelle Memorial Institute
Birkbeck College (England)
Burroughs Corporation
California Institute of Technology
Cambridge Language Research Unit (England)
Case Institute of Technology
Chemical Abstracts Service
Columbia University
Documentation, Inc.
Dow Chemical Company
Eastman Kodak Company
Federal Telecommunications Laboratories
Eugene Garfield Associates
Georgetown University
Computation Laboratory of Harvard University
Herner, Meyer and Company
International Business Machines Co.
International Telemeter Corporation
Lehigh University Library
Librascape
Arthur D. Little, Inc.
Low Temperature Research Station (England)
Magnavox Co.
Massachusetts Institute of Technology
National Academy of Sciences-National Research Council
National Bureau of Standards
National Cash Register Co.
North American Aviation Inc.
Ramo-Wooldridge Corporation
RAND Corporation
Rutgers University
Sperry Rand Corp.
Stanford Research Institute
Teleregister Corporation
U. S. Patent Office
University of Michigan
University of Pennsylvania
University of Virginia
University of Washington
Western Reserve University
Zator Company

APPENDIX B

A PARTIAL LIST OF TECHNICAL ABSTRACTING PUBLICATIONS*

Accountant's Index
Acoustical Society of America
Acoustical Society Contemporary Papers, Journal
Aeronautical Engineers Index and Review Abstracts
Aeronautics, Index
Agricultural Index
Agriculture, Bibliography of
Agronomy Abstracts
Air Pollution
Air University Periodical Index
Allergy and Applied Immunology, Quarterly Review
Alloy Digest
Aluminum Abstracts Bulletin
American Concrete Inst. Proc.
American Documentation
American Journal of Nursing
American News of Books
Analytical Abstracts
Analyticus Cancer, Index
Anco
Anesthesia and Analgesia Current Index
Animal Breeding
Annotated Bibliography of Economic Geology
API Technical Abstracts
Applied Chemical Abstracts, Journal
Applied Entomology, Review of
Applied Mechanical Review
Applied Physics, Journal of
Applied Spectroscopy
Art Index
Asian Studies, Journal of
ASTIA Card Service
ASTIA Unclassified Reports
Astronomical Newsletter
Atomic Energy Reporter

Battelle Technical Review
B.C.U.R.A. Bulletin
Best's Bulletin Service
Bibliographic Index
Biography Index
Biological Abstracts
Biological Science, International Abstracts of
Book Review, International
British Abstracts
B.S.E.A. Abstracts
Building Science Index
Business Service Checklist
Buttersworth Card System

Canada, Bibliography of
Canadian Index
Canadian Patent Office Record
Cancer Current Literature
Card Service, Advance Abstracts
Ceramic Abstracts
Ceramic Abstracts, British
Chemical Abstracts
Chemical Abstracts, Analytical
Chemical Abstracts, British
Chemical Engineering News
Chemical Literature
Chemical Market Abstracts
Chemical and Physics Abstracts, British
Chemical Spotlight
Chemisches Zentrablatt
Child Development Abstracts
Cinnotalid Bibliography of North American Geology
Classified Reports (ABC), Abstracts of
Computers and Automation
Corrosion Abstracts

* From a survey by Western Reserve University

Corrosion et anti-Corrosion Abstracts
Corrosion Engineers Abstracts, National Society of
Crerar Metal Abstracts
Crippled Children Bulletin of Current Literature, National Society for
Cumulative Book Index
Current Chemical Papers
Current Technical Literature, Index to

Dairy Science Abstracts
Data
Dental Abstracts
Dental Literature, Index to
Dirivent Patent Service Dissertation Abstracts
Distillation Literature and Abstracts
Document Index
Dyers and Colourists, Journal Society

Eastman Kodak
Eastman Kodak Library Reports
Education Index
Electrical Engineering Abstracts
Electronics Abstracts
Engineering Index
Engineer's Digest
EPA Technical Digest
Essay and General Literature Index
European Technical Digest
Excerpta Medica

Fats, Oils, Detergents Abstracts
Field Crop
Files Coping the Technical News
Fisheries, Commercial, Abstracts
Fisheries Abstracts, F.A.O. World
Food, Current Abstracts
Food Science Abstracts (British)
Food, Index and the Literature Journal of Food
Forestry Abstracts
Fuel Abstracts

Gas Abstracts
Gaylor's Technical Service
General Electric Internal Bulletins and Reports
Geological Abstracts
Geographical Publications, Current
Geophysical Abstracts
Glass Technical Abstracts, Journal Society
Government Classification Cards
Great Britain Dept. of Science and Industries Research, Translation of Russian

Herbage Abstracts
Highway Research Abstracts
Historical Abstracts
Horticultural Abstracts
Hosiery Abstracts
Hospital Abstract Service
Hospital Literature, Cumulated List of
Hospital Literature, Index to Current
Hygiene, Bulletin of

IGT Abstracts
IMM Abstracts
Industrial Arts Index
Industrial Diamond Bibliography
Industrial Health, Achives of
Industrial Hygiene Digest
Industrial Labs
Information Service Bulletin
Ink Maker
Instrument Society of America
International Index
International Institute for the Conservation of Museum Objects
Interplanetary, British
Iodine Abstracts and Reviews
IPC Library Notes
IRE Abstracts
Iron and Steel Institute Abstracts, Journal

Labor--Personnel Index
Lectrodex
Leukemia Abstracts
Library Bulletin of Abstracts
Library of Congress Air Pollution
Library of Congress Bibliography of Translation from Russian
Library of Congress, Books; Subjects

Library of Congress Central Europe
Accession
Library Literature
Light Metals Bulletin
Literary Notes

Magnesium Review and Abstracts
Management Abstracts
Market Abstracts
Material Construction, Review of
Mathematical Abstracts
Medical Abstracts
Medical Digest, International
Medical Literature, Current List
Medical Science, International
Abstracts of
Medical and Veterinarian Mycology
Review of
Medical and Veterinarian Zoology,
Index-Catalogue of
Medicus, Index
Medicine, Modern
Metal Finishing
Metal Literature, ASM Review
Metals Journal, Institute of
Metallurgical Abstracts
Metallurgical Abstracts (British)
Metals Review
Meteorological Abstracts
Military Affairs
Milk and Milk Products, Abstracts
of Literature
Mond Nickel Bulletin
Monitor

National Defense
NACA Research Abstracts (Card File)
Natural and Synthetic Fibers
Naval Research Laboratories
Neurology and Psychology, Digest of
New Testament Abstracts
New York Times Index
Non-Destructive Testing
Non-Ferrous Metals, British
Nuclear Science Abstracts
Nutrition Abstracts
Nutrition Reviews
NYSEM Bibliography of Electr. Micr.

Obstetrics and Gynecology Survey
Official Gazette of U.S. Patent
Office
Olin Mathieson Chemical Corp.
Opthamalic Abstracts and Research

Packaging Abstracts
Paint, Colour, Review of Current
Literature Relating to
Paint, Varnish and Lacquer Assoc.,
British
Paint, Varnish and Lacquer Assoc.
National
P.A.I.S.
Paper Chemists, Bulletin of the
Institute
Paper Making and U.S. Patents,
Bibliography of
Pasteur, Bulletin Institute
Patent Journal (Union of S. Africa)
Patent Research Office Patent Lists,
International
Patents Abstract Journal (British)
Pediatric Current Literature,
Abstracts from
P. B. Reports, Index to
Personnel Administration
Personnel--Management Abstracts
Pesticides Abstracts
Petroleum, Journal of the Institute
(Abstract section)
Petroleum Technology
Philips Technical Review
Philippine Periodicals, Index to
Photographic Abstracts
Physics Abstracts
Plant Breeding Abstracts
Plant Disease Reporter
Plastics Fed, Abstracts, British
Plastics Technology
Poliomyelitis Current Literature
Prevention of Deterioration Abstracts
Printing and Lithographic Abstracts
Psychological Abstracts
Public Affairs Information Service
Bulletin
Public Health Engineering Abstracts
Publisher's Weekly

Quality Control and Applied Statistics
Quality Control and Industrial
Statistics Abstracts
Quarterly Cumulative Index Medicus

Radio Engineers, Institute of
Reader's Guide
Refrigeration Abstracts
Rehabilitation Literature
Report of NRL Progress
Research Information Service
Resins, Rubbers, Plastics
Revue d'Aluminum
Road Abstracts
Rubber Abstracts
Rubber Formulary
Russian Accessions, Monthly
Accessions

Schnelidienst--Literature
Science Abstracts
Science Instr. Research Assoc.,
British
Science and Technical Papers,
Abstracts of
Science and Technical Reports,
Bibliography of
Semiconductor Electronics
SIPRE Bibliography
Sociological Abstracts
Soil Science, Bibliography
Soils and Fertilizers
Solid Propellants
Special Library Consultants
Specifications and Rel. Pub. Air
Force, Index of
Specifications and Standards, U.S.
Army
Specifications and Standards, U.S.
Navy
Spectrographic
Stanford Handbook
Statistical Methods in Industry,
International Journal of
Subject Index to Periodicals
Subject Index to Periodicals, British
Sugar Industries Abstracts
Surgery, International Abstracts of
Surgical Digest, International
Surgery and Gynecology, Quarterly
Review
Synthetic Liquid Fuel Abstracts
Synthetic Methods of Organic
Chemistry (Theilheimer)

Tappi
Technical Abstracts
Technical Book Review Index
Technical Digest Service (new)
Technical Journals
Technical and Electrical
Industries-File
Technical Reports
Technical Survey
Textile Industry, Journal of the
Textile Technical Digest
Textracts
Tobacco Abstracts
Toilet Goods Association
Translated Contents List of
Russian Periodicals
Translation Monthly
Tropical Disease Bulletin
Tuberculosis Index and Abstracts

United Nations Documents Index
Uniterm Index of Chemical Patents
Universal Oil Products Abstracts
Unlisted Drugs
U.S. Bureau of Census Cataloguing
U.S. Dept. of Commerce (Office of
Technical Service)
U.S. Government Monthly Publica-
tion Catalogue
U.S. Government Research Reports
U.S.D.A. Medical and Veterinarian
Zoology
U.S.D.A. Soil-Water Conservation
U.S.D.A. Fish and Wildlife

Vacuum Abstracts
Veterinary Bulletin
Veterinarius Index
Vide
Vitamin Abstracts

Water Pollution Abstracts
Weed Investigation, Bibliography of
Welding, Bibliographical Bulletin for
Welding Journal, British
Welding and Metal Fabrication
Wilson Indexes

Wireless Engineer's Abstracts
Wistar Institute
World Medicine, Abstracts of
World Veterinary Abstracts Journal

Z.D.A. Abstracts
Zoological Record

APPENDIX C

A REPRESENTATIVE LIST OF PUBLIC AND COMMERCIAL TECHNICAL TRANSLATING SERVICES

American Institute of Biological Sciences - Publishes four Russian biology journals in complete English translation.

American Institute of Physics - Publishes eight Russian physics journals in complete English translation.

American Mathematical Society - Publishes annual volumes of Russian mathematical papers.

Associated Technical Services - A technical translating service providing material in 25 languages. Also issues periodic lists of articles translated in chemistry, physics, electronics, medicine, etc., predominantly Russian, but including many languages especially among Soviet countries.

Berlitz Translation Service

Columbia Technical Translations - Publishes Physics Series of the Bulletin of the Academy of Sciences of the USSR.

Consultants Bureau, Inc. - Publishes 19 journals in the fields of chemistry, physics, electronics, geology, biology. Also issues translated tables of contents free and from time to time publishes collections of important papers on subjects of current interest.

Engineering Societies Library

Far Eastern and Russian Institute

Henry Brutcher, Technical Translations--Issues monthly list of translated articles available, with abstracts, from Russian, Polish, Japanese, German, and occasionally other languages.

Institute of the Aeronautical Sciences

International Physical Index Inc. - Translates, abstracts, and indexes over 60 leading Russian electronics and automation journals monthly. Complete bibliographic and translation services covering Russian language publications of the physical sciences also available.

Morris D. Friedman, Russian Translations - Issues frequent lists of translated articles.

Pergamon Institute - Publishes an English translation of the Russian journal "Elektrichestvo," and translates three leading Russian journals in the fields of radio engineering, communications, and electronics. Also translates and publishes Russian books in English. (Pergamon Press)

Primary Sources - Translates and publishes selected Russian technical papers from four Soviet journals dealing with research in metallurgy--to be published quarterly beginning with first issue (Quarterly Review) March, 1958.