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THE CHANNELS OF TECHNOLOGY ACQUISITION IN COMMERCIAL FIRMS, AND THE NASA DISSEMINATION PROGRAM

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SUMMARY

Much of American industry is looking for new technology for application to its products, services, and processes. The Federal Government supports about two thirds of the nation's current research and development (R & D), and R & D is the primary source of scientific and technological information. Yet industry, except for that concerned with aerospace, defense, nuclear energy, and medical service, makes little direct use of the results of government-supported R & D.

The research report examines some of the problems of making government R & D results available for broad industrial use. Specifically, it describes the technology-acquiring process by which commercial firms get externally-generated technological information. Based on these findings, it suggests how government-developed technology might better be communicated to industrial firms, through the communication channels they customarily use.

Major Findings

Technology acquisition channels were studied in 62 commercial firms and organizations within four industries: battery, printing machinery and reproduction equipment, industrial controls, and medical electronics manufacturing firms. The channels used in 11 vocational-technical education institutions were also examined. The results are tabulated by industry in the report, but "industry" does not appear to be a very useful classification system for generalizing about technology-acquisition behavior.

This behavior is somewhat better described according to the functional responsibilities of the individual acquirer of technology. Three functional categories, (1) research-oriented personnel, (2) product-oriented personnel, and (3) technical management, personnel, are used as the basis for presenting some of the major study findings in the following table which identifies the six most important channels for two modes of technology acquisition—maintaining current awareness, and obtaining information to solve a specific task or problem.[1]

Possibly the most notable finding here is the importance of textbooks and handbooks for problem solving and the heavy reliance on trade publications for maintaining awareness. The crucial role of journals for research-oriented personnel and on supplier channels (supplier personnel catalogs) for product-oriented and technical management personnel is also significant. The other external channels studied but not ranking in the first six include (not in order): customer personnel, mass media, abstracting services,

[1]The 17 categories of channels evaluated are listed in table II-1, page 18, and are described on pages 24 through 27. The three functional types of personnel are defined in pages 22 through 24. The two modes of information search are discussed on page 23.

SIX MOST IMPORTANT CHANNELS FOR ACQUIRING TECHNOLOGICAL INFORMATION FROM OUTSIDE THE FIRM (ranked from top down in each category)

Type of individual	Mode of technology acquisition	
	For awareness	For problem solving
Research-Oriented	Journals Meetings Trade publications Texts Consultants Gov't publications	Journals Texts Consultants Meetings Libraries Supplier personnel
Product-Oriented	Trade publications Journals Meetings Catalogs Supplier personnel Texts	Texts Supplier personnel Catalogs Trade publications Journals Meetings
Technical Management	Trade publications Journals Meetings Supplier personnel Catalogs Texts	Supplier personnel Journals Texts Catalogs Consultants Meetings

dissemination centers, clipping services, formal courses, patents, associations, and others. These findings are based on research and data acquired through individual interviews, group interviews, and self-administered questionnaires—all carried out during 1966.

Ready access and familiarity with a given channel related well to the importance attributed to it. Government sources and channels, for government-supported research results, were generally rated low. Many commercial industry people are not acquainted with the government channels; those who know them often consider it too much trouble to winnow out the useful information from the masses of material (a criticism applied less strongly to other channels, too). The concensus was that "worthwhile" government contributions to technology would be reported through non-governmental channels.

Many in industry are somewhat aware, and somewhat suspicious, of the role of government in establishing new technology dissemination systems. There is skepticism about the costs of such systems. However, entirely apart from government channels, there is also a notable lack of information available in commercial firms about the cost or the effectiveness (to the firms) of their present technology acquisition activities. Based on very limited data, the annual costs of externally acquiring technological information are estimated at $3,000 to $12,000 per professional research, development, and engineering employee.

Suggestions

Suggestions for enhancing technology transfer are proposed in Section III of this report for industry, universities, and government. These include the following:

Industry could profit by developing better accounting and control systems for the acquisition and/or generation of new technology. The relative costs of acquiring technology from outside the firm versus re-inventing appear very difficult to compare based on the present quality of information available to individual firms. Other suggestions for industry touch on:

(1) The importance of industrial support of continuing education for scientists and engineers.

(2) The opportunities for productive new relationships between Federal agencies supporting R & D and the publishers of books and periodicals.

(3) The need for industry-wide participation in the development of new technology transfer systems—the establishment of which appears inevitable.

(4) The need for firms to actively seek out externally generated technology, relevant to the firm's interest.

The universities have wide opportunities to innovate in technology transfer, since they furnish many of the services and channels for new technology. Better integration of these into the teaching process appears feasible. Other suggestions for this sector include the need for:

(1) Expanded continuing education programs for industrial scientists and engineers, including off-campus programs.

(2) Re-examination of accrediting policies and other obstacles to use of industry and government employees as part-time faculty members.

(3) Greater emphasis by schools of librarianship on preparation for technology transfer problem solving.

(4) Greater emphasis on problem-solving and choice-making courses for science and engineering students.

(5) An acceptance, by academic researchers, of more responsibility for transfer, including transfer from their own sub-disciplines to local and regional industry, and interdisciplinary transfer within the academic community.

The Federal Government is taking responsibility and has the resources for establishing new national technological information systems. Close participation of broad segments of industry in the design and establishment of these systems would be helpful in making them most effectively contribute to the transfer of government-generated technology to all prospective users. Without such participation, industry acceptance and use of the systems is apt to be low. Overspecialized systems, usable mainly by limited classes of industry, might create new anti-trust and fair competition problems. Other suggestions for consideration by government include:

(1) Greater efforts to acquaint industrial scientists and engineers with the existence of government-sponsored research that is potentially useful in their work. This would involve information on both the sources of and the channels for acquiring such information.

(2) Greater and more selective dissemination through existing technology communication channels of government research results.

(3) Encouragement of closer relationships between government research centers and contractors, and university faculty and students.

(4) Development of means, through such Federal programs as the State Technical Services, to foster better library service on government research publications.

(5) The deductability from taxable income of expenses for all continuing education. This appears to be an important part of any national policy to enhance technology transfer.

(6) Consistency, among Federal agencies, on technology transfer and dissemination policies to ease the problems of the industrial firms interested in acquiring government-developed technology.

The text of the report details the concepts and findings of the research. It also relates the research to these and other suggestions for improved technology transfer.

INTRODUCTION

People who apply new technology may generate it from within their own minds, often with the help of information from others. They may find the needed technology elsewhere in their own organization, or they may acquire it from outside their organization.

The research reported here explored the latter process—the acquisition by industrial firms and organizations of technological information from outside their own organization. Specifically, it examined the technology-acquiring behavior of research, development, and engineering personnel in selected firms as perceived by the acquirers and their supervisors, and it identified and measured the relative importance which they attributed to the information channels used in this process.

Purpose

The study is designed to assist the Office of Technology Utilization of the National Aeronautics and Space Administration (NASA) in its role of disseminating information on new knowledge resulting from NASA aerospace activities to the business, scientific, and engineering communities, to other government agencies, and to interested public and private organizations.

The National Aeronautics and Space Act of 1958[1] requires NASA to provide "the widest practicable and appropriate dissemination of information concerning its activities and the results thereof." It is evident that NASA has energetically sought to carry out this charter: one which complements the necessary communication of information among participants in the space program, and one which coincides with the normal impulse to extend awareness of one's own accomplishments.

Inherent in the NASA Technology Utilization (T. U.) program is another dimension—speed—which complements the urgency attached to disseminating and circulating information within the space program itself. Mr. James E. Webb, NASA Administrator, has said:

> The Office of Technology Utilization has two basic goals: <u>to accelerate</u> the transfer of NASA's technological advances to the civilian/industrial community and to encourage efforts within regions to make the best possible utilization of space technology...[2] (emphasis added).

Also, Mr. Breene M. Kerr, NASA Assistant Administrator, Office of Policy Analysis, listed as the first objective of the Technology Utilization program: "<u>To shorten the</u>

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[1]Public Law 568, 85th Congress, 72 Stat.

[2]Address to Kokomo, Ind., Chamber of Commerce, Dec. 3, 1963.

time gap between the development of new knowledge and its broad and effective utilization"[3] (emphasis added).

Scope

This report concerns the technological information acquisition behavior and practices of research, development, and engineering personnel in four categories of manufacturing industry: batteries, printing machinery and reproduction equipment, industrial controls, and medical electronics; and in one category of service: vocational-technical education, both public and private. These offer an assortment of non-aerospace industries which are, in varying degrees, seeking and applying new technology, but they obviously are not representative of commercial industry as a whole.

The criteria for selecting these particular industries are described in Appendix C (Methodology) as are other limitations and qualifications about the results of this study.

Broad extrapolation from these results to statements about technology acquisition behavior throughout American industry is not justified. However, the analysis of these results may direct attention toward some aspects of the "big picture"—particularly the activities of industry, universities, and government where change should be dealt with or even encouraged.

The research, development, and engineering personnel in the participating firms were the major source of information. They included research and development staff in corporate and division laboratories, engineers concerned with product and process design and development, and technical administrators responsible for research and development and engineering activities. Response was deliberately sought from persons considered by their supervisors to be particularly active in technology acquisition from external sources; the respondents are, not therefore, typical of the average practicing research, development, and engineering personnel. Rather, they are the people who are counted on for acquiring technology from outside the firm. Information was also gathered from operating heads, librarians, and market research and planning staff.

This research placed primary emphasis on the external information channels, through which technology was acquired from outside the firm. The research objectives germane to this are as follows:

(1) Development of basic knowledge of how scientists and engineers in five selected commercial industries acquire technology from external sources.

(2) Determination of the relative importance of the different channels in each industry, and for each category of user (researcher, engineer, and others).

(3) Estimation of which existing and new channels have the greatest present and potential value for use by firms in the five industries in acquiring usable space technology.

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[3]Testimony before the Subcommittee on Advanced Research and Technology, Committee on Science and Astronautics, House of Representatives, Apr. 1966.

Technology Transfer

The concept of technology transfer has attracted increasing attention in the last five or six years. The growing effort to apply new knowledge to the development of hardware and systems required for national defense, for the space program, and for new industrial equipment, has drawn increasing attention to the processes by which knowledge is transformed into new products, processes, services, systems, and techniques.

Recently, large proportions of research and development spending have been concentrated in those agencies, institutions, and firms which conduct research and development for the government. Three-fifths of the nation's stock of research, development, and engineering personnel have been drawn into such government-related work. All of this has focused attention on the need to move scientific and technological knowledge out of the often-restricted government areas in which it is generated and to make it more available to commercial industry. This heightened interest has led to increased inquiry into the processes of technology transfer. Yet, there is no fully standardized definition of the concept—nor, probably, can there be.

Technology is here considered to be technical information, including scientific knowledge, making possible the conception, development, design, production, and distribution of goods and services. The term transfer means just that: the effective communication of such information from one person or source to a recipient who accepts it for consideration and possible application. Transfer is particularly concerned with the movement of information from one stage in the developmental process to another, e.g., vertically, from phenomena-oriented research to applied research to development; or horizontally, in movement from one sector of the economy to another. These concepts are described more fully in the report.

The Report

Some concepts of technology transfer and of the technology information acquisition process are described in Section I. From this perspective, the details of research research results are reported in Section II. These are largely empirical data gathered by interviews and questionnaires, and they classify technology-acquiring personnel and identify the communication channels they use.

The major institutions involved in technology transfer—government, industry, and universities—are identified in Section III. Their roles relative to information generated in this research are discussed and suggestions are made for additional technology transfer activities by each. Section IV describes NASA's technological information dissemination activities, and Section V presents a subjective evaluation of these activities. Appendices A, B, and C describe the industries studied, outline the research methodology, and present some material that supplements the discussion in Section II.

SECTION I

CONCEPTS OF TECHNOLOGY TRANSFER

This section describes concepts dealing with the technology transfer process. It offers two diffusion patterns that are characteristic, at least in part, of the technology transfer process, and discusses key factors influencing the process.

It should be emphasized that this research is concerned with the communication of technology. It has been suggested by Marquis and Allen that this is quite a different process from the communication of scientific information.[1] Their view is supported by the results reported here in Section II[2] (although these do not wholly support their contention that technological communication and scientific communication are largely independent of each other).

The Diffusion Concept

The complex process, of technology transfer is a part of a larger process: the diffusion of innovation. Rogers simply defines diffusion as the spread of a new idea from its source of invention or creation to its ultimate users or adopters.[3]

A more elaborate characterization of the diffusion process, and one which identifies its sociological elements, is given by Katz, Levin, and Hamilton:

> The process of diffusion is defined as the (1) acceptance, (2) over time, (3) of some specific item—an idea or practice, (4) by individuals, groups or other adopting units, linked (5) to specific channels of communication, (6) to a social structure, and (7) to a given system of values, or culture.[4]

Note that this definition requires acceptance or application of an innovation—not merely awareness of its existence. It also identifies time as a key factor. And it focuses

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[1]Donald G. Marquis and Thomas J. Allen: "Communication Patterns in Applied Technology." American Psychologist, Nov. 1966, p. 1052.

[2]The technological communication system described in Section II can be contrasted with the scientific communication systems as described by Menzel. Herbert Menzel: "Scientific Communication: Five Themes from Social Science Research." American Psychologist, Nov. 1966, pp. 999-1003.

[3]Everett M. Rogers: Diffusion of Innovations, The Free Press of Glencoe, N.Y. 1962, p. 13.

[4]Elihu Katz, Martin L. Levin, and Herbert Hamilton: "Traditions of Research on the Diffusion of Innovation." American Sociological Review, vol. 23, Apr. 1963, pp. 237-52.

attention on the importance of the social structure (e.g., the industry-government-university structure) as well as the system of values or the culture within which individuals and organizations operate.

The diffusion process applies to social customs, theological concepts, dress fads, new products, and new knowledge. The technology transfer process, as defined in the Introduction and as used in this report, is similar in nature to the diffusion process discussed above, but it differs in scope: it is limited to technical items and concepts; and while it involves understanding and acceptance by the user of information on the new technology, it may or may not involve application to the extent of embodiment in a product or process.[5]

The terms "new technology" or "innovation," used in this context, imply only that they be perceived as new by the individual or organization receiving them. They may be "old" in another firm, industry, or culture.

Functional Elements of the Technology Transfer Process

The technology transfer process as described by Welles, _et al._, assumes the existence of a body of knowledge (extant knowledge plus that continually being generated) and identifies two major activities: (1) the communication of technology, and (2) the application of technology.[6] Elaborating on this description, and utilizing the concept of an information transfer chain discussed in the report by President's Science Advisory Committee (The Weinberg Committee),[7] the functional elements, in simplified form, of the technology transfer process are illustrated in figure I-1.

As shown in figure I-1, the transfer of technology among individuals, firms, and segments of industry involves four functions: (1) the initial reporting activity of the innovator or generator of new technology; (2) the dissemination of this information toward potential users; (3) the acquisition of the information by a potential user; and (4) the evaluation and possible application of the innovation or new technology to the work in

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[5]The concepts of diffusion and technology transfer are discussed at greater length in Chapters VII and VIII, "Diffusion of Technological Information," in an earlier DRI report. John G. Welles, _et al._: _The Commercial Application of Missile/Space Technology_ University of Denver Research Institute, Denver, Colo. 1963, pp. 191-225.

[6]Six categories of technology transfer where missile/space _R_ & _D_ have made contributions to the commercial economy are described, with examples of each: (1) stimulation of basic and applied research; (2) development of new or improved processes and techniques; (3) improvement of existing products; (4) increased availability of materials, testing equipment, and laboratory equipment; (5) development of new products; and (6) cost reduction. John G. Welles, _et al._: Ibid, p. 2.

[7]President's Science Advisory Committee, _Science, Government, and Information, The Responsibilities of the Technical Community and the Government in the Transfer of Information_, U.S. Government Printing Office, Wash. D.C., 1963, p. 13.

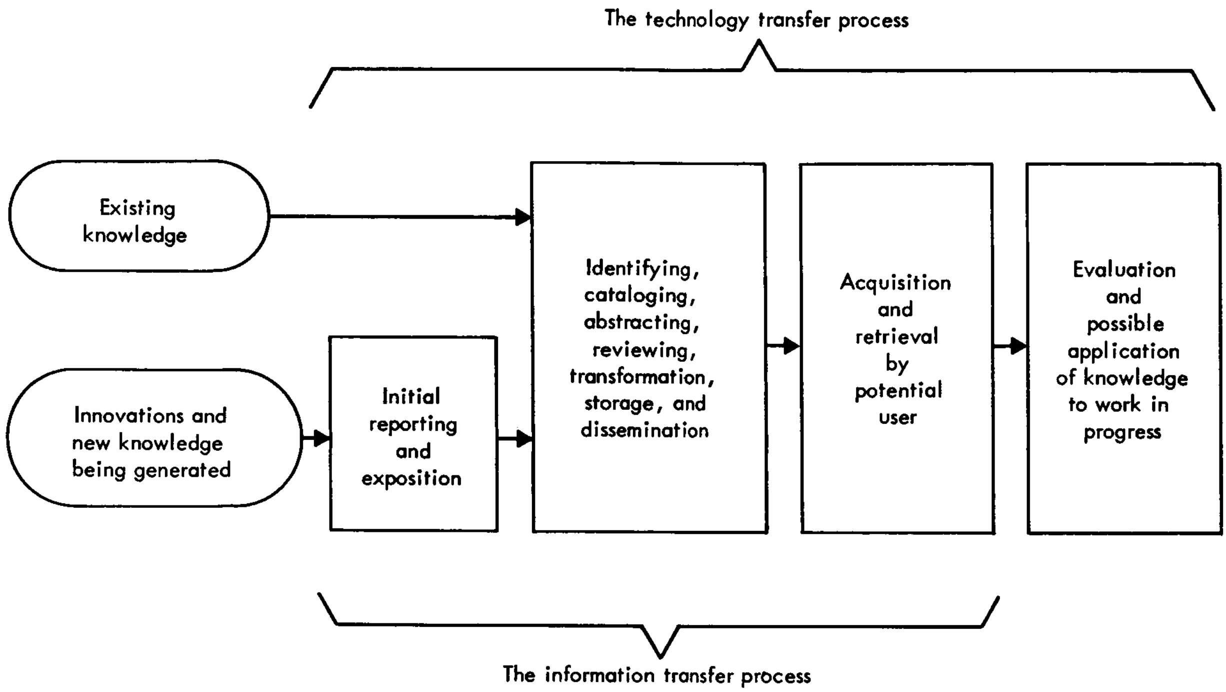

Figure I-1. Functional Elements of the Technology Transfer Process.

process. The first three activities constitute the information transfer process and include a variety of sub-activities, including: cataloging, indexing, abstracting, storage, reproduction, translation, synthesis and transformation. But merely making information available does not constitute technology transfer—a recipient must also make use of it. Use implies acceptance and evaluation of the information but not necessarily adoption of the technology.

The initial reporting and exposition activity is usually performed by the innovating individual or organization. The acquisition and application activities are performed primarily by the technology user or adopter. The document handling and information dissemination activity is performed simultaneously by technology generators, by potential users of technology, and by a variety of information specialists and transfer agents.

The activity on which this report focuses is the user acquisition activity—specifically, the technological information acquisition activity of individuals in selected commercial firms. It does not explore the last functional element in figure I-1—the application process.

Technology Diffusion Patterns

The discussion of the functional activities occurring within the technology transfer process fails to indicate direction as the process operates over time. The next subsection describes two characteristic patterns roughly observable within the transfer process.

Vertical diffusion.—There is a tendency for one type of innovation, phenomena-oriented ones generally resulting from basic research, to diffuse vertically as illustrated in figure I-2. Such innovations spread from a basic research environment through an applied research stage and on to development and product design stages. The laser and the transistor are typical of this class of innovation. As the phenomena become better understood and our ability to manipulate them increases, uncertainties regarding the phenomena decrease and more people are willing to manipulate and experiment with them. Concurrently, the experimental cost tends to decrease and the number of perceived applications tends to increase. Information on such an innovation, developed in one research lab, soon is picked up by other researchers, after which it is dealt with by developmental groups and eventually by those designing a product.

As the innovation traverses these vertical stages it also scatters, i.e., it tends to interest a greater number and variety of organizations. As the uncertainties associated with the phenomenon are reduced and the costs associated with experimenting decrease, more firms have the capabilities and resources to do something with the innovation. As the technology moves down toward the product level, the developments based on the original information may be less and less similar to each other, e.g., there may be less commonality in applications.

An innovation still at the research stage in the transfer process is reported through different kinds of channels than when it is ready for application at the product design

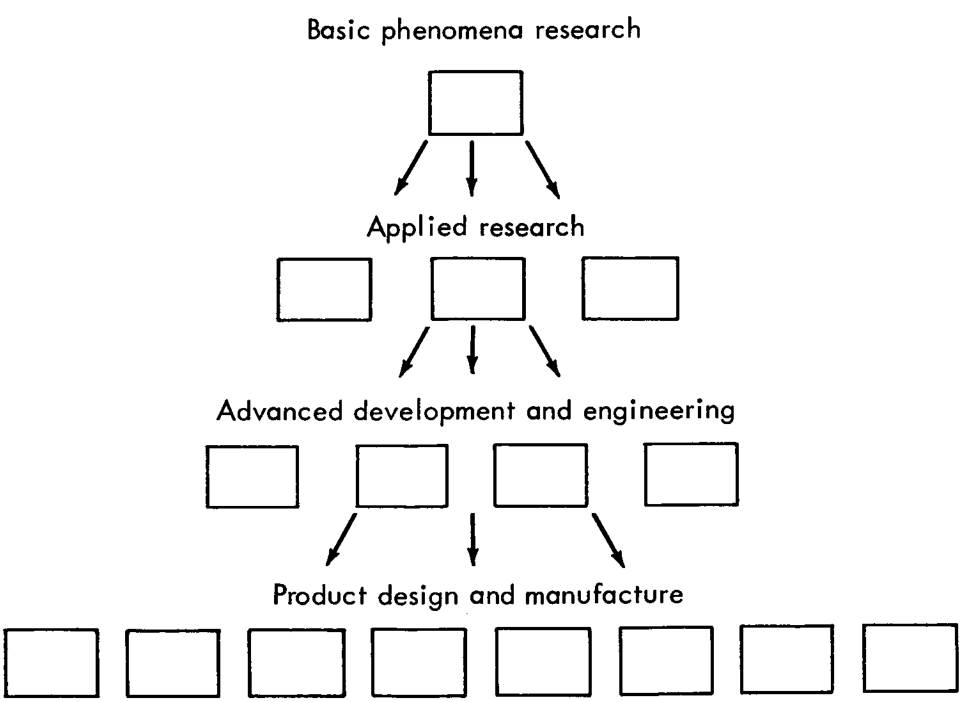

Figure I-2. One Dimension of Technology Transfer—Vertical Diffusion of Phenomena-Oriented Innovations.

stage. In the early stages, details about the innovation appear in the research and professional channels, while brief mention of the innovation may appear in the product-oriented channels and the mass media. Later, when the innovation is being adopted into materials or other products, details about it appear in the commercial, product-oriented, and trade publication channels. Such innovations are not necessarily dramatic; they may only lead to incremental changes.

While the above pattern appears to hold true for phenomena-oriented innovations, such as the laser, there is at least one other major class of innovations for which this may not be the case. This is the Edisonian or better-mousetrap type of innovation occurring in the form of a new product (the incandescent electric light) or incremental improvements to products or processes. These innovations may originate almost anywhere, certainly not just in a research environment, and they probably have less regular flow or diffusion patterns. Information about them may flow through a variety of channels, particularly commercial channels announcing their availability for sale.

Horizontal diffusion.—Another dimension of the technology transfer process is the horizontal diffusion illustrated in figure I-3. Innovations and new technology which first appear in the sophisticated, high-performance systems and products procured by government (especially DOD, AEC, and NASA) often tend to be applied next by manufacturers of materials and components, then by producers of industrial products and machinery, and finally this technology may affect manufacturers of consumer goods. This horizontal flow may start from any of the levels shown in figure I-2.

High performance, high quality, and durability are generally more valued for defense and aerospace products (at the left in fig. I-3) than for consumer goods (on the right). Thus a manufacturer of consumer goods tends to wait until an innovation, or new technology related to his product line, becomes well-understood and relatively inexpensive to utilize before he adopts it. However, he may rather readily develop or apply innovations in capital goods used in his processing or manufacturing techniques. Again, there is a tendency for scattering, i.e., as the cost and the uncertainties associated with the

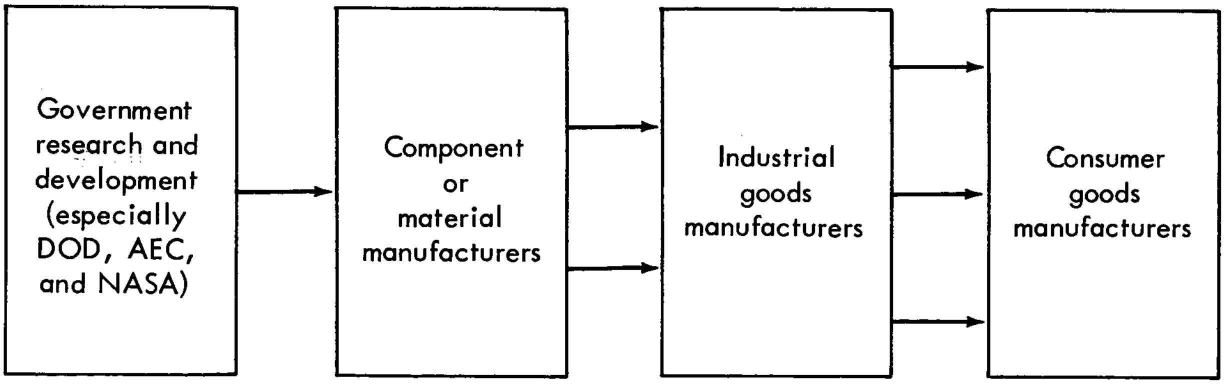

Figure I-3. A Second Dimension of Technology Transfer—Horizontal Diffusion with Scattering.

innovation decrease, more and more firms are willing to adapt and then adopt the innovation.

Examples of every stage of level-to-level and block-to-block flow (figs. I-2 and I-3) were described by respondents during this research. However, no effort was made to trace the full length of any vertical or horizontal flow.

Key Factors Influencing the Technology Transfer Process

Many factors influence the technology transfer process and add to it several dimensions of complexity. While it is not within the scope of this study to analyse these factors in detail, seven of them deserve mention. These factors interact with the four functional activities discussed earlier and illustrated in figure I-1, and also influence the manner and rate with which technology diffuses both horizontally and vertically.

1. Nature of the technology or innovation. —Technology is classified here into six types (as discussed more fully in Section II): (1) basic scientific knowledge, (2) design concepts, (3) analytical techniques, (4) production techniques or performance data, (5) new products, materials or services, and (6) new applications for existing products, materials, or techniques. Each type of technology interests different research, development, and engineering people at different points in time, and each may diffuse through unique patterns of information channels.

2. Nature of the innovator or technology generator. —The pressures operating on an innovator and the motivations for him to initially report on the innovation may differ greatly depending on whether he is a researcher, a design engineer, a test or production engineer, an entrepreneur, or a high-level manager. The researcher may be strongly motivated to publish, whereas the test or production engineer may simply wish to incorporate the innovation into his operations. The entrepreneur and the manager may be most strongly motivated to patent and exploit the innovation.

3. Characteristics of the transfer agent. —The nature of the transfer agent involved in the information process can also be important in determining who receives the information, how rapidly, in what form, and with what degree of credibility or perceived utility. If the transfer agent is sensitive or closely coupled to the needs of potential users and is able to screen and effectively evaluate information, he may be very instrumental in speeding the transfer of new technology or innovative ideas. A respected colleague or trusted salesman can be much more influential in transferring new technology than an information specialist or librarian. The latter may know how and where to find relevant information, but have little influence in achieving application, and may deliver much information that is not directly appropriate.

4. Nature of the technology user. —The use of technical information depends in part on whether the potential user is: a research-oriented person or a product-oriented individual; a key decision-maker in the firm or a relatively powerless lower-echelon engineer; an innovative person or an individual satisfied with the status quo. Each utilizes

different patterns of information channels and sources, each perceives and appraises an innovation differently, and each plays a different role in the technology acquisition and application process.

A problem of increasing acuteness occurs as technology becomes more specialized and fast-changing. The technical specialist may be insensitive to the seemingly remote political and economic implications of new technology, while the decision-makers who are presumably sensitive to these implications may have difficulty understanding and evaluating sophisticated new technology.

Not only do different types of individuals rely on different sources and channels for acquiring technical information, but every individual's information-seeking activity has multiple dimensions. A simple dichotomy adopted in our study separates problem-directed information searches from general awareness information acquisition.[8]

5. The organizational environment.—The organizational environment within which technology is generated, transferred, or acquired affects the transfer process. Is the industry old and traditional or a vigorous emerging one that values research results and depends heavily on a broad range of technology? Is the industry's market subject to competitive invasion by firms now outside the industry? Is the firm highly specialized or widely diversified? Does management prefer innovations which are revenue-producing or cost-reducing? Is the firm an assembler of components or does it produce all its own products? Does the firm have an effective library or an information acquisition system? Is the firm large or small?

These factors—and many more—affect technology transfer, but a given combination of factors does not insure uniform behavior by all firms so affected. Diversity seems to be the rule.

6. Nature of the information dealing with the innovation or new technology.—The manner in which the innovation is described can influence its visibility to and acceptance by a potential user. Is the description a highly condensed abstract, or does it discuss the technology in detail and include pertinent illustrations and data? Is the innovative

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[8]Menzel, elaborating on the work of Voigt, suggests five dimensions: (1) the current approach, motivated by the need to keep up-to-date with one's field; (2) the everyday approach, which demands information for the specific task at hand; (3) the exhaustive ap-approach, which calls for covering all the relevant information in a field (usually done prior to the start of a new project); (4) the brush-up-on-a-new field approach, that is, an area not previously attended too closely; and (5) browsing outside one's predefined area of attention approach. Menzel suggests that the first three should be further categorized by whether the individual is seeking information about data and results, or methods and procedures, or theoretical concepts; and by whether the information sought is within one's own field or some other field. Herbert Menzel: "The Information Needs of Current Scientific Research." The Library Quarterly, vol. 34, Jan. 19, 1964, pp. 4-19.

concept merely mentioned, or is it well described with a discussion of the significance and implications?

7. Nature of the media or channels in which the technical information is stored or disseminated.—Information channels have been categorized in many ways (e.g., formal and informal; oral and written; commercial and professional; or into the 17 channels discussed in Section II of this report).

Regardless of how the channels are classified, it is apparent that the nature of the channel used strongly influences the technology transfer process. An innovative concept may diffuse rapidly if introduced initially at a well-attended conference, whereas it may languish unheard of for years if initially reported in narrowly-read scientific journals or contract research reports. Fortunately, over a period of time, most new technology is reported through a variety of oral and written channels. This redundancy of channels permits innovative concepts to be discussed in a variety of ways and disseminated to different kinds of people. Information in one channel may reinforce or supplement that in another.

The Concepts, as Related to This Research

The major objective of this study was to explore the network of technological information channels presently used in commercial industry. The next section, which describes the information acquisition activities of individuals in selected commercial firms, approaches this task by identifying and evaluating the communication channels presently used for information acquisition activity. An attempt is also made to remain sensitive to other factors that influence the use of specific channels: the type of individual, the organizational environment, the motivation for the search, and the position of the firm and the industry relative to the vertical and horizontal diffusion patterns.

SECTION II

THE TECHNOLOGY ACQUISITION PROCESS IN COMMERCIAL FIRMS

This section describes the nature, scope, and significance of the technology acquisition activities of individuals and firms in four selected manufacturing industries and one category of educational service.[1] It examines the complex information network of external communication channels through which research, development, and engineering personnel presently acquire technological information. (See table II-1.) Additional related topics are discussed in Appendix B including a crude estimate of the costs incurred by a firm for its technological information acquisition activities.

Rough data on a firm's internal communication channels are also included to tentatively compare their importance to the external channels. However, primary attention is given to external channels.

Highlights

- About half of the firms contacted had formalized company information acquisition programs which included a library and one or more full-time information specialists, and only about 10 percent had what might be termed strong library services. Most firms relied primarily on the individual information acquisition activities of their personnel.

- The size and scope of company libraries and information services tended to increase with size of firm, but other factors appeared to be more important in determining the strength of a firm's information acquisition program: dependence on advanced technology, strong emphasis on research, management philosophy, and whether the firm was in a newly emerging and growing industry.

- Few individuals or firms seriously attempted to systematically assess their information needs and their information activities in terms of costs, or effectiveness in meeting needs, or in terms of alternative approaches.

- Individuals and firms needed and sought different classes of information relevant to new technology: (1) awareness that relevant or applicable technology exists; (2) leads and clues about where to locate needed information; (3) detailed technical information; (4) judgments about the significance, the secondary implications, the cost of new technology,

[1]The four industry categories studied were: batteries, medical electronics, industrial controls, and printing machinery and reproduction equipment. The service was vocational-technical education. The battery industry was selected as the pilot industry for the project, and was studied more intensively than the others. Appendix A contains definitions of the industries selected and an analysis of each industry's economic characteristics which may affect technology acquisition behavior.

and the time lag until its commercial availability; (5) evaluation of the quality, credibility, completeness, and limitations of the technical information.

- Each of the above classes of information was needed in varying levels of detail depending on the individual, his motivation for seeking the information, the nature of his task, and the time constraints.

- Because of the different classes of information and levels of detail needed, there commonly was a complementary use of multiple information channels, e.g., oral and written channels, commercial and professional channels.

- The typical respondent devoted roughly two hours a day to the acquisition of technical information.

- As a group, information channels within the firm were almost as important as all channels outside the firm. The printed media channels were about equal in importance to the verbal channels.

- When searching for information to solve a problem, individuals relied on different sets of external information channels than the ones they used in maintaining general awareness. For general awareness, professional journals and trade publications were the two most important channels, followed closely by conferences and meetings, supplier personnel, and catalogs. For problem solving, textbooks and professional journals were

TABLE II-1.—THE 17 EXTERNAL INFORMATION CHANNELS QUESTIONNAIRE RESPONDENTS WERE ASKED TO RANK

Supplier or vendor personnel
Vendor or supplier catalogs, etc.
Customer or contractor personnel
University and other outside consultants
Conventions, conferences, symposia, trade shows, etc. (and papers resulting from these meetings)
Trade publications
Professional journals
Libraries (other than personal or in-house libraries)
Textbooks and handbooks
Government publications, manuals, reports, etc.
Mass media—newspapers, TV, magazines, etc.
Abstracting or indexing services
Formal information dissemination centers (e.g., Battelle for metals)
Clipping services
Formal courses at a college or university
Patents
Professional societies, industry associations, etc.

the most important, followed closely by supplier personnel and by catalogs. If one combines supplier personnel and catalogs into a single "commercial" channel, this becomes the most important channel for both awareness and for problem solving.

- Ready access to and familiarity with particular information channels appeared to be major determinants of the channels an individual selected to acquire technical information.

- Research, development, and engineering personnel responding to our inquiry made surprisingly little use of some external channels which are actively in the information transfer business, such as libraries, abstracting and indexing services, or formal information dissemination centers. These channels were used more by technical librarians within the firms.

- Government sources and information channels were not highly regarded, nor extensively used. This was due in part to personal biases against government per se, partly to skepticism about the value of government-developed technology, and in part simply to unfamiliarity with particular government channels of potential value. Individuals who had some prior government or aerospace experience tended to be more familiar with government publications and to use them more, but they did not rate them more important than did those without such prior experience.

- There were major differences among the industries in the types of channels relied on, in the variety of channels utilized, and in the time devoted to acquiring technical information. The battery industry, for example, relied very heavily on one particular publication, whereas the other industries utilized a more diffuse pattern of publications.

- Three types of individuals, identified as research-oriented, product-oriented, and technical management, displayed very different patterns of information acquisition activity. They differed in the amount of time spent in acquiring information and in the types of information channels they used.

The Data

The data presented in this section were obtained in two ways: interviews with management and technical personnel in 73 firms (79 organizational entities) within the industries; and from 480 self-administered questionnaires completed by research, development, engineering, and technical management personnel. A sample of the questionnaire is included in Appendix C, Methodology. In most cases, interviews were conducted with the operating head of the organization, with key technical managers under him, and with one or more scientists and engineers in the firm. These interviews were used to obtain an overall view of the firm's management philosophy, its operations, its use of technology, and its information acquisition activities. The interviews were also a valuable source of evaluative comments and subjective assessments of specific information activities and channels—information which is difficult to obtain through self-administered questionnaires.

Of the 480 questionnaires returned, about two-thirds were from individuals within the 73 firms visited. The remaining (136) were from individuals contacted through publication mailing lists; they represent firms from other industries (including a few from aerospace), universities, and government organizations.

Respondents ranged from junior technical personnel without a college degree to senior researchers with Ph.D.'s; however, the respondent group is biased toward senior engineers and scientists, and men suggested by their superiors as being particularly concerned with technology acquisition. Also included were librarians, marketing personnel, and top-level managers. The distribution of highest degree attained was: Ph.D., 19 percent; master's degree, 26 percent; bachelor's degree, 50 percent; and no college degree, 5 percent. The majority had degrees in engineering, mathematics or the physical sciences. Median age of respondents was 40 years and their median annual salary was $12,400. (Appendices B and C, discuss the study methodology and limitations, respondent characteristics, and describe in detail the questions asked in the personal interviews and on the self-administered questionnaire.)

The "Typical" Questionnaire Response

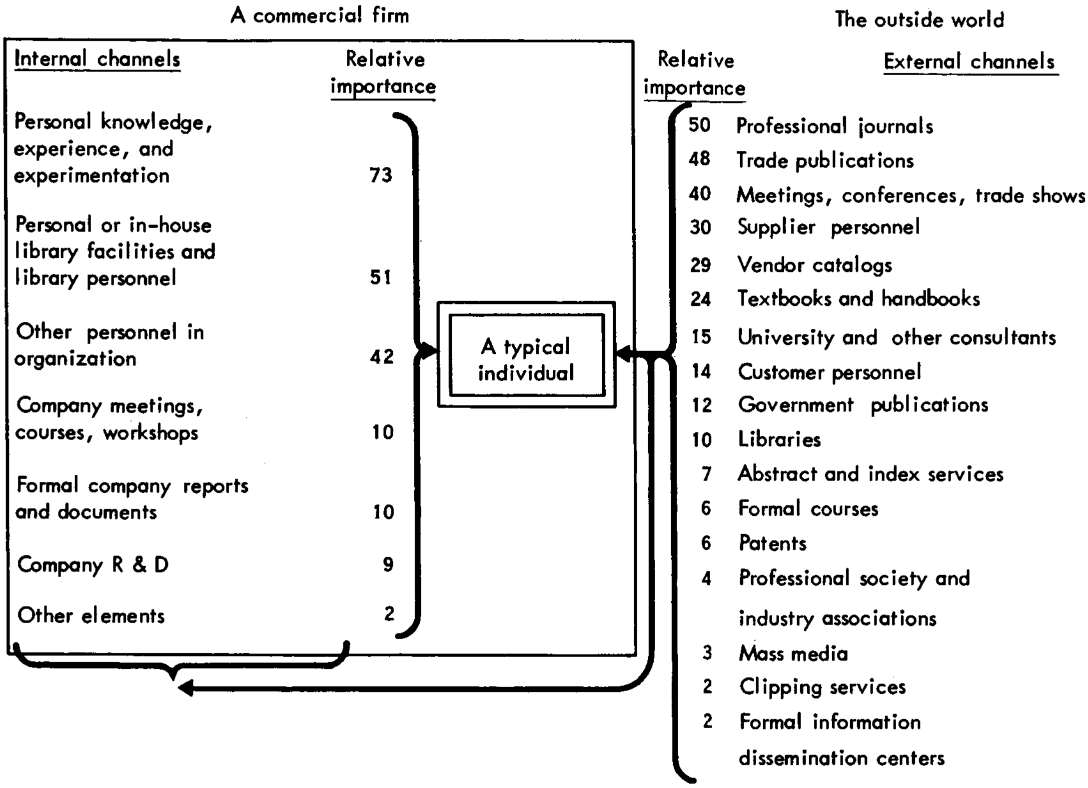
An overview of the "typical" individual's technological information acquisition process is illustrated in figure II-1. While this overview represents the average of all 480 respondents it is probably less meaningful than subsequent presentations by industry and type of individual, for there is no "typical" individual. Yet this overview approach provides a useful introduction to the technological information acquisition process. Two major classes of information channels (internal and external) are listed in decreasing order of importance, and alongside each channel is an index of importance. This index, whose maximum value is 100, was derived from weighted rankings of all 480 questionnaire respondents.

Aside from his own personal knowledge, education, and experience (here labeled a "channel" for convenience), the "typical" individual relied mainly on two channels within the firm: (1) his own or the firm's library facilities; and (2) other colleagues within the organization.

The external channels are ranked in figure II-1 by their importance for maintaining general awareness. We shall see later how these rankings shifted when an individual was engaged in a problem-solving search for information.

There is considerable variation in the nature of the first six external channels listed in figure II-1. Two of them, professional journals and textbooks, are clearly textual sources. Two of the others, meetings and conferences, and supplier personnel are predominantly verbal channels. The last two, trade publications (textual) and vendor catalogs (textual), could be grouped with supplier personnel (verbal) and called commercial channels.

The respondents indicated that the internal channels as a group were nearly equal in importance to all external channels for providing technological information. In some



The indices of relative importance were derived from weighted rankings, and have a maximum possible value of 100. The indices for internal channels cannot be compared with those for external channels. The "channel" of "personal knowledge, experience, and experimentation" is such a personally internalized source of information that it is almost impossible to compare with the other channels listed here.

Figure II-1. The Information Channels an Individual Within a Commercial Firm Uses To Acquire Technological Information.

contrast to this, Myers reports that for 75 innovations studied within six firms, 56 percent of the information inputs came through channels external to the firm, 13 percent through internal channels, and 31 percent through multiple channels not separately identifiable.[2] Allen, on the other hand, reports that while channels external to the organization may be more heavily utilized for obtaining technological ideas, the ideas and technical solutions generated within the organization are the ones most frequently accepted and applied.[3]

While it is difficult to clearly define formal and informal channels, one can distinguish between textual channels, i.e., those which use printed information, such as

[2]Sumner Myers, Industrial Innovations, Their Characteristics and Their Scientific and Technical Information Bases. A Special Report to the National Science Foundation (Washington: National Planning Association, 1966), p. 15.

[3]T. J. Allen, The Differential Performance of Information Channels in the Transfer of Technology. M.I.T., Sloan School of Management, Cambridge, 1966, p. 17.

professional journals, trade publications, vendor catalogs, textbooks, government publications, libraries, etc., and verbal channels, those which rely heavily on verbal communication, such as other personnel in the organization, company meetings, supplier personnel, conferences and trade shows, customer personnel, etc. Using these categories, it appears that textual channels were about equal in importance as a group with verbal channels. Most individuals tended to use both verbal and textual channels in a complementary manner.

Identifying the Three Types of Respondents: Research, Product and Management

It was anticipated that there would be significant differences in technology acquisition among the five industries on which we concentrated our research, and differences were found in the number and kinds of publications used, in the nature and effectiveness of professional and trade organizations, and differences in the kinds of technological information sought. However, there appeared to be equal or more important differences in technology acquisition behavior among firms within the same industry. The proliferation of conglomerate firms and the dependence of almost all firms on an ever increasing variety of technologies makes industry classification rather meaningless for attempts at generalization.

It soon became apparent that there was another dimension or classification approach which was at least as significant as the industry classification: a classification by function of individual respondent. Field interviews and questionnaires both suggested that there were three separable response patterns and that these related to work activity and responsibility. The three types of individuals were categorized as: research-oriented; product-oriented; and technical management. The criteria for sorting respondents into these three categories are not precise and it was necessary to use some subjective judgments based on an individual's answers to many questions contained in the questionnaire.

The following guidelines and criteria were used in identifying a respondent who fell in the research-oriented category. He was essentially concerned with phenomena or analytical kinds of problems. He could be doing basic or applied research or pre-prototype design and development. He typically would be titled research scientist, research engineer, project supervisor, or senior scientist. He was more apt to have a degree in physics or chemistry than engineering, and he was apt to have a Ph.D. In his response to the problem-directed search section of the questionnaire, he tended to work toward understanding, measuring, or applying knowledge of natural phenomena. In his ranking of types of technology important to his job he was mainly concerned with basic scientific knowledge, analytical techniques, or possibly new products, materials, or components.

The product-oriented individual met somewhat different criteria. Essentially he was concerned with the application of available materials and components for the development, design, and production of a product. While he might hold any title, typically it would be product engineer, test engineer, or development engineer, and his degree was more apt to be in engineering than in physics, chemistry, or mathematics. His problem-directed search tended to involve the application of usable and saleable technology, including the selection of components, prototypes, and production items. In his ranking of types of technology most important to his job, he tended to rank highest design concepts, technological performance, new applications, and new products.

Guidelines for classifying an individual as a technical management type included: that he was typically an administrative, high-level manager of technical personnel spending the majority of his time away from technical work. For convenience, a few were in staff positions, e.g., market research or planning. A few librarians were also included in this category. He might have either a non-scientific or engineering degree and generally his salary, except for librarians, tended to be over $20,000 a year.

While it was relatively easy to identify those who fell into the management category, it was generally more difficult to determine whether an individual was in the research or product category. The respondents in the vocational-technical education industry were the most difficult to classify into the three categories, whereas those in the pilot industry, i.e., the battery industry, were fairly readily classified. Thus, because the three categories were not precisely defined and because complete information about the respondent was not available, the three groups are neither precise characterizations nor clearly distinct.

Despite its drawbacks, this scheme for classifying individuals into three types appears useful, for each of the types exhibited unique characteristics in the kinds of channels used, the kinds of information desired, and the manner in which information was sought and applied. Support for this conclusion that the information acquisition patterns of research-oriented personnel differ markedly from those of product-oriented personnel was recently reported by Marquis and Allen. As a result of their recent research, they, "...conclude that the communication patterns in the two areas of activity are not only largely independent of one another, but qualitatively different in their nature."[4] The "two areas" they refer to they identify as two streams of activity: (1) "...variously called science, pure science, basic research, or fundamental research..."; and (2) "...a parallel activity which includes applied research, exploratory development, and engineering development."[5] They label the latter "technology." The two groups they describe are more distinct than the research and product categories used in this report; almost all "research-oriented" personnel contacted during this project were doing applied research and are considered to be in the area of technology.

While the data are not conclusive, it appears that differences among these three types of individuals were more fundamental than those occurring among the five industries examined, and hence can be more confidently extrapolated to other individuals in other commercial firms or industries. While it appears safer to generalize from type of individual characteristics than it does to generalize from industry characteristics, there

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[4]Donald G. Marquis and Thomas J. Allen, "Communication Patterns In Applied Technology." American Psychologist, Nov. 1966, p. 1062.

[5]Ibid.

are obvious limitations to both. Results are tabulated both by industry and by type of individual.

The distribution of the three types in each industry were relatively similar, except for the battery industry which included a much higher proportion of research-oriented personnel and fewer management personnel. In the battery industry, 38 percent of the respondents were research-oriented, compared to a 3 to 13 percent range in the other industries. (See table B-2 for distribution by industry.) Some of the inter-industry differences are probably accounted for by this variation in mix.

External Channels—Definitions and Characteristics

Evaluation and analysis of external information channels used to acquire technical information were based on a classification of 17 types of channels. Table II-1 lists these 17 categories as they were defined for questionnaire respondents. Semantic difficulties and imprecise distinctions among categories caused some apparent confusion for respondents, particularly with respect to trade publications and professional journals. A few respondents who listed only trade publications among the technical publications they regularly read ranked professional journals above trade publications in importance—indicating that they probably considered these to be "professional" journals.

Supplier and vendor personnel were very important sources of technical information, particularly for engineers. Supplier personnel are often technically trained field representatives, engineering liaison personnel, or even the supplier's R & D personnel, all of whom were valued for four reasons: (1) their ability to understand and discuss technical problems; (2) their ability to suggest a variety of possible solutions based on their familiarity with analogous situations in other firms, which places them in the role of an informal consultant or interacting sounding board; (3) their accessibility, both in terms of the ease with which they can be approached and their ability to provide quick answers about products and materials; and (4) their role as sources of information on new products, materials, and services about to appear on the market.

While vendor or supplier catalogs serve many of the same functions as vendor personnel, they cannot provide personal interaction, and they tend to be less up-to-date. Yet catalogs were very important because they provided the very specific technical information typically desired for day-to-day tasks, and individuals could keep them in their personal files for instant reference. The compendium or multi-manufacturer type catalogs also were valued for comparing competing lines of components, and for providing leads on whom to contact or where to look next. Catalogs were sometimes criticized for their lack of price information.

Customer or contractor personnel were relatively unimportant sources of information unless they were key technical personnel. Apparently most contacts with customers or contractors were with buyers or project monitors, who as administrators lacked technical expertise. However, many individuals interviewed felt that government contractor personnel could serve as valuable information sources, for frequently they are the most knowledgeable about critical state-of-the-art problem areas and have access to many innovative concepts and valuable technical information. Customer personnel were often mentioned in interviews as useful sources of information on competitors' products. Information from customers was sometimes formalized through lost sales reports or customer needs reports required of the firm's own salesmen.

University and other consultants were typically used in two ways: to solve or investigate specific problems; or to serve as awareness aids and idea stimulators through informal dialogues with staff members. Frequent disappointment was expressed in results furnished by consultants, both individual consultants and the larger consulting firms, when they were asked to explore general areas rather than specifically defined problems.

Conventions, conferences, symposia, and trade shows were highly ranked channels not so much for their formal presentations or papers as for the opportunity they provided to meet and exchange information with colleagues and to inspect new product displays. Many individuals questioned indicated that formal papers presented at meetings tended mainly to serve the interests of the speaker (by boosting his status), and that they typically failed to include proprietary or really useful information. The major value of meetings was the opportunity for informal discussion and the opportunity to directly question and evaluate those researchers making presentations. Equipment displays may offer similar opportunities. While both local and national meetings were important, the highest value was placed on meetings which narrowly focused on the individual's particular field of interest.

Trade publications were extremely important sources of information, particularly for the product and management types of individuals. Trade publications tend to cover restricted fields and deal with applicable technology within the state-of-the-art, and the many trade publications within the same field tend to duplicate coverage of innovations and new technology. They were valued for their technical articles, which tend to be practically oriented or of the survey type; for their general news of the industry or subject covered; and for the information they provide on new products through both advertisements and new product sections.[6]

Professional journals, which were rated extremely important sources among researchers, tend to be oriented toward specialized disciplines and serve as a forum for the more fundamental and state-of-the-art work in a field. Some have very strict review and screening requirements for submitted papers and accept no advertising. Others include invited papers, staff-written survey articles, and carry advertising. Many professional societies publish both types, using the latter to carry society and industry news and applications information.

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[6]Scott suggests that periodicals are most useful in supplying "...useful information which is not being deliberately sought...". His respondents tended largely to read trade publications. Christopher Scott: "The Use of Technical Literature by Industrial Technologists." IRE Transactions of Engineering Management, EM-9, June 1962, pp. 76-86.

Libraries outside the firm were more important for problem-solving searches than for general awareness, but were not widely used sources of information. Librarians within the firm tended to be the main direct users of public and university libraries outside the firm, although these uses were often in response to requests by staff members. Because of the specialized nature of their in-house libraries they used outside libraries for information not directly pertinent to the field of the company. The medical electronics industry was the heaviest user of external libraries, in part because the firms tended to be too small to afford large in-house libraries and in part because the development of medical instruments required much research in the extensive medical literature.

Textbooks and handbooks tend to be from two to five years or more behind the state-of-the-art. Nevertheless, they were one of the most important sources of information for problem solving. Written primarily by academicians, they provide the broad, in-depth coverage a periodical cannot. The tables, charts, and indexes were considered particularly useful. Another apparent reason for their importance was the familiarity individuals had with texts used in their formal training. Having learned to use a particular text or handbook, they continued to rely on it. Textbooks were particularly important in vocational-technical education.

Government publications were not perceived as major channels for acquiring technological information. The variety and mass of government publications tended to overwhelm people and many were simply not familiar with potentially useful sources, and did not know how to screen and select relevant material. Specialized government publications such as the U. S. Patent Office Official Gazette were used and highly valued by at least one individual in most firms. Most individuals felt it too difficult to retrieve relevant material from the mass of government publications and indicated that they expected to learn of important government-developed technology through trade and professional channels. In several firms, those interviewed felt that it wasn't really practical to keep up with and use government technology unless one's firm had government R & D contracts.

Mass media including newspapers, popular magazines, radio and television were seldom sources of detailed technological information, although many expressed the view that television in particular could be. They did occasionally convey initial awareness of innovations, but seldom provided information in adequate detail.

Abstract and index services and publications were primarily a source of search clues and were scarcely used by respondents as sources of technical information, with the exception of Chemical Abstracts. Because they index already-published articles and reports, index publications tend to be at least a year behind the state-of-the-art. While the abstracts in such publications are meant to aid individuals in determining whether the abstracted work is of interest, many felt that the abstract was so shallow and of such poor quality that it was little better than the title as an aid to screening. Chemical Abstracts, either because of its quality and coverage, or because it was familiar to so many, was frequently mentioned as a model other publications should follow.

Formal information dissemination centers, such as Battelle's Metals Center, store vast amounts of information, usually in particular subject areas, and provide special services, such as comprehensive bibliographies, selective retrospective literature searches, technical consultation, and referrals, as well as dissemination of publications and reprints. Yet they were not widely used, in part because they were not readily accessible. Some interviewees preferred either to rely on available internal services or go directly to known sources of new technology. Going through an information center, they felt, would simply add time and communication problems.

Clipping services provide clients with specified kinds of material mainly from trade and mass media sources, but with some services now monitoring professional journals. This channel has been most used for marketing and competitor information, but several firms had effective in-house clipping service activities on technical information. A service which provides copies of the table of contents page of technical publications was subscribed to by several firms who viewed it as an efficient means for maintaining awareness of developments without having to subscribe to hundreds of journals.

Formal courses were valued not so much as sources of innovative ideas and new technology as they were as means for acquiring new competence. This channel covered courses given internally by the firm and supplier courses, but most of the course-taking reported involved university attendance. Many of the respondents are believed to have classed their coursework in the internal channel of "personal knowledge, experience, or experimentation," rather than ranking it as an external channel.

Patent literature, although not widely used, was highly valued, both for the specific and detailed technical information it contained and for that portion of a patent application which surveyed the state-of-the-art. Most firms had at least one person monitoring the U. S. Patent Office Official Gazette and in many cases foreign patents were also monitored, especially in those countries where applications do not receive lengthy reviews.

Professional societies handle most of their information dissemination through channels already listed, e.g., journals, conferences and abstracts. Industry associations vary in the nature and quality of information services they provide. Some focus on establishing industry standards, while others sponsor some research and attempt to encourage the application of new technology within the industry. While many associations sponsor meetings, most were viewed as being business, rather than technically, oriented and of small value as channels for acquiring technical information. This was less true in the printing machinery and reproduction equipment industry.

The Relative Importance of External Channels of Technological Information

Respondents were asked to rank the five most important external channels used for both their general awareness information needs and for their problem-solving information needs. Figure II-2 lists the 17 external channels described previously in this section and indicates the relative importance of each channel for all respondents.[7]

Not surprisingly, professional journals, trade publications, and professional meetings ranked high in importance for acquiring technical information. Low ranking was given to libraries, abstract and index services, formal courses, and formal information dissemination centers. However, since one cannot completely isolate professional journals and textbooks from libraries and abstract or index services, it was perhaps not a totally realistic weighting of channels.

As figure II-2 shows, there were important differences in the external channels used for awareness versus problem-solving searches. In a problem-solving situation, textbooks and handbooks became the most important source for all respondents, followed by professional journals and supplier personnel. (If supplier personnel and catalogs were lumped together, the combined supplier-sourced channels would be most important of all.) Trade publications, meetings, conferences, and trade shows were relatively less important in problem-solving situations than they were for general awareness. Understandably, libraries roughly doubled in importance for problem-solving compared with awareness.

It is apparent that in a problem-solving situation the individual demanded more specific technical information as evidenced by the high ranking of textbooks, professional journals, and supplier personnel. In the awareness situation he was more concerned with keeping in touch with broad statements about technology pertinent to his field. For this, he relied heavily on trade publications, meetings, and professional journals.

Industry comparisons.—Indications of the differences encountered among the five industries are illustrated in figure II-3, which similarly ranks the relative importance for each industry of the ten most important external information channels.

Professional journals were particularly important for both awareness and problem solving in the battery and medical electronics industries. This appears due to the advanced technology used in these industries and to their strong emphasis on research which gave them a higher percentage of research-oriented personnel. Trade publications, which were more important for awareness than for problem solving, were highly ranked in all but the battery industry. Several channels were more important for problem solving than for general awareness, including: supplier personnel, catalogs, textbooks and handbooks, and libraries outside the firm.

The medical electronics industry stood out from the other industries in its ranking of consultants and outside libraries. Firms in this industry maintained close ties with

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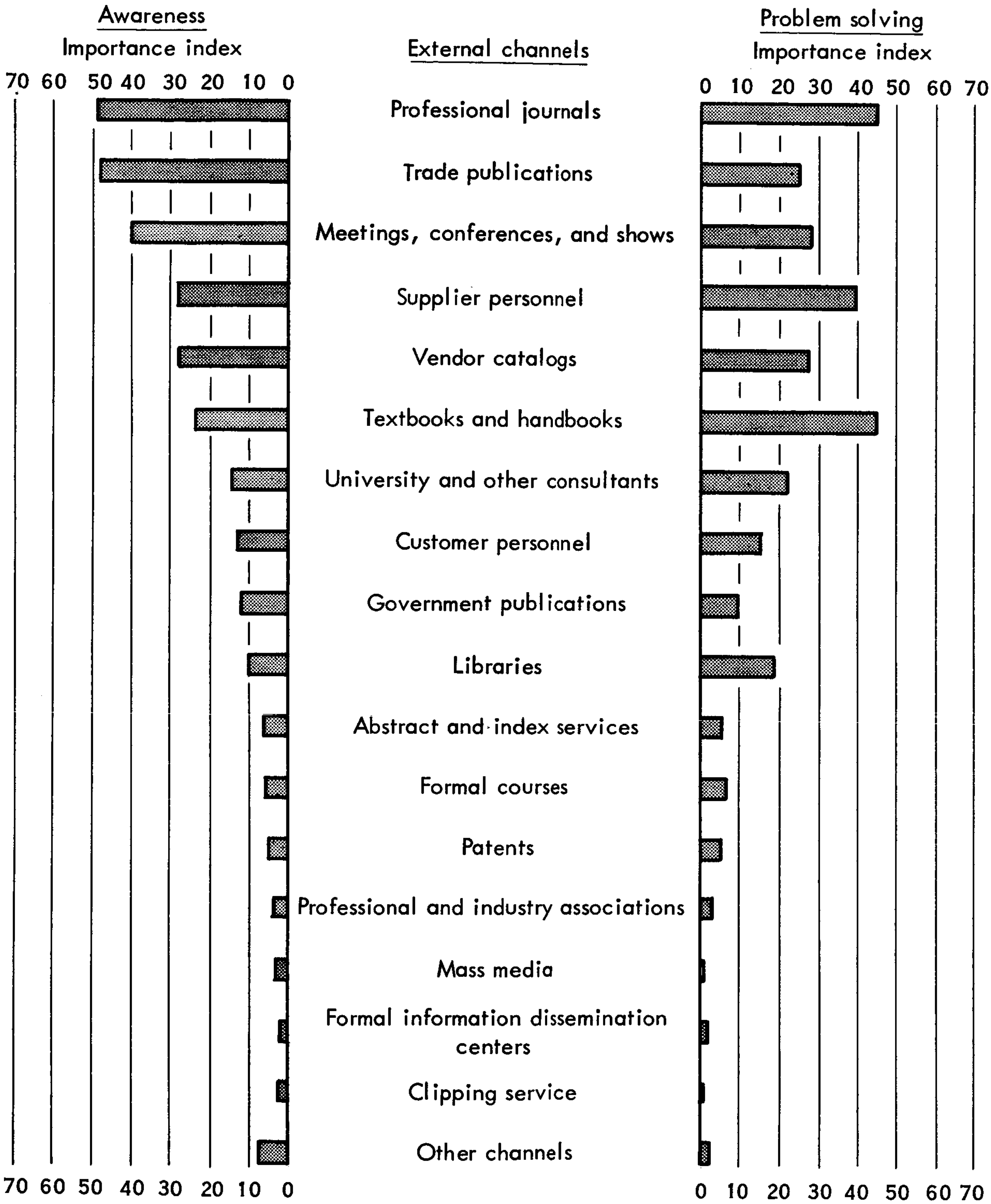
[7] The index of importance was arrived at by weighting respondents' first five choices by 5, 4, 3, 2, and 1, respectively; adding the total points; and dividing the sum by N x 5. The maximum possible index of 100 would be assigned to a channel which all respondents unanimously selected as most important.



Channels listed in decreasing order of importance for awareness. The data for this figure are tabulated in Appendix A, tables A-4 and A-5.

Figure II-2. Importance Ranking of External Information Channels for All Respondents.

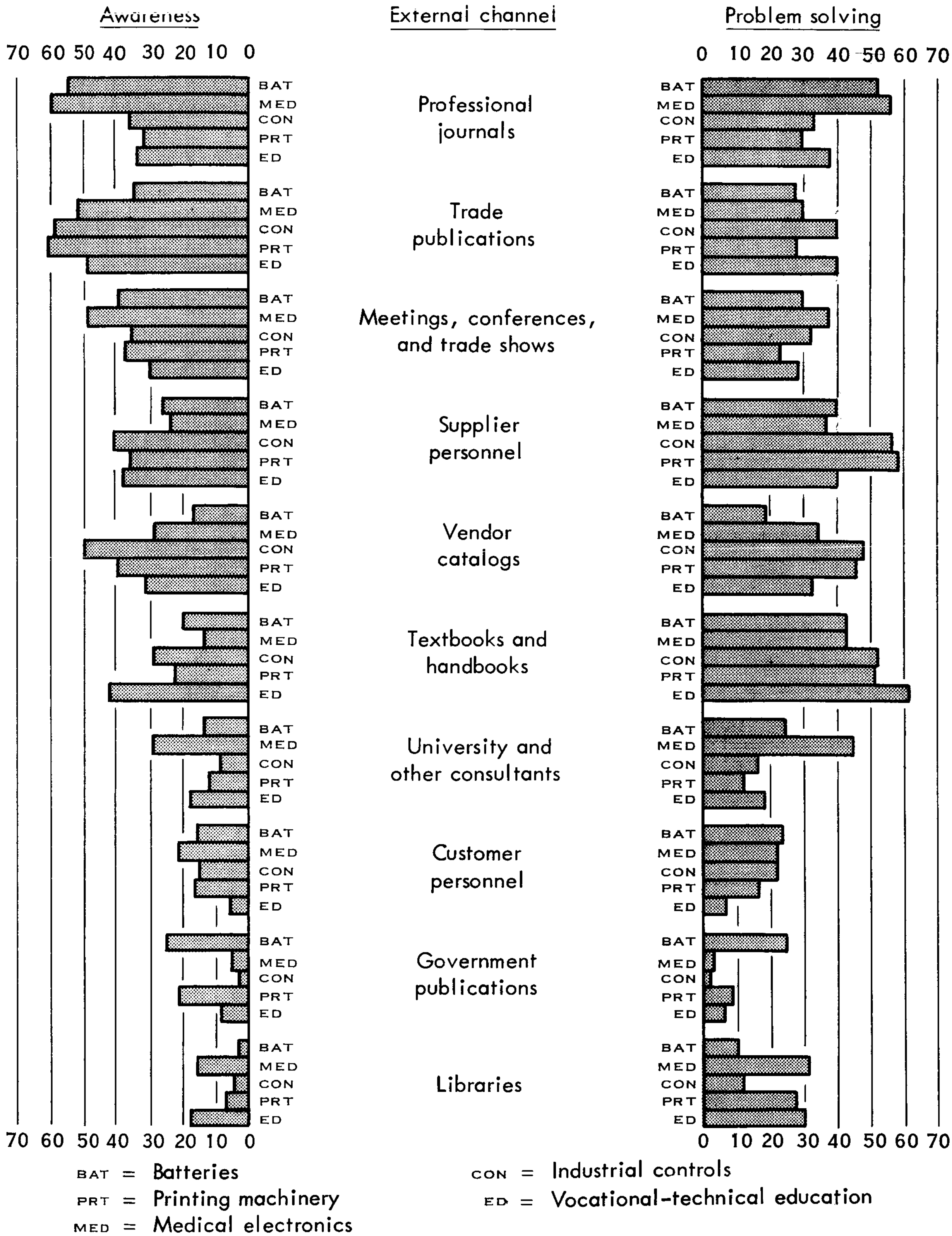


Figure II-3. Importance Ranking of External Information Channels by Industry.

hospitals and medical schools in order to effect the necessary liaison between the medical and engineering disciplines needed to develop medical electronic products.

The battery industry stood out in its relatively high ranking of government publications. The Signal Corps' sponsorship of the highly valued annual Power Sources Conference probably accounts for some of the importance given to government publications.

The research, product, and management breakdown.—The relative importance of external channels for research-oriented, product-oriented, and management individuals is portrayed in figures II-4, II-5, II-6 and comparatively in figure II-7.

As shown in figure II-4, the research-oriented individual placed greater importance on professional journals than on any other channel for both awareness and problem-solving situations. Professional meetings and conferences were second in importance for awareness, followed by trade publications. For problem solving, textbooks took second place and consultants, third. All other channels were of relatively minor importance.

In contrast, both product-oriented and management persons relied fairly evenly on the first six external channels listed in figures II-5 and II-6. Furthermore, if the importance rankings of supplier personnel and vendor catalogs are combined, this combination would be by far the most important channel for both management and product-oriented individuals, whereas for research-oriented persons the combination would rank no higher than third for either awareness or problem solving.

Product-oriented respondents ranked trade publications first for awareness, followed by professional journals, meetings, and vendor catalogs. In problem solving, they ranked textbooks first and supplier personnel a close second, with vendor catalogs third.

Among management persons, trade publications ranked highest for awareness, followed closely by professional journals, meetings, and supplier personnel. In contrast to the other types, management personnel ranked supplier personnel highest for problem solving, with professional journals and textbooks second and third.

Publications, analyzed by industry.—Analysis of the publications read by respondents revealed that in some industries respondents concentrated heavily on one publication, while in others, their attention was diffused among many publications. Table II-2 shows the number of specific publications mentioned by various percentages of respondents within each industry as well as the total number of different publications mentioned within each industry category.

As indicated in table II-2, the battery industry relied heavily on one particular publication: 68 percent regularly read this professional journal, while in second place, read by only 21 percent, was a general news publication of another society. In the medical electronics industry, the most frequently mentioned publications were: a professional journal (46 percent), a trade publication (28 percent), and a commercial general survey

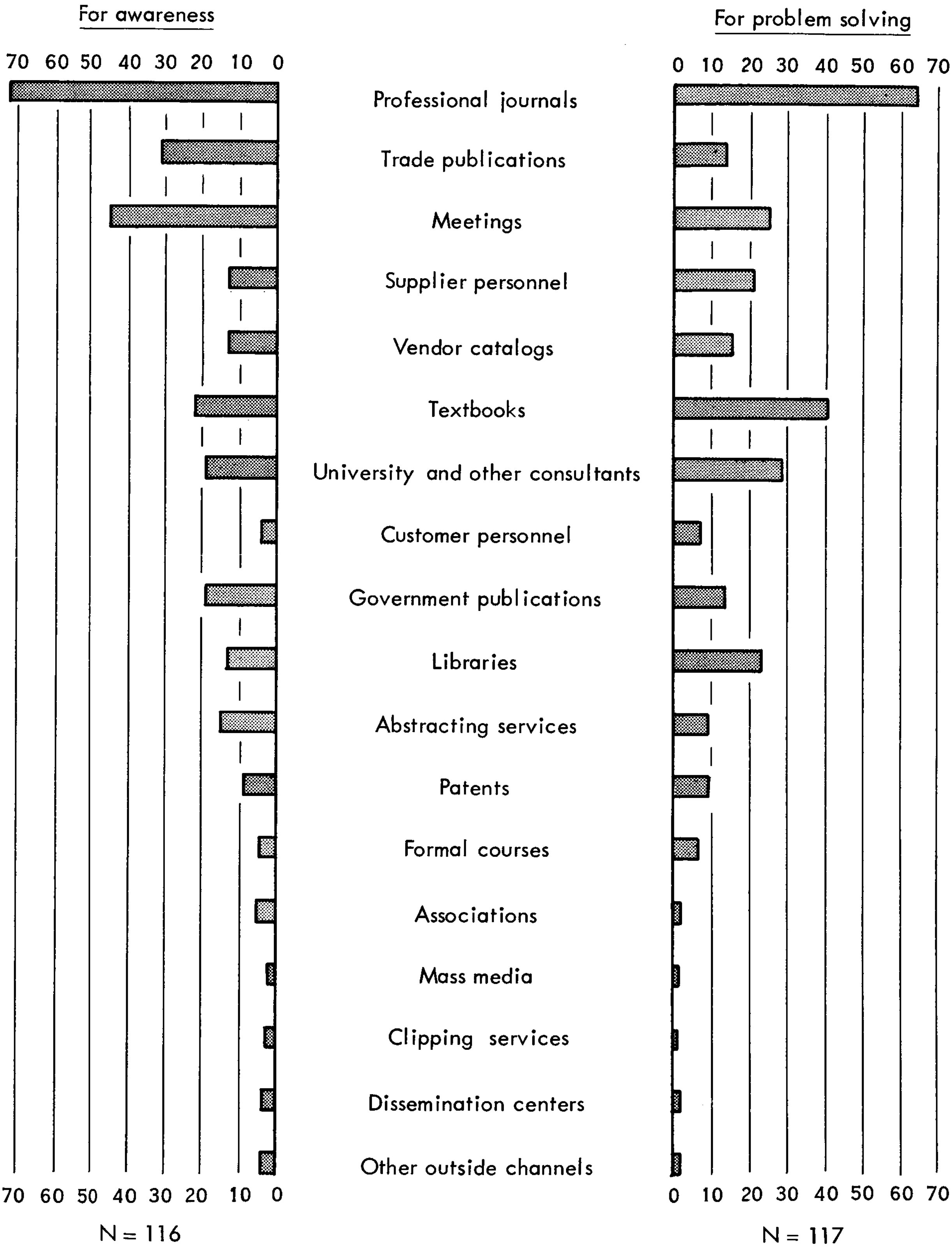


Figure II-4. Importance Ranking of External Information Channels by Research-Oriented Personnel.

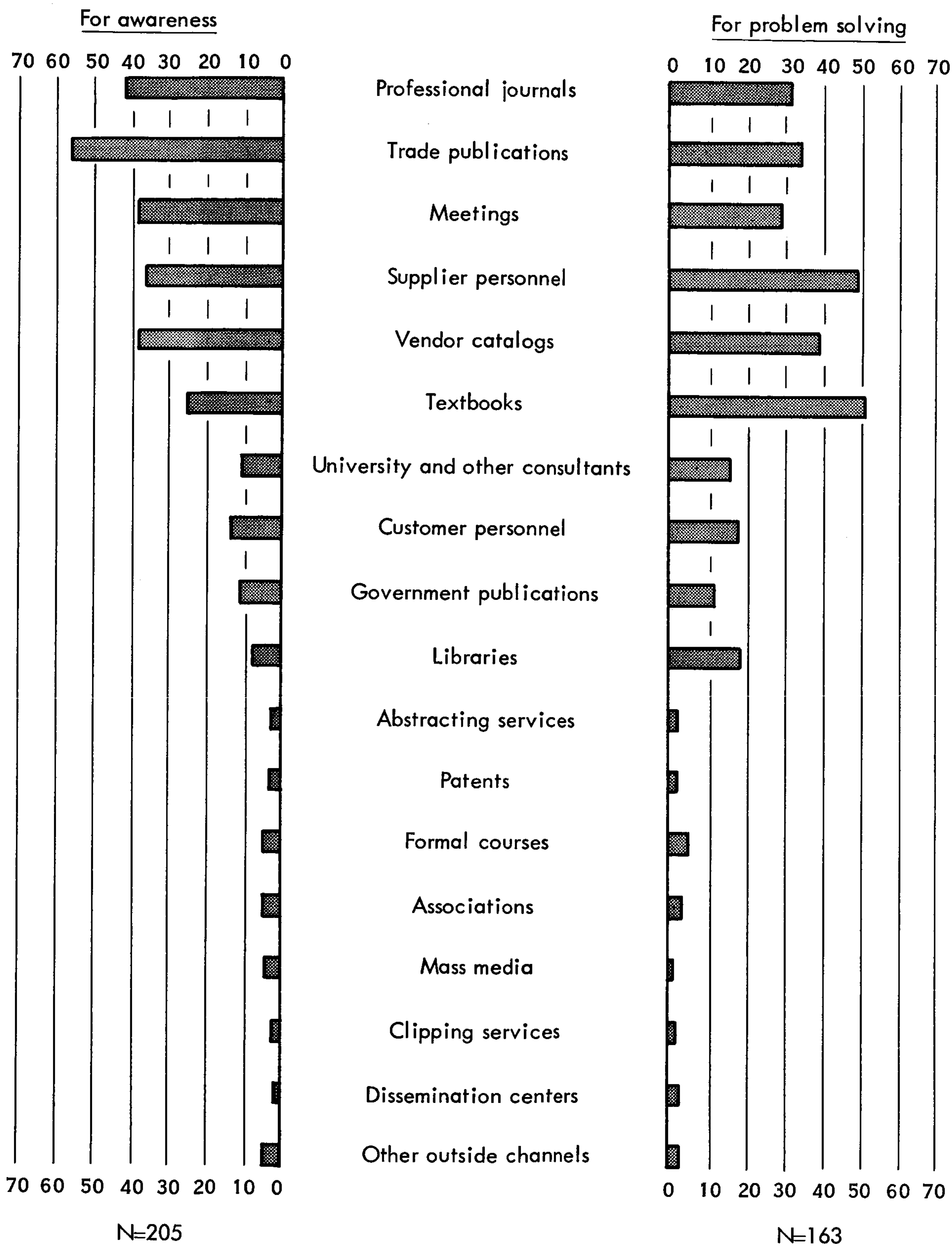


Figure II-5. Importance Ranking of External Information Channels by Product-Oriented Personnel.

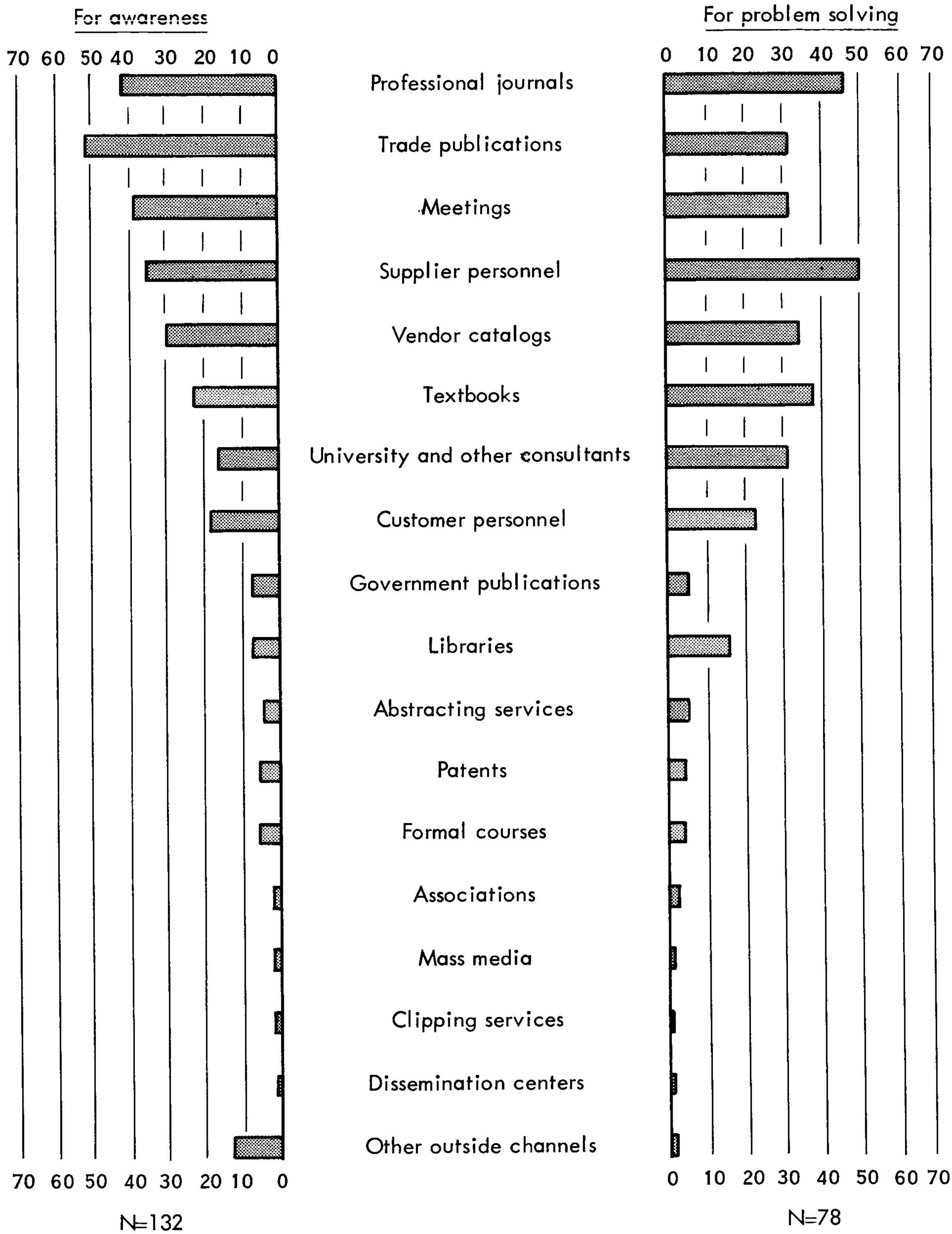


Figure II-6. Importance Ranking of External Information Channels by Technical Management Personnel.

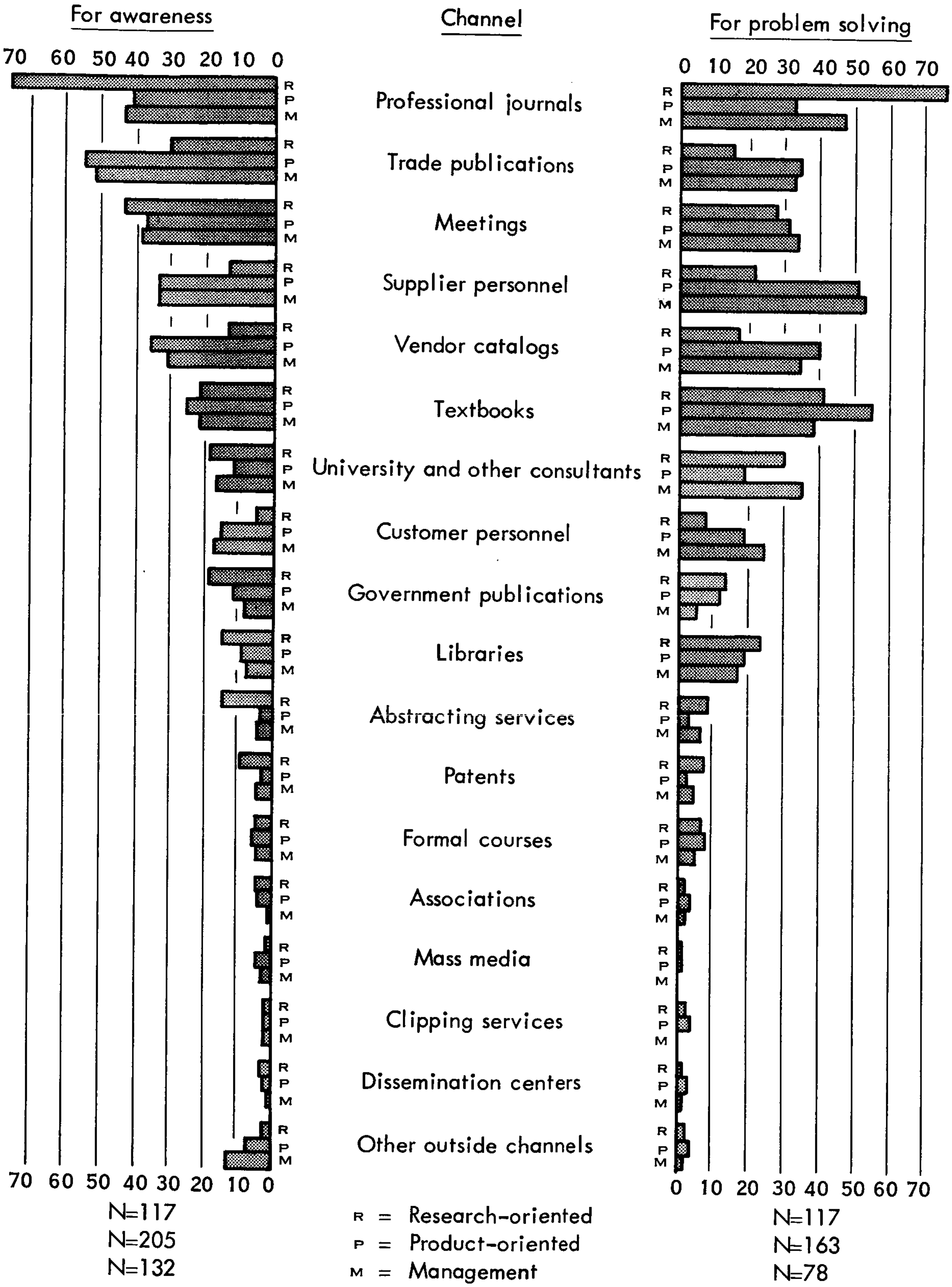


Figure II-7. Importance Ranking of External Information Channels for Research, Product, and Technical Management Personnel.

TABLE II-2.—DISTRIBUTION, BY INDUSTRY, OF RESPONDENTS MENTIONING SPECIFIC PUBLICATIONS

Percent of respondents mentioning the specific publication	Number of specific publications mentioned by industry				
	Battery	Medical electronics	Industrial controls	Printing machinery	Voc.-tech. education
< 5%	106	109	80	80	109
5- 9	16	15	6	24	9
10-19	10	6	4	2	6
20-29	1	2	4	-	-
30-39	-	-	3	2	-
40-49	-	1	-	1	-
50-59	-	-	-	-	-
60-69	1	-	-	-	-
Total different publications mentioned	134	134	97	109	124

publication (20 percent). Among respondents in the industrial controls industry, three publications tied for most frequent mention, each with 33 percent: a professional journal; the same professional society's general news and survey publication; and a trade publication. In the printing machinery and reproduction equipment industry, the top three publications were all trade publications, and were mentioned by 43 percent, 30 percent, and 30 percent of respondents respectively. Respondents in vocational-technical education showed the most diversity in publications regularly read; most frequently mentioned was a trade publication with only 18 percent, followed by another trade publication with 16 percent.

There was industry overlap for two publications. One professional society's publications were among the three most regularly read in both the medical electronics industry and the industrial controls industry, while one trade publication was among the two most regularly read in both medical electronics and vocational-technical education.

Classes of publications.—Analysis of the publications read by respondents provided corroboration of their later importance ranking of professional journals relative to trade publications. The analysis classified publications into four categories: (1) trade publications; (2) general survey-type publications of professional societies, e.g., Spectrum; (3) strictly professional journals; (4) an "other" category which included survey publications, such as International Science and Technology and Scientific American; abstract and index publications; and business publications. The analysis by type of individual covered only mentions for those publications listed by four or more of the 480 respondents, thus these percentages are only approximate.

Table II-3 shows by industry and type of individual the percent of publication mentions which fell into the four major categories: trade publications; general publications of professional societies; professional journals; and other.

About one third of the mentions in the battery and medical electronics industries were professional journals as opposed to 8 percent or less in the other three industries which relied heavily on trade publications. Research-oriented individuals mentioned professional journals much more frequently (52 percent) than did product-oriented (14 percent) or management (19 percent) individuals. The percentage of general or survey-type publications of professional societies did not differ substantially by either industry or type of individual.

The Relative Importance of Internal Versus External Channels

While the major research effort was on external communication channels, it appeared important to inquire about other aspects of an individual's information acquisition activity. Respondents were asked to indicate whether they felt external or internal channels were more important for acquiring technical information. Among all respondents, 34 percent indicated external channels were more important, 22 percent felt internal channels to be more important, 36 percent felt that both were equal, and 8 percent either did not know or failed to answer the question. Thus there was a slightly higher value placed on external channels. The smaller firms especially placed a higher value on external channels than did the larger firms. (See discussion of size of firm as a factor in Appendix A.)

There was almost no difference among functional types of individuals in their assessment of the relative importance of external and internal channels. Similarly, except for the battery industry, there was very little inter-industry variation. In the battery industry, 40 percent indicated that internal channels were most important, 22 percent rated external channels, 32 percent felt they were equal, and 8 percent either did not know or did not answer. A major factor probably was that a large percentage of battery industry respondents came from firms with good internal library facilities and capable library personnel and services. An obvious difficulty occurs in classifying a firm's library as an "internal" information source, for most of the documents and books in any library originally come from outside the firm.

Another serious difficulty in making this comparison was that of classifying the technological information acquired by hiring or transferring in new personnel. Such people brought in resources of education and experiences which immediately became "internal" resources—a type of technology acquisition not covered in the questionnaire, but mentioned a number of times in interviews.

Comparative Importance of Types of Internal Channels

There was a surprising amount of consistency among all respondents in their order-of-importance ranking of the six kinds of internal channels. As shown in figure II-8, which lists the six channels in decreasing order of importance for all respondents, there

TABLE II-3.—NUMBER OF MENTIONS OF PUBLICATIONS READ REGULARLY BY PUBLICATION CATEGORY AS A PERCENT OF TOTAL MENTIONS BY INDUSTRY AND TYPE OF INDIVIDUAL

Category of publication regularly read	Percent of mentions falling into each category							
	Type of individual**			Industry				
	Research oriented	Product oriented	Management	Battery	Medical electronics	Industrial controls	Printing machinery	Voc.-tech. education
Trade publications	16%	64%	52%	41%	29%	76%	72%	66%
General and survey publications of professional societies	22	12	15	12	25	10	10	23
Professional journals	52	14	19	36	30	8	7	6
Other types*	10	10	14	11	16	6	11	5

*Includes business, survey, and abstract publications.

**Data by type of individual include only mentions for those publications mentioned four or more times among all respondents.

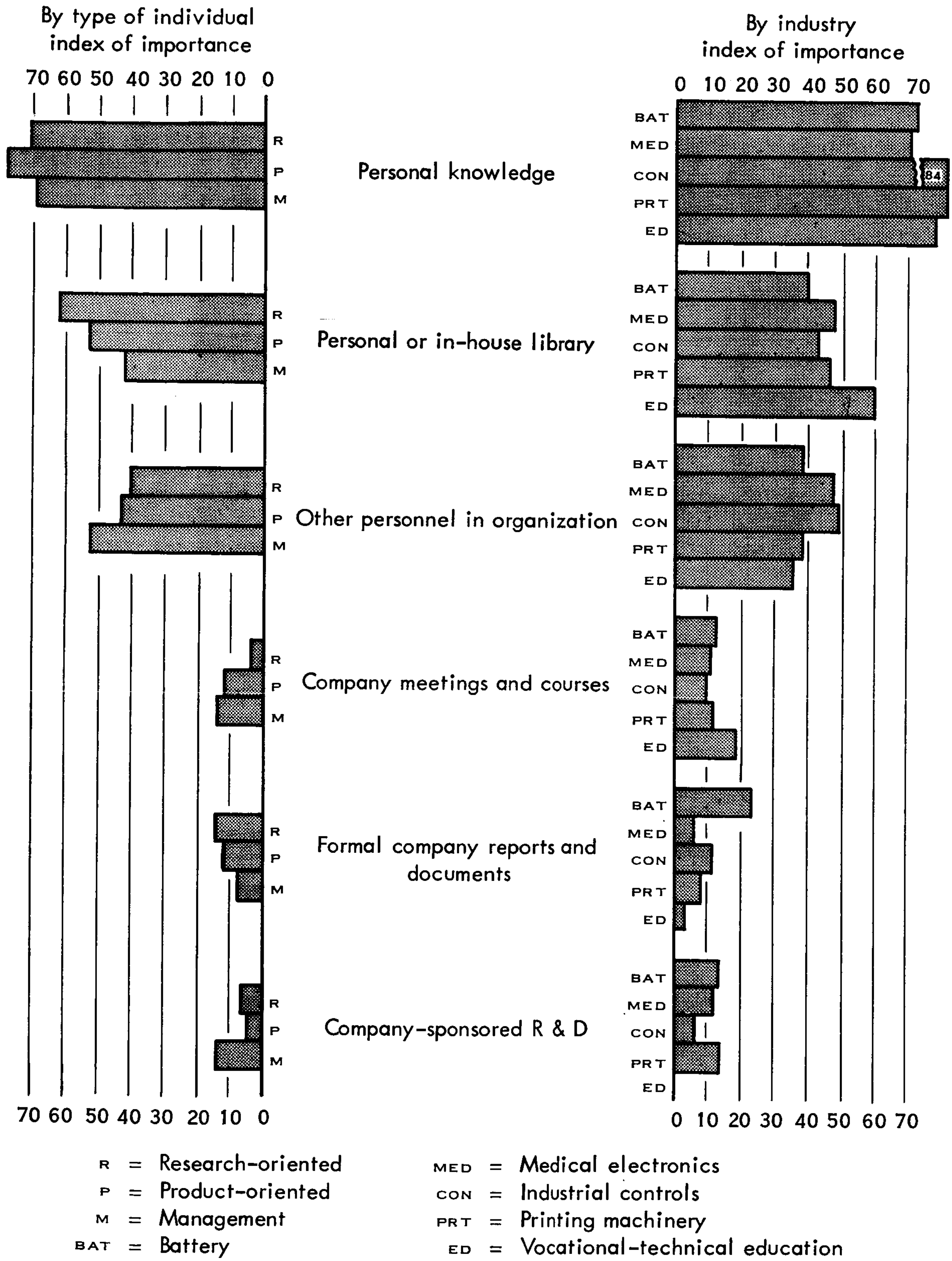


Figure II-8. Importance Ranking of Internal Information Channels by Industry and Type of Individual.

was little variation either by industry or by type of individual. The first three channels (an individual's own knowledge and experience; his personal library or the firm's library; and other colleagues in the firm) were considerably more important than the last three internal channels—which tend to involve company-generated information.

The Technological Information Acquisition Activity When Solving a Specific Problem

Each respondent was queried about his most recent problem-directed search for technical information. The questions were designed to obtain better understanding of the activities and the sequence of steps an individual took to acquire information needed for a specific task. Figures II-9 and II-10 are reproductions of the questions asked and represent two typical answers.

Figures II-9 refers to the steps taken in solving a research-oriented problem, while figure II-10 deals with a product-oriented problem. Problems involving the selection or purchase of a new product or material tended to fall in the product-oriented category. Research-oriented problems were those which: (1) applied the understanding of a phenomenon; (2) involved analysis or experimental measurements; or (3) involved the development of a new process. The classification was made on a rather subjective basis, and in many instances there was inadequate information about the problem. Therefore, the distinctions between the product and the research-oriented problems are admittedly imprecise.

The type and frequency of problem-directed searches.—Table II-4 summarizes the type and frequency of problem-directed searches for the 354 respondents who answered this question. About 60 percent of the problems motivating the search were product-oriented, roughly 30 percent were research-oriented, and the remainder were not readily classified. Among the research-oriented individuals, the problems were about evenly split between product-oriented and research-oriented, whereas among management and product-oriented individuals about 65 percent of the problems motivating the search were of the product-oriented variety.

Among all respondents, the median number of such problem-directed searches conducted each month was about three, with research people generally conducting fewer such searches than either management or product-oriented individuals. While the median elapsed time between the start of such a search and the final action taken as a result of the search was about 30 days, there was considerable variation among respondents. For some, the elapsed time was only a few days, while for others it involved as much as six months to a year.

The sequence of steps generally used in a problem-directed search.—While it is difficult to identify a typical sequence of steps which an individual goes through in a problem-directed search for information (because the kinds of information sought and the number of steps taken vary considerably with the individual and the problem), there was a frequently-occurring pattern of steps among respondents. Table II-5 attempts to convey this pattern of search steps.

A. Your most recent instance of a problem-directed search.

Problem motivating search: Needed to know about a gas diffusion process.

Steps or channels used in search	Time spent searching	Time lag between request for info & receipt of info	Results of each step or channel used: Provided no help	Provided some background data	Provided valuable data	Provided leads on new info sources
(1) Consulted experienced colleagues	40 min.	0			X	
(2) Looked through Chem Abstracts	3 hrs.	0				X
(3) Looked through Engineers Index	3 hrs.	0			X	
(4) Looked through journal articles in our library	2 hrs.	0			X	
(5) Ordered journal articles not immediately available	5 min.	2wks		X		
(6) Obtained and looked through other articles referred to in first articles	1 hr.	2wks		X		
(7) Looked through standard textbooks and works on subject	1 hr.	0		X		

B. Was any action taken as a result of this problem-directed search?

(1) Used in making a decision X

(2) Resulted in adoption of innovation

(3) Nothing done

(4) Other action (explain)

C. How much time elapsed between the start of your problem-directed search and the final action? 2 to 3 weeks

D. How many such searches involving at least two hours of effort do you make, typically, in a month? one half

Figure II-9. A Typical Answer to the Problem-Directed Search Question for a Research-Oriented Problem

A. Your most recent instance of a problem-directed search.

Problem motivating search: Needed a particular kind of power amplifier

Steps or channels used in search	Time spent searching	Time lag between request for info & receipt of info	Results of each step or channel used: Provided no help	Provided some background data	Provided valuable data	Provided leads on new info sources
(1) Looked through own catalogs	45 min.	0	X			
(2) Reviewed own file of literature references on instrumentation	1-2 hrs.	0	X			
(3) Inquired among electronic engineers in own organization	45 min.	0		X		
(4) Asked consultant (on his next visit)	20 min.	1 month				X
(5) Wrote supplier for information	10 min.	2-3 wks.		X(rejected)		
(6) Replied to ad in a periodical on apparatus news	10 min.	3 wks.			X	
(7) Ordered equipment	10 min.					

B. Was any action taken as a result of this problem-directed search?

(1) Used in making a decision X

(2) Resulted in adoption of innovation X

(3) Nothing done

(4) Other action (explain)

C. How much time elapsed between the start of your problem-directed search and the final action? 2 to 3 months

D. How many such searches involving at least two hours of effort do you make, typically, in a month? 5 or more

Figure II-10. A Typical Answer to the Problem-Directed Search Question for a Product-Oriented Problem

TABLE II-4.—TYPES OF PROBLEMS WHICH STIMULATED PROBLEM-DIRECTED SEARCHES, AVERAGE NUMBER OF SEARCHES PER MONTH, AND AVERAGE ELAPSED TIME BETWEEN START OF SEARCH AND FINAL ACTION FOR ALL RESPONDENTS WHO ANSWERED AND BY TYPE OF INDIVIDUAL

	By type of individual			All respondents (354)
	Research oriented (108)	Product oriented (158)	Management (88)	
1. Nature of problem which stimulated information search:				
a. Research-oriented, percent	49	16	23	28
b. Product-oriented, percent	44	63	68	58
c. Other not classified, percent	7	21	9	14
2. Median number of such problem-directed searches made per month	2.0	3.4	3.0	2.9
3. Median elapsed time between start of search and final action				30 days

TABLE II-5.—THE KINDS OF CHANNELS OR INFORMATION SOURCES MOST FREQUENTLY USED IN A PROBLEM-DIRECTED SEARCH

Search step	Most frequently used channels for all respondents	Other sources or channels frequently mentioned for each step by type of individual		
		Research oriented	Product oriented	Management
1.	Personal or in-house library	Colleagues in organization Textbooks Abstract or index	Colleagues in organization Vendor catalogs	Own work Colleagues in organization
2.	Colleagues in organization	Library Abstract or index	Supplier personnel Library	Supplier personnel Library
3.	Supplier personnel	Colleagues in organization Professional journals	Colleagues in organization Vendor catalogs Consultant	Own work Colleagues in organization
4.	Own work, test or evaluation			

In searching for information, the individual generally first went to his personal files or to textbooks or other publications in his own office for an initial clue as to where to go next. For his second step he typically asked a colleague in the organization either for specific technical information or for help in locating a potential source of information. Following this, he then went to a supplier or sales representative for information about a product, material, or service. The search was typically concluded by some action on the part of the individual involving an evaluation of the information he had received and/or testing of products or materials, or simply the decision to resolve the problem in a particular way.

While there were many similarities in the kinds of channels utilized and the sequence of steps taken among each of the three types of individuals, there were also differences. In the first step, the research-oriented individual frequently contacted colleagues, or went to textbooks, or examined abstract and index publications. On the other hand, if the product-oriented searcher did not start with his personal or in-house library, he generally went either to other colleagues in the organization for information or looked through vendor catalogs. The management man relied both on his own calculations or analysis and on other colleagues within the firm if he did not start initially with the material in his personal or in-house library. For the second and third steps, the research-oriented individual frequently went to the abstract or index publications and to professional journals, whereas the product-oriented individual frequently went directly to supplier personnel, vendor catalogs, or called on a consultant.[8]

A total count of the types of channels listed (for all steps in the search) by the 357 respondents who answered this question, provided an interesting comparison with the earlier ranking of external channels for problem solving. The left-hand column below lists the external channels mentioned in the most recent instance of a problem-directed search. Only the channels mentioned 15 or more times are included. They are in order of decreasing number of mentions. The right-hand column lists the external channels in decreasing order of importance based on their ranking by respondents for the problem-solving mode (see table II-2).

Channels ranked by frequency of mention in instance of a recent search	Channels ranked by index of importance for problem solving
1. Supplier personnel	1. Textbooks
2. Consultants	2. Professional journals
3. Vendor catalogs	3. Supplier personnel

[8]Additional analysis may help to identify the kinds of channels which are most frequently used as a means for getting clues on where to look next versus those channels which are primarily used to acquire the technical information sought. In addition, it may be possible to identify the amount of time an individual is willing to devote to each type of channel until he moves on to another channel or source of information, and to identify typical time lags which occur for each channel between the time the information is requested and the time the information is received.

4. Textbooks
5. Professional journals
6. Abstract services
7. Libraries
8. Government publications
9. Customer personnel
10. Trade publications
11. Meetings
12. Patents
13. Associations

4. Vendor catalogs
5. Meetings
6. Trade publications
7. Consultants
8. Libraries
9. Customer personnel
10. Government publications
11. Formal courses
12. Abstract services
13. Patents
14. Associations

Major differences in the two rankings occurred for the following channels: meetings, trade publications, consultants, and abstracting services. However, perceived importance and incidence of use may be quite different dimensions, and valid comparisons are difficult to design.

The Use and Relative Importance of Government Sources and Information Channels

Assessing the importance of government-generated technological information is difficult because of problems in isolating government information sources and channels. For example, it is difficult to precisely classify research sponsored by the government but reported and disseminated in a report published and partially disseminated by a private contractor. Similarly, much of the technology developed under government contracts and by government researchers is reported in professional journals and trade publications, and much government information is included in abstracting and indexing publications. Generally, however, respondents treated government-published and disseminated research as "government publications, manuals, reports, etc.," and also some government-sponsored research information moving through other channels.

Although complete evidence is lacking, individuals with strong political biases regarding the role of the government appear to allow these biases to affect their evaluation of government information sources. For example, an individual who is suspicious of governmental intervention in business affairs may consciously avoid using government information sources and rate them as of little importance, regardless of the potential value of the information to him.

A paraphrasing of some of the comments made during personal interviews may convey a flavor of how individuals in commercial firms view government-sponsored research and government information sources.

> We don't get any "know-how" from government reports because no one reveals proprietary information in a government report.

> Information generated by government contracts and government-sponsored research is not proprietary and is therefore of very little interest to our firm.

Reports resulting from government-sponsored research represent an important source of information for our company. Particularly the Inter-Agency Advanced Power Group Project Briefs.

The main problem with government technical information is that the data are not very accessible and are very highly specialized.

I find it extremely difficult in government research publications to find out that the investigators really didn't learn anything. You're misled by most government publications to believe that a great accomplishment was made.

No product has ever come out of government-sponsored research. I don't think it's worth my time to scan all the material coming out of government work just for one information nugget.

It's hard to get information about government research unless you have a government contract.

We make little use of any government research reports because it takes too much time to search or monitor it for any possible payoff.

Substantiating the rather negative tone of these comments are the data from a specific question included in the questionnaire. An individual could check "Government-developed technology not pertinent to my job so make no special effort to keep up with it." Table II-6 summarizes the percent of respondents who answered this question affirmatively, saying that government technology was not important to their work.

While 21 percent of all respondents answered the statement affirmatively, there was considerable variation by type of individual and by industry. Research-oriented individuals apparently valued government-developed technology more than either the product-oriented or the management individuals. Only 7 percent of the respondents in the battery industry indicated that they felt that government technology was not important and this industry had a high proportion of research-oriented respondents. On the other hand, about one-third of those in the industrial controls, printing machinery, and vocational-technical education industries felt that government technology was not important. However, the 21 percent of respondents who answered this question affirmatively probably lacked familiarity with government publications because only about 19 percent of this group had ever used <u>any</u> of the six specific government and NASA channels (as opposed to about 75 percent among all respondents). Only 17 percent of this group had any prior government experience (as opposed to 30 percent of all 480 respondents).

Of those with prior government or aerospace work experience (144), only 12 percent felt that government technology was unimportant; while of those without such prior experience (331), 26 percent answered this question affirmatively. Thus, those with government or aerospace experience were less willing to reject government-generated technology. Familiarity did not breed contempt, but neither did it lead to appreciably higher importance indexes.

TABLE II-6.—RESPONDENTS WHO FEEL GOVERNMENT-DEVELOPED TECHNOLOGY IS NOT IMPORTANT TO THEIR JOBS

	By type of individual			By industry					All respondents
	Research oriented	Product oriented	Management	Battery	Medical electronics	Industrial controls	Printing machinery	Voc.-tech. education	
	(Percent)								
Government technology unimportant, hence do not keep up with	13	27	20	7	14	36	33	36	21

TABLE II-7.—USE OF SPECIFIC NASA AND OTHER GOVERNMENT INFORMATION CHANNELS

Channel	All respondents			Respondents with prior government experience			Respondents without prior government experience		
	Heard about	Have used	Will continue to use	Heard about	Have used	Will continue to use	Heard about	Have used	Will continue to use
	(percent)			(percent)			(percent)		
1. NASA Tech Briefs	56	32	25	60	39	31	54	29	22
2. NASA Regional Dissemination Center	18	5	4	20	6	6	17	4	3
3. NASA Technology Utilization Surveys	31	14	11	36	18	18	29	12	8
4. Clearinghouse for Federal Scientific and Technical Information	40	28	24	49	38	35	37	24	19
5. IAA	17	6	5	27	12	10	12	4	3
6. STAR	24	14	12	33	26	23	20	9	7

To determine familiarity and evaluation of specific government information channels, we asked respondents to indicate whether they had heard about six specific channels, whether they had used them, and whether they would continue to use them. The channels were: NASA Tech Briefs; Regional Dissemination Centers established by NASA; NASA Technology Utilization Surveys; Clearinghouse for Federal Scientific and Technical Information, U.S. Department of Commerce; International Aerospace Abstracts (IAA); and NASA's Scientific and Technical Abstract Reports (STAR). Table II-7 identifies the percentage of all respondents as well as those with and without prior government or aerospace experience who had heard about, used, and indicated they would continue to use these specific channels.

It is apparent that the majority of respondents were not even aware of the existence of most of these information channels. Best known of the channels were NASA's Tech Briefs and the Clearinghouse. Fewer than one-third of all respondents had heard about any of the other four channels. Of those who had heard of a specific channel, roughly one-half indicated they had used this channel. However, if a respondent indicated he had used a channel he generally indicated he would continue to use it. This suggests that ignorance of government channels plays an important part in explaining their relatively low popularity. The comparison of data for those with and without prior government or aerospace experience tends to support this thesis. Those with prior government experience tended to use and value these six channels more, particularly the last three: the Clearinghouse, IAA, and STAR.

Table II-8 indicates the percent of respondents, by both type of individual and by industry, who have heard about and who will continue to use these specific government channels. The research-oriented individuals were much more familiar with the Clearinghouse, IAA, and STAR than were either the product-oriented or management personnel. Also the battery and medical electronics industry respondents were much more familiar with these same three channels than were those in the other three industries. Except for NASA Tech Briefs, individuals in the industrial controls industry were least familiar with any of these specific government channels. The research-oriented individuals apparently valued the government channels more than the other two types. A considerably larger percentage of researchers than either product or management respondents indicated they would continue to use these channels.

Conclusion

The research results described above were summarized in the Highlights at the beginning of this section. Three conclusions will be offered here.

Research, product, and management types. Technology acquisition behavior patterns seem most understandable when examined by the functional activity of the acquirer: research-oriented, product-oriented, or management.

Some technological information media specialize for specific industries. However, many channels ignore industry "boundaries," just as many R & D activities are better described by the disciplines involved than by the markets they serve.

TABLE II-8.—RESPONDENTS WHO HAVE HEARD ABOUT AND WHO WILL CONTINUE TO USE SPECIFIC NASA AND OTHER GOVERNMENT INFORMATION CHANNELS

	By type of individual			By industry					All respond-ents
	Research oriented	Product oriented	Man-age-ment	Battery	Medical elec-tronics	Industrial controls	Printing machinery	Voc.-tech. education	
	Percent of respondents who have heard about channel								
1. NASA Tech Briefs	58	54	55	67	64	60	38	40	56
2. NASA Regional Dissemination Center	18	17	18	27	18	7	12	21	18
3. NASA Tech. Util. Surveys	36	30	27	34	34	23	20	29	31
4. Clearinghouse	53	34	37	41	52	30	38	20	40
5. IAA	31	14	10	27	20	4	10	14	17
6. STAR	41	19	19	36	38	9	15	19	24
	Percent of respondents indicating they will continue to use channel								
1. NASA Tech Briefs	31	24	20	49	38	14	10	5	25
2. NASA Regional Dissemination Center	3	3	6	8	5	0	0	1	4
3. NASA Tech. Util. Surveys	16	9	8	10	12	3	7	5	11
4. Clearinghouse	41	18	18	32	27	19	18	2	24
5. IAA	10	3	4	10	4	3	0	1	5
6. STAR	28	6	7	20	16	3	5	1	12

Diversity of channels. The apparently effective acquirers of technological information tap many channels. Some channels complement each other and add to each other's value. Some reinforce, some legitimatize. Some redundancy of channels appears to be desired by those acquiring information; redundancy is probably also important for effective dissemination.

Ignorance means non-use. Government sources and channels of technological information are not considered highly important by the respondents to this research. However, they are more accepted and more used by people who are acquainted with the material.

SECTION III

IMPLICATIONS FOR INDUSTRY, UNIVERSITIES, AND GOVERNMENT

Three large institutions—actually whole sectors of our society—are concerned with technology transfer. Each of the three is a generator of new technology; each of the three is a user of technology; and the three, together, furnish most of the channels through which technological information passes.

These three main sectors are industry, universities, and the Federal Government. The field work and analysis during this research project called attention to the present role of each, and pointed to the suggestions for change made later in this Section.

Industry's Role in Technology Transfer

There are, of course, great variations among the firms making up all of industry. But as a whole, industry hasn't greatly changed its role in technology transfer in recent years.

Industry is primarily motivated by the search for profits, plus the often-attributed managerial needs for continuity, maximization of sales, resolution of internal conflicts, and other conservative objectives. New technology usually contributes only small incremental changes in products and processes, whether the technology is acquired externally or generated from within.[1]

For some firms, major changes or breakthroughs in new products and processes may be quite expensive, suddenly making obsolete large investments (in money and prestige) in production and marketing facilities. This threat influences industry's needs for information on new technology: industry management needs early awareness of advances in state-of-the-art which may affect their products and processes. However, most managements are able to wait until new materials, components, and subsystems are almost commercially available before making decisions on embodying their technology in their processes or outputs.

There are forces pushing industry toward new roles in technology transfer. The large conglomerate, diversified corporations offer interesting opportunities for the transfer of technology. In one firm visited during the project, quarterly seminars are held for the engineers of the varied divisions to exchange information both on their own work and on new developments in their fields. The head of research and development of

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[1]Sumner Myers: Industrial Innovations, Their Characteristics and Their Scientific and Technical Information Bases. A Special Report to the National Science Foundation. National Planning Association, Wash. D.C., 1966.

one division of this corporation described the importance to his group of hearing about a forthcoming price cut in micrologics. The information substantially affected their development plans for a new product line. It has been reported elsewhere how the Industrial Systems Division of Aerojet-General Corporation drew upon the computer sciences capability of its parent corporation to substantially improve its automated materials handling systems and achieve a real competitive advantage.[2]

However, there seems to be little consistency in industry's efforts to synthesize innovation out of the varied technological resources available in the several divisions of a large firm. Some firms make extensive efforts to encourage such inter-divisional awareness and transfer, and others seem disinterested in the problem.

A more important influence for change may be the increasing importance in the American economy of the large defense and space firms. These government contractors have specialized in the rapid conversion of scientific information into systems and hardware, pushing the state-of-the-art in many areas under urgent customer demands and with massive customer funding. Similar but less dramatic efforts have gone on for many years, of course, in such industrial organizations as Bell Laboratories, du Pont, and General Electric.

In all of these cases, parts of U.S. industry have been seeking more efficient technology acquisition and utilization methanisms.[3] The Engineers Joint Council is interested in technical information system design. Some trade associations undertake technology transfer activities, others do not. However, this research identified very few commercial (non-defense, non-aerospace) firms consciously trying to accelerate technology transfer and application or to innovate in technological information acqusition. It is suspected that the same statement could be made of American industry in general.

The Universities' Role in Technology Transfer

It is a safe generalization that the universities are vital participants in the technology transfer process. They generate scientific information, they contribute to engineering knowledge and techniques, and they use both of these in the academic training of scientists and engineers. But their traditionalist orientation has kept this role a comparatively slow changing one in most universities.

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[2]U.S. Arms Control and Disarmament Agency: Defense Industry Diversification, A Report Prepared by John S. Gilmore and Dean C. Coddington, University of Denver Research Institute, U.S. Government Printing Office, Wash. D.C., 1966, pp. 133-150.

[3]And apparently with some success. A British observer offers a comparison saying, "An important factor is the 'lead time': the time to take a new idea, from the initial decision, through research, development, and design, to first regular production... Much of America's success seems to be due to the short lead times they achieve, often some 20-30% shorter than ours; for example, 2 years shorter in computers, 1 to 2 years shorter in aircraft." A. H. Cottrell, "Science and Economic Growth," New Scientist, 512 (September 8, 1966), p. 542.

The universities are often the sources for other important channels of technology transfer. Many of the professional societies and their journals are university-based. The technical textbooks and many handbooks and references are largely written by academic personnel. Universities furnish many of the consultants used by industry; they sponsor many scientific and technical conferences; and many abstracts originate in university-based work.

Transitional forces also are affecting the university's roles in technology transfer. Massive Federal funding of university research for defense, space, and health missions supports increasing generation of new scientific and technical knowledge in the universities. The need for continuing education for industrial scientists and engineers is bringing the universities closer to industry. These closer contacts with government activities and with industry may be leading to more mobility of personnel, facilitating moves back and forth (thus easing technology transfer) among the three sectors.

In addition, a few schools are pioneering in technology transfer. Some universities operate specialized Department of Defense information centers (the effect of these on the university's technology transfer activities is uncertain, however). Western Reserve University helped in the establishment of the American Society for Metals information center. Several universities operate Regional Dissemination Centers for NASA. A number of universities are beginning to participate in special technology transfer programs encouraged by the Office of State Technical Services.

Generally, though, these specific instances are exceptions rather than the rule. From the viewpoint of the firms contacted in this research, it appears that the universities are primarily concerned with technology transfer only through the traditional educational process.

The Changing Role of Government in Technology Transfer

Government, the third sector, has the fastest evolving role in technology transfer. The direction of this change is crucial to the other two—industry and universities—because of the leverage government exerts through its massive research and development spending.

The new era started in World War II with establishment of the National Defense Research Committee (NDRC) in 1940. With this committee and its successor, the Office of Scientific Research and Development (OSRD), began large-scale government support of research and development and the application of the resulting technology toward a major national goal: defense.

A precedent was set by a government agency for which cost was no object but speed was all important: the Army's Manhattan District implemented the atomic bomb development project which sprang from early NDRC and OSRD work. This was the first grand scale effort to manage the rapid development of usable technology and hardware from basic scientific knowledge.

Since that time Federal Government spending on defense, atomic energy, and—more recently—medical and space research has grown tremendously. Federal funds support a preponderance of the scientific and engineering work done in the United States. The resulting volume of research results has pushed the government agencies to establish numerous specialized information centers and mechanisms seeking to make the results available to those needing such information to achieve their various government missions. As a result, there has been increasing attention by both executive and legislative branches of government to the problems of making government-financed scientific and technical information available for academic use and industrial exploitation.

The Congress noted this problem in the Atomic Energy Act of 1946 in requiring a program for the dissemination of scientific and technical information on atomic energy.[4] The Space Act of 1958 suggested that NASA take an active role in disseminating information resulting from its research programs.[5] Most recently, in the State Technical Services Act of 1965, the Congress said:

> The Congress finds that wider diffusion and more effective application of science and technology in business, commerce, and industry are essential to the growth of the economy, to higher levels of employment, and to the competitive position of United States products in world markets. The Congress also finds that the benefits of Federally financed research, as well as other research, must be placed more effectively in the hands of American business, commerce, and industrial establishments.[6]

Congress thus stated that it is national policy to foster efficient communication and exchange of scientific and technological information—to foster technology transfer. In the meantime, a number of executive agencies have tried to deal with this problem, as required by the above statutes, and several study groups have examined and reported on it.[7]

Among the most significant results of the latter was the Weinberg Committee, which noted that the government has a great concern with: (1) the management of information needed in its own research programs (both that carried out within government research

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[4]Public Law 585, 79th Congress, 60 Stat.

[5]Public Law 568, 85th Congress, 72 Stat.

[6]Public Law 182, 89th Congress, 79 Stat.

[7]In the 1880's a Congressional Commission considered this problem and concluded that "the government's scientific establishment and the scientific communities in the universities had already grown too complex for such a change in organizational structure." Richard L. Lesher and George J. Howick: "Background, Guidelines, and Recommendations for Use in Assessing Effective Means of Channeling New Technologies in Promising Directions." Applying Technology to Unmet Needs, Appendix Volume V, Technology and the American Economy, Studies prepared for the National Commission on Technology, Automation, and Economic Progress, U.S. Government Printing Office, Wash. D.C., 1966, p. V-275.

centers and that contracted out), and (2) the problems of making research information generally available. This led them to conclude that the government must pay attention to both the technological information systems within the government and those outside.[8]

More recently the Committee on Scientific and Technical Information (COSATI) of the Federal Council for Science and Technology concluded that "because of the Federal Government's major involvement in science and technology, the Federal Government should assume the leadership in the evolution of the information and document-handling systems network."[9]

Less formally, there appear to be two other significant trends in government policy affecting technology transfer. One is the growing demand that Federally-supported research be more evenly diffused over the country. Possibly more important for technology transfer is the pressure for visible and problem-solving results from research.[10]

These pronouncements show the Federal Government to be concerned about and willing to intervene in existing technology transfer systems. They also suggest that the government role is changing more rapidly than those of industry or the universities. However, the diversity of policies, statements, and suggestions by different government agencies and at different levels makes it difficult to anticipate just what the new government role will be.

A Changing System

The technology transfer system is evolving, with government taking an increasing role and announcing its intention to do even more. On the other hand, the firms interviewed during this project were generally skeptical of extensive governmental tampering with the system. None of our respondents felt that the existing system is badly out of equilibrium; none of them felt that the existing system is breaking down. There were complaints that too much information was available and that too little of it was of high quality. But our respondents spoke of these as irritations rather than as overwhelming problems. They saw the present system as generally fitting their perceived needs.

Technology Transfer as a Market Process

What is the nature of this technology transfer system which at least a part of commercial industry finds generally satisfactory? Some details of it have been described in

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[8]President's Science Advisory Committee: Science, Government, and Information, The Responsibilities of the Technical Community and the Government in the Transfer of Information, U.S. Government Printing Office, Wash. D.C., 1963, p. 1.

[9]Recommendations for National Document Handling Systems in Science and Technology, Committee on Scientific and Technical Information (COSATI), Federal Council for Science and Technology, Nov. 1965 (Clearinghouse, PB 168 267, AD 624 560).

[10]D. S. Greenberg: "Basic Research: The Political Tides Are Shifting." Science, June 24, 1966, pp. 1724-1726.

Sections I and II of this report. In more general terms, though, technology transfer takes place in a sort of intellectual and economic market process.

Technology transfer involves exchange.[11] Technological information is exchanged for money, for the satisfaction inherent in communication with other human beings, for prestige, and for other more or less tangible rewards.[12] Many of these compensations are hard to quantify. They certainly furnish incentives, however, and some can be equated with the demand side of a market.

Like a market, the technology transfer system also helps organizations allocate their resources to the different channels (and other means) of technology acquisition which they wish to tap. The relative importance—an indicator of utility—of different channels to parts of commercial industry was discussed in Section II. While the information obtained through different channels is often not priced, the acquirer certainly would benefit from knowing the comparative costs of methods of acquiring it.

A knowledge of costs and information on channel effectiveness permits resource allocation decisions similar to those resulting from a price system. Presently, most firms deal with this cost-effectiveness calculation by intuition, tradition, and intrafirm bargaining.

Some channels of technological information more easily fit market definitions. The purchase of new materials, components, and subsystems from suppliers is an important part of technology transfer. The purchase of information in the form of texts and publications is a market process. Royalties, patent licenses, and consulting relationships all involve conventional markets. The labor market for scientists and engineers is, to say the least, active.

Possibly the most vital market function is the continual testing of the quality and usefulness of scientific and technological information. This takes place as some information is selected by users, or by editors, or by journal referees, at the same time that

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[11]Rosenbloom has said, "The transfer of technology...depends primarily on the exchange of information rather than upon the exchange of things." This study agrees with his conclusion, but with the reminder that the commercial channels which often transfer technology through the sale of materials, components, and subsystems, are highly important. Richard S. Rosenbloom: Technology Transfer—Process and Policy. National Planning Association Report #62, Washington, D.C., 1965, p. 22.

[12]Glaser lists some forms of the rewards for information contribution by scientists as "...eponymy, prizes, awards, fellowships, scholarships, honorary memberships and committee work in scientific organizations, editorships, honorary degrees, professorships, chairs, lectureships, consultantships, mention by historians of science, publication, acknowledgements in other's work, and evaluations by colleagues." Barney G. Glaser: Organizational Scientists: Their Professional Careers. Bobbs Merill, Indianapolis, 1964, p. 2.

other information is rejected. Other information channels are tested by this acceptance versus rejection process, as are competing materials and components. Specialized or habitual market relationships guide users toward specialized technological information and thus do much screening and selection.

The exchanges in technology transfer are not all exchanges of information for information, nor do they all involve the exchange of information for money. However, there appears to be enough exchange activity involved in technology transfer to validate the market analogy. The market functions of exchange, aid in resource allocation, evaluation of quality, and screening and selection for use are important functions of existing technology transfer systems. Proposed system changes should be considered in the light of their contributions to those functions.

If Change is Inevitable, What Changes are Best?

Although this project did not examine all aspects of technology transfer, it led us to a number of suggestions, based on our observations of technology transfer process. The suggestions for industry are offered from the standpoint of what we perceived as the self-interest of industry, and so are the suggestions for the universities. The suggestions for government are made from the assumption that it is or soon will be established public policy to encourage technology transfer, as announced in the State Technical Services Act.

Suggestions for Industry

Commercial industry, as observed in this project, has made surprisingly little effort to manage its technology acquisition effort. Such management would seemingly involve developing an accounting system identifying and measuring the costs of technology transfer and technology acquisition activity. Such a management effort would involve filling the gaps in a firm's technology transfer and technology acquisition activities, and controlling undue duplications. It would assist in managing personnel and other resources devoted to these activities. Technology acquisition may turn out to be as important a functional activity as marketing or purchasing, and it would appear to deserve increased managerial attention. Certainly some firms are sophisticated both in their technology acquisition systems and in their awareness of what their technology acquisition activities are, but such firms were a small minority of those contacted during this research.

An increasing number of firms are supporting continuing education for their scientific and engineering personnel. This appears to be an important function and one which should be considered by any firm recognizing a need to stay current with and use developing technology.

The publishing industry faces rather unique pressures from the new governmental mechanisms for disseminating scientific and technical information. These governmental systems may offer competition, but the volume of governmental information being made available also offers the publishers new opportunities to search, monitor, evaluate, and distribute information on new technology, particularly that generated in the governmental sector. The competitive threat seems to be presently most perceived by the textbook publishers, but it probably will affect periodicals publishers too.[13]

From this challenge, and from a governmental policy encouraging technology transfer, new relationships and new media may develop. Selective searches of information center materials and continuing relationships with government research agencies appear to offer opportunities to both book and periodical publishers.

It appears that all of commercial industry can contribute to the evolution of new technology transfer systems. Manufacturers certainly would be well advised to participate in the design and evolution of the new technology transfer systems that government agencies are studying.

Suggestions for the Universities

The universities undoubtedly have a growing role in the continuing education of people involved in technology acquisition. As mentioned before, over a third of the respondents to this research inquiry had taken coursework in the previous 12 months. Innovations will probably result from opportunities for off-campus work and in the use of new teaching media. Our respondents favorably mentioned such examples as the University of California Extension programs and the MIT short courses.

Another innovation for continuing education, and for the more traditional teaching activities, may involve acquisition of teaching capability to a greater extent from industry and government.[14] This may mean that the universities and their accrediting organizations should re-examine faculty quotas for doctoral degrees as these schools move to improve their capabilities for education and technology transfer.

The schools of librarianship in the universities appear to be key points in the technology transfer process. Technical librarians need training in the processes of technology transfer and of technology acquisition beyond the existing concern with books, journals, and documentation.[15] In addition to computerized systems, there particularly is a need for more capability for dealing with government documents and commercial media such as catalogs.

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[13] Lee C. Deighton: "The Future of Printing in an Information-Hungry Society." Paper presented to the Printing Industries of America in New York City, Jan. 18, 1966.

[14] The Foxboro Company has begun an industry-education partnership with Dartmouth College's Thayer School of Engineering. Under the New Educational Partnership Program, Foxboro will send an engineer to the Thayer School to lecture and otherwise participate in the educational programs with graduate students. Foxboro manufactures industrial control systems and instruments." Technology Week, Oct. 31, 1966, p. 49.

[15] The Interuniversity Education Council (EDUCOM) offers universities opportunity to participate in policy, problem solving, and innovation in technology transfer activities.

Scientific and engineering curricula could well include problem-solving courses emphasizing technology acquisition. Students could be exposed to government research publications, and technical libraries should include up-to-date catalogs of appropriate materials, components, subsystems, and instrumentation. Guest lecturers could be invited from component manufacturers, representatives, and sales engineers, and courses might involve choice-making problems among components, materials, and instrumentation.

Suggestions for the Federal Government[16]

Our research indicated that many people in commercial industry involved in technology acquisition do not even think of government research as offering the possibility of useful information for them. Even less are they convinced that the government research dissemination channels are worth monitoring or searching (see table II-7). A majority of the respondents in the firms studied assume they will hear of any worthwhile government contributions to technology through non-governmental channels, while a substantial minority (as high as 36 percent in two industries studied) assume that government-developed technology is not even pertinent to their work (see tables III-1 and II-6). Therefore, it appears important that there be more government interaction with all of the educational processes through which commercial industry scientists and engineers acquire their education.

The very skepticism of many commercial industry personnel about the usefulness (to them) of government-developed technology argues for dissemination through the conventional channels carrying the prestige of the intellectual market place. Government technology passing through these channels may be more readily accepted because it has survived the competitive process of screening and editing and is somewhat preselected for the users.

It is suggested that internships for scientific and engineering faculty members and graduate students be arranged in government research establishments[17] and also in government R & D contractor facilities. To make this effective, contractors should be encouraged to participate with the assurance that the costs of such activities are fully allowable under their contracts.

Schools of librarianship might be encouraged to innovate in technology transfer by interested Federal agencies or through legislation such as the National Defense Education Act. The Office of State Technical Services programs may be useful tools to foster better service in existing libraries on various government publications communicating technology.

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[16]The suggestions for government actions reflect an assumption that it is public policy to enhance technology transfer in this country.

[17]Similar suggestions are made by Sydney G. Roth: A Study of NASA-University Relationships, Final Report: U.S. Government Printing Office, Wash. D.C., 1964.

Professional journals with their board of referees and editors serve a vital purpose in their market-process of judging the utility of scientific and technological publications. It is suggested that government agencies ask these journals what help they could use from government to facilitate their increasingly difficult job as technology transfer channels.

TABLE III-1.—METHODS USED FOR KEEPING IN TOUCH WITH NEW TECHNOLOGY DEVELOPED WITHIN VARIOUS GOVERNMENT PROGRAMS ACCORDING TO RESPONDENTS IN THE FIVE INDUSTRIES STUDIED

Methods	Research-oriented respondents	Product-oriented respondents	Management respondents
By personal contacts	39%	20%	28%
Attending trade and professional meetings	39	19	31
Through trade and professional publications	59	59	63
Through indexing services	33	12	13
By government announcements and publications	54	36	46
Other	20	6	15
Government-developed technology not pertinent	22	30	21

This table differs from Table II-6 which covered all respondents to questionnaires. This table reports only on respondents from the five industries studied. For details, see Appendix C, Methodology.

To our respondents, the Clearinghouse for Federal Scientific and Technical Information appears to be the most widely known source of government technological publications. As such, it would seem to merit support and cooperation from all of the governmental technology generating agencies.

As technology proliferates and as the number of specialties grow, continuing education is apt to become more and more necessary for, among others, scientists and engineers. The deductibility, from taxable income of continuing education expenses should be assured by the Congress if the enhancement of technology transfer is to be consistently treated as public policy.[18]

Consistency in technology transfer policy is a problem throughout government. Different agencies have varying policies about making their research results readily available to commercial industry.[19] More uniformity is needed, and it would seem that the growing demands for socially useful research results will encourage agencies to move toward more effective and more user-oriented dissemination.

The Federal Government is leading the way toward national systems of technological information. It should make maximum use of existing channels of technological communication and of existing resources. It should seek the participation of universities and industry (including publishers of journals, trade magazines, and textbooks), in the design of such systems. It seems particularly important that industries and firms thought of as being less technologically sophisticated be included in such design efforts, in addition to representatives of the engineering societies. Otherwise, overspecialized information systems might be oriented toward particular groupings of firms and might have upsetting effects on existing industry structure and industry concentration relationships. Experience with mission-oriented, government-supported information centers may not be wholly applicable to fostering technology transfer in the commercial industry and university sectors. These latter groups are essential participants if the fruits of government R & D are to be shared by industry and consumers.

Our research indicates that commercial industry research, product, and management personnel all spread their technology acquisition efforts over numerous channels. This pattern is not apt to change abruptly. It suggests that new systems be designed for redundant dissemination into various channels, including those now in use.

Big new technology information systems will probably be best accepted (and this means best used) if they evolve, rather than if they are developed in sudden and revolutionary fashion.

Acceptance and use of new systems will also depend on showing commercial industry scientists and engineers the value of government technology to them, if they are to be

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[18]Such deductions might be justified expenses of earning income which Pechman calls "...the only theoretically necessary deductions..." On the other hand, he criticizes deductions which primarily subsidize personal expenditures. His final test, that deductions "...have such overwhelming social priority under present institutional arrangements as to warrant the use of tax incentives" may be met by the need to foster continuing educational effort by all, including those involved in technology transfer. Such individual expenditures may also be justified as investments in national resources, leading to national economic growth. Joseph A. Pechman: Federal Tax Policy. The Brookings Institution, Wash. D.C., 1966, p. 78.

[19]This was also a complaint of the Bowen Commission. Technology and the American Economy, Volume 1, Report of the National Commission on Technology, Automation, and Economic Progress (Washington: Government Printing Office, 1966), p. 104.

expected to participate in the exchange relationship which makes up technology transfer. This again argues for their early participation in system planning so that their technology usefulness criteria and their selectivity requirements can be incorporated. They can be expected to ask that new systems either embody or effectively simulate the market functions of present systems.

Paraphrasing the old profundity that "war is too important to leave to the generals," the design of new technology transfer systems appears too important to be left exclusively to information specialists. And it should be emphasized again that the requirements for technological information systems may be quite different than those for scientific information systems. Major programs placing "...the benefits of Federally financed research...more effectively in the hands of American business, commerce, and industrial establishments,"[20] will require the participation of diverse firms and of the universities, as well as of the representatives of government agencies.

Conclusion

Industry, the universities, and the Federal Government are all involved in technology transfer, an exchange process that is changing, probably at an accelerating rate, with much of the change resulting from government activities.

The research reported here points to some suggested actions by which industry, universities, and government might enhance technology transfer. The research has also led the authors of this report to analogize the transfer process with market mechanisms and functions.

These market-type functions—exchange, resource allocation, quality evaluation, and screening and selection for use—appear important to effective technology transfer. It is suggested that maintaining or improving their quality is most likely if industry and university people participate fully with government representatives in development of new technology transfer systems.

[20]Public Law 182, op. cit.

SECTION IV

DESCRIPTION OF NASA'S SYSTEM FOR DISSEMINATING TECHNOLOGICAL INFORMATION

It is evident that NASA's Office of Technology Utilization has conscientiously attempted to utilize the parallel efforts of other NASA offices whenever these coincided with technology utilization purposes or supplemented them. Therefore, in this Section the term "Technology Utilization Program" is used in the broad sense to describe the consolidated NASA efforts rather than only those functions directly controlled or initiated by the two divisions of the Office of Technology Utilization: the Technology Utilization Division and the Scientific and Technical Information Division.

Development of the Technology Utilization Program

Spurred on by the goals of "widest practicable dissemination" and "acceleration of transfer," the creators of NASA's Technology Utilization Program have chosen to concentrate their initial efforts toward creativity and measured experimentation in developing a broad variety of knowledge dissemination methods. As a result, the program includes a spectrum of publications, a battery of services (some conventional and others highly advanced), and a number of inventive special techniques. The system can be characterized by such attributes as energy, profusion, and imagination.

It is unlikely that NASA could have reached its present level of activity in this area if each tentative advancement in technique had been forced to undergo a rigid evaluation before receiving a trial in the marketplace. However, NASA has now reached a stage in the maturity of the program where it is measuring the cost and effectiveness of its methods and reallocating resources from the weaker to the stronger approaches, while continuing to experiment.

Components of NASA's System

To permit ready analysis of the relationship of NASA's Technology Utilization Program to the systems used by commercial industry, it is necessary to categorize and briefly describe the components of NASA's system. This will be done according to the three major divisions previously mentioned: publications, services, and special techniques.

Publications

NASA publications consist of several series which bear NASA's own imprint, and a variety of publications from other sources, for which NASA is responsible (as sponsor or author). Most of the NASA publications are prepared primarily for NASA and its contractors, to distribute necessary information among participants in the space program. (This is a major function of NASA's Scientific and Technical Information Division.) However, the same publications serve a useful secondary purpose in the Technology Utilization Program. Those publications which are specifically prepared for technology utilization purposes are marked with an asterisk.

The NASA-published series include:

A. Technical Reports and Documents:
   1. Technical Reports.
   2. Technical Notes.
   3. Technical Memorandums.
   4. Contractor Reports.
   5. Technical Translations.
   6. Special Publications, including conference proceedings, monographs, data compilations, handbooks, sourcebooks, and special bibliographies.
   7. _Tech Briefs_*.
   8. Technology Utilization Reports* and Notes*.
   9. Technology Utilization Compilations*.
   10. Technology Surveys.

B. Publications Abstracts and Bibliographies:
   1. Scientific and Technical Aerospace Reports (_STAR_)
   2. Continuing bibliographies on space-related technical subjects.

The NASA-sponsored or -authored publications of others include:

A. Technical Reports and Documents:
   1. Articles in scientific and technical journals, prepared by NASA personnel. Some of these are abstracted in IAA (see below).
   2. Textbooks and reference books sponsored by NASA but published commercially.
   3. _AEC-NASA Tech Briefs_* and Technology Utilization Reports.

B. Publication Abstracts and Bibliographies:
   1. International Aerospace Abstracts (IAA) published by the American Institute of Aeronautics and Astronautics under NASA contract.
   2. Reliability Abstracts and Technical Reviews.

Each of the above-listed publication series is described more fully below.

NASA Publication Dissemination Policies

NASA's policies on public dissemination on its various publication series appear to be based on its desire to "provide the widest practicable and appropriate dissemination of information" while following the standing instructions of Congress to avoid free dissemination of publications and to encourage cost sharing by the user wherever practical.

Distribution. NASA has a prime interest in the rapid distribution of materials among its own offices, contractors, and grantees, in the furtherance of the space program. Except for classified material (which is handled in compliance with security regulations) and certain proprietary documents, a NASA-registered contractor has ready access to all publications he needs. This includes both NASA-published items, and other publications, not generated by NASA, which are abstracted in STAR. So long as the contractor is registered with NASA and there are no distribution limitations on the material he requests, there is no impediment to his getting whatever he asks for. Furthermore, through reciprocity, NASA and the Department of Defense provide free copies of all publications direct to each other's contractors upon request. The documents are provided to the eligible organizations either in microfiche or hard copy, as requested.

NASA technical literature also is distributed without charge to other U. S. Government agencies, to educational institutions, to numerous public libraries and report centers, and to other organizations, domestic and foreign, having exchange agreements with NASA. This includes segments of the business and professional press. Automatic distribution in 34 specific subject categories is available.

Individuals or organizations not included in the categories mentioned may purchase NASA Technical Reports from the U.S. Government Printing Office or from the Clearinghouse for Federal Scientific and Technical Information. NASA Technical Notes and NASA Technical Translations may be purchased from the Clearinghouse only.

NASA will provide a free copy of a normally-sold publication to an individual requestor in cases where this is the least costly means of responding to a request for information.

Tech Briefs are considered to be primarily announcement media, and are provided without charge to selected users whose functions relate, in a general way, to the space program. Users who do not meet NASA's selection criteria may obtain Tech Briefs from the Clearinghouse at an annual cost of $24 or at a cost of 15 cents per copy. Tech Briefs go to a mailing list of nearly 11,000.

NASA library activities. NASA headquarters and each NASA field installation maintain libraries varying in size and scope to serve particular reference and bibliographic needs. Although these libraries are operated primarily for NASA employees, the agency makes its unclassified publications freely accessible to the scientific community and the public. This is accomplished through automatic distribution of NASA publications to about 50 public libraries located throughout the United States. Through interlibrary loan arrangements, these documents are available to other libraries as well.

Federal Regional Technical Report Centers. Eleven Federal Regional Technical Report Centers are maintained at research and university libraries located in major scientific, industrial, and educational areas throughout the United States. The primary mission of these centers is to make available to the general public unclassified reports issued or distributed by NASA, the Atomic Energy Commission, the Department of Defense, and other government agencies. Reports are supplied by the Clearinghouse for Federal Scientific and Technical Information.

Funds for the operation of the centers were originally provided by the National Science Foundation. Although financial support for servicing the report collections was withdrawn in July, 1964, the report centers at the 11 institutions continue to receive copies of government reports, including those of the National Aeronautics and Space Administration, and provide related reference services to the regional areas they serve.

Descriptions of Individual Publications Series

Each of the publications series listed on page 63 is described more fully below:

Technical Reports (TR's). Each publication in this series is the final report of a complete NASA research project, or presents some other information considered of current interest and lasting importance to aeronautics or space science. NASA Technical Reports are intended for the widest practical distribution. They do not contain security-classified information or information with other distribution limitations. Around 50 are published each year.

Technical Notes (TN's). This series presents results of completed segments of continuing research projects or results of smaller research programs. They are not as complete as Technical Reports; the information in several Technical Notes may eventually be combined in a single Technical Report. Technical Notes are intended for wide general distribution and do not contain classified material or information restricting their distribution. Approximately 600 are published annually.

Technical Memorandums (TM's). Technical information requiring a limited distribution for security or other reasons is usually presented in the form of Technical Memorandums. Reports in the series may contain unconfirmed or preliminary data, classified information (there is very little of this), proprietary information, or information of limited general interest, intended for a specific audience. If the information contained in a declassified Technical Memorandum is considered to be of general interest at the time it is declassified, it may be reissued in the form of a Technical Report or Technical Note. About 150 Technical Memorandums are issued each year.

Contractors Reports (CR's). Scientific and technical information generated under a NASA contract or research grant generally appears in the form of a report issued by the contractor or grantee. While there is no standard format for such reports, those that merit release under NASA auspices are issued in the uniform Contractors Report (CR) series. The decision to issue a report in the CR format is made by the appropriate program office at NASA headquarters, which also determines the distribution. Like the

Technical Memorandum series, Contractors Reports sometimes contain classified, proprietary, or unconfirmed information, and their distribution is restricted accordingly.

Technical Translations (TT's). The Technical Translations series consists of verbatim English translations of foreign language research documents which are considered worthy of translation and distribution by NASA, or are requested by its contractors or other affiliated organizations. These translations are made either by a small NASA staff (if urgently needed) or by one of six translating firms under NASA contract.

Special Publications (SP's). NASA uses the term "Special Publications" to cover scientific and technical publications falling outside the scope of the report series described above. In many cases Special Publications present highly technical information, either for a broad interdisciplinary audience or a selected lay audience. They contain information generated by NASA activities, but do not ordinarily report results of individual NASA-programmed scientific efforts. They may be prepared by any of the NASA field installations, by the Technology Utilization Division or the Scientific and Technical Information Division at NASA headquarters, or by NASA contractors and grantees.

Special Publications include, but are not limited to, proceedings of scientific meetings sponsored or co-sponsored by NASA, technical reviews, state-of-the-art monographs, formal bibliographies, glossaries, and handbooks or other compilations of tables, charts, and data. Some 125 documents have been issued in the six subseries of Special Publications since 1961.

The SP series includes all reports (except Tech Briefs) issued by the Technology Utilization Division which present knowledge of potential value to industry.

Tech Briefs. These are one- or two-page bulletins describing individual NASA innovations, inventions, devices, methods, discoveries, or concepts arising from the space programs which are believed to be novel and to have potential use elsewhere in science or industry. Over 1,200 Tech Briefs have been published since the beginning of 1964, and the rate of publication is accelerating. A mid-1966 analysis showed the following breakdown by subject category:

Electrical/electronic	44%
Mechanical	33
Materials/chemistry	15
Energy sources	7
Life sciences	1
	100%

Tech Briefs are designed to receive broad distribution to the public, and to be "published quickly in order to reach potential users as soon as possible and to encourage commercial application." They are sent to a mailing list of nearly 11,000 and also have a substantial distribution to special requesters. Frequently, trade and professional journals reprint Tech Briefs or base short articles on them.

Normally, the innovation is first described informally in an internal document prepared by a Technology Utilization officer at a NASA field installation or contractor plant. These documents are reviewed by one or more private technical research institutes (serving under NASA contract) and are evaluated for significance and novelty; the better ones are rewritten into Tech Briefs.

Separate supplemental information (so-called "back-up") packages are prepared for the large majority of Tech Briefs which are not complete in themselves, to provide substantially complete descriptive information and specifications to a potential user. The package is available on request.

Technology Utilization Reports and Notes. The primary thrust of these publications is directed to the utilization of space program technology in non-aerospace science or industry. They cover individual innovations, or clusters of related innovations, having relatively great potential and lasting importance.

Technology Utilization Compilations. A new publication series will announce these compilations and describe groups of related incremental advances, such as computer programs, electronic circuits, shop hints, etc.

Technology Surveys. These are comprehensive guidebooks designed to highlight aerospace program advances in the state-of-the-art in fields where NASA has made significant contributions, and to guide the reader to other (including non-aerospace) sources of related information. They contain both timely information (as do Technology Utilization Reports and Notes) and data on less recent developments which contributed to the present body of knowledge. NASA has published 12 surveys, and has 25 others in progress.

Scientific and Technical Aerospace Reports (STAR). This semimonthly publication, issued in its present form since 1963, contains abstracts of unclassified report literature relevant to the science and technology of aeronautics and space. Abstracts, 70 percent of which are author-initiated, are arranged by 34 major subject areas and indexed by more than 6,000 terms. Each issue is indexed by subject, corporate source, author, report number, and NASA accession number. NASA and NASA-contractor reports are included, together with reports of other government agencies, universities, and research organizations in the U.S. and abroad. Foreign-language reports and English translations issued in report form also are included. Journal articles prepared by NASA and NASA contractors are announced and indexed for reference purposes. STAR is sold by the Government Printing Office on an annual subscription basis. Indexes are issued quarterly and the fourth quarterly volume is a cumulative index for the entire year.

Continuing bibliographies on space-related technical subjects. NASA publishes (as part of its SP Series) continuing annotated bibliographies on several technical subjects related to the space program. An example is Aerospace Medicine and Biology: A Continuing Bibliography. This is an annotated bibliography, issued approximately monthly since July, 1964, covering all Library of Congress accessions in the area of aerospace-related medicine and biology. It covers biological, physiological, psychological and environmental effects related to space flight, and related problems of sanitation, pharmacology, toxicology, safety and survival, life-support, exobiology, and personnel factors. For other bibliographies the supplementary issues are considerably less frequent than Aerospace Medicine and Biology. Subjects include: Lasers and Masers; Lubrication, Corrosion, and Wear; Planetary Atmospheres; Aerospace Science; Communication Satellites; High Energy Propellants; and Lunar Surface Studies.

Journal articles. Numerous articles by employees of NASA and the agency's contractors appear in scientific and technical journals each year, reporting various activities in the nation's space program. These are announced and indexed in the NASA-supported semimonthly abstracting publication, International Aerospace Abstracts.

NASA's policy is to encourage the preparation of articles by its employees, although there apparently is some variation among research centers as to the rewards for publication (in prestige or promotional enhancement), the degree of editorial assistance (if any) provided to the author, and the relative priority given to journal publication in contrast to publication as a NASA Technical Note. NASA will, under specified conditions, pay customary page charges in professional journals for employee articles.

Textbooks and reference books. On two occasions thus far, NASA has sponsored the writing and commercial publication of text/reference books: Glasstone's Sourcebook on the Space Sciences and Corliss' Space Probes in Planetary Exploration. In each case, the book was planned to fill a significant gap in the literature, and to permit a wider distribution of information on space technology than would have occurred without NASA's active sponsorship. Further books are anticipated.

AEC-NASA Tech Briefs and Technology Utilization Reports. These documents, begun in 1966, are directly analogous to their NASA counterparts. The joint product of the two sponsoring agencies, the documents report innovations developed in certain AEC laboratories (Argonne and others) or from AEC-NASA jointly sponsored R&D programs. The innovations are sent by AEC in preliminary form to NASA, where they flow through NASA's evaluation-publication-dissemination channels until issued as jointly-sponsored documents.

International Aerospace Abstracts (IAA). This companion publication to STAR, sponsored by NASA, is published twice a month by the American Institute of Aeronautics and Astronautics. It covers books, periodicals, conference proceedings, and other published media in aeronautics and space science and technology. Coverage is worldwide and includes works in original languages and in translation. The subject headings and the indexing systems used in this publication are identical with those used in STAR. Abstracts are arranged by 34 major subject headings and indexed by subject, author, corporate source, publication number when applicable, and NASA accession number.

Reliability Abstracts and Technical Reviews. This is a highly-specialized abstract series of relatively limited distribution, prepared for experts in the area of product and program reliability.

Services

NASA provides the following services as part of the Technology Utilization Program:

(1) Operation (under contract) of seven Regional Dissemination Centers and a regional dissemination program serving small business firms.

(2) Information search and retrieval services for industrial contractors.

(3) A technological information utilization service, to identify technological advances having transfer potential and to respond to inquiries concerning them.

(4) Consultation with visitors to Technology Utilization field offices, and processing of telephone and mail inquiries for technical information at NASA field installations.

(5) The licensing of NASA-owned patents.

(6) Sponsorship of three Biomedical Application Teams.

(7) Dissemination of computer programs developed by or for NASA.

(8) Distribution of selected British and Canadian documents, and documents of the Advisory Group for Aeronautical Research and Development (AGARD).

(9) Cooperative programs with other agencies:

a. Vocational Rehabilitation Administration.
b. Small Business Administration.
c. Office of Law Enforcement Assistance and the President's Commission on Law Enforcement and Administration of Justice.
d. Bureau of Public Roads.
e. Office of State Technical Services.
f. Clearinghouse for Federal Scientific and Technical Information.

The following additional services are now in planning stages:

(10) Development of a NASA/SCAN information service to supplement the current SDI system for selective dissemination of information.

(11) Feasibility study of a computer-linked, direct access, data retrieval system.

(12) Planned dissemination of NASA standard specifications data.

Each service is described more fully below.

Regional Dissemination Centers. In recent years, the technology dissemination technique receiving greatest emphasis has been the operation, under contract, of seven experimental Regional Dissemination Centers (RDCs). Each center provides a variety of specially-tailored services to private industrial firms, which pay an annual membership fee to partially (and eventually, fully) support the centers' operation. A similar regional dissemination program, specializing with small business firms, is conducted by the Technology Use Studies Center, under contract to NASA. The services provided by the RDCs include:

- Retrospective search—Searches by computer of government scientific and technical documents to provide comprehensive information relating to a member's specific interest. The search covers 230,000 documents (increasing at the rate of 5,000 per month) and provides bibliographies, abstracts of reports, and/or complete copies of reports, as desired.

- Selective information dissemination—All current incoming technical reports (some 5,000 per month) are searched automatically by computer, then screened manually, to select those matching the interest profiles of member companies. This service is intended to promote current awareness by combining an extensive search with basic screening of non-applicable data.

- Industrial applications—A technical expert on the RDC staff reviews the technical reports in his specialty. Those considered of unusual potential for commercial industry application are selected and sent to the member companies having interests in the specialized field.

In December, 1966, there were 243 member firms in the growing RDC clientele.

In a related effort, NASA sponsors studies by the Office of Industrial Applications at the University of Maryland, designed to improve the effectiveness of dissemination techniques for technical knowledge.

Data search and retrieval services for industrial contractors. In its conduct of the space program, NASA has developed a capability of providing retrospective information search, retrieval and bibliographic reference services to NASA offices, as well as to NASA and DoD contractors and to NASA grantees. The provision of these services, by the Scientific and Technical Information Division, is directly analogous to the distribution of NASA publications to these recipients.

Although this activity is not conducted for Technology Utilization purposes, it indirectly serves to augment the T.U. Program. That is, the capability which has been developed to serve the aerospace industry is a resource which can be made available to serve non-aerospace industry. The services to NASA and DoD contractors are provided by NASA's Scientific and Technical Information Facility in College Park, Maryland, which is operated under contract by Documentation, Inc. The Facility was established to acquire, organize, process, and report worldwide aerospace information and to accomplish high-speed retrieval and dissemination of this information.

The Facility automatically receives and catalogs significant scientific and technical documents that result from NASA, or NASA-supported, investigations. It also receives documents derived from interagency agreements and from NASA exchange agreements with domestic and foreign organizations (150 organizations in 40 countries). Items of value are abstracted, indexed, and entered into the announcement and searching systems.

A contract was recently signed for the compilation of a NASA technical thesaurus, covering some 20,000 terms used in the NASA information system. This major effort will involve NASA contractors and professional societies.

Operation of technological information utilization service. The Technology Utilization Division operates the related services of identifying technological contributions of the space program which have potential applicability elsewhere in the economy, and of responding to inquiries concerning them. The response techniques include preparing specific information replies, referral to NASA publications, and referral to non-NASA information sources and publications.

Field office visits and inquiries. During 1965, approximately 1,500 persons visited NASA Field Center Technology Utilization Offices, to obtain person-to-person transfers of technology by talking to NASA researchers working in areas of their interest. In addition, the T.U. officers processed many inquiries by mail and telephone. These officers, assigned to the NASA field installations, are expected to serve as active catalysts between those who generate new knowledge in and for NASA and those who seek to utilize such knowledge.

Their primary task is to identify innovations, discoveries, and significant improvements that may have applicability elsewhere in the economy, and to document these in a form which will promote their accessibility by potential users.

Patent licensing. Some of the space-program technology is patentable, and the patent process serves as a channel for the dissemination of this technology. Some patents are held by NASA, and normally these are available for commercial use under license, on a non-exclusive, royalty-free basis. Still other patents are waived by NASA to NASA contractors who developed the inventions.

Information on the existence and availability for use of these patents reaches industry in several ways. Each NASA Tech Brief includes, where applicable, information on patent ownership and licensing availability. This information normally is included by periodicals which publish articles based on Tech Briefs.

The Official Gazette of the U.S. Patent Office, the traditional source of patent information to the public, contains descriptive abstracts of all patents when issued. Certain trade associations (e.g., the Research and Engineering Council of the Graphic Arts) publish their own lists of patent abstracts which concern their specialty, using the Gazette as a data source.

NASA's Office of Patent Counsel distributes, on request, a cumulative list of all NASA patents by title, number and date of issue, and categorizes them according to license exclusiveness or non-exclusiveness.

Biomedical Application Teams. The Biomedical Application Team, a unique organization designed to promote technology transfer between the fields of aerospace and biomedicine, consists of a small interdisciplinary group of scientists and engineers at a NASA-contracted research organization. Currently, there are three such teams. The first, at Midwest Research Institute, Kansas City, Mo., has affiliations with several medical schools, including St. Louis University, the University of Kansas, and the University of Minnesota; it was created in November, 1965. The other teams, organized in August 1966, are at Southwest Research Institute, San Antonio, Tex., and the Research Triangle Institute, Durham, N.C., each with medical school affiliations. Each team is expected to have both an intimate knowledge of NASA information sources and the technical capability to recognize potential biomedical applications when searching NASA's technology information system. Each Biomedical Application Team becomes an active transfer agent between NASA and several biomedical research teams in medical schools, hospitals, and research institutes.

The transfer process consists of five phases:

(1) A medical problem or barrier impeding medical research progress is defined, normally by a medical school staff member acting as consultant to the Biomedical Application Team, and a one- or two-page Medical Problem Abstract is prepared, describing the problem in functional terms.

(2) The team conducts a widespread function-oriented search of NASA sources (both information and personnel) to identify as many potential solutions as possible.

(3) Each potential solution receives a preliminary evaluation by the team, and the promising ones are referred to the problem originator for laboratory and clinical evaluation.

(4) Typically, some modification of the item is necessary to adapt it suitably for medical use. This often requires a series of successive modification-evaluation cycles before the item is clearly acceptable. (This work is encouraged, but not sponsored, by NASA.)

(5) Finally, the transfer is documented and suitably disseminated through professional channels (journals, seminars, etc.) to physicians and equipment manufacturers. This step is normally expected to be taken by the medical research groups.

Computer programs dissemination. To improve utilization of the computer technology developed as part of the space program, NASA has established a dissemination system utilizing NASA field installations and the facilities of the University of Georgia.

Computer programs developed at the NASA installations or by NASA contractors are obtained by Technology Utilization officers, evaluated, and programs of interest are selected for abstract publication. Their availability is publicized in Tech Briefs, as well as by the trade press and other media. The program itself (tapes, cards, run instructions) is sent to the University of Georgia's project for reproduction of card decks and tapes. Industrial users desiring programs purchase them from the University at the cost of reproduction, distribution, and overhead.

Distribution of British, Canadian, and AGARD documents. NASA's Scientific and Technical Information Division acts as the distribution point for selected British, Canadian, and AGARD (Advisory Group for Aeronautical Research and Development) documents. These are made available without charge to those government agencies, industrial organizations, and academic institutions which contribute to the national space program or support it directly. NASA does not provide these documents to the general public, although some can be purchased from commercial sources.

Cooperative programs with other agencies. In addition to its close ties with the Department of Defense and the Atomic Energy Commission, NASA has established several joint programs with other agencies, which promote the ends of technology dissemination. The most significant of these are described below:

(a) Vocational Rehabilitation Administration (VRA): Under terms of a July, 1966 agreement between NASA and VRA, vocational rehabilitation scientists at four VRA research centers specify their unsolved problems in restoring the disabled to productive life. NASA research center staffs and Biomedical Application Teams search out space-related innovations which appear as potential solutions and communicate these to VRA scientists for evaluation, adaptation, and encouragement of the commercial development of new devices.

(b) Small Business Administration (SBA): An agreement between NASA and SBA covers the experimental dissemination by NASA of technological innovations to small business firms. The program is intended to strengthen the competitive positions of small firms in a rapidly changing economy. The program has two parts: first, to provide a full range of Regional Dissemination Center services to some prototype small businesses at a moderate fee; second, to utilize SBA field offices as NASA technology dissemination channels to selected small business firms. Thus far, four NASA-sponsored RDCs are involved in the SBA program.

(c) Office of Law Enforcement Assistance (OLEA), U.S. Department of Justice: In a series of interrelated activities, NASA is providing experimental services to various agencies concerned with law enforcement. OLEA receives RDC services (including retrospective searches and selective dissemination of information) similar to those given to industrial members. The program is designed to provide both improved crime detection and control devices using NASA technology, and new police administrative techniques based on space program management methods.

(d) Bureau of Public Roads (BPR): NASA's Langley Research Center and BPR have jointly produced an educational film on the hydroplaning effects of tires on wet roads, designed for an automobile-driver audience.

(e) Office of State Technical Services (OSTS): The State Technical Services Act of 1965, designed to assist small and medium-sized businesses by providing information on R & D, has been assigned to OSTS to administer. OSTS, recognizing "the early and consistent success of the NASA/RDC programs," and the complementary nature of OSTS and NASA activities, has recommended to its designated state agencies that their programs be pursued in cooperation with the RDCs sponsored by NASA and that the agencies utilize the RDCs wherever appropriate. NASA and OSTS also are cooperating in other ways.

(f) Clearinghouse for Federal Scientific and Technical Information: In its role as the central point in the government for the collection, announcement, and sale to the public of federally-sponsored R & D reports, the Clearinghouse is a channel for the dissemination of NASA technology. Once a supply of documents is provided by NASA to the Clearinghouse for announcement (and all NASA publications indexed in <u>STAR</u> are released in this fashion), the Clearinghouse, as a policy, will make copies available for sale perpetually in either hard-copy or microfiche form. After the NASA supplies are exhausted, the Clearinghouse will reprint copies.

The Clearinghouse selects certain documents considered to be of the greatest general interest to businesses and the public, and prepares an announcement which stresses the potential industrial applications. These are categorized according to 57 business/scientific subjects, and are disseminated selectively to those of the 6,000 paid subscribers to the Clearinghouse <u>Fast Announcement</u> service who have expressed an interest in a particular subject category.

<u>Planned NASA/SCAN Information Service</u>. Plans currently exist for the development of a NASA/SCAN Information Service involving NASA field installations, Regional Dissemination Centers, and major contractor organizations. This service (named after Selected Current Aerospace Notices) is designed as a more economical but effective substitute for the SDI (Selective Dissemination of Information) system now in use. The current system requires the searching, categorizing, and dissemination of information according to the unique interest profiles of many individual users. SCAN intends to supplement this with a predetermined series of interest categories, which will continue to be adequately selective for user needs but will reduce the volume and cost of searches.

<u>Computer-linked data retrieval system</u>. NASA's Scientific and Technical Information Division has contracted for an analysis of an experimental, computer-based, on-line information retrieval system. The system would provide direct access by an operator at a console to over 400 million characters of stored information. It would permit real-time random-access querying by scientists and engineers of the information bank, thus vastly magnifying the ease and speed of a retrospective data search, and permitting modification of the search strategy as it progresses. The analysis also will evaluate the use of a remote terminal retrieval facility, which could expand the utility of the system

by permitting remote consoles and time-shared use of the computer by engineers and scientists in dispersed locations.

Planned dissemination of NASA specifications. Recognizing that nationally-accepted specifications for materials and products are of considerable value to industry—both to manufacturers and purchasers—NASA now plans to disseminate information on those standard specifications which have been developed by NASA itself and its contractors for use in the space program. A preliminary listing of some 4,300 NASA specifications has been compiled, cross-indexed by subject, and is being circulated internally for comment and correction. After necessary revision, it is planned for publication in NASA's SP-series. The dissemination of specifications is expected to be a continuing program.

Special Techniques

NASA is now providing or experimenting with certain special techniques of technology dissemination, other than those which can be considered as publications or services. These include:

(1) The sponsorship of professional conferences, seminars, or presentations.

(2) The funding of research projects, and of related facilities for research and its dissemination.

(3) The production and use of motion pictures.

Conference sponsorship. NASA has sponsored certain major conferences and seminars as a means of advancing technology utilization (in addition to other purposes). These include the annual National Conference on the Peaceful Uses of Space, and special conferences such as the Lewis Research Center's Petroleum Technology Conference, the Marshall Space Flight Center's symposia, the NASA-Industry Program Plans Conference, the NASA University Program Review Conference, and the Conference on Space, Science, and Urban Life. Normally, industry and university representatives are invited to the conferences. NASA publishes the proceedings of sponsored conferences as part of its Special Publications series.

NASA also promotes panel discussions and encourages the presentation of papers by staff members at other conferences, where NASA is not a sponsor. Examples include the Midwest Research Institute's series of seminars on industrial applications of space technology, and a panel on Space Technology and Medicine at the Symposium of the Association for Advancement of Medical Instrumentation.

Funding of research projects and facilities. NASA has for some time sponsored a program of research contracts and grants, which is designed to help implement NASA's in-house efforts in reaching its mission goals. Some of these grants are to foundations, some to universities, and some to individual researchers. Certain of the grants sponsor research activities intended to serve the ends of the Technology Utilization program.

For example, NASA supports the Lovelace Foundation of Albuquerque, New Mexico, in its Atlas of Information Project, which includes the development of an automated aerospace and environmental medical information system.

Motion pictures. Although NASA has not yet made extensive use of motion pictures as a technology dissemination medium, tests of their relative effectiveness are underway. If successful, NASA will prepare films to demonstrate technological innovations having high potential utility outside the aerospace program, in those cases where the written word is inadequate to convey the technology, and will offer them to government agencies, trade and industrial associations, universities, and others who would aid in this communication. NASA has prepared a film containing six examples of useful technology transfer and is using it in conjunction with supplementary written information (i.e., Tech Brief backup packages) which is made available to industrial audiences. Other films which indicate the preliminary direction of this effort are those on the electromagnetic hammer, on hot drape forming, and the NASA-Bureau of Public Roads film mentioned above.

SECTION V

A SUBJECTIVE EVALUATION OF NASA'S TECHNOLOGY UTILIZATION ACTIVITY

NASA's Technology Utilization (T. U.) Program can be described as having three attributes: energy, profusion, and imagination. The term "cost-effective" is not used for two reasons: first, no rigid cost-effectiveness evaluation has been made; second, NASA has deliberately given more attention to creating and experimenting with novel methods than to quickly eliminating less successful ones. This policy, for the developing stages of the T. U. Program, does not appear unwise.

As was inevitable from the rapid growth of the program, certain techniques held considerable theoretical promise but failed of acceptance by the potential clients. Certain of these methods probably cause the NASA Technology Utilization personnel to feel (in Conan Doyle's terms) "...how a battery feels when it pours electricity into a non-conductor."

In Section II of this report is a summary of a survey of industrial researchers, which illustrates the extent of their familiarity with selected NASA Technology Utilization channels and their reliance on those channels. That summary, representing a cross-section of opinion, and reflecting the test of both intellectual and economic marketplaces, should be given attention. However, it also can be presumed to reflect inertia and uncertainty about new institutions. This section of the report is intended to complement those findings with a subjective evaluation of NASA's use of the channels, based on a variety of personal impressions received during the survey process.

Speed in Technology Dissemination

First, there is considerable question as to the stress NASA places on speed in disseminating technological information. The emphasis on rapid identification, publication and distribution of material evidently causes the inclusion of some information of marginal quality and utility. (It is only speculative to consider whether speed also hampers thoroughness, causing certain information of potential value to be overlooked; this is considered possible but less likely.) With a few exceptions, commercial research, development, and engineering personnel seemed more concerned with the technical quality of the innovation than with the rapidity of its communication. In a problem-solving search, emphasis was placed on credibility of the report and ease in locating it, rather than in timeliness. For maintaining current awareness, there seemed to be an overwhelming sentiment for elimination of the trivial, the obscure, and the rehashing of old knowledge. Selectivity and quality were considered important; rapidity of communication was much less so. (An exception is the general desire to be aware of advances in state-of-the-art which may affect long-range planning or R & D budgeting. For these purposes, the trade press and other awareness channels are considered important.)

NASA might profitably review its Technology Utilization Program to determine where the emphasis on speed causes inadequacies in the evaluation and editorial processes. Apparently, many industrial users of NASA T. U. material would prefer more care given to improving quality and utility, even at the cost of some delay. It is realized, of course, that many NASA publications are primarily designed for users in the space program. These users are doubtless much more time conscious than users in the industry sectors contacted in this study.

NASA Publications

NASA's system of distribution for publications seems well-suited for the goals of the T. U. Program. This is particularly true of the cost-free dissemination, without a rigid screening (which would appear impractical, and perhaps disfunctional), to NASA and DoD contractors. This relatively liberal distribution policy (although not designed for T. U. purposes) results in a potential widespread dissemination of NASA publications among a large segment of American businesses. The limitations to the potential are the lack of recognition by some eligible contractors that they have this opportunity, and their lassitude in making the necessary requests.

Technical librarians within industry in many cases do not take the initiative. The contacts made during the study revealed a wide variation in their knowledge of government publications and data sources. Some were familiar with TAB but not STAR; some had heard of STAR but not IAA; most had heard of none of them.

The 11 Federal Regional Technical Report Centers appear, in theory, to offer a tremendous leverage. That is, the effort in establishing them should be greatly multiplied by their usefulness as reservoirs of technical information for their regions. Unfortunately, in at least one case, the reservoir lacks thirsty customers. Whether or not it is typical, this Report Center averages only 500 requests annually a surprisingly light utilization. Of course, even this infrequent use might conceivably be sufficiently worthwhile to justify the expense of operating the Center, but there is considerable doubt that the Center is well-enough known to have reached its potential. Industrial researchers appear to be even less aware of its existence than do professional librarians, as would be expected.

Another contributing factor to the low utilization of this particular Center seems to be the lack of proper equipment. Although some 200,000 documents exist, largely on microfiche, there is only one microfiche reader and not even one workable microfiche printer at the Center. This reflects the lack of operating budget since National Science Foundation financial support ceased in 1964. It appears disfunctional to weaken the Center's effectiveness in such a manner, after making such a substantial contribution to creating it, staffing it, and providing it with a continuing supply of documents. (The Center appears to be well-organized and competently staffed; no criticism of these controllable factors is intended.)

There can be little criticism of NASA's policy to utilize to the fullest extent for T. U. Program purposes (consistent with national security) the publications series prepared by The Scientific and Technical Information Division. Indeed, this seems only prudent and economical. While certain space publications may not have been designed for a commercial audience, they certainly can serve as a reservoir of knowledge for such an audience. Extra copies of Technical Reports cost amazingly little, considering their permanence, their communication power, and their availability to anyone who uses modern library services.

An executive of the Clearinghouse for Federal Scientific and Technical Information indicated that there was considerable demand by their industrial clientele for certain "outstanding" NASA publications, and gave as examples Selected Welding Techniques and others of the Technology Utilization Reports and T. U. Notes series. He also spoke favorably of the popularity of certain Technology Survey publications (e.g., Inorganic Coatings), and singled out NASA's entire SP-series as "very popular." Many of these publications, evaluated in the broad context by comparison with all government documents which the Clearinghouse distributes, are considered to be of considerable general interest and significance (e.g., the "Significant Achievements In..." space science series).

This is not to say that all NASA technical documents enjoy the high regard of industry. On the contrary, there is a recurring critical note among some industrial researchers. Most often, this criticism centers about Tech Briefs, and perhaps is most common in those persons whose only contact with NASA is through Tech Brief distribution. The critical view is by no means universal, however. An R & D director in a major industrial firm feels them to be sufficiently important that he insists on personally reviewing them. After screening, he sends promising ones to his designers who "use them, but won't admit it."

However, because of the NASA-established incentives for issuing Tech Briefs rapidly and in quantity, their technical quality has been generally perceived as being uneven. The numerous valuable ones have (according to industry reports) been submerged in a flood of trivia. Criticisms have been heard that the "innovations" lack novelty, significance, and applicability. Unfortunately, many critics extend this opinion to all NASA publications and to NASA technology in general. The Technology Utilization Division has already recognized this fact and has instituted a program of redirection and review to upgrade the quality of Tech Briefs.

NASA's Services

The Regional Dissemination Centers provide services which, in theory at least, are characterized by their breadth, completeness, and the personal contact which promotes responsiveness to the individual needs of the member firms. There are certainly some criticisms by subscribers as to how promptly and completely the RDC's function, but there seems to be little criticism of the concept. Indeed, some industrial research personnel define a needed, ideal information system in terms which closely describe an RDC.

It is fairly evident that most American industrial researchers have never heard of an RDC, even though their firms are potential clients. This could be a major reason why RDC's are not yet self-supporting. The lack of awareness may have many causes, not all of which are readily correctable. However, one cause may be lack of assertiveness by RDC staffs.

Since RDC criticisms seem to be predominantly directed at the practice rather than to the concept, the problem may be one of administration—one that NASA can evaluate more fully.

The concept of Biomedical Application Teams appears promising, both for their continued effectiveness and as a model for analogous activities in other technical fields. The keys to their apparent success are their interdisciplinary composition, their direct, active contact with NASA technology, the evident cooperation of the medical profession, and their use of effective paths of information exchange leading to general implementation. If these factors can be found in other areas as well, NASA may well consider extending the Application Team concept.

NASA's Special Techniques

The programs of conference sponsorship appear desirable and worthwhile. NASA appears to have been rather selective in sponsoring special conferences; it seems appropriate to continue this selectivity, even though it limits the gross quantity of participants, so that NASA conferences will enjoy a reputation for quality. Many respondents in the survey condemn the uselessness of attending certain conferences in their professional areas, and state a need for choosing the worthwhile ones. There appear to be enough mediocre conferences already.

NASA has shown considerable ingenuity and initiative in establishing cooperative T.U. programs with other agencies. This displays awareness that joint programs are a useful method of multiplying program effectiveness while avoiding the dangers of staff proliferation and mission duplication.

The Clearinghouse for Federal Scientific and Technical Information directly complements NASA's T.U. function by serving as an active information dissemination agent. The relatively large percentage of survey respondents who are familiar with the Clearinghouse gives evidence of its value as a source of information on NASA technology applications.

APPENDIX A. BACKGROUND INFORMATION ON INDUSTRIES AND FIRMS INCLUDED IN THE STUDY

The purposes of this appendix are:

(1) To describe the economic characteristics of the five industries included in the study, noting similarities and differences.

(2) To describe how the characteristics of each industry and firm studied relate to the patterns of acquiring technological information from external sources.

(3) To give miscellaneous information on characteristics of channels and of respondents. These include costs of information acquisition, effects of size of firm on channel use, time lags associated with specific external channels, and respondent characteristics.

Battery Industry (Pilot Industry)

Economic characteristics. The battery industry employs over 26,000 persons and has annual sales in excess of $800 million. Within the industry, automotive storage batteries account for over half of total sales and employment. Other important segments are alkaline-manganese, silver-cadmium, and silver-zinc cells used by the military (for missiles and torpedoes primarily), rechargeable nickel-cadmium batteries (for small household appliances), and other primary batteries for flashlights, hearing aids, portable radios, etc.

Generally speaking, establishments in the battery industry are small (only nine have more than 500 employees) and have not diversified into other products or markets. The storage battery industry primary product specialization ratio (a measure of homogeneity) is 98 percent—an extremely high degree of specialization.[1]

Of the five industries studied, the battery industry has the highest proportion of sales to the Federal government (about 5 percent—see table A-1). Also, a much larger proportion of the spokesmen interviewed in the battery industry have had some experience in government research and development (see table A-2). These spokesmen, to

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[1]A manufacturing firm is assigned to one of 425 four-digit Standard Industrial Classification categories (or industries) on the basis of its dominant or primary product line. While some establishments produce only the primary products of the industry in which they are classified, it rarely happens that all the establishments in an industry specialize to that extent. The primary product specialization ratio relate the production of primary products to total output. The source of this ratio is the 1963 Census of Manufacturers, U.S. Bureau of the Census, Government Printing Office, Wash. D.C., 1966.

TABLE A-1.—SUMMARY OF ECONOMIC CHARACTERISTICS, FIVE INDUSTRIES

Industry characteristics	Battery industry	Medical electronics industry	Printing machinery and reproduction equipment industry	Industrial controls industry	Vocational-technical education field
(1) Total annual sales volume (or other measure of size)	Total industry sales were $711 million in 1963 vs $507 million in 1958. Total employment of 26,000.	$150 million sales in 1966. Sales were $105-115 million in 1964.	Total product sales were nearly $700 million in 1963. Total employment was over 30,000.	Sales of the industry were $649 million in 1963. Total employment was about 33,000.	16,000 graduates/year; expected to reach 50,000/year by 1970
(2) Expected rate of increase in sales	Steady growth expected at rate of 5-7 percent per year	13-15 percent annually (vs. 20-22 percent during past 4-5 years)	9-10 percent annually with reproduction equipment industry portion higher than printing machinery	Sales increasing at annual rate of about 10 percent.	From 1958 to 1964, enrollment increased from 20,000 to 90,000, or up 350 percent in 6 years. Number of schools went from 260 to 800. Last rate expected to continue.
(3) Proportion of sales to federal government; major agencies dealt with	About 5 percent DOD, NASA, Signal Corps	Very limited, although many customers received Federal support for their activities—NIH, PHS, NASA	GPO 5 percent; Corps of Engineers	Less than 5 percent	Many are supported by state and local government, U.S. Department of Health, Education, and Welfare

(4) Types of customers served	OEM, replacement market through wholesalers	Hospitals and medical schools, clinical laboratories, medical research laboratories, physicians, and patients, NASA	Newspapers; trade press; magazine, catalog, book publishers	Extremely wide range of customers—paper, steel, textile mills—production facilities	3/4 of graduates employed by private industry, primarily electrical equipment, machinery, chemicals, and aerospace
(5) Size of firms (in terms of sales or employment); share of the market by major firms; number of firms	298 establishments; 9 have 500 or more employees; 86 have from 1-4 employees; and remainder are in middle categories	100 firms; 8 have more than $5.0 million in sales —many are very small with sales under $500,000	About 700 establishments with 9 in the printing trades machinery employing over 500 employees	339 establishments in the industry; 12 have 500 or more employees; 115 have between 1-4 employees; 187 are between 5-99 employees	At least 900 schools at present—vary in size from 6 to 8,700 students, with an average enrollment of 421
(6) Proportion of sales put into research and development	Less than 2 percent	Probably high—depends on what is included	Little research—less than 1 percent; Development—5 percent	Research—1 percent; Development—12 percent	Very little R & D performed by teachers in technical schools
(7) Nature of R & D performed (phenomena-oriented, applied product development, etc.)	Applied and product development Some phenomena research	Applied and product development, much product testing. Some phenomena.	Product development in printing machinery area. Considerable research on copying techniques.	Applied and product development	Very little

TABLE A-1.—SUMMARY OF ECONOMIC CHARACTERISTICS, FIVE INDUSTRIES - Concluded

Industry characteristics	Battery industry	Medical electronics industry	Printing machinery and reproduction equipment industry	Industrial controls industry	Vocational-technical education field
(8) Major external forces influencing the industry	Growth of "need" for convenience goods by general public; auto sales; freight rates; material costs (lead)	High levels of medical research; availability of funds for hospital equipment; pressure for labor savings in hospitals; Medicare	Competition from other sources of communication; new means of doing tasks; changes in public taste for reading material	New components and materials; emphasis on automation	Job opportunities for graduates, changing training of scientists and engineers, Federal funds for training
(9) Major problems facing the industry	Lack of diversification, innovative substitute product would damage present industry structure	Lack of understanding by many firms of the medical market; physicians' lack of familiarity with electronics; communications problem; long acceptance time required for new devices	High demand for equipment output and accuracy may be beyond capabilities; institutional changes	Traditional methods in a changing world	Availability of qualified teachers, rapid growth, attracting high caliber students, being considered inferior to engineering schools, teacher obsolescence

(10) Major engineering and scientific disciplines represented; most important professional societies	Chemists, chemical engineers, metallurgists, electronic engineers, physicists. Electrochemical Society Am. Chem. Society	Electronics engineers, physicians IEEE Bio-Medical Electronics professional group	Mechanical—some chemical and metallurgy-electrical optics	Electrical and electronic engineers IEEE	Electronics, mechanical and data processing technologies account for nearly 85 percent of total. American Society for Engineering Education
(11) Major industry trade associations	American Association of Battery Manufacturers	Scientific Apparatus Makers Ass'n; International Federation for Medical Electronics; Association for the Advancement of Medical Instrumentation	Graphic Arts Technical Foundation R & E Council of Graphic Arts Industry	National Electrical Manufacturers Association	American Technical Education Ass'n.

whom organization points of view are attributed throughout this Appendix A, are generally operating heads or vice presidents in charge of R & D or engineering. Their opinions were elicited through personal interviews.

The organizations contacted in the battery industry tended to place a higher value on the results of government-sponsored research than firms contacted in the other four industries. For example, spokesmen for four of the thirteen battery firms contacted thought that government-sponsored research was important to the firm and another four felt it was of some value. Only one firm felt that government-sponsored research was of little or no value. For comparisons with the other four industries, see table A-3.

Technology varies tremendously from firm to firm in the battery industry. A few firms do highly sophisticated work on military and space contracts while many others conduct little or no R & D, concentrating instead on producing a standard line of batteries and closely related products.

Additional economic characteristics of the battery industry are included in table A-1.

Technology acquisition patterns. The battery industry has a stronger professional society in The Electrochemical Society than exists in any of the other four industries. The Journal of The Electrochemical Society is widely read in the industry, and the national meetings of the Society are well attended. It is not surprising, then, that professional journals rank first in importance in the battery industry for both problem solving and general awareness needs (see tables A-4 and A-5).

The industry also differs markedly from the other four in that government publications attained an importance index of 25 (versus from 0.9 to 10.6 in the other four) as an external source of technological information[2] (see tables A-4 and A-5). This may be due to the higher proportion of government sales (see table A-1), the larger proportion of government contracting experience (see table A-2), and the greater pertinence of government-sponsored R & D to the industry. In the questionnaire results, only seven percent of the battery industry respondents indicated that government-developed technology was unimportant to them (versus 36 percent in industrial controls and vocational-technical education and 33 percent in printing machinery).

The data collected in this study also suggest that individuals in the battery industry rely more on informal, personal contacts to obtain technological information. Persons surveyed reported a median of 40 telephone or personal conversations dealing with technical information in the 30-day period preceding completion of the questionnaire. This exceeds the number reported by individuals in the other industries (see table B-3).

[2]Questionnaire respondents were asked to rank, in order of importance, the five most important external sources of technological information for both problem solving and general awareness needs. The index numbers used reflect the order of importance of each source mentioned. The maximum possible points for any source would be 100. See more detailed explanation on table A-4.

The personal interviews tended to substantiate the questionnaire results concerning the importance of personal contacts. For example, the director of the product development laboratory of a major firm said, "A source of valuable information is represented by friends and colleagues within the industry and at universities. We meet these people at some of our industry professional meetings, conferences, and symposiums."

This same laboratory director estimated that about 70 percent of the useful information acquired at professional meetings came from informal contacts and personal conversations. "The chance to talk to an individual who has presented a paper gives us a chance to size him up and to judge whether or not his work is all it's worked up to be," said the director.

Medical Electronics Industry

Economic characteristics. The medical electronics industry was the smallest industry included in the study with annual sales of $150 million per year. It is also the most rapidly growing industry studied, with a past growth rate of 20-22 percent per year. It is estimated that future growth will be at the rate of 13-15 percent annually (see table A-1).

Principal product lines making up the medical electronics industry are diagnostic and monitoring devices, therapeutic devices (pacemakers, respirators, etc.) clinical lab devices (blood cell countmeters), and devices used in research (ergometer, ballistocardiograph). The industry has about 100 firms, many of which are very small. Only eight firms have sales of more than $5 million per year (see table A-1).

The medical electronics industry is relatively new and easy to enter. In fact, one of the problems of the industry has been the pattern of very large corporations with a product or product idea entering the field with a big splash, and then being forced to withdraw within a year or two without appreciable success. The common reason for failure appears to be the lack of good marketing practices and a "name" in the field. The industry is presently in a shake-down phase and it appears likely that many of the present firms in the field will be absorbed by larger and more successful firms, or eliminated.

Another characteristic of the industry is that many of the firms are assemblers of components and major pieces of equipment produced by other firms. This, of course, influences the acquisition of technical information in that suppliers and vendors play an important role (see table A-4).

The technology employed by firms in the industry is highly sophisticated and important to their competitive position. However, very few firms in the industry depend upon contracts with Federal agencies to acquire new technical information. Only three of the organizational entities contacted indicated that government-sponsored research and development was important in terms of dollar volume (20 percent or more) and new technology development (see table A-2, question 6). Surprisingly, only two of the 21 organizations contacted thought that government-sponsored research had much value to them (see table A-3, question 8).

Technology acquisition patterns. The medical electronics industry makes greater use of university and other outside consultants than any of the other four industries studied. The individuals responding to the questionnaire ranked consultants as having an importance index of 44, compared to 25 in the next closest industry (batteries). This heavy reliance on consultants appears due to the youthful nature of the industry, and particularly to its close contacts with researchers in medical schools and research-oriented hospitals.

Professional journals were the only category of technological information exceeding consultants (see table A-4). In problem solving, researchers and engineers in medical electronics gave the professional literature an importance index of 56 as compared to only 31 in the printing machinery and reproduction equipment industry (see table A-4).

Researchers and engineers in medical electronics attend more meetings per year (average of 2.0 per respondent versus 1.2 for the next highest) and rank meetings higher as a source of technological information (see tables A-4, A-5, and B-3).

Printing Machinery and Reproduction Equipment Industry

Economic characteristics. The printing machinery and reproduction equipment industry includes about 700 establishments, 30,000 employees, and has sales in excess of $800 million per year. The sales figure might be as high as $1.2 billion if all related office equipment were included. Most of the 15 organizational entities contacted in this industry were in the printing presses and printing trades machinery sector (SIC 3555). A small number of firms producing photocopying equipment, microfilming equipment, blueprinting machines, duplicating machines, and related items were also contacted. Contact was not made with some of the organizations newly "invading" printing machinery markets with semi-automatic platemakers, computerized typesetting, and other radical innovations.

In comparison to the other four industries studied, the printing machinery industry is traditional in its methods of operation. In recent years, however, the industry has made rapid strides in developing and applying new technology. Eight of the 15 firms contacted were working in highly sophisticated technical areas, and in the remaining seven, persons interviewed considered new technology to be important to the success of the firm.

The industry is not highly diversified with a primary product specialization ratio of over 90 percent.

Technology acquisition patterns. Since firms in the industry purchase a high proportion of their components from outside suppliers (see table A-2, question 4), researchers and engineers rely upon suppliers and vendor catalogs for much outside technical information. The questionnaire respondents said they thought supplier personnel were most important in solving problems (a channel ranked sixth most important in medical electronics, see table A-4). Reading of trade publications is the most commonly used method of keeping up technological awareness in the printing machinery industry. Professional journals ranked fifth in importance for general awareness needs.

Patents appear to be a fairly significant source of technological data in the printing machinery industry (see tables A-4 and A-5). This is thought to result from the existence of several patent abstracting services carried on by industry associations and universities. Meetings are less important than in any of the other industries studied (see table A-4), and respondents from this industry belong to a smaller number of professional organizations (see table B-3). As expected telephone and personal conversations dealing with technological information are the lowest among the four manufacturing industries studied (see table B-3). All of this seems to reflect a high degree of proprietary secrecy which is traditional in the printing machinery industry.

Industrial Controls Industry

Economic characteristics. Although the intent of this study was to focus on producers of motor speed controls, the field of study was broadened to include all industrial controls. In practice, the manufacturers of motor speed controls are not separate from producers of starters, control accessories, electronic controls, and other industrial controls. The following industry data applies to the industrial controls industry.

Sales of firms in the industry were $649 million in 1963, increasing at an annual rate of about 10 percent. Employment was 33,000, and there were 329 companies with 339 establishments in the industry in 1963.

The industrial controls industry is not highly specialized. Many large corporations have divisions or subsidiaries in industrial controls, and many industrial control producers are diversified into other markets and products. Industry primary product specialization ratio is 79 percent (see earlier explanation).

The firms contacted in the industrial controls industry generally do not appear to be highly demanding of new technology. Technology is important to practically all the firms contacted (see table A-2), but very few have significant research and development programs underway or can be regarded as pioneers in new technology. Much of their production operations involve the assembly of components—some of which are produced by the firm and some of which are bought from vendors.

Of the 13 organizations contacted, only one indicated that government-sponsored R & D is important to its firm. Few of the individuals contacted had had any experience with government-sponsored research. There was little familiarity with any of NASA's technology utilization efforts. Surprisingly, half of those contacted had a perceived value of government research as being important or of some value (see table A-3, question 8).

Technology acquisition patterns. Government publications were considered to be of negligible importance in technical problem solving, compared with a substantial ranking in the battery industry.

Major sources of technical information in this industry are suppliers for problem solving, and trade publications for general awareness. Vendor catalogs are second in importance for awareness and third in importance for problem solving.

Vocational-Technical Education

Economic characteristics. Vocational-technical education refers to post-high school training in fields such as electronics and mechanical, data processing, chemical, civil, aeronautical, plastics, and instrumentation technology. It is a rapidly growing part of the total education field. The number of schools offering vocational-technical education has increased from 260 to over 800 in the six years prior to 1964. The enrollment in vocational-technical education has increased from 20,000 to 90,000 during this same six-year period. Furthermore the growth rate of the field is expected to accelerate in the future.

The instructors in most vocational-technical education schools are graduate engineers who have had some industrial or commercial experience. They generally suffer, as a group, from an inferiority complex relative to other educators. While they are certain that they are carrying on a needed and worthwhile activity, they feel inferior to the instructors and professors at four year colleges and universities.

The importance assigned to keeping up to date with new technological developments seems to vary considerably from one school to another. In some institutions, the teaching staff spends considerable effort keeping up to date with the latest industrial practices and attending summer courses. In other instances, instructors are resigned to the fact that they are not working at the frontiers of new technology and are content to teach the students the more established technology.

Very few of the organizations or individuals contacted in connection with this study had experience with government-sponsored research or were familiar with government sources of technical information (see tables A-2 and A-3). However, many were generally aware that tremendous technological strides were being made and felt that they should be making greater effort to keep up with these changes.

To a considerable extent, the instructional staff in vocational-technical education schools is made up of part-time teachers who hold full-time jobs in nearby industries. Under these circumstances, the instructor will normally rely upon his job-related activities to help keep him current in his classroom teaching. Among full-time instructors, there appears to be a high regard for the value of the experience obtained by part-time instructors.

Technology acquisition patterns. As would be expected, textbooks and formal courses play important roles in filling both the problem solving and awareness needs of individuals in vocational-technical education (see tables A-4 and A-5). Interestingly, trade publications rank ahead of professional journals in both problem solving and awareness.

Supplier personnel and vendor catalogs show up to a considerable extent in keeping vocational-technical education instructors up to date with new technology. While a portion of this response may be due to instructors holding jobs in industry, it is also an indication that vocational-technical education people do attempt to stay in close contact with the people who may hire their graduates.

In the channel importance indices, "other" channels were ranked more often than in the four manufacturing industries. This almost invariably referred to industry advisory committees, set up to keep the schools current on industry needs.

TABLE A-2.—SUMMARY OF CHARACTERISTICS OF ORGANIZATIONAL ENTITIES CONTACTED

Organizational entity characteristics	Industry				
	Battery	Medical electronics	Printing machinery	Industrial controls	Voc.-tech. education
1. Major activities:					
- Produce products	4	20	14	11	-
- Research and development	9	1	1	2	-
- Education	-	-	-	-	12
2. Position in industry:					
- Leader	1	1	1	-	-
- One of the leaders	7	4	1	6	1
- Significant factor	2	3	12	2	2
- Small factor	3	12	1	4	9
- Don't know	-	1	-	1	-
3. Degree of specialization:					
- Over 90% in one industry	10	13	13	2	5
- 50%-90% in one industry	2	1	-	-	2
- Less than 50% in one industry	1	7	2	12	5
- Don't know	-	-	-	1	-
4. Types of operations performed:					
- Assemble purchased components	-	13	8	4	-
- Produce components and materials, and assemble	5	7	7	8	-
- Non-product organization	8	-	-	-	12
- Don't know	-	1	-	1	-
5. Technological position:					
- Technology highly sophisticated	8	12	8	2	-
- Important, but not pioneering	5	8	7	10	12
- Don't know	-	1	-	1	-

6. Value of government-sponsored R & D:					
Important—for $ volume (20% or more) and new technology developed	5	3	2	-	-
Important—for $ volume (20% or more) but not new technology	2	1	-	-	-
Important—for new technology developed, but not $ volume	1	1	2	1	-
Unimportant for either $ volume or new technology	5	11	5	10	12
Don't know	-	5	6	1	-
7. Highest ranked person interviewed:					
President	1	8	3	1	5
Vice President, Research	2	2	5	3	-
Vice President, Development	2	-	-	-	-
Director of Research	5	1	2	-	-
Program Manager	-	2	2	5	-
Other	3	8	3	3	7
8. Number of employees:					
10,000 and over	-	-	1	4	-
5,000 - 9,999	-	-	2	3	1
1,000 - 4,999	-	-	1	-	3
500 - 999	2	1	1	-	3
100 - 499	4	4	4	-	5
50 - 99	5	3	-	-	-
1 - 49	-	7	1	2	-
No answer	2	6	5	3	-

Source: Interviews conducted by DRI staff members during the period of February-September, 1966.

TABLE A-3.—SUMMARY OF SELECTED TECHNOLOGY ACQUISITION ACTIVITIES OF ORGANIZATIONAL ENTITIES CONTACTED

Question and response	Battery industry	Medical electronics industry	Printing machinery and reproduction equipment	Industrial controls industry	Voc.-tech. education field
(1) Staff members studying for advanced degrees:					
None	1	3		2	1
1 - 5%	-	-		1	6
6 - 10%	1	-	1	-	2
11 - 15%	1	-		1	-
15% +	-	2	4	3	1
No answer	10	16	10	5	1
(2) Does the organization subscribe to an indexing service:					
No	2	11	6	5	11
Yes	7	3	7	5	1
No answer	4	7	2	2	-
(3) Does the organization maintain in-house technical library facilities:					
No library	4	9	8	3	2
Central library—no librarian	2	2	2	1	-
Central library—part-time librarian	3	-	-	1	1
Central library—full-time librarian	4	5	4	5	8
No answer	-	5	1	2	-
(4) Does the library offer special services:					
No library	4	9	7	3	2
No special services	7	4	4	3	9
Special services	2	3	1	1	-
No answer	-	5	3	5	1

(5) Familiarity with NASA Technology Utilization Program:					
Receive STAR	7	6	2	2	1
Receive Tech Briefs	6	4	3	3	-
Belong to RDC	2	-	1	1	-
Other	4	5	2	2	-
Unfamiliar with TU activities	2	8	4	6	11
No answer	-	3	3	-	-
(6) Reactions to NASA's Tech Briefs:					
Favorable comments	1	1	1	-	-
Unfavorable comments	3	5	3	3	-
No answer, other comments, or unfamiliar with	9	15	11	9	12
(7) Reactions to NASA's STAR:					
Favorable comments	1	2	-	1	-
Unfavorable comments	3	3	3	2	-
No answer; other comments; unfamiliar	9	16	12	9	12
(8) Perceived value of government-sponsored research to the firm:					
Important	4	1	1	3	-
Some value	4	1	5	3	-
Little or no value	1	6	6	2	6
No answer	4	13	3	4	6

Source: Interviews conducted by DRI staff members during the period of February-September, 1966.

TABLE A-4.—RANKING OF EXTERNAL CHANNELS FOR PROBLEM SOLVING

	Orientation			Industry					All respondents
	Research oriented	Product oriented	Manage-ment	Battery	Medical elec-tronics	Industrial controls	Printing machinery	Voc.-tech. education	
Supplier personnel	20.2	49.9	50.8	40.7	36.0	56.4	57.9	40.8	40.5
Vendor catalogs	15.5	39.9	34.2	18.1	37.6	49.1	44.3	33.6	30.8
Customer personnel	7.2	18.8	23.9	21.8	20.5	20.0	15.3	5.0	16.1
Univ. & other consult.	28.4	16.4	32.8	24.6	44.6	14.7	10.3	15.8	23.8
Meetings	25.9	28.6	32.4	30.4	37.5	31.1	21.6	28.8	28.5
Trade publications	14.6	34.2	31.6	27.1	29.8	40.5	27.0	40.8	27.3
Professional journals	65.8	31.6	46.1	52.9	56.0	32.4	31.1	37.0	44.7
Libraries	23.3	18.1	16.5	9.3	32.1	9.8	27.9	30.0	19.5
Textbooks	41.6	52.8	37.9	43.2	42.9	52.0	51.1	60.4	45.9
Government publications	14.3	11.0	5.6	25.9	2.6	0.9	6.3	5.0	10.6
Mass media	0.7	0.6	0.3	0.0	1.5	1.4	0.0	0.0	0.6
Abstracting services	9.1	2.9	5.9	8.2	1.5	1.8	8.4	0.8	5.6
Disseminating centers	1.4	2.2	0.5	1.4	3.0	0.0	2.1	0.4	1.6
Clipping services	0.5	1.5	0.3	0.0	2.4	0.4	0.0	2.9	0.9
Formal courses	6.2	6.5	4.6	2.9	2.0	6.2	2.6	15.5	6.0
Patents	8.9	2.5	4.7	7.5	3.5	2.3	11.1	0.0	5.0
Associations	2.3	4.4	2.9	1.1	1.0	4.9	4.2	3.8	3.4
Other outside channels	1.9	2.7	1.8	6.8	3.4	0.0	4.7	0.4	2.2
N =	117	163	78	56	41	45	38	49	358

Note: Indices were computed by assigning 5 points to a first place ranking, 4 points for second, etc. These points were summed, and divided by 5 times the number of respondents. Thus, if every respondent had ranked libraries first, it would have received an importance index of 100.

TABLE A-5.—RANKING OF EXTERNAL CHANNELS FOR AWARENESS

Channels	By Type of Individual			By Industry					All respondents
	Research oriented	Product oriented	Manage-ment	Battery	Medical elec-tronics	Industrial controls	Printing machinery	Voc.-tech. education	
Supplier personnel	13.2	35.4	35.1	27.4	23.7	40.6	35.8	36.0	29.6
Vendor catalogs	13.4	37.1	30.6	15.4	29.4	50.0	39.0	30.9	29.1
Customer personnel	4.7	15.9	18.1	16.3	22.0	15.0	15.4	6.0	13.6
Univ. & other consult.	19.3	11.5	17.2	13.5	29.6	8.1	11.8	18.8	15.2
Meetings	44.8	37.8	39.0	39.4	50.8	35.0	36.4	29.9	40.0
Trade publications	31.8	55.7	51.6	34.4	53.5	59.4	62.1	50.8	48.5
Professional journals	73.9	41.3	42.0	54.4	58.4	35.9	31.6	34.4	49.9
Libraries	14.7	8.5	8.2	3.1	17.5	3.8	7.5	18.5	10.0
Textbooks	22.3	26.2	22.8	20.6	13.8	29.7	22.5	42.0	24.2
Gov't publications	19.1	11.0	8.6	25.4	6.3	3.9	22.4	8.3	12.4
Mass media	1.2	5.7	1.1	4.4	2.1	5.9	2.9	1.8	3.2
Abstracting services	15.0	3.7	4.0	12.5	7.3	9.4	8.1	0.5	6.7
Dissemination centers	3.1	1.5	0.9	0.8	2.0	0.0	1.8	0.2	1.7
Clipping services	2.1	1.9	2.3	3.7	4.8	0.6	3.9	1.2	2.0
Formal courses	5.2	5.7	5.3	1.7	2.0	6.3	5.4	11.5	5.5
Patents	9.5	3.3	5.6	7.5	6.9	0.3	14.4	0.0	5.6
Associations	5.5	5.2	1.7	2.3	1.7	5.5	2.8	4.1	4.3
Other outside channels	3.3	5.7	13.2	11.7	6.1	7.2	8.8	12.0	7.3
N =	116	205	132	72	50	64	57	82	453

APPENDIX B. ADDITIONAL ASPECTS OF THE TECHNOLOGY ACQUISITION PROCESS IN COMMERCIAL FIRMS

This appendix includes data and analyses which supplement the material in Section II. It covers in more detail respondent characteristics and their information acquisition activities. It discusses the types of technology respondents sought, and presents a crude estimate of the costs incurred by firms for their information acquisition activities. It also explores the influence of firm size on the use of government technology and government information channels. Finally, it briefly discusses time lags associated with different kinds of information channels.

Quantitative Characteristics of Respondents and Their Technological Information Acquisition System

Characteristics of the 480 questionnaire respondents are summarized in table B-1, which identifies the education level attained; the percent of respondents who had prior aerospace or government experience with either NASA, DoD, or AEC; the respondents' median salary; and their median age. The data are presented both by type of individual and by industry. The distribution of functional types of individual among industries is presented in table B-2. There were 123 respondents who fell into the research-oriented category, 215 into the product-oriented category, and 142 who were classed as management-type individuals. The number of respondents by industry were as follows: battery industry 73, medical electronics 56, industrial controls 70, printing machinery 60, and vocational-technical education 85. In addition, there were 136 respondents contacted through various direct mail approaches who did not fall into one of the five industry categories. The questionnaire results from these respondents are included in the total respondent category and also in the three types of individual categories. Because many of these 136 respondents come from universities, government laboratories, and aerospace firms, a "non-commercial" bias has been introduced into our data. This has probably given an upward bias to the familiarity with and importance of government publications, and raised the number of respondents with prior aerospace related experience.

There was a fairly high proportion (45 percent) of respondents who had either a masters or a Ph.D. degree, and among the three types of individuals, almost 50 percent of the research-oriented had Ph.D. degrees, whereas only 3 percent of the product-oriented had a Ph.D. Of the five industries, the battery industry had the highest percent of respondents with Ph.D.'s—33 percent. While a surprisingly high percentage of respondents indicated some prior aerospace or government experience (30 percent overall), about two-thirds of those who claimed such prior aerospace or government experience indicated it was for only five years or less.

The median salary figure for management personnel is depressed because of the inclusion in this category of people within the technical education industry whose salaries are generally considerably lower than salaries of their counterparts in industry. Actually about 12 percent of the respondents who gave salary figures, indicated their salary was in excess of $20,000 a year.

TABLE B-1.—CHARACTERISTICS OF QUESTIONNAIRE RESPONDENTS BY TYPE OF INDIVIDUAL AND BY INDUSTRY

Characteristics	By Type of Individual			By Industry					All respondents
	Research oriented	Product oriented	Management	Battery	Medical electronics	Industrial controls	Printing machinery	Voc.-tech. education	
	(percent)			(percent)					
1. Highest degree attained:									
a. Less than college grad.	1	7	6	1	6	7	4	10	5
b. College grad.	18	53	44	37	39	58	55	41	41
c. Post grad. no degree	9	11	6	7	11	7	8	11	9
d. Masters	24	26	29	22	33	23	23	38	26
e. Ph.D.	48	3	15	33	11	4	11	0	19
2. Prior aerospace or gov't experience	42	24	29	19	38	23	25	21	30
3. Median salary in dollars	13,800	12,200	15,600	14,300	14,000	11,700	14,000	11,100	12,400
4. Median age in years	38	39	44	39	37	38	41	43	40

TABLE B-2.—DISTRIBUTION OF FUNCTIONAL TYPES AMONG INDUSTRY RESPONDENTS

	Research-oriented	Product-oriented	Management
		(percent)	
Batteries	38	42	19
Medical electronics	12	45	43
Industrial controls	3	66	31
Printing machinery	13	55	32
Vocational-technical education	11	51	39

Note: This tabulation covers only respondents employed in firms actively engaged in the industries studied.

Table B-3 identifies by type of individual and industry some of the quantitative characteristics of the technological information acquisition process employed by questionnaire respondents. Because there was so much variation in reported reading time and number of conservations, tables B-4 and B-5 include a tabulation of the means and standard deviations for these two categories.

While the number of professional and technical publications read by individuals in each of the categories was relatively similar, there were sizable differences among both types of individuals and industry groups in almost every other characteristic listed in table B-3. Respondents in the battery, medical electronics, and vocational-technical education industry categories belonged to a larger number of professional organizations than did respondents in the two other industry categories. The research-oriented and management individuals typically belonged to twice as many professional organizations as did the product-oriented individuals.

The Electrochemical Society was conspicuously strong in the battery industry, whereas in each of the other four industries there was a wide variety of professional organizations rated as important. The Electrochemical Society appears to focus on and serve very well the special interests of the battery industry, whereas there is really no professional organization specifically tailored to the needs of the printing machinery industry.

Individuals spent about as much time reading technical material on the job as they do reading at home. Research types read more on the job than at home, while managers tend to do more reading at home than at work. Research-oriented people spent almost twice as much time reading as product-oriented individuals. Respondents in the battery and medical electronics industry did more reading than individuals from either the industrial controls or the printing machinery industry. This may be due to the fact that a higher percentage of respondents from the battery and medical electronics industry were research type people who by the nature of their work were required to do more reading. Most of the companies contacted during the study indicated that they had no explicit policy

TABLE B-3.—QUANTITATIVE CHARACTERISTICS OF THE TECHNICAL INFORMATION ACQUISITION PROCESS BY ALL RESPONDENTS, BY TYPE OF INDIVIDUAL, AND BY INDUSTRY

Characteristics	By Type of Individual			By Industry					All respondents
	Research oriented	Product oriented	Management	Battery	Medical electronics	Industrial controls	Printing machinery	Voc.-tech. education	
Median no. of prof. org. belonged to	1.9	0.8	1.6	1.4	1.2	0.8	0.4	1.4	1.4
Median no. of prof. and tech. publ. read	3.8	3.5	3.6	3.9	3.7	3.6	3.7	2.8	3.6
Median no. of hours in last 30 days reading tech. literature:									
At work	20	11	15	20	20	10	11	15	15
At home	15	10	20	15	20	12	10	20	15
Total*	38	22	34	32	38	24	22	33	27
Median no. of conf. and mtgs. attended in last 12 mo.	1.7	1.1	1.6	1.2	2.0	1.2	1.2	0.9	1.4
Median no. of formal courses taken in last 12 mo.									0.6
Median no. of phone or personal conversations dealing with tech. info. in last 30 days:									
Persons within org.	20	20	40	38	20	28	16	10	20
Persons outside org.	5	10	10	10	5	10	10	5	10
Total*	24	25	42	40	30	38	25	15	30

*Totals may differ from the sum of subcategories because not all individuals broke down their answer by subcategory.

TABLE B-4.—NUMBER OF HOURS SPENT READING TECHNICAL MATERIAL IN LAST 30 DAYS

	By Type of Individual			By Industry					All respondents
	Research oriented	Product oriented	Manage-ment	Battery	Medical elec-tronics	Industrial controls	Printing machinery	Voc.-tech. education	
At work									
Median	20	11	15	20	20	10	11	15	15
Mean	30	16	23	28	25	15	21	21	22
Standard deviation	31	15	26	32	22	14	26	24	24
At home									
Median	15	10	20	15	20	12	10	20	15
Mean	26	16	24	25	25	16	15	25	21
Standard deviation	30	16	21	30	23	12	15	27	22
Total									
Median	38	22	34	32	38	24	22	33	27
Mean	56	33	47	53	50	31	35	45	43
Standard deviation	58	37	45	62	43	46	40	47	47

TABLE B-5.—NUMBER OF TECHNICAL CONVERSATIONS (PERSONAL AND TELEPHONE) IN LAST 30 DAYS

	By Type of Individual			By Industry					All respondents
	Research oriented	Product oriented	Management	Battery	Medical electronics	Industrial controls	Printing machinery	Voc.-tech. education	
With persons inside firm									
Median	20	20	40	38	20	28	16	10	20
Mean	44	41	57	50	67	53	40	20	47
Standard deviation	89	62	67	56	132	74	57	37	73
With persons outside firm									
Median	5	10	10	10	5	10	10	5	10
Mean	10	17	30	29	20	14	12	11	18
Standard deviation	13	35	49	56	43	18	12	20	36
Total									
Median	24	25	42	40	30	38	25	15	30
Mean	57	60	83	96	82	65	56	35	66
Standard deviation	108	98	105	140	138	89	85	75	103

regarding reading on the job. Most individuals interviewed indicated that technical reading was an acceptable activity during working hours, but that time was not available to do as much reading there as they found necessary.

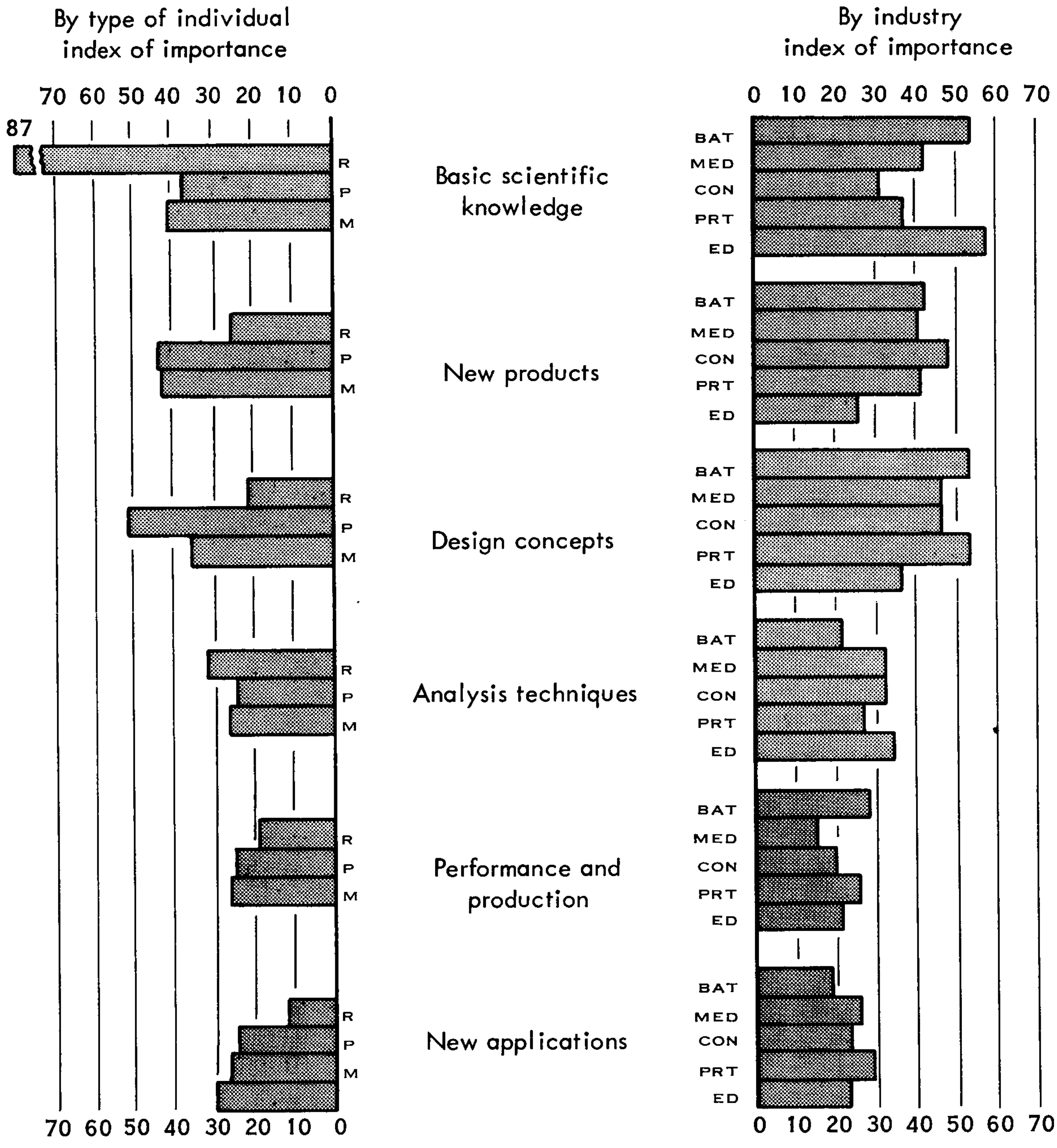
The data on the number of conferences and meetings attended in the last 12 months includes both local and national meetings, either professional or trade, and appears to verify the comments of firm managers interviewed who stated that, while they had no explicit policy regarding meeting attendance, they liked to send an individual to at least one major meeting a year.

The data summarizing the number of telephone and personal conversations dealing with technical information are perhaps the least reliable of any of those on table B-3, as evidenced by the large variation shown in table B-5. The range of answers given was extremely wide both among different kinds of individuals and in the same industry. Part of this is probably due to the fact that it is difficult to accurately estimate how many telephone or personal conversations one has per day or per month, in part because it is difficult to know what to include as a conversation dealing with technical information, and partly because different personalities have widely varying conversation habits. However, the relative differences among categories do appear reasonable. One would expect the management type individual to engage in more such conversations than either research or product-oriented individuals, because talking to and coordinating with others is one of the major functions of management. Not surprisingly, individuals conversed more frequently with persons within their organization than those outside their organization.

Types of Technology Used by Commercial Firms

In attempting to identify the kinds of technology most important to individuals in commercial firms, we asked respondents to rank, in order of importance to their jobs, six categories of technology. Figure B-1 and table B-6 identify the relative importance of each kind of technology for each of the five industries and for each of the three types of individuals. The six types of technology are assigned importance indices, with the maximum value being 100, and are listed in decreasing order of importance for all questionnaire respondents. It is apparent that the inter-industry differences are relatively small except for those respondents in vocational-technical education in the first two categories.

However, there are major differences, particularly between the research types compared with the other two, product and management. The research-oriented man rated basic scientific knowledge considerably higher than either of the other two categories, and rated new product and application information considerably lower than the other two classes of people. Because one of the criteria in identifying the research-oriented individuals was his high ranking of basic scientific knowledge, this result was to be expected. Surprisingly, both the product-oriented and the management categories of individuals rated the types of technology in almost an identical fashion; design concepts being the one category where there was substantial difference.



R = Research
P = Product
M = Management
BAT = Batteries

MED = Medical electronics
CON = Industrial controls
PRT = Printing machinery
ED = Vocational-technical education

The index of importance was arrived at by weighting a respondents first three choices 3, 2, 1 respectively, adding the total points and dividing by the maximum possible number of points, thus the maximum importance index is 100.

Figure B-1. Types of Technology—Ranked by Index of Importance to the Job for All Respondents, by Type of Individual and Industry.

TABLE B-6.—TYPES OF TECHNOLOGY—RANKED BY INDEX OF IMPORTANCE TO THE JOB FOR ALL RESPONDENTS, BY TYPE OF INDIVIDUAL, AND BY INDUSTRY

Type of technology	By Type of Individual			By Industry					All respondents
	Research oriented	Product oriented	Management	Battery	Medical electronics	Industrial controls	Printing machinery	Voc.-tech. education	
Basic scientific knowledge	87	36	40	52	42	32	37	57	50
Design concepts	20	50	36	53	46	46	53	36	38
Analysis techniques —scientific or management	31	24	31	22	32	32	25	34	28
Technological performance data or production techniques	18	24	26	28	14	20	25	21	23
New products, components, materials, or services	25	43	42	42	41	47	41	26	38
New applications for existing products, materials, or techniques	12	24	26	19	25	22	29	22	22

Note: The index of importance was arrived at by weighting a respondent's first three choices 3, 2, 1 respectively, adding the total points and dividing by the maximum possible number of points, thus the maximum importance index is 100.

In retrospect, it is apparent that the six types of technology were not adequately defined in the questionnaire and that there was not sufficient distinction between categories. It probably would have been better to have included a larger number of categories, each of which were more thoroughly and specifically defined, but such complexity was a strong deterrent to questionnaire response. One problem with this classification was that there appeared to be a tendency for many people to rank basic scientific knowledge as one of their first three choices even though it was apparent from examining the kinds of professional organizations they belonged to and the kinds of technical publications read that many of these individuals really did not make much use of basic scientific knowledge in their work.[1]

Cost Estimates of a Commercial Firm's Technological Information Acquisition Activities

One of the objectives of our research was to acquire information about the firms' costs attributable to different information acquisition activities. The major difficulty was that most firms had simply never attempted to estimate their costs assignable to information acquisition activities. In only two of the roughly 80 firms and organizations in which we conducted personal interviews with key management personnel, was it possible for the firm to develop a detailed estimate of its information acquisition costs. There may also have been some hesitancy on the part of firms to provide us cost information, because it might divulge proprietary information, but our judgment was that the cost information had simply never been compiled. Thus the cost information contained in this Appendix should be considered highly uncertain. In each company contacted we asked for completion of an estimate of information acquisition costs using as a framework the costs sheets contained in Appendix C, Methodology. We were able to acquire even rough estimates of such costs in only about a dozen of the companies visited. Because of the difficulty in acquiring cost information and because the firms varied in size and other characteristics, it appeared impossible to estimate costs for either a typical firm or costs for typical firms of various sizes. Instead, we have attempted to identify the costs on a per professional employee basis. We leave it to the reader to extrapolate these data to groups of employees or to individual firms.

Two sources of information have been used in estimating our costs figures: one was the information presented by individual respondents in the questionnaire regarding the amount of company time they spent reading, attending meetings and conferences outside the firm, and the amount of time they spent in telephone or personal conversations dealing with technical information. The second source was the information provided by

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[1]Myers' findings strengthen our doubts about the credibility of this question on types of technology. The nature of information inputs stimulating the 75 innovations he studied were distributed as follows: design and performance information - 42%; performance characteristics information - 19%; state-of-the-art information - 6%; capital equipment information - 3%; materials information - 15%; information on manner of use of equipment or materials - 11%; experimental or test procedures information - 4%; op. cit., p. 20.

roughly a dozen firms on their cost estimate sheets. This latter source was the primary input in our estimates of the amount of money spent on journals, magazines, books and reports, company paid tuition, consultant fees, telephone charges, and fees and travel costs associated with attendance at seminars, conferences and trade shows.

Costs associated with an individual's information acquisition activities. —In estimating how much of an individual's salary cost could be allocated to his information acquisition activities, we utilized the data presented in tables B-3 and B-5. These estimated the hours an individual spent reading technical material on the job, and the average number of telephone conversations he engaged in, as well as the median number of conferences and meetings attended in the past year. Translating these data into percentages of an individual's working time spent on each activity, we arrived at the information presented in table B-7. In calculating the percent of working hours we used a figure of 160 hours per 30-day period which, while a trifle low, we felt accounted for vacations and holidays. The percent of individual's working time spent at meetings and conferences outside the firm was based on a median figure resulting from our questionnaires, which indicated that about five man-days per year were devoted to attending such meetings. While we have no idea what the average duration of an individual's telephone or personal conversations may be, we have assumed two times; either 6 or 18 minutes per conversation and feel that these represent a reasonable range.

As shown in table B-7, the average respondent spends roughly 20 to 28 percent of his working time acquiring technical information. Because there were fairly sizable differences in the amount of time devoted to reading by industry and by type of individual, we developed time and cost figures by type of individual and by industry. Multiplying the percent of working time devoted to information acquisition by the median annual salary of respondents in each category, gross estimates were made of the annual straight salary costs per professional employee for his information acquisition activities.

Costs associated with an entire firm's technical information acquisition activities.— From the dozen estimates of a firm's information acquisition costs, we allocated the costs on a per professional employee basis. The range of these costs is indicated in table B-8 (except the straight salary item derived from questionnaire responses as discussed in the previous subsection). The total costs per professional employee attributable to information acquisition activities appear to fall somewhere between $2,000 and $7,500 annually. A probable mean figure would be on the order of $4,000. These estimates do not include any overhead added to the straight salary of professional employees or library staff personnel because it was felt that many of the other items included in our estimate may normally be a part of this overhead in many firms. If these items, such as journals and books, tuition, consultant fees, telephone charges, and costs associated with attending conferences and professional meetings, are not normally a part of the overhead figure, then the total cost per professional employee should probably be increased by an amount equal to a firm's overhead rate. This might increase the per professional employee cost to somewhere between $3,000 and $12,000 annually.

TABLE B-7.—ESTIMATED TIME AND DIRECT COSTS ASSOCIATED WITH AN INDIVIDUAL'S TECHNICAL INFORMATION ACQUISITION ACTIVITIES

Activity	By Type of Individual			By Industry					All respondents
	Research oriented	Product oriented	Manage-ment	Battery	Medical elec-tronics	Industrial controls	Printing equipment	Voc.-tech. education	
	Percent of working hours spent on activity								
Reading at work	19	10	14	17	16	9	13	13	14
Company time spent at meetings and conferences	2*	2*	2*	2*	2*	2*	2*	2*	2
Company time engaged in phone or personal conversations (assuming 6 or 18 minutes per conv.)	4-11	4-11	5-16	6-18	5-15	4-12	4-10	2-7	4-12
Total % working time	25-32	16-23	21-32	25-37	23-33	15-23	19-25	17-22	20-28
Median annual salary, $	13,800	12,200	15,600	14,300	14,000	11,700	14,000	11,100	12,400
Annual salary cost per individual for above information acquisition activities	3,400 to 4,400	2,000 to 2,800	3,300 to 5,000	3,600 to 5,300	3,200 to 4,600	1,600 to 2,600	2,700 to 3,500	1,900 to 2,400	2,500 to 3,500

*Meeting attendance time was unavailable by type of individual or by industry, so the median time for all respondents was used.

TABLE B-8.—AN ESTIMATE OF THE ANNUAL TECHNICAL INFORMATION ACQUISITION COST TO A FIRM ON A PER PROFESSIONAL EMPLOYEE BASIS

Information acquisition item for a firm	Range of costs to a firm per professional employee (in dollars)
Straight salary time per professional employees for reading, conversing, and attending conferences and meetings (overhead not included)*	2,000 to 5,000
Library staff*	0 to 800
Journals, magazines, books and reports	20 to 200
Tuition	10 to 50
Consultant fees	30 to 500
Telephone charges	50 to 500
Seminar, symposia, conference fees, and travel costs	50 to 500
Total per professional employee	2,170 to 7,550

*Overhead was not added to straight salary figures because some of the other items listed may form a part of the overhead expense in a firm. If overhead were to be included, the range of total costs per professional employee would increase to about $3,000 to $12,000.

The Effect of Firm Size on Use of Government Technology

The size of a firm, measured in terms of number of employees divided into four categories (100, 100-999, 1,000-4,999, and 5,000), apparently affects an individual's information activity.[2] While time spent reading was not affected by firm size, the number of meetings and conferences attended annually was. For firms with less than 100 employees, 22 percent went to no meetings in the last year and 26 percent went to only one meeting. For firms with more than 5,000 employees, the percentages were 13 percent and 12 percent respectively. Yet in most of the smaller firms there were at least one or two individuals who attended many meetings each year. The opportunity was just not extended to as many as it was in the larger firms.

While one might have expected individuals in smaller firms to make more use of outside consultants, there was no difference in either use or importance ranking of consultants by size of firms. The use and relative importance of government publications for awareness did increase slightly with increasing size of firms, but not significantly, and the increase was not consistent among the four size groups.

[2]The information on firm size is that given by questionnaire respondents. It sometimes refers to total employment in the respondent's corporation, sometimes to that in his division or organization.

However, there was a consistent and significant increase in awareness and use of the six specific government channels (Tech Briefs, RDC's, Technology Utilization Surveys, Clearinghouse, IAA, and STAR) as firm size increased. Table B-9 summarizes the percent of respondents by size of firm who had heard about and who had used these six channels.

The increase in awareness and use of these six channels as firm size increased was probably due to a variety of factors. Larger firms tended to have in-house libraries which regularly received some of these publications.

That the larger firms provided better access to publications and other information channels within the firm is borne out by data on the importance of internal channels relative to external channels.

Of those in firms with less than 100 employees who answered this question (59 respondents), 17 percent felt internal channels were most important, 47 percent felt external channels were and 36 percent felt both were equal. The 110 respondents from firms with more than 5,000 employees were distributed: 28 percent for internal, 31 percent for external, and 41 percent for both equal.

Time Lags Associated With Specific External Channels

The time lags associated with different kinds of external communication channels were of interest in this study, but were difficult to probe in detail.

In his review of the research literature related to the flow of behavioral science information, Paisley reports on a study conducted by the American Psychological Association in which the time lags associated with the conduct and reporting of a typical behavioral research project are identified over a five-year period:

TABLE B-9.—PERCENT OF RESPONDENTS BY SIZE OF FIRM WHO HAD HEARD OF AND USED SIX GOVERNMENT CHANNELS

Channel	Percent who have heard about, by size of firm				Percent who have used, by size of firm			
	<100	100-999	1,000-4,999	>5,000	<100	100-999	1,000-4,999	>5,000
Tech Briefs	42	57	52	67	17	29	35	49
RDC	14	12	21	19	3	4	7	7
T. U. Survey	22	29	34	41	4	11	20	26
Clearinghouse	39	39	43	46	28	28	40	35
IAA	12	15	23	20	0	10	8	12
STAR	19	20	26	32	10	16	16	20

Taking as time zero the date of journal publication, the research typically began at minus 36 months (i.e., three years before). The work reached a reportable stage at about minus 20 months and was probably circulated in some written form and also presented orally at colloquia and meetings between minus 20 and minus 12 months. At about minus 8 months an article based on the research was submitted to a journal. During this period reprints were distributed and the author may have entered a second phase of oral presentation, perhaps at an invited conference. If the research was supported by an organization desiring a final report, such a document was probably sent off at about this time. After the article is published, reprints are distributed, first perhaps to a mailing list and subsequently as requested. By about plus 12 months Psychological Abstracts has abstracted the article. At about plus 18 months or later (depending upon the subject matter reviewed in a given year), the article may be mentioned in the Annual Review of Psychology. Roughly five years has then lapsed since the research was begun.[3]

While the conduct and reporting of research in the behavioral sciences may not be typical of other scientific and engineering disciplines, the sequence of events may be similar to that which occurs in other disciplines, even though the absolute time lags are different.

Using information collected from various sources during our study, we attempted to identify the range of time lags in the dissemination of information associated with various kinds of communication channels. Figure B-2 summarizes these rather speculative estimates for 13 types of information channels. Time zero is considered to be the point at which the technology is reportable. The bars represent the time range, while the triangle represents a "typical" time point. The textual information sources such as professional journals, abstract publications and textbooks have fairly significant time lags associated with them, whereas the verbal personal conversations and local professional meetings involve very small time lags.

Table B-10 shows the relative importance of information channels within a firm as ranked by each type of individual and by individuals in each industry.

[3]William J. Paisley: The Flow of (Behavioral) Science Information, A Review of the Research Literature. A Report of the Institute for Communication Research (Stanford University, Palo Alto, Calif., 1965, p. III-43.

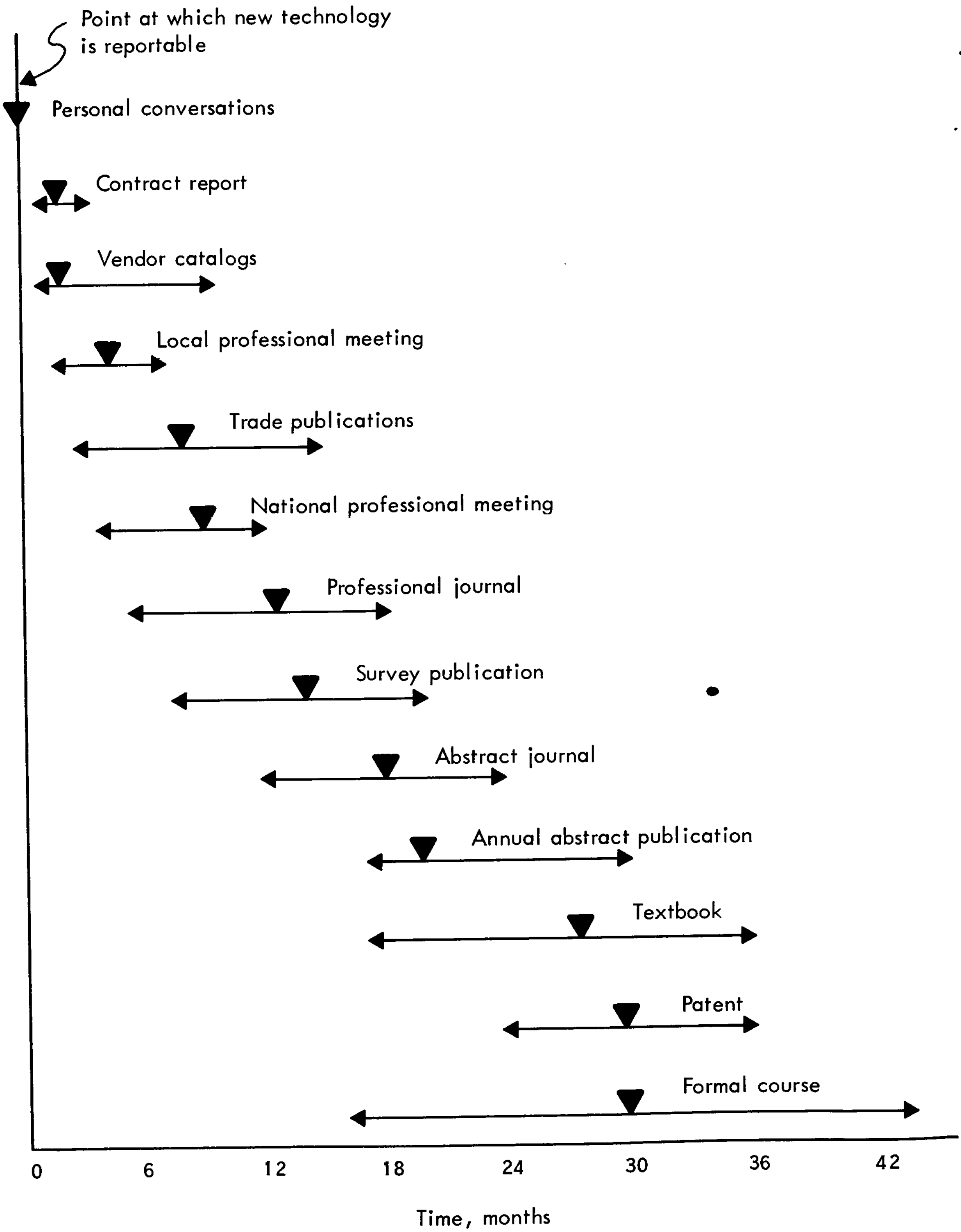

Figure B-2. Time Lags in Information Dissemination for Various Kinds of Channels.

TABLE B-10.—INTERNAL CHANNELS RANKED BY INDEX OF IMPORTANCE TO THE JOB FOR ALL RESPONDENTS, BY TYPE OF INDIVIDUAL, AND BY INDUSTRY

Type of internal channel	By Type of Individual			By Industry					All respondents
	Research oriented	Product oriented	Management	Battery	Medical electronics	Industrial controls	Printing machinery	Vol.-tech. education	
1. Personal knowledge, experience or experimentation	71	78	67	72	70	84	80	77	73
2. Personal or in-house library facilities and library personnel	61	52	40	41	49	43	46	60	51
3. Other personnel in organization, colleagues, etc.	37	40	50	38	47	49	39	36	42
4. Company meetings, courses, workshops, etc.	3	12	14	12	11	10	11	19	10
5. Formal company reports and documents	14	11	7	24	5	11	9	2	10
6. Company-sponsored R & D	7	6	14	13	12	6	13	0	9
7. Other	3	2	2	4	2	2	2	2	2

Note: The index of importance was arrived at by weighting a respondent's first three choices 3, 2, 1 respectively, adding the total points and dividing by the maximum possible number of points, thus the maximum importance index is 100.

APPENDIX C. METHODOLOGY

The methodology employed in the research effort described in this report was aimed at satisfying several objectives including:

(1) Development of basic knowledge of how scientists and engineers in five selected commercial industries acquire technology from external sources.

(2) Determination of the relative importance of the different channels in each industry, and for each functional category of user (research, product, and management).

(3) Analysis of which existing and new channels have the greatest present and potential value for use by firms in the five industries in acquiring usable space technology.

(4) Examination of the methods used by NASA to disseminate space technology to commercial industry.

This appendix describes the procedures used in gathering the data required to meet objectives 1, 2, and 3. Section IV of the report describes the methods used by NASA to disseminate space technology.

There are several limitations that should be noted before proceeding with the description of methodology.

First, the firms selected for information gathering were not representative of all commerical industry, and therefore the results of the research cannot be extended to other commercial industries without important qualification. Thus, our results do not come from a representative sample of any well-defined universe, but we believe they do represent a reliable statement of technology acquisition behavior in the firms studied.

Second, individuals experienced difficulty in responding to questions concerning how they acquired technical information. This was apparently because few people are accustomed to thinking about their own habits and patterns of keeping informed, and also because of semantic difficulties.

Third, the respondents within the firms studied did not represent a cross section of all research, development, and engineering personnel. The individuals interviewed, and those responding to the self-administered questionnaire, tended to be among the more senior staff members, making decisions on the application of new technology. They were often the people who first came to mind when an operating head or research head referred us to those on his staff whom he perceived as being most concerned with acquisition of new technology.

Industry Selection

Early in the project, several criteria for selection of the five industries were developed jointly by the NASA Technology Utilization Division and Denver Research Institute staff members. Those criteria, or guidelines for selection, are listed below:

Receptivity and desire for new technology.

Geographical dispersion (desired some degree of dispersion yet sufficient concentration to make personal contact economically possible).

Mix of traditional, stable firms as well as rapidly growing organizations.

Mix of large and small firms; closely held and broad public ownership; durable and nondurable products; domestic and international sales; government and internally-funded R & D.

Accessibility to firms in the industry; likelihood of cooperation.

Likelihood of present or potential use of aerospace technology.

One or more industries to have strong trade and/or professional associations.

Manageable size of industry (several very large industries were eliminated from consideration since the scope of the study would not have permitted a useful investigation).

Minimum of overlap among industries selected.

An initial list of 35 possible industries was developed, and these were evaluated using the criteria described. A numerical rating system based on the importance of each criterion was then used to reduce the list of possible industries to a dozen. These were discussed with NASA, and after further investigation, and some preliminary contacts, five were selected for inclusion in the study. These were:

(1) Medical electronics (primarily physiological monitoring equipment).

(2) Batteries (the pilot industry, which was studied most intensively).

(3) Printing machinery and reproduction equipment.

(4) Industrial controls.

(5) Vocational and technical education (post-high school).

Appendix A contains a summary of economic characteristics of each of the five selected industries, and includes comparisons of the firms contacted within the industry as a whole.

Shown below are the number of firms and individuals personally contacted during the study:

Industry	Number of firms visited[1]	Individual & group interview contacts
(1) Batteries	11	56
(2) Medical electronics	22	49
(3) Printing machinery and reproduction equipment	16	41
(4) Industrial controls	13	27
(5) Vocational and technical education	11	44
Totals	73	217

Note: Plus 35 other organizations described on pages 136 and 137 with 45 contacts.

In general, efforts were made to interview in three to five major firms in each industry.[2] Many smaller organizations were also included.

Corporate research and development laboratories of firms in each industry were special targets for contact efforts. In retrospect, these interviews were among the most productive in terms of depth of information received, and the number of individual contacts made.

Interview techniques.—The initial contact in a firm or organization was usually at the operating head level, or with the head of R & D or engineering. The prime aims of the initial interview were to obtain an overall view of the firm and its technology acquisition efforts to obtain permission for further interviewing in the firm, and to decide what groups or individuals within the firm to contact for additional information.

The next step was to interview research, development, and engineering administrators, product managers, chief scientists, librarians, and others. The types of questions asked are listed on the interview checklist attached (see Appendix C, Exhibit 1). In several instances, individuals were asked to complete the cost form, also attached (see Exhibit 2). (Very few firms had information in a form permitting completion of this form.)

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[1]In three instances, more than one organization within a firm was contacted.

[2]With the exception of medical electronics, where certain of the few major firms did not wish to participate, these efforts were successful.

Exhibit 1

CHECKLIST FOR PERSONAL INTERVIEWS

(1) Background on research or engineering group:

(a) Number of people including number of professionals
(b) Types of disciplines represented
(c) Proportion of government-sponsored work

(2) Is the firm a systems assembler or a producer of basic components and materials?

(3) How does the organization view its role as a leader (or follower) in the "state-of-the-art" in its industry?

(4) What are your views regarding carrying out government research contracts as a way of keeping up with technological change?

(5) What are the most important external sources of technical information for your people? (Probe and jog memories with the following list.) Order of importance?

(a) Suppliers and sales reps
(b) Consultants, research firms, professors
(c) Attendance at conferences and meetings (plus proceedings)
(d) Industry grapevine
(e) Government research reports
(f) Formal educational programs
(g) Market research (identify customer needs?)
(h) Distribution of article reprints (common practice?)
(i) Trade or industry associations (How much help?)
(j) Magazine articles

(6) Do you have a significant number of staff members studying for advanced degrees (fields, universities, level of degree)?

(7) Do you have any type of formal in-house training programs for your technical staff?

(8) What publications are most important to your technical people? (probe)

(9) What is your policy regarding reading of technical publications on the job? How much time would you estimate your people spend per week with on-the-job reading? Home reading? How about yourself?

(10) Do you subscribe to any indexing services (Chemical Abstracts, Institute for Scientific Information services)?

Exhibit 1. —Concluded

(11) Do you monitor foreign technology (conferences and proceedings, patents, publications)?

(12) How do you view patents? Do you attempt to patent your own inventions? Attitude toward others' patents?

(13) Do you worry much about the cost of re-invention? Is this a significant problem in your industry?

(14) Do you maintain in-house technical library facilities? Do you have a librarian?

(15) On government research reports, how do you keep up with what is available? (probe familiarity with STAR, Tech Briefs)

(16) What is your policy regarding the presentation of papers at technical conferences?

Individual scientists, engineers, and teachers were interviewed, and were also asked to complete the self-administered questionnaire (described later in this appendix). Where possible, DRI staff members met with the individuals to explain the purposes of the project, and to offer instructions for completing the self-administered questionnaire.

In six organizations, loosely-structured group interviews were carried out. There were usually from four to seven people participating in these tape-recorded discussions. This technique proved useful, particularly in the early stages of the project, as a means of detecting variations in information acquisition methods among individuals in the same organization, and as a source of ideas for improving the present system of technical information dissemination. It also generated some conversation on topics which individual questionnaire respondents did not mention, particularly on competitors' products as sources of technological information.

In all of these procedures, information was obtained on information acquisition behavior as perceived by the acquirer, or his supervisor, or his peers.

Self-Administered Questionnaires

Early in the project it became evident that many administrators were reluctant to allow us the time to interview individual engineers and scientists. The self-administered questionnaire form attached was developed in an attempt to solve this problem (see Exhibit 3). Earlier versions of this form, which were field tested on over 75 persons, proved to be too lengthy and complicated. The attached form represents a compromise—desired detail and depth of information were sacrificed so that the respondent could complete the form in 30-45 minutes. Exhibit 3 contains a sample cover letter, and a copy of the questionnaire form.

Exhibit 2

TECHNOLOGY ACQUISITION COSTS

Cost of technology acquisition varies among organizations. We have estimated the readily identifiable costs for two different firms below. As an aid in our study, we would like to have an estimate for your organization.

	Estimated Annual Costs		
	Company A	Company B	Your Company
Total employees	12	34	________
Professional employees	3	10	________
Journals, magazines, books	$ 500	$ 1,500	$________
Library personnel	-	-	________
Company-paid reading time, including overhead	10,000	20,000	________
Tuition	400	600	________
Company time in contact with consultants and researchers, including overhead	2,000	5,000	________
Consultant fees	2,000	6,000	________
Telephone charges to outside information sources	3,000	2,000	________
Seminar, symposia, conference fees, travel and employee time	900	4,000	________
Information from customers and users	-	5,000	________
Company time in contact with sub-system suppliers	1,000	6,000	________
Others (please note) ________	-	-	________
Totals	$19,800	$50,100	________

Exhibit 3. —Sample Letter and Self-Administered Questionnaire

University of Denver
COLORADO SEMINARY

DENVER RESEARCH INSTITUTE UNIVERSITY PARK, DENVER, COLORADO 80210

Dear Sir:

We are studying the ways in which people, such as you, keep up to date on new technical information. As a part of this research project, we are asking a limited number of key scientists and engineers in the printing and reproduction equipment industry to complete the form attached.

Based upon what we learn in this NASA sponsored study, we hope to suggest improvements in present means of disseminating government-developed technology.

Your response will be kept confidential, and we have no desire to probe into any classified or proprietary data. Only a select group is being asked to participate in this survey, therefore, your reply is extremely important to us.

Please answer each question as completely as you can, and in the order asked. Base your answers on your own experience--not on how you think an ideal scientist or engineer might reply.

The six major areas covered in the attached form are:

I. Professional Organizations, Publications, Meetings, and Courses
II. Internal Channels of Technological Information
III. Outside Channels of Technological Information
IV. General Questions
V. Types of Technology Used in Present Job
VI. Problem Solving Experience

We will partially repay you for the 30-45 minutes required by (1) sending you a copy of the results of this inquiry, and (2) offering you a $10 honorarium.

Thank you very much for your assistance. If you have any questions, please feel free to call me collect at Area Code 303, 753-2612.

Sincerely,

John S. Gilmore
Project Director

JSG:sb
Encl.

Exhibit 3.—Continued

PART I. PROFESSIONAL ORGANIZATIONS, PUBLICATIONS, MEETINGS, AND COURSES

A. Please list the professional organizations you belong to:

(1) Most important organization in keeping up to date with new technical and scientific developments ______

(2) Next most important professional organization ______

(3) Third most important professional organization ______

(4) Others (please list here or in margin) ______

B. Please list the professional and technical magazines and journals you read:

(1) Most important ______

(2) Next most important ______

(3) Third most important ______

(4) Others (please list here or in margin) ______

C. How many hours would you estimate you spent in the last 30 days in reading scientific and technical material?

(1) Reading at work (hours) ______

(2) Reading at home (or elsewhere) (hours) ______

D. Please list any conferences, conventions, symposia, or professional meetings you have attended within the last 12 months:

(1) ______ (3) ______

(2) ______ (4) ______

E. For the meetings listed above:

(1) Estimate the number of man-days spent at these meetings (man-days) ______

(2) Estimate the number of miles travelled (round-trip) in attending these meetings (miles) ______

(3) If you presented a paper(s) at any of these meetings, please estimate the total number of hours in preparing for the meeting (excluding background research time) (hours) ______

F. If you have participated in a formal course in the past 12 months, (even though it may not have been completed), please provide the following information:

Course Title	Total number weeks attended	Number of meetings each week	Time spent each week in preparation
(1) ______	______	______	______
(2) ______	______	______	______
(3) ______	______	______	______

Exhibit 3.—Continued

PART II. INTERNAL CHANNELS OF TECHNOLOGICAL INFORMATION

A. In the first column, please check (x) the channels listed below that you have used in the past 12 months. Also, in the second column, please rank the three most important in descending order (the most important is 1, etc.).

	Technological Information Channels Within Your Firm	Used in Past 12 Months	Order of Importance
(1)	Personal or in-house library facilities and library personnel	______	______
(2)	Personal knowledge, experience or experimentation	______	______
(3)	Other personnel in organization, colleagues, etc.	______	______
(4)	Company meetings, courses, work shops, etc.	______	______
(5)	Company sponsored research and development (other than your own work)	______	______
(6)	Formal company reports, document acquisition notices, or other formally distributed company documents	______	______
(7)	Others (please identify)		
	________________	______	______
	________________	______	______

PART III. OUTSIDE CHANNELS OF TECHNOLOGICAL INFORMATION

A. In the first column, please check (x) the channels listed below that you have used in the past 12 months. In the second and third columns, please rank the five most important in descending order (the most important is 1, etc.).

	Technological Information Channels Outside Your Firm	Used in Past 12 Months	Order of Importance: For Awareness	Order of Importance: For Problem Solving
(1)	Supplier or vendor personnel	______	______	______
(2)	Vendor or supplier catalogs, etc.	______	______	______
(3)	Customer or contractor personnel	______	______	______
(4)	University and other outside consultants	______	______	______
(5)	Conventions, conferences, symposia, trade shows, etc. (and papers resulting from these meetings)	______	______	______
(6)	Trade publications	______	______	______
(7)	Professional journals	______	______	______
(8)	Libraries (other than personal or in-house libraries)	______	______	______

(Continued on next page)

Exhibit 3.—Continued

(9)	Textbooks and handbooks	______	______	______
(10)	Government publications, manuals, reports, etc.	______	______	______
(11)	Mass media -- newspapers, TV, magazines, etc.	______	______	______
(12)	Abstracting or indexing services	______	______	______
(13)	Formal information dissemination centers (e.g., Battelle for metals)	______	______	______
(14)	Clipping services	______	______	______
(15)	Formal courses at a college or university	______	______	______
(16)	Patents	______	______	______
(17)	Professional societies, industry associations, etc.	______	______	______
(18)	Others (please list)	______	______	______
	______	______	______	______
	______	______	______	______

B. How do you keep in touch with new technology developed within various government programs (NASA, Department of Defense, AEC, etc.)? (Check as many as appropriate)

(1) By personal contacts ______

(2) By attending trade and professional meetings ______

(3) Through trade and professional publications ______

(4) Through indexing services ______

(5) By government announcements and publications ______

(6) Other ways (please identify) ______ ______

______ ______

(7) Government-developed technology not pertinent to my job so make no special effort to keep up with it ______

C. Please indicate your familiarity with the information channels listed below: (Check as many of the columns as appropriate for each channel)

	Channels	Have heard about	Have used	Will continue to use
(1)	Tech Briefs (NASA)	______	______	______
(2)	Regional Dissemination Centers (ARAC, Wayne State, Pittsburgh)	______	______	______
(3)	Technology Survey (NASA)	______	______	______
(4)	Clearinghouse (Commerce Department)	______	______	______
(5)	IAA (International Aerospace Abstracts)	______	______	______
(6)	STAR (Scientific and Technical Aerospace Reports)	______	______	______

Exhibit 3.—Continued

D. Do you have any suggestions for making aerospace-developed technology more readily available to your industry?

(1) Greater use of trade and professional publications ______

(2) Faster dissemination of technological information ______

(3) More reliance on abstracting or indexing services ______

(4) Special periodicals or newsletters from government agencies ______

(5) Presentations before professional societies ______

(6) Others (please list):

______ ______

______ ______

______ ______

PART IV. GENERAL QUESTIONS

A. In comparing internal versus external channels of technological information, which are most important to you?

(1) Internal channels most important ______ (3) Both of equal value ______

(2) External channels most important ______ (4) Don't know ______

B. What barriers, or specific problems, have you encountered in your attempts to acquire new technological information?

(1) Too time consuming ______

(2) Difficult to identify and reach source ______

(3) Proprietary or classified data ______

(4) Information too general; does not contain sufficient technical detail ______

(5) Others (please list)

______ ______

______ ______

______ ______

C. What are your suggestions as to how these problem areas might be eliminated or by-passed?

(1) Better indexing ______

(2) Better writing of reports, articles, etc. ______

(3) Better communication of sources of information available ______

(4) Others (please describe)

______ ______

______ ______

______ ______

______ ______

Exhibit 3.—Continued

D. Please estimate the number of times in the past 30 days you have had telephone or personal conversations dealing with technical information:

(1) With persons in your organization ____________

(2) With persons outside your organization ____________

E. If you have had experience with machine information storage and retrieval systems, please indicate the system used:

____

F. Would you identify or describe the capabilities and characteristics of what you think would be an ideal information acquisition system:

____

____

____

____

PART V. TYPES OF TECHNOLOGY USED IN PRESENT JOB

A. Shown below are some types of technological information which may be important to you. Please rank the <u>three</u> most important to you (the most important is 1, etc.). Then indicate the depth of information usually desired for all types of technology you use.

Types of Technology Used	Order of importance to your job	Depth of information usually desired (if appropriate, check more than one)			
		Detailed information	Some Detail	Keeping up Awareness	None
(1) Basic scientific knowledge	____	____	____	____	____
(2) Design concepts	____	____	____	____	____
(3) Analysis techniques -- scientific or management	____	____	____	____	____
(4) Technological performance or production techniques	____	____	____	____	____
(5) New products, components, materials, or services	____	____	____	____	____
(6) New applications for existing products, mat'ls, or techniques	____	____	____	____	____
(7) Others (please identify)					
____	____	____	____	____	____
____	____	____	____	____	____

Exhibit 3.—Continued

PART VI. PROBLEM SOLVING EXPERIENCE

We would like you to recall the most recent instance in which you purposefully sought specific new technological information (as opposed to the regular technical awareness reading you do). To qualify, the instance should represent a task which required at least two hours of your time, and one which involved technical considerations. The task could be the selection of a new component, or the collection of relevant published research papers on a particular subject, or the design of some aspect of a complex system.

Please identify the sequence of steps you went through, the time spent on each step, the time lag between request and receipt, and the results of each step. To illustrate the approach and clarify the format of your response, we have included a sample below. On the next page is a form on which to record your answers.

SAMPLE REPLY

Problem motivating search: Needed a new or different kind of metal alloy to improve a company product

	Steps or channels used in search	Time spent searching	Time lag between request for info & receipt of info	Results of each step or channel used: Provided no help	Provided some background data	Provided valuable data	Provided leads on new info sources
(1)	Looked through own catalogues	10 min	0	✓			
(2)	Asked colleague in same department	5 min	0		✓		✓ 3, 5
(3)	Looked through library's index of Battelle reports	1 1/2 hours			✓		✓ (didn't use any)
(4)	Wrote for three documents	10 min	1 week	✓ Arrived too late			
(5)	Called metallurgist at University of Ivory Tower	20 min					✓ 6
(6)	Called sales manager at American Metals Mfg. Co.	10 min	0			✓	
(7)	Selected alloy from American Metals Mfg. Co. for test					✓	

Exhibit 3. —Continued

A. Your most recent instance of a problem-directed search.

Problem motivating search: ____

____

Steps or channels used in search	Time spent searching	Time lag between request for info & receipt of info	Results of each step or channel used: Provided no help	Provided some background data	Provided valuable data	Provided leads on new info sources
(1) ____________	______	______	______	______	______	______
(2) ____________	______	______	______	______	______	______
(3) ____________	______	______	______	______	______	______
(4) ____________	______	______	______	______	______	______
(5) ____________	______	______	______	______	______	______
(6) ____________	______	______	______	______	______	______
(7) ____________	______	______	______	______	______	______

B. Was any action taken as a result of this problem-directed search?

(1) Used in making a decision ____________________

(2) Resulted in adoption of innovation ____________________

(3) Nothing done ____________________

(4) Other action (explain) ____________________

C. How much time elapsed between the start of your problem-directed search and the final action? ____________________

D. How many such searches involving at least two hours of effort do you make, typically, in a month? ____________________

Exhibit 3.—Concluded

RESPONDENT PROFILE

Date ____________________

(1) Name of your firm or organization? ____________________

(2) Location (city and state)? ____________________

(3) Size of your firm?

1 - 19 employees	______
20 - 99 employees	______
100 - 499 employees	______
500 - 999 employees	______
1,000 - 4,999 employees	______
5,000 and over employees	______

(4) Your job duties?

Development engineer	______
Research engineer	______
Research scientist	______
Teacher	______
Project supervisor	______
Field engineer	______
Librarian	______
Management	______
Other (please describe)	______

____

____

(5) How many persons do you directly supervise? ____________________

(6) What is your educational background (college or university programs only)?

Degree	Major Field	Year	College or University

(7) Years with present organization? ____________________

(8) What is your age?

20 - 30 years	______
31 - 40 years	______
41 - 50 years	______
51 - 60 years	______
61 years and over	______

(9) What is your salary range?

$ 7,499 or less	______
$ 7,500 to $ 9,999	______
$10,000 to $14,999	______
$15,000 to $19,999	______
$20,000 to $24,999	______
$25,000 and over	______

(10) Have you ever worked for an aerospace firm, NASA, Atomic Energy Commission, or Department of Defense?

Yes ______

No ______

If yes, how many years? ______

(11) If you would like a copy of the results of this survey, please put your name and address below:

____

____

____

THANK YOU FOR YOUR HELP!

Because of the time required to complete the form, and the need for thoughtful response, respondents in specific firms were offered $10 plus a copy of the research results. They were encouraged to complete the form during their off-hours, and to regard the $10 as an honorarium. A very few individuals took offense at the idea of being paid to complete the form, but most seemed pleased to receive the $10. (A half dozen individuals liked the $10 so well they completed two questionnaires!) Company officials usually seemed more cooperative when advised of the existence of an honorarium which would encourage their employees to complete the form at home rather than on company time.

Limitations of the self-administered questionnaire form and technique.—We are reasonably satisfied with the results of the self-administered interview. The results are consistent with the information obtained in the direct interviews. Most individuals appear to have exercised care in completing the form. The proportion of respondents (discussed later) was surprisingly high considering the nature and complexity of the questions asked.

On the negative side, some of the questions appear to have lacked clarity. For example, responses to question IB (Please list the professional and technical journals you read) indicated that there is disagreement on what constitutes a professional or technical journal. In response to this question, a few individuals listed government reports, indexing services, and other miscellaneous business or trade publications. There were also semantic difficulties with the six types of technology listed in part V A.

It would also have been desirable to have even more categories in the types of external channels (part III A), including: other colleagues outside the firm; and survey magazines (such as Scientific American or International Science & Technology). In this, as in other parts of the questionnaire, the problems of getting response limited the quantity of detail we could obtain.

Response.—As originally conceived, the self-administered questionnaire was to be left with individuals working for the organizations contacted. However, as the project progressed it became obvious that a larger response was necessary in order to carry out cross-tabulations by industry, occupation, type of organization, etc. Therefore, it was decided to supplement the direct distribution through the use of mail contacts. Table C-1 shows the number of forms distributed, and the percentage response for each industry.

The mailing lists for each industry came from a variety of sources. In the battery industry, early interviews indicated the key position of The Electrochemical Society, Inc. Therefore, The Electrochemical Society was contacted and agreed to supply a list of its members in the Battery Division. From the list, 200 names were selected to receive self-administered questionnaires. Since the battery industry was selected as the pilot industry, it was decided here to follow the practice of paying $10 for a completed form. This partially accounts for the relatively high response from the mailing to members of The Electrochemical Society.

TABLE C-1.—DISTRIBUTION AND RESPONSE USING THE SELF-ADMINISTERED QUESTIONNAIRE FORM

Industry	Direct Distribution			Mail Distribution				
	Number distributed	Usable responses received	Percent response	Number distributed	Usable responses received*			Percent response
					Industry	Other	Total	
Battery	66	48	73%	228	25	86	111	49%
Medical electronics	67	48	72	215	8	38	46	21
Printing machinery and reproduction equipment	89	48	54	200	12	5	17	9
Industrial controls	75	49	65	200	21	3	24	12
Vocational-technical education	60	53	88	167	32	4	36	22
Total	357	246	69%	1,010	98	136	234	23%

*A number of responses to questionnaires distributed by direct mail came from individuals not currently working in the five industries. These questionnaires were not used in industry-related analysis, but were used in compiling total data.

In addition, 28 persons who attended the 19th Annual Power Sources Conference were sent questionnaires. The number sent and response are included in the mail distribution tabulation.

In medical electronics, the Institute for Electrical and Electronic Engineers (IEEE) cooperated by supplying a list of members of its Electronics in Medicine and Biology professional group. From this list, 200 names were selected, and questionnaire forms were mailed.

In addition to the IEEE mailing, 15 persons attending the meeting of Bio-Medical Telemetry Conference, March, 1966 in San Francisco, California were asked to complete the form.

One magazine was frequently mentioned by engineers in the industrial controls, and printing and reproduction equipment industries as an important publication. Therefore, its publishers were contacted and agreed to participate in the project by selecting a sample of 200 subscribers in each industry.

In vocational and technical education, direct mailing lists were developed with the assistance of state officials in Colorado, Illinois, Oregon, and Pennsylvania. These states were selected because they were geographically dispersed, and because personal contacts had been made with a number of technical education schools in each state.

In the selection of individuals to receive the self-administered interview form, mailing lists were screened to omit any firms or individuals who might have received a form through direct contact.

Other Contacts and Sources of Information

Shown below is a summary of other types of organizations personally contacted, and the number of contacts made.

Type of Organization	Number of Individual contacts
Abstracting and Indexing services (private)	3
Book publishers	4
Formal information dissemination centers	4
Government agencies (excluding NASA)	2
Professional societies	3
Trade associations	9
Trade publications	12
Others	8
Total	45

The primary purposes of these contacts were (1) to find out how they viewed information on aerospace technology as being germane to their work, (2) how the organization being interviewed viewed their role as a channel, source, or transfer agent for such information, and (3) suggestions for improving the flow of information to their audiences.

In addition, a number of principal investigators on current research projects closely related to this one were personally contacted, and their methodology and preliminary results discussed.

Analysis of the Interview and Questionnaire Data

One of the major tasks was to tabulate the 480 self-administered interview forms received in a manner suitable for numerous cross-tabulations. For example, it was determined early in the project to cross-tabulate by industry, functional activity, previous experience with government or aerospace research, and size of firm. The results of this effort are contained in the text, and in Appendix B.

Another major task was to tabulate, in a standard form the 80 interviews conducted in organizations in the five industries. A partial summary of results is contained in Appendix A and much of the subjective information is contained in the text of the report.

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