

# INFORMATION

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*an exploitable commodity*

ROWENA W. SWANSON



**Air Force Office of Scientific Research \* Office of Aerospace Research  
United States Air Force \* Arlington, Virginia**

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*Directorate of Information Sciences*



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**United States Air Force ★ Arlington, Virginia 22209**      **APRIL 1968**

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*Half the world is driven by technological power, and half by the passion to gain this power. For the seekers, there is a shortcut that was not available earlier. They need not generate the knowledge that leads to power; they can draw on the existing fund. For knowledge there is, and to spare. The problem is how to share it, to get it where it is desperately needed. And in this sharing the giver loses nothing, but even gains, by helping span this gulf that bisects and divides our world.*

Joseph E. Stepanek

(Ref. 72)

## FOREWORD

Large and small nations, irrespective of their level of industrialization, have a common interest in their state of technological progress. The attainment of higher levels of production, the development of improved and new processes and products, bring prosperity, higher living standards, and the stimulus for further achievements.

Israel seeks accelerated rates of industrial expansion. Low in many natural resources but high in actual and potential skilled manpower resources, Israel is capable of exploiting a product of our age -- scientific information. In this, Israel can compete favorably with the most technologically advanced nations.

How scientific results can be converted into salable products of industrial operations rests, in part, on industrial experience and permissive research budgets that are yet scarce in Israel. However, the ability to identify potential areas for exploitation, the ability to extrapolate from the known to the unknown, the ability to perceive relationships among hitherto unrelated bits of data, foresight, intuition -- these are also necessary raw materials for science-based industries. These factors do not depend on gross national product or, necessarily, on prior experience. They depend, rather, on fertility of the mind produced by education, training, and an environment conducive to their growth.

"Technology transfer" is under intense scrutiny in the United States. This term refers to mechanisms for transforming research results into practical applications. Studies to date suggest that there is no best procedure, no best environment, for nurturing technology transfer. Nor are there predictive tests that conclusively identify men with creative or innovative abilities. Studies do suggest, however, that different forms of information transmission must occur to spark man's mind (or men's minds) and to effect communication of ideas through decision channels at a level of understanding sufficient for acceptance and action.

It is the contention of this paper that, though phenomena resulting in technology transfer may not be amenable to complete formalization, they can be materially aided and possibly multiplied several fold through proper attention to the role of information in the various phases of the transfer process from scientific research to production.

A variety of enterprises have evolved, probably most extensively in the United States, to make scientific and management information accessible to user groups. In the main, however, their services are not personalized or exhaustively comprehensive and place the burden on the user to be his own information sifter and searcher. This paper does not presume to predict The Optimal System for information transmission. It hypothesizes only that economically profitable, viable information systems are possible at the present time for many environments. For each instance, though, comprehensive analysis and careful planning are prerequisites that encompass evaluation of the knowledge gained thus far about systems, retrieval techniques, and human information-seeking behavior and realistic appraisals of actual and potential user groups and needs and available sources of information, manpower, machines, and money.

Israel appears now in a good position for self-examination for information system development for technology transfer. She is beginning to emphasize the importance of applied and industrial research. A Center for Scientific and Technological Information has been established within the National Council for Research and Development. Several studies of manpower and information resources, organizational structures for research and development, and government science policy have been made. Capability for the design and implementation of information systems is growing steadily through educational programs and operational experience. Moreover, Israel presents an almost unique environment, at this time, for exploring the practicability of a national-scale network of interacting subsystems capable of satisfying the various management and technical information requirements needed for a rapidly advancing economy.

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## INTRODUCTION

This paper is written from the viewpoint that information systems are rapidly becoming a necessity for growing technology-based economies.

Three usually unrelated sources of information are used for documentation. The first is history-of-science literature. The more factual these records are, the clearer a picture they present to this author of the crucial role of information transmission in almost all accomplishment. The second is broadly characterizable as management-science literature. This considers both economic and political milieus, as well as, more narrowly, the structure and behavior of organizations and the performance of people within them. The third is the information-sciences literature that concentrates on the design and operation of information systems, both at the systems level and at the level of individual hardware and software components.

None of this wealth of knowledge and experience conclusively establishes the viability of the information systems that are proposed here. These are systems of our time, made possible by and demanded by current scientific and technical achievements. These have created the requirement for systems. These also provide the tools for accomplishment.

## CASES OF USE OF INFORMATION

Elaborate and expensive schemes are being developed today, at least in affluent countries, to promote the transmission and use of information. Some of these schemes are discussed in the section below on "Performance of Information Services." This section is concerned less with schemes than with phenomena and human behavioral characteristics that seem to be related to flow and use of information in a fundamental way.

For the past fifteen years, anthropologists, sociologists, and indus-

trial economists have been studying the diffusion of information on new products and processes in various communities. How do ideas become known? How does the knowledge spread? How does information gain acceptance? How does it get put to use?

In 1962, Everett M. Rogers published a landmark survey of over 500 diffusion studies /1/. Ironically, there had been little diffusion of results on diffusion from one discipline to another before Rogers' work. Over half (286) of the studies he discusses pertain to the diffusion of farm innovations reported by rural sociologists. Nevertheless, the generalizations he made appear applicable to such instances as innovations in education, the use of new drugs, and the introduction of new processes in industry. The main thrust of Rogers' work is that diffusion depends as much on psychological and sociological factors as it does on the substantive information to be diffused.

Rogers' main generalizations /2/, adapted to an information frame-of-reference, are as follows:

1. Diffusion depends on four crucial elements: (a) items of information; (b) communication of them from one individual to another; (c) the environment or social system; (d) the time period.
2. Information diffuses more rapidly in modern social systems typified by a developed technology, a high value on science and education, cosmopolitanism (interaction with persons outside the system or in other than local areas), and carefully and economically rational planning, as distinguished from traditional environments.
3. Acceptance of new information proceeds through five stages of con-

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/1/. Everett M. Rogers. Diffusion of Innovations. New York: Free Press of Glencoe, 1962.

Rogers' scholarly effort itself reflects the information retrieval difficulties faced by the individual researcher. His study is particularly weak on diffusion in industrial environments. He does not cite another comprehensive survey - John Jewkes, et al., The Sources of Invention, London: MacMillan & Co., Ltd., 1958 - that could have provided him with much relevant data.

/2/. Rogers suggests that his generalizations be viewed as ranging "somewhere between hypotheses and principles." At many points, he notes areas needing research.

ceptualization: awareness, interest, evaluation, trial, and adoption.

4. Rate of acceptance is a function of characteristics of the information, as perceived by the individual in his social system (emphasis by this author). Rogers highlights five characteristics:

- (a) relative advantage of the information over that which it supersedes /3/;
- (b) compatibility with existing information and with values set by cultural norms;
- (c) degree of complexity to understand and use;
- (d) divisibility or extent to which information can be accepted in stages (trial on the installment plan); and
- (e) communicability or degree to which information can be transmitted to others or its embodiments observed.

5. Individuals are classifiable into five categories on the basis of their acceptance rates:

- (a) innovators (the first 2.5% of the population);
- (b) early adopters;
- (c) early majority;
- (d) late majority; and
- (e) laggards.

Adopter distributions follow a bell-shaped curve over time and approach normality.

6. Earlier adopters are in closer contact with origins of new information. They use a greater number of different information sources; the sources are more impersonal and cosmopolite. They tend to be younger in age; have higher social status and a more favorable financial position; engage in more specialized operations; have a different mental ability; and frequently are opinion leaders /4/.

7. Opinion leaders /5/, individuals who influence acceptance deci-

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/3/. A crisis sometimes sharpens the focus on relative advantages. Launching of the Sputnik produced a re-evaluation of U. S. policy on research and development programs.

/4/. Rogers suggests that innovation "offers a fertile field in which to test theories of deviant behavior."

sions of others, conform to social system norms but differ from their followers in information sources (more impersonal, technically accurate, and cosmopolite), in social participation, in social status, and in innovativeness. Personal influence is greatest at the evaluation stage of conceptualization (see 3. above); on later rather than earlier adopters; and when inadequate information creates uncertainty /6/.

8. Change agents, persons who are employed to transmit information and influence acceptance decisions, are most effective at the trial stage of conceptualization; are more important to earlier adopters; and are more successful with the higher status portion of their clientele. The change agent faces complex communication problems in his linkage role between two social systems /7/.

\* \* \* \* \*

Though histories of invention, inventors, and industrial achievements do not emphasize information flow patterns, as the diffusion literature does, these patterns are embedded in the histories. How do they compare with Rogers' generalizations? How do they match with the way today's scientists, engineers, and managers acquire, transmit, and use information? A few case studies are examined below from an information viewpoint.

The first is a trace of some of James Clerk Maxwell's research as reported by T. K. Simpson /8/. Simpson's objective was to discover whether Maxwell attempted direct experimental verification of the theory of electromagnetic propagation through a medium. His study shows that:

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/5/. A number of descriptors have been used in the literature to characterize these individuals. Rogers cites the following: key communicators; leaders; informal leaders; information leaders; adoption leaders; fashion leaders; consumption leaders; local influentials; influentials; influencers; tastemakers; style setters; sparkplugs; gatekeepers.

/6/. Rogers notes the paucity of studies on non-followers.

/7/. Rogers suggests that the change agent should be responsible for improving his client's competence to evaluate information and for changing his social norms rather than for influencing acceptance per se.

/8/. Thomas K. Simpson. "Maxwell and the Direct Experimental Test of His Electromagnetic Theory." Isis, vol. 57, 4, no. 190 (Winter 1966) 411-432.

- (a) Scientists of the period relied on three modes of communication -- personal correspondence within peer groups, scientific publication, and personal visits.
- (b) Maxwell did not conduct the experiments because he viewed his work slightly differently (i.e., as a theory of optics) from the way we interpret it with hindsight.
- (c) Prominent scientists like Hertz did not keep up with all of the literature, even in a main area of interest.
- (d) Later publication (by Helmholtz) sometimes receives greater attention and broader citation than original work (by Joseph Henry).
- (e) Personal correspondence (between Maxwell and Faraday) gives the communicants an information advantage with respect to unpublished work.
- (f) Extensive independent, but collaborative, research (Rowland in America, Helmholtz in Germany, and MacKenzie and Nichols in Canada) stimulates and advances scientific inquiry.
- (g) Timing is important to discovery. Hertz's successful measurements of electromagnetic wave propagation in air were made possible because he was able to perceive his objective from a cumulation of bits of knowledge and the orientation of his professor, Helmholtz; also, he had a method of measurement for achieving it.
- (h) Knowledgeable individuals (like G. G. Stokes) can fail to recognize discoveries even when they are demonstrated. Stokes' inability to recognize a "vivid instance" of electromagnetic propagation thereby discouraged D. E. Hughes from publishing his results.
- (i) Management device: (the Berlin Academy prize) can serve as a stimulant to scientific inquiry.

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A. W. Thackray studied the Dalton period to discover the origin of John Dalton's chemical atomic theory /9/. He observes that Dalton's thinking

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/9/. Arnold W. Thackray. "The Origin of Dalton's Chemical Atomic Theory: Daltonian Doubts Resolved." Isis, vol. 57,1, no. 187 (Spring 1966) 35-54.

emanated from his lifelong interest in meteorology. Dalton first proposed a theory for mixed gases. He successively progressed from questions of heat, gas physics, and meteorology to wider chemical problems as he perceived the need to determine relative particle sizes and weights. Thackray suggests that:

(a) Dalton's atomic theory had no origin; it rather evolved as he was required to formulate rules to make his theory of mixed gases explicit.

(b) Chemists saw no significance in Dalton's particle-weight calculations until an explanation of his method of calculation and demonstrations of its applicability were subsequently published.

(c) Thomas Thomson, a chemist and first expositor of Dalton's method, was slow to recognize the full significance of Dalton's work. His textbook description, after three years of direct communication with Dalton, was cautious and tentative. Dalton's views were not accepted until Thomson published a paper using Dalton's method. (Thomson, in earlier books and letters, had been highly critical of Dalton's mixed gas theory.)

(d) Dalton and Thomson were both ignorant of weight tables published in Europe about ten years before Dalton's.

\* \* \* \* \*

R. McCormach's paper on Henri Poincaré's introduction to quantum theory shows that the confrontation occurred at a private, five-day conference in November 1911, attended by about 20 physicists from different countries /10/. Poincaré would not have been invited if the conference had been limited to persons working in the field. Max Planck could identify only 4 well-known physicists who qualified. The proceedings are history and show that no one contributed more to the discussion than Poincaré. In the eight months before his death at 58 years of age, Poincaré developed a strong proof for quantum theory and commented that he found it difficult to decide which of the accepted premises of physics to abandon next. This vignette shows that:

(a) Age is not a bar, either to the acceptance of new ideas, or their

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/10/. Russell McCormach. "Henri Poincaré and the Quantum Theory." ibid., vol. 53, 1, no. 1 (Spring 1967) 37-57.

creative development, or to the rejection of once firmly held opinions /11/.

(b) Even members of a closely knit intellectual group differ widely in their willingness to receive and their ability to understand and exploit information. Joseph Larmor declined an invitation to attend the Congress, saying he had not been able to keep up with progress in the field. Poincaré's piercing questions sharpened Planck's perception and influenced the direction of Planck's later work. Several physicists of the period tried to explain away the premises behind Poincaré's mathematics.

(c) Ideas develop along a continuum of thought. As Poincaré influenced Planck, he was influenced by H. A. Lorentz, president of the Congress, who emphasized central questions that appear in the main argument in Poincaré's study.

(d) The development of ideas knows no national boundaries. Poincaré's work spread rapidly through England, aided by a 1914 translation by C. G. Darwin; a 1913 address by James Jeans, a Congress attendee, at a meeting of the British Association; a 1912 paper of J. W. Nicholson, a Cambridge colleague of Jeans; and a 1914 monograph of Jeans that publicized both the work of Poincaré and the related substantiation of the Dane, Niels Bohr, who visited England after hearing from E. Rutherford about the 1911 Congress.

(e) Attitudes influence the acceptance of ideas. The British were lukewarm to Planck's abstract statistical reasoning, but they could follow Poincaré's mathematical analysis and his concrete picture of a mechanism. Discussion of Einstein's light-quantum hypothesis, called by Planck a speculation that had missed the target, was a glaring omission at the Congress, perhaps because his method of reasoning from statistical fluctuations was unfamiliar. Earlier work of Paul Ehrenfest, a Viennese living in Russia, that yielded Poincaré's results by another route, became known after his correspondence with Poincaré.

/11/. Planck observed: "An old man will be inclined to ignore the hypothesis, the enthusiast will welcome it uncritically, the skeptic will seek grounds to deny it, the productive man will test it and fructify it. Poincaré, in the profound paper he dedicated to the quantum theory, proved himself youthful, critical, and productive." Ibid, p. 40.

\* \* \* \* \*

F. M. Scherer's account of the Watt-Boulton steam engine venture is a saga of efforts to convert ideas to industrial application /12/. The genesis of this invention occurred in the instrument-making shop of James Watt at Glasgow University. Watt, asked to repair a small Newcomen engine, wondered why it consumed large amounts of steam and, presumably while strolling on the Glasgow Green, he decided to try condensing steam in a vessel separate from the operating cylinder. He quickly translated the idea to some form of device, but 11 years passed before the idea was realized in a commercial, full-scale prototype. Watt needed money for model building that he first obtained from a University friend, then from an entrepreneur, Dr. John Roebuck. Matthew Boulton bought Roebuck's bankruptcy interest and opened a shop in Soho for research and development. Whether Watt would have pursued his idea without the prodding of Roebuck (who encouraged him to obtain patent protection) and Boulton (who gained a patent extension and financing) is problematic. Whether Watt impeded his own progress by refusing to delegate work to others, by pursuing fruitless experiments on large numbers of cylinder variations, and by a negative attitude to the pursuit of invention is also problematic /13/. This history emphasizes that:

(a) Information per se does not yield practical applications. Quite different types of effort from that leading to discovery are often required for commercial production.

(b) Adequate funds and their judicious management are essential for applied research and exploratory development. Watt discontinued work for long periods when he lacked money.

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/12/. F. M. Scherer. "Invention and Innovation in the Watt-Boulton Steam-Engine Venture." Technology and Culture, vol. 6, no. 2 (Spring 1965) 165-187.

/13/. In 1769, seven years before success, Watt wrote to Roebuck: "Consider my uncertain health, my irresolute and inactive disposition, my inability to bargain and struggle for my own with mankind: all which disqualify me for any great undertaking." In 1785, with his debts paid, he wrote to Boulton: "On the whole, I find it now full time to cease attempting to invent new things, or to attempt anything which is attended with any risk of not succeeding, or of creating trouble in the execution. Let us go on executing the things we understand, and leave to rest to younger men, who have neither money nor character to lose." Ibid. p. 173, 174.

(c) Knowledgeable entrepreneurship can be critical to successful applications. Roebuck understood the engine as an aid to pumping water from his coal mines. Boulton envisioned a world market, perceiving the broad applicability of the invention. Boulton was a risk taker but, gaging the reward, he actively participated in managing his Soho plant and in technical work, and he was able to transmit information to secure financing and sales.

(d) Different levels of perception and types of information processing are necessary for the transformation of ideas to applications. Watt had scientific curiosity. He retained this, resuming invention (double-acting engine; a converter for reciprocating to rotating motion; etc.) after the commercial prototype was built. He had little skill in applied research and exploratory development, seeming unable to select fruitful alternatives without exhaustive trial and error. This should have been delegated more extensively to engineers and craftsmen. Boulton contributed business acumen, entrepreneurial effort, and sufficient managerial ability to carry the venture to financial success.

\* \* \* \* \*

Other records suggest that:

- The mission orientation of research sponsors influences research directions and can shorten time periods required for development, if not for discovery. Wallace H. Carothers and several Harvard colleagues were invited to the duPont laboratories to work freely -- on polymers. The group produced a range of neoprene polymers and then - nylon fiber. Development of the fiber took four years (1935 - 1939), \$6 million, and a team of 230 technical experts /14/.

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/14/. John Jewkes, David Sawers, and Richard Stillerman. The Sources of Invention. London: MacMillan & Co., Ltd., 1958.

This book is a basic text for the consideration of causes and consequences of industrial innovation. Case histories are included for 51 notable inventions. The authors wonder whether nylon would have enjoyed this development effort if the discovery had been made in a university and non-exclusive licenses were dispensed to chemical and other firms.

• Isolation of a scientist from sources of information can adversely affect his research progress and his ability to communicate the significance of his work. Both Army and Navy experts and Robert H. Goddard exhibited instances of myopia. Goddard, always secretive in his research, needed prodding to brief the military on his missile developments. Unaware of their needs, he was unable to convince them of the significance of his work, and he was relegated to minor projects. Lacking either vision or funds, the military discontinued his early projects and paid little attention to results that were not immediately applicable to hardware. By contrast, Theodore von Kármán and others, who published freely and led team efforts, saw their work exploited far beyond what they could individually have achieved /15/.

• Discovery can arise from the recognition of an unlooked-for relationship between items of information (the so-called serendipity factor). During experiments in a Ford Motor Co. laboratory on the wettability of nickel for titanium carbide, an accident occurred. Nickel touched and dissolved part of a molybdenum shield; the nickel-molybdenum compound demonstrated perfect wettability for titanium carbide. After five years of research and development, Ford is using the compound and licensing it for use as a superior, lower-cost cutting tool material than tungsten carbide /16/.

• The "state-of-the-art" strongly influences the exploitation of information, the generation of new information, and the quality of both. Papers contained in a symposium volume honoring the centennial of H. C. Sorby's discovery of microstructure in steel reflect a portion of the history of the development of metallurgy. Metallurgy progressed through three stages:

- (1) a protoscientific period to 1885 dominated by empirical methods and some efforts to understand phenomena;
- (2) a theory-constructing period stimulated by chemical science of the 19th Century; and
- (3) the period since about 1920 introduced by the application of X-ray

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/15/. Milton Lehman. This High Man: The Life of Robert H. Goddard. New York: Farrar Straus, 1963.

/16/. J. E. Goldman. "The Role of Science in Innovation," in Proceedings of a Conference on Technology Transfer and Innovation, May 15-17, 1966. Washington, D.C.: National Science Foundation, 1967. NSF 67-5. At p. 92-97.

diffraction to metals and alloys.

Metals science acquired its base from work in chemistry, electricity, magnetism, and thermodynamics. Scientific metallurgy had little effect on metallurgy technology until the 1920's when theory, particularly physical theory, became sufficiently advanced to explain and predict phenomena. Progress in the modern period is also directly related to the development of new instruments and experimental techniques that, in turn, have aided the advancement of metals science. This mutually reinforcing progression has carried with it the identification of new materials requirements and the willingness of industry and government to sponsor basic, as well as applied, metals research /17/.

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A broader perspective on past, and present, events shows the influence of national and international groups on macro patterns of information production, transmission, and use. Colonization, for example, transferred such technological know-how as knowledge of rubber tree cultivation from European experimental gardens to Asia and Africa, and Cornish mining techniques to Australia. Industrial expansion consolidated communications between the nations of Western Europe and North America, at least on empirical and traditional technology /18/. Today's current volume of scientific research in the United States, as well as emphasis in such areas as atomic energy, aerospace sciences, and medical sciences, reflects national objectives. Effects of U.S. actions can be seen in the decisions of other nations to increase their investments in scientific research. The U.S. level may have been influenced by U.S.S.R. achievements in space flight. Information flow patterns that Great Britain is now fostering for industrial ex-

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/17/. Cyril Stanley Smith, ed. The Sorby Centennial Symposium on the History of Metallurgy. (Metallurgical Society Conferences, vol. 27). New York: Gordon and Breach Science Publishers, 1965.

The author obtained the information in the above text from John G. Burke's review of the Symposium volume in Technology and Culture, vol. 8, no. 1 (Jan. 1967) 82-86.

/18/. William Woodruff and Helga Woodruff. "Economic Growth: Myth or Reality, the Interrelatedness of Continents and the Diffusion of Technology, 1860-1960." Technology and Culture, vol. 7, no. 4 (Fall 1966) 453-474.

ploitation of technology may, in turn, be adopted by other countries. New channels for information exchange have appeared with the creation of international bodies ranging from the United Nations and the Organization for Economic Co-operation and Development (OECD) to the European Molecular Biology Organization. Other new patterns are being developed as nations narrow the technology gap. /19/

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Comprehensive analyses are beginning to be made of individual and organizational factors that influence the generation and acceptance of ideas within today's industrial environments. One of these studies examined the selection and processing of ideas in 34 small and moderate size U.S. firms (10 to 1000 employees) engaged in electronics manufacture /20/. Data were gathered on a total of 390 ideas reported by 86 managers and engineers over a six-week period (plus six additional weeks for seven firms). The ideas were of the following types:

Change of input material	37
Change in production method	175
Change in design of product	84
New product	58
Other (service facilities, etc)	47
	401

In eleven instances, the ideas were classified in two categories. The ideas were associated with the following sources of information:

Self	205
Employee	102
Business associate	49
Customer	30
Supplier	26

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/19/. Services for Small-Scale Industry. Geneva, Switzerland: International Labour Office, 1961. Studies and Reports, New Series, No. 61.

See also: Max Ways. "Why Japan's Growth is Different" Fortune, vol. 76, no. 6 (Nov. 1967) 127-9, 246, 248, 250, 252, 257-8, 260, 262, 266.

/20/. Robert Burton Martin. Some Factors Associated with the Evaluation of Ideas for Production Changes in Small Companies. Evanston, Illinois: Northwestern University, Aug. 1967. NASA Grant NSG-495. Rept. 67/29.

Trade journal	17
Newspaper or magazine	14
Trade show	5
Other	8

456

The total reflects the multiple-source origin of a number of the ideas.

Basing his investigation both on prior economic and sociological studies and pilot tests, Robert Martin established fourteen propositions that were subjected to analysis through questionnaire and interview techniques. The data negated his initial assumption, that the processes of idea selection and idea evaluation are influenced by the same variables in approximately the same way. For the phase in which ideas are selected for evaluation, he observed the following distinctions among propositions and individuals receiving ideas for evaluation:

PROPOSITION	All Evaluators	Production Managers	Company Presidents
1. The more employees in a firm, the larger the flow of perceived ideas for evaluation	Supported	Not supported	Not supported
2. The greater the risk-taking propensity of the idea evaluators, the larger the flow of perceived ideas for evaluation.	Partially support.	Not supported	Supported
3. The greater the age of the idea evaluator, the smaller the flow of perceived ideas for evaluation.	Not supported	Not supported	Not supported
4. The greater the idea evaluator's dissatisfaction with sales and cost levels, the larger the flow of perceived ideas for evaluation.	Not supported for dissatisfaction with sales levels. Some support for dissatisfaction with cost levels.		
5. The greater the formal education of the idea evaluator, the larger the flow of perceived ideas for evaluation.	Not supported.	Supported	Not supported
6. The greater the exposure of the idea evaluators to outside contacts and sources of information (a) business travel, (b) attendance at trade shows, (c) attendance at professional meetings, (d) reading professional, trade, and business publications, the larger the flow of perceived ideas for evaluation.	Supported for (d) Not supported for (a), (b), (c)	Supported for (c) and (d)	Supported for (a) and (c)

7. The greater the freedom of the organization to alter its product, the larger the flow of perceived ideas for evaluation.	Partially support.	Not supported	Not supported
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Reasons given by the evaluators for the acceptance or rejection of an idea related to the propositions in the following way:

PROPOSITION	All Evaluators	Production Managers	Company Presidents
1. The more employees in a firm, the larger the flow of ideas accepted.	Supported	Not supported	Not supported
2. The greater the risk propensity of an idea evaluator, the larger the flow of ideas accepted	Not supported	Weakly supported	Not supported
3. The higher the age of the idea evaluator, the smaller the flow of ideas accepted.	Not supported	Not supported	Not supported
4. The greater the idea evaluator's dissatisfaction with sales and cost levels, the larger the flow of ideas accepted.	Both supported for moderate levels of dissatisfaction.	Not supported	Supported for cost levels
5. The greater the formal education of the idea evaluator, the larger the flow of ideas accepted.	Partially supported	Not supported	Not supported
6. The greater the exposure of the idea evaluator to outside contacts and sources of information (a to d above), the larger the flow of ideas accepted	Supported for (d) only	Supported for (a) only	Supported for (a), (b), & (c)
7. The greater the freedom of the organization to alter its product, the larger the flow of ideas accepted.	Partially support.	Not supported	Not supported

Evaluators occupied the following job categories with respect to the ideas distributed among them:

President or vice-president and general manager	106
Manufacturing or production vice-president	27
Chief engineer	65
Manufacturing or production supervisor	61
Manager of quality control	19

Various types of engineers	73
Plant manager	22
Production or production-control supervisor	14
Other	3

Among unexpected findings is the absence of correlation of idea selection and evaluation with dissatisfaction over sales. The experiment, however, was conducted during a high sales period. The lack of support for education (proposition 5), except among production managers, is associated with the low level of technical sophistication of most of the products. The variations in significance among types of outside contacts and sources of information appear related to the roles of the different evaluators. The president, as the interface between the organization and the environment, relies on personal communication from professional sources. Managers, and to a greater degree, technical employees, depend on the literature as well as on professional contacts as information sources. Distinguishing the evaluators with respect to the status of their organization as autonomous or as a division within a corporation did not affect the results. /21/

\* \* \* \* \*

Though best ways are not yet known for promoting human information processing and information transfer, sufficient guidelines exist for empirical approaches to the institution of conducive environments. The Bell Telephone Laboratories, for example, are applying a "total process" or systems concept that is expected to improve information flow and the discovery-to-applications cycle /22/. Britain's new Ministry of Technology has the specific mission of increasing industry use of existing knowledge. To achieve

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/21/. See also Robert Charpie. "The Business End of Technology Transfer." In Proceedings of a Conference, op. cit. (ref. 16), 46-52. The Union Carbide Corp. receives about 500 new ideas annually but accepts only one per 100 to 200 to examine beyond initial appraisal.

/22/. J. A. Morton. "A Model of the Innovative Process (as Viewed from a Science-Based Integrated Industry," Proceedings of a Conference, op. cit. (ref. 16), p. 21-31.

See also: John Walsh. "Bell Labs: A Systems Approach to Innovation is the Main Thing." Science, vol. 153, no. 3734 (July 1966) 393-396.

this objective, the Ministry has begun to interface a large number of engineering and aircraft industries with almost all of the government's research establishments that are now under its jurisdiction. Consolidations in the aircraft, shipbuilding, and computer industries are beginning to show economic gains /22a/. Industry is re-examining itself to understand how it has been absorbing technology and why only an estimated 30% of available technology has been used /22b/. Industry is also beginning to acknowledge the importance of human factors in the information exploitation process and the need for new organizational structures and collaborative information schemes.

Information handling is a discipline to itself. It appears today to be emerging from the protoscientific to the theory-constructing stage.

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/22a/. "Excerpts of a Speech Given by British Minister of Technology Rt. Hon. Anthony Wedgwood Benn, P.C., M.P." Newsletter of the International Computation Centre, no. 53 (Oct-Dec 1967) 7-9.

But see "British Computer Corp. Plan Prompts Infighting." Datamation, vol. 14, no. 3 (March 1968) 127.

/22b/. Utilizing R & D By-Products. New York: American Management Assn., Inc., 1967.

## PERFORMANCE OF INFORMATION SERVICES

This section, like the former one, makes no attempt to be comprehensive but seeks only, by example, to illustrate patterns for their implications on information acquisition and use.

A variety of formal mechanisms for transmitting information are prevalent, at least in the United States. These are:

Investigator-generated documents (journal articles, reports)

Secondary-source documents (treatises, review papers, instructional texts)

Newsletters (of special-interest groups)

Abstract periodicals

Accession lists (books- and documents-received lists)

Bibliographic compilations (annotated and unannotated)

Selective information services

Conferences (followed, and sometimes not, by proceedings)

Specialized study institutes (accompanied, and sometimes not, by texts)

This section concentrates primarily on secondary-source services (e.g., abstract periodicals, selective information services). Specifically excluded is consideration of most of the "user surveys," studies of use of services by actual or potential clientele. Several of the more informative of these have been summarized elsewhere /23/. They give some indication of services that are used, but little on human factors aspects of use, i.e., why information is sought, how it is processed, and how it influenced courses of

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/23/. Rowena W. Swanson. Move the Information ... A Kind of Missionary Spirit. Arlington, Va.: Air Force Office of Scientific Research, June 1967. Rept. AFOSR 67-1247; AD-657,794. At p. 68-81.

/24/. Researchers in the field could learn from the diffusion literature. Most user studies examine particular types of services rather than the acquisition behavior and interests of the individual. Many studies are accomplished by impersonal questionnaire, responses to which may or may not accurately reflect circumstances. For example, if a person acquires many books, journals, and abstract periodicals, does he necessarily use them? If he uses some but not others, why? If he acquires little, is he bereft of information, or does he have other sources? Etc.

action /24/. It is thought that a look at the services themselves might enable better comparison with their acceptability and their likelihood of being patronized.

\* \* \* \* \*

The specialized information center has become a popular mechanism for serving a group of users having similar interests. The services that had been provided /25/ by Battelle Memorial Institute's Transducer Information Center (TIC) fit with this author's concept of the activities this kind of center should perform. TIC's services included the following:

A Quarterly Accessions List (abstract bulletin) that announced a selected sample of Center acquisitions (16% of acquisitions during the final reporting period)

A semi-annual compilation of transducer research and testing contracts

Visits to transducer users and manufacturers (66 user and 138 manufacturer organizations during the reporting period)

Summary reports in areas of growing interest (one on nuclear radiation effects on transducers was prepared during the reporting period)

Responses to requests for information (over 1000 were processed in the final 16 months; 58% were non-technical, such as requests for TIC publications)

Reference services to Center visitors /26/

TIC users included government agencies and universities as well as transducer users and manufacturers, a total of 348 regular clients as well as occasional inquirers. It depended for information principally on announcement bulletins of government documentation centers and technical and scientific journals /27/. During the final period, it processed 2287 items of the following types:

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/25/. Sponsorship of the TIC was discontinued in September, 1967.

/26/. W. E. Chapin, G. L. McCann, and W. E. Veazie. Operating a Transducer Information Center. Columbus, Ohio: Battelle Memorial Institute, Jan. 1968. Contract AF 33(615)-5758. Rept. AFFDL-TR-67-154; AD-662,349.

/27/. Its main sources were the Defense Documentation Center's Title Abstract Bulletin (TAB); the National Aeronautics and Space Administration's Scientific and Technical Aerospace Reports (STAR); International Aerospace Abstracts; the Interservice Data Exchange Program's (IDEP) Summary Sheets and Reports; and over 50 technical and scientific journals.

Screening and Acquisitions

- YAB (3)
- STAR (3)
- IAA Abstracts (5)
- Journals and Books (2)
- IDEP Summary Sheets (1)

Legend

- (1) Technical Specialist
- (2) Information Specialist
- (3) Analyst
- (4) Clerk-Typist
- (5) Report Department

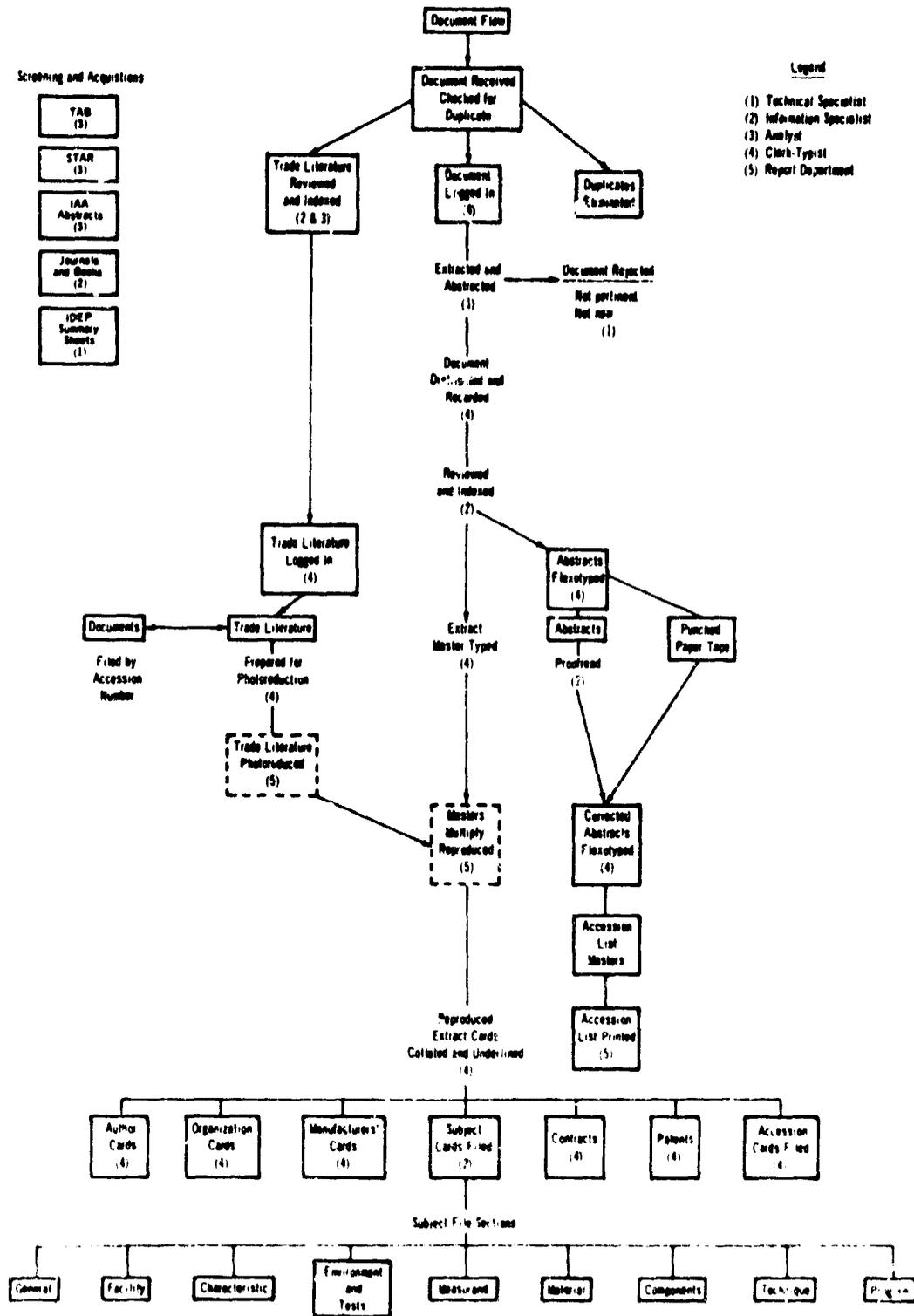


Figure 1. Document Processing Flowchart

research reports	1098
evaluations	221
specifications	34
manufacturers' data	409
journal articles and surveys	510
bibliographies	15

The flow chart in Figure 1 shows the document handling system. The Center's annual budget was about \$80,000.

TIC provided what might be called "active" information services. An extreme type of a "passive" service would furnish only information specifically asked for. This author classifies libraries and information centers that acquire on their own initiative but do not supply any materials except in response to requests as "passive." Most of TIC's services, by contrast, reflect the high degree of subject proficiency and awareness of information needs of its clients on the part of its professional staff. The abstract bulletin, for example, was a reference guide to many users because it had passed through two technical screenings -- the first for selection of materials for the Center's collection, and the second a subset of these. The contract compilation gave managers and program directors reasonably current information needed for their project planning. A discouraging finding of user surveys is low incidence of use that correlates to some extent either with lack of knowledge of the existence of services or lack of knowledge of how to use the services. TIC staff visits to researchers and manufacturers provided two-way education. TIC members briefed on services but they, in turn, learned about the work and information needs of their customers. Through feedback, TIC became aware of particular problem areas for which special information products were needed. This led to the preparation of three TIC-generated summary reports for which staff members searched information sources and subject fields other than their own to insure comprehensiveness. TIC, located in Ohio, literally went to the user through a branch office in Los Angeles, an area having the greatest concentration of manufacturers and users of transducers in the U.S. Notably, the only service TIC customers appeared disinterested in was a monthly compilation of tables of contents of journals.

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Spurred by the manipulative capabilities of computers, many information system designers have been intrigued by the possibility of providing personalized information services to users. The term, Selective Dissemination of Information, or SDI, has become generic to this concept. Ideally, an SDI system should match user information needs with the items stored in the system and give the user all of the items applicable to his needs but none of the items that are not applicable. A refinement on this is a concept of weighting the descriptors by which the user defines his needs, to limit, should he desire, the number of items he is furnished to a pre-specified "most-applicable" cut. Another refinement is a provision for "feedback" to enable the user to alter his "profile" of descriptors at regular intervals. Several additional refinements give the user various options, such as an ability to specify the type of system output, e.g., bibliographic, abstract, or full-document information. The cost accounting assumption is that SDI will be but one component of a fully integrated information system, with costs of data preparation shared with other operations such as accession-list, catalog-card, and book-index production. Despite the existence of some SDI systems, implementation appears still in a proto-scientific stage.

As part of the U.S. Army's technical library improvement program /28/, the Information Dynamics Corp. (IDC) surveyed twenty SDI systems /29/. Many of the systems use the machine-readable products of one or more of the large documentation centers with consequent limitations based on the configurations and constraints of these inputs /30/. IDC found no commonality in criteria by which systems evaluate their operations. Thus, the "results reported" elements in the system descriptions appended to IDC's report are

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/28/. The Army Technical Library Improvement Studies, or ATLAS, program.

/29/. William A. Bivona and Edward J. Goldblum. Selective Dissemination of Information: Review of Selected Systems and a Design for Army Technical Libraries. Reading, Mass: Information Dynamics Corp., Aug. 1966. Contract DA-19-129-AMC-957(N). Rept. IDC-8074; AD-636,916.

/30/. The text refers to the following sources: Defense Documentation Center; National Aeronautics and Space Administration; National Library of Medicine; and Chemical Abstracts Service.

difficult to interpret. For example, statistics from the IBM Technical Information Retrieval Center, Yorktown Heights, that serves 1200 users in the U.S. and 250 in Europe, show 79.1% relevance as marked on returned notices. This drops to 45% if calculations are based on the total number of notices sent. Other systems separate responses that request documents from those expressing interest but not wanting documents. The NASA SDI system, with 700 users, reported 50 to 60% relevance based on a 60% return. The statement: "15% to 18% requested documents" defies further quantification.

Only one system, IBM's SDI-3, that uses a 1401 computer, furnished a cost analysis. No comment is made in the survey on cost effectiveness. SDI-3 monthly costs to process 50 items with abstracts daily are:

Fixed costs:	Personnel	\$ 4100
	3 826 card punches	480
	Punched cards	50
	Contingencies	500
	Total	\$ 5130

Variable costs:	(per 100 profiles at 5 notices per person per day)	
	8K 4-tape 1401	\$ 2200
	(5 hrs/day extra shift, 40% of prime shift rental)	
	Forms	1100
	Photocopies	800
	(900 sheets/day)	
	Contingencies	300
	Total	\$ 4400

Estimated cost per profile per month:	\$ 9.53
Unit cost (2000 profiles per month):	\$ 7.00

IDC also provides the following costs for operating a printing cycle for 3000 input documents disseminated to 600 users who receive an average of 150 notices (1000 characters distributed over 20 lines of text):

<u>Computer Printing Costs</u>		<u>Offset Printing Costs</u>	
Key and verify 3000 abstracts:		On typewriter or Flexo- writer (35¢ ea) \$ 1050	
On keypunch (19¢ ea)	\$ 2850		
Record:		On offset masters 300 (10¢ ea)	
On magnetic tape	10		
(5 min, \$120/hr)			
Print:		On offset press 450 (15 hrs, \$30/hr)	
On 1000 line/min.	2250		
printer (30 hrs, \$75/hr)			
Total:	\$ 5110		\$ 1800

IDC's minimum configuration for an SDI system is a digital computer, three magnetic tape transports, a high-speed printer, and punched card input/output equipment.

IDC's subsequent nine-month pilot test of a prototype SDI system for the U.S. Army Natick labs appears to have been less than satisfactory /31/. The test used a 1000-document sample and 25 subjects having a broad range of interests from the Clothing and Organic Materials Division. A vocabulary was generated based on three thesauri as the test progressed. Lack of a completely integrated subject vocabulary is stated as the most limiting factor in the experiment. In the fourth of four production runs, a comparison of manual and machine selections yielded relevance percentages of 55% and 45%, respectively. Participants appeared interested in retaining SDI outputs that included abstracts, but their minimal responses suggest an absence of real involvement, possibly because they knew the experiment was to be short lived.

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Unique among service organizations is the Institute for Scientific Information in Philadelphia. Founded in 1956 as Eugene Garfield Associates,

/31/. Selective Dissemination of Information (SDI), Vol. I - Pilot Test at U.S. Army Natick Laboratories. Reading, Mass.: Information Dynamics Corp., May 1967. Contract DA-19-129-AMC-957(N). ATLAS Rept. 15; IDC-8074-2; AD-654,997.

Same title, Vol. II - Implementation Manual. June 1967. ATLAS Rept. 16; IDC-8074-3; AD-654,996.

it has developed and adapted a variety of mechanisms to enable users to retrieve information from the steadily growing journal literature. It now provides, for fees, ten services:

The Science Citation Index (SCI), a list of current citations to earlier papers;

Index Chemicus, a weekly (biweekly before 1967) graphic abstracting and indexing service to new chemical compounds and their syntheses;

Encyclopaedia Chimica Internationalis, an annual cumulation of Index Chemicus with subject, molecular formula, author, and journal indexes. (Volumes for 1960-62, 1962-63, 1963, 1964, 1965, and 1966)

Current Contents in three editions: Physical Sciences, Life Sciences, and Chemical Sciences, weekly compilations of tables of contents of foreign and domestic journals in the respective subject fields; over 1600 journals are represented (foreign language contents are translated to English);

Automatic Subject Citation Alert (ASCA), an SDI system furnishing weekly reports to users; initiated in 1965;

Original Article Tear Sheets (OATS), dissemination of original journal pages of any paper reported, abstracted or indexed by the above services;

ISI Search Service, custom searches in response to requests; and  
ISI Magnetic Tapes, contents vary, furnished weekly /32/.

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/32/. The costs for the services are as follows:

SCI - \$1250 (educational) and \$1950 (industrial) for the first copy, \$625 for the second copy, annually, for the years 1964, 1965, 1966, each of which is an eight-volume cumulation. The 1961 Index, in five volumes, costs \$700.

Index Chemicus - \$350 (educational), \$700 (industrial), annually.

Encyclopaedia Chimica Internationalis - the educational and industrial rates are, respectively, \$600 and \$1200 for 1960-62; \$325 and \$750 for 1962-63; \$300 and \$600 for 1963; \$400 and \$750 for 1964.

Current Contents - the Life Sciences and Physical Sciences editions each cost \$60 (educational) and \$100 (industrial) annually; Chemical Sciences costs \$100 annually.

ASCA - \$100 (U.S., Canada, and Mexico); \$110 (other, airmail) annually

OATS - \$2 per article (up to 20 pages); \$2 for each additional 20 pages or fraction.

ISI Search Service - \$25 for the first hour, \$10 for each succeeding hour.

ISI Magnetic Tapes - cost depends on the file purchased, starting at about \$5000 per year.

A version of Current Contents was conceived in 1953 when Garfield was a member of the Johns Hopkins University Welch Medical Library Indexing Project /33/. This first effort, for the library science, documentation, and computer journals, as well as a second for the management and social sciences literature, died for lack of customers. The third attempt, begun in 1958 for the life sciences, resulted from customer demand /34/. ISI estimates that Current Contents are read by over 60,000 scientists weekly.

The Science Citation Index (SCI) is patterned after Shepard's Citations, a research tool that has been used by the legal profession since 1873 /35/. It is based primarily on an association-of-ideas concept, i.e., on the premise that an author cites earlier papers because of a subject relationship he has found between them and his own work. This type of association avoids the semantic ambiguities that arise in the use of words for subject description and the omission of relationships that might not be obvious to a casual reader or third-party indexer. Citation indexes are effective, however, only to the extent that bibliographies in published papers refer to prior work. Analysis of SCI data shows that the average published paper is cited less than once each year. The average number of sources citing a particular reference did not increase appreciably as SCI expanded its coverage (see Figure 2). The data thus negate the assumption that usual citation practices would give an unwieldy number of sources for a reference /36/, although the low incidence of citation may reflect unfamiliarity with prior work. ISI files disclose instances of duplication. Figures 3, 4, and 5 show sections of the Index. The citation section for the journal litera-

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/33/. The principal objective of the Welch Project was to study the application of machine methods to handling the medical literature. Its findings were used in the creation of the National Library of Medicine's Index Medicus.

/34/. Current Contents, Life Sciences, vol. 10, no. 9 (Feb. 1967) 5-8.

/35/. Eugene Garfield. "Citation Indexes for Science." Science, vol. 108, no. 3159 (July 1955) 108-111.

In this paper, Garfield discusses difficulties he had encountered in searching the literature. Might one infer that he perceived the need for an SCI-type tool as a result of his own experience?

/36/. Eugene Garfield. "'Science Citation Index' - A New Dimension in Indexing." Science, vol. 144, no. 3619 (May 1964) 649-654.

Year	1966	1965	1964	1961
Cited references	3,400,000	3,336,000	2,128,113	1,395,530
Different journals cited	20,000	20,000	20,000	20,000
Book reviews indexed	30,000	25,000	16,116	
Authors whose works were cited	460,000	439,000	323,889	257,900
Source journal items indexed	300,000	235,801	151,639	101,944
Author entries in Source Index to Year's literature	576,000	576,000	390,838	
Source journals	1,600 (approx)	1,147	700	613

Figure 2. Statistics for Science Citation Index

SCIENCE CITATION INDEX						
	Cited Author	Citing Author	Cited Year	Publication	Citing Year	Vol. Page
	↓	↓	↓	↓	↓	↓
Reference	ACHER N		58	SOC CHIM BIOL		40 2005
	ACHER R			NATURE	L 64	201 191
	ACHER R		58	J BIOL CHEM		233 116
	ACHER R			NATURE	L 64	201 191
	FARNER DS		58	ZWEITES INTERNATIONAL AM SCIENT		52 137
	ACHER R		61	BIOCHIM BIOPHYS ACTA		51 419
	ACHER R		61	NATURE	L 64	201 191
	FARNER DS		61	HISTOPHYSIOLOGIE COM		52 137
	ACHER R		63	S ZOOL SOC LOND		94 83
	ACHER R			NATURE	L 64	201 191
	DICKER SE		63	S ZOOL SOC LOND		94 83
	ACHERMAN L		54	CANCER DIAGNOSIS TRER		64 170 186
	DIAZBAZAN N		53	LANCET		23 281
	ACHESON U		53	J PEDIAT		64 101
	ACHESON ED		59	J CHRON DIS		10 499
Source				LANCET	64	1 388
	ANSELL BM		60	QUART J MED		29 489
	EDWARDS FC			ANN RHEUM D	64	23 64
				GUT	64	5 1
	ACHESON ED		61	BRIT MED J		1 668
	ACHESON ED			BR J PREV S	64	18 8
	ACHESON ED		61	BRIT MED J		2 929
	TAYLOR KB			GASTROENTY	64	46 99
	ACHESON HM		54	BRIT J PREV SOC MED		8 59
	ACHESON RM			BR J PREV S	64	18 25
	ACHESON RM		54	HUN BIOL		26 343
	ACHESON RM			BR J PREV S	64	18 25
	JOHNSTON PE		54	J ANAT		7 1
			56	HUMAN BIOL		92
	MORTICONI EJ			ACRIDINES		
		56	J AM CHEM			
			J CHEM			
		58	J AM CHEM			
			J AM CHEM			
		60	J AM CHEM			

Figure 3. Science Citation Index (journals section)

Figure 4.

Science Citation Index  
(patents section)

SCIENCE CITATION INDEX						
PATENT SECTION						
Cited Patent	Citing Author	Cited Year	Citing Inventor	Citing Patent	Vol.	Page
3046657	NEWCOMB WC	'62	MENTER	3120704 US	P 64	
3046711	COPPING BG	'62	HARRISON	3118537 US	P 64	
3046751	SIROCKY PJ	'62	GARDNER	3122000 US	P 64	
3046767	KLEIN WG	'62	NICKELL	3116621 US	P 64	
3046933	SCHMID RG	'62	KEMENY	3118473 US	P 64	
3046936	BRONSON GA	'62	SIMONS	3117022 US	P 64	
3046942	STANZEL GA	'62	HALE	3118427 US	P 64	
3046974	BRETT RE	'62	KIMBERLEY	3119358 US	P 64	
3047013	BOCHAN J	'62	BAUMBACH	3118468 US	P 64	
3047020	BAGWELL MU	'62	BARRETT	3116503 US	P 64	
3047026	GALLOWAY FM	'62	KAMM	3119415 US	P 64	
3047041	AMICI L	'62	BOTTASSO	3117614 US	P 64	
3047067	ROBICHAU TJ	'62	WILLIAMS	3123138 US	P 64	
	YOUNG BM	'62		3123137 US	P 64	
3047081	RITZMANN OF	'63	GEOPHYSICS		R 64	29 131
3047107	TURNER BR	'62	PARINENTER	3119471 US	P 64	
3047141	DOHOVAN M	'62	BURNS	3119516 US	P 64	
	WIMEL AJ	'62	LONG	3120897 US	P 64	
		'62	RICHHOND	3117702 US		
				17707		

SOURCE INDEX						
Source Journal	Vol.	Page	Source Year	No. Ref.	Issue	I.S.I. Acc. No.
ACEVEDO HF			GOLDZIEH JW			
BIOC BIOP A	82	118	64	14R	N1	80191
METABOLISM OF 84-14C84-ANDROSTENE-3,17-DIONE BY NORMAL HUMAN PROSTATIC TISSUE						
ACF IND INC	SEE		ANDERSON CE	3122382	US	
ACF IND INC	SEE		BOLLER HA	3120641	US	
ACF IND INC	SEE		JEEP CW	3121188	US	
ACF IND INC	SEE		PRICE WG	3117879	US	
ACF IND INC	SEE		SHEPHERD GY	3117455	US	
ACH FIB SER	SEE		WOLLNER HJ	3117402	US	
ACH RAILV S	SEE		GIEBEL MC	3121400	US	
ACHA IG			AGUIRRE MJR			
CAN J MICRO	10	99	64	N	9R N1	81454
PROTOPLASTS FROM CONIDIA OF FUSARIUM CULMORUM						
ACHA PN			AGUILAR FJ			
AM J TROP M	13	48	64	11R	N1P1	80401
STUDIES ON CYSTICERCOSIS IN CENTRAL AMERICA & PANAMA						
ACHENBAC JD						
J ACOUST SO	34	10	64	9R	N1	80824
APPROXIMATE TRANSIENT SOLUTIONS FOR COUPLED EQUATIONS OF THERMOELASTICITY						
ACHER R			CHAUVET J			
NATURE	201	191	64			
ISOLATION OF PINBACK BY VASOPRESSIN						
CHERSON ED						

Figure 5.

Science Citation Index  
(Source Index)

ture, Figure 3, is alphabetic by first author of the cited reference. The "type code" identifies the nature of the paper as an abstract (A), editorial (E), letter (L), patent (P), review (R), etc. The U.S. patents section, Figure 4, is numerically ordered by cited patent number. The source index,





fied of their existence. An optional service, ASCAmatic, furnishes copies of papers with the ASCA report. The present ASCA system incorporates two sets of modifications made to the original 1965 system to increase a user's flexibility in selecting search terms. The flexibility, however, demands of users a form of self-discipline in formulating their profiles /38/. The ASCA report (Figure 9), through combinatorial options, can be a browser's tool or a specific and precise current-awareness device. The recently instituted ISI search service was designed with a view to the small user who cannot afford purchase of ISI's magnetic tapes or the SCI volumes /39/.

Since ISI's income is solely from sales, user acceptance can be inferred from the growth of its services, both in scope and diversity. The coverage accords with ISI's and other estimates that, of the 50,000-odd scientific and technical journals being published in over 65 languages, less than 1300 account for over 90% of the significant reports (approximately 250,000 papers per year). Journals continue to be added, nevertheless, to augment ISI's capabilities in specialty fields. The progressive expansion of ISI's services is indicative of more than user acceptance. The papers cited here reflect a continuous effort by Garfield and his staff to explore new approaches to information handling and retrieval. Not all of these have been or are profitable. Through tests and studies of user response, services have been modified or discontinued. ISI's services and experiments have, in turn, been educating users to potentials realizable from information systems. Garfield expects the cost of services to remain stable or decrease as appreciation for information services increases. Moreover, with proper planning, they can become increasingly varied and specific to individual requirements. The services made practical or enhanced by availability of the Science Citation Index input encourage further developments.

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/38/. Eugene Garfield and Irving H. Sher. "ISI's Experiences with ASCA - A Selective Dissemination System." Journal of Chemical Documentation, vol. 7, no. 3 (Aug. 1967) 147-153.

/39/. Eugene Garfield. "ISI Services in the Design of Small-User Systems." Journal of Chemical Documentation, vol. 6, no. 3 (Aug. 1966) 164-168.

In theory, periodicals that provide abstracts and indexes to subsets of the journal and report literature should be powerful tools for current awareness and retrospective search. The following practical considerations impose drawbacks to realizations:

Costs	The classification problem
Volume	The "needle-in-the-haystack" problem
The "language" problem	The manpower problem

The average estimated cost to process an item is \$30 if it is abstracted and \$7.50 if it is only indexed /40/. Thus, the cost to abstract and index the 250,000 papers per year noted above is \$7.5 million. Federal government documentation centers together handle an estimated 250,000 items /41/. If most of these are technical reports, the cost burden doubles. However, these totals only reflect the science and technology literature. To serve the field of science and technology, such items as engineering drawings, data bases, patents, and trade publications would have to be added. Excluded from this discussion are other fields such as the social sciences and the humanities that must cope similarly with quantities and varieties of information.

The "language" problem is alluded to in the Information Dynamics Corp. SDI experiment and with reference to the Science Citation Index above. This is a problem engendered by at least three factors: changing terminology or meanings associated with terminology over time; varying degrees of overlap in synonymy among terms; and the imprecision of language for describing concepts that introduces ambiguity. A total of 876 man-weeks, including 556 man-weeks of 9 lexicographers, were consumed to produce the 17,000-descriptor Defense Documentation Center - Engineers Joint Council Thesaurus of En-

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/40/. Raymond P. Barrett, et al. A System Study of Abstracting and Indexing in the United States. Falls Church, Va.: System Development Corp., Dec. 1966. Contract NSF-C-464. Rept. TM-WD-394; PR-174,249.

/41/. The System Development Corp. survey gives a total of 234,282 items abstracted by all federal centers in 1965. The centers do not abstract all accessions. The survey shows that, of the 234,282, only 30,651 abstracts were written in-house; the remainder were author or contractor prepared. Ibid, p. 29.

gineering and Scientific Terms /42/. Language and classification problems contribute to thesaurus compilation and the creation of controlled vocabularies for indexes. The value of a controlled vocabulary is noted above. To establish one acceptable to users and the using system is a difficult chore. For the DDC-EJC Thesaurus, the terms of 145 selected vocabularies were merged and evaluated. Decisions on the sequencing of terms proved the most perplexing to the Thesaurus team. In some instances, a clear rule could be formulated (e.g., "radar antennas" instead of "antennas, radar"). In others, order affects meaning ("nitrogen organic compounds" vs. "organic nitrogen compounds"). Others necessitate spelling conventions ("electro optics," or "electro-optics," or "electrooptics"). Still others affect both the size of the vocabulary and the classificatory conceptualization that must be made by the indexer and searcher (e.g., should "automatic transmission fluids," "automatic transmission," and "transmission fluids" all be vocabulary terms, or should the first be derivable from coordination of the latter two, or ... etc.).

The "needle-in-the-haystack" problem refers to hidden information. The relevant paper in the obscure journal is one example. Of greater frequency, papers in proceedings volumes remain unknown because they are not individually abstracted or indexed. There is an even greater likelihood that significant results in papers that are abstracted or indexed are not reflected in the abstracts or index terms. Often, the information system demands this omission because of restrictions on the length of the abstract, or on the allowable number of index terms. Perhaps as often, abstractors and indexers do not perceive a particular significance or do not have time, in a production operation, to study the contents for significance. Of particular concern at the so-called "cutting edge" of science and invention are papers that report the new or novel, but in old terminology, so that they are overlooked.

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/42/. J. Heston Heald. The Making of TEST, Thesaurus of Engineering and Scientific Terms. Washington, D.C.: Department of Defense, Nov. 1967. Rept. ONR-26; AD-661,001.

The project cost \$438,386.

The general scarcity of skilled manpower is compounded in the abstracting and indexing professions. Though a consensus suggests the desirability that this work be done by subject specialists, it is accorded second-class status by many employers. The exacting nature of the work and unattractive salaries are further deterrents.

Budget limitations, if no others, have placed practical ceilings on the range of all abstracting and indexing services. The result has been a proliferation of services to fill gaps and satisfy specialized information needs. The 550-odd services presently operating in the United States may give as much confusion to users as they do help. They emanate from professional societies, government agencies, industrial organizations, universities, and commercial enterprises who market services as their principal products. The cost of this productivity is estimated at \$50 million annually /43/. Several studies of duplication have been made. John Martyn checked the references in comprehensive bibliographies on specific subjects against abstract periodicals appropriate to the subject fields. Results averaged for 19 bibliographies containing 3093 references disclosed that 21% of the references appeared in no abstract periodical, 27% were abstracted once, and 52% had been abstracted more than once /44/. A common pattern is the following for 432 references in a bibliography on the biological control of insect pests and weeds:

<u>References</u>	<u>% of Total</u>	<u>Times Abstracted</u>
31	7%	0
106	25%	1
99	23%	2
84	19%	3
95	22%	4
17	4%	5

Studies to recommend a plan for eliminating unnecessary duplication /45/ and using available resources more efficiently are themselves beginning

/43/. Ref. 41, p. 8.

/44/. John Martyn. "Tests on Abstracts Journals: Coverage Overlap and Indexing." Journal of Documentation, vol. 23, no. 1 (March 1967) 45-70.

to proliferate. One of the most recent of these concludes that abstracting and indexing services "must be viewed as a subsystem within the framework of a national document handling system" /46/. The investigators found a lack of reliable data on which to base comparisons of abstracting and indexing services, or on which to base tests enabling such comparisons. That limited successes could be achieved within the framework of the National Federation for Science Abstracting and Indexing Services (NFSAIS), a cooperative society of non-profit services, suggests that broader ventures may be possible /47/. Though strong government leadership is proposed, a central question seems to be the degree of involvement the federal government has, may wish to exercise, or may wish to delegate to a government or non-government body, and the limits of its jurisdiction.

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Reminiscent of communication that used to flourish among scientists, the Information Exchange Groups (IEG) sponsored by the National Institutes of Health (NIH) between 1961 and 1966 are success stories despite their discontinuation. The plan for each group was to identify a sharply focused field of scientific inquiry, select a chairman who would ensure that every active worker in the field would become a member, and maximize communication among them. The central IEG office in Washington transmitted any communication submitted by a member to all members of his particular group, dispatching to members outside the U.S. by air mail. A "communication" was anything a member chose to submit -- a pre-publication manuscript, a comment, a request for information, a protest, a disagreement, etc. Members were expected to treat the items, called IEG Memoranda, as personal communications, i.e., not as part of the literature, and to honor priorities of discovery disclosed through this medium. David Green, chairman of IEG No. 1 (for the field of electron transfer and oxidative phosphorylation), reports that his group exchanged only 27 memoranda during its first two years, but "the

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/45/. Repetition is not necessarily duplication, since an item may be appropriate to several subject areas.

/46/. Ref. 41, p. 126.

/47/. Ref. 41, p. 160-162. The report also discusses on-going collaboration within international organizations including the International Council of Scientific Unions (ICSU) and UNESCO.

floodgates opened" thereafter, almost 800 memoranda being distributed during the next four years. The membership of IEG No. 1 was 725 at its demise, 329 being residents in 32 countries outside the U.S. /48/. Green estimates that about 90% of the important papers in his field were being circulated to members at least six months before they appeared in journals. Green writes:

"The days of library hunting were over for workers in the seven fields" (there were seven Groups).

The Groups were terminated when the editors of five biomedical journals, acting together, advised the NIH that they would not publish any manuscripts that had been IEG Memoranda. Green disagrees with the editors' decision (not with NIH's) for several reasons. First, three who represented society publications acted without consulting their publication committees. Principally, however, Green views the Group as a forum valuable in the creative phase of scientific discovery, while hypotheses are being formulated and experiments conducted. Communications at this stage are not suitable for publication. He distinguishes this from the time for publication that follows "when the dust has settled." "The IEG reestablished debate and dialogue among scientists." Moreover, he notes that the journals do not like controversy and are satisfying "only a diminishing part of the needs of the scientific disciplines in respect to communication of information." Workers in foreign countries reported that they were able, for the first time, to be current with their U.S. colleagues. "The end of IEG meant the return to scientific isolation of a large number of investigators in laboratories outside the U.S."

The 1966 cost for printing and distributing Memoranda for the seven IEG's was \$416,000. The annual cost per member was \$140, or \$1 for every \$73 of research cost. Two of the groups were not successful. This Green attributes to "the choice of the right umbrella to hold an IEG together."

\* \* \* \* \*

Not to be overlooked is the yeoman's service possible from large documentation centers. Though their breadth of coverage precludes their serv-

/48/. David Green. "Death of an Experiment." International Science and Technology, no. 65 (May 1967) 82-84, 86, 88.

ing the specialist comprehensively, and though processing times and distance from originating sources of information mitigate against current awareness value, their reliability as a source of some information with some currency should not be underestimated. When their budgets provide for the costs of bibliographic compilation or retrospective searching and the duplication of documents for distribution, they obviate the need for similar activities in fragmented fashion at many smaller installations. This can be a particularly effective resource either at the beginning of a search to obtain a general orientation, or toward the end to check for omissions.

The Defense Documentation Center is an exemplification of this type of facility. With an operating budget of \$10,091,000 in Fiscal Year 1966, DDC's 472-man civilian staff (4 military) performed the following services:

Announced 47,891 new titles in its semi-monthly Technical Abstract Bulletin and added 776 unannounced new titles to its collection /49/  
Satisfied 677,000 requests for documents (632,183 in "hard copy," 44,817 in microform). (Requests from shelf stock were filled in an average of 2.1 work days, and from reproduction in 6.1 work days.)  
/50/

Compiled 17,403 bibliographies (99% machine processed) in an average of 3.3 work days each (each furnished an average of 137 citations)

Maintained six field offices in major research and development areas in the U.S. (Boston; New York City; Dayton, Ohio; Los Angeles; San Francisco; Washington, D.C.).

Its manpower expertise and computer facility (Univac 1107) were employed during the period for the design and implementation of a storage-and-retrieval system for resumés of Department of Defense-sponsored research projects (called the Work Unit Data Bank System). Engaging up to 56% of its 100-odd systems and programming staff and 11 contract personnel, DDC produced an operational system for 18,584 resumés and provided 924 management reports (285 requiring special printouts) by the end of the Fiscal Year. Members of its staff also participated in the Thesaurus project discussed above /51/.

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/49/. The DDC collection contains approximately 850,000 reports in all areas of science and technology.

/50/. A total of 1,506,996 requests were received during FY 66. Through a cooperative arrangement with the Clearinghouse for Federal Scientific and Technical Information (CFSTI), CFSTI filled 665,263 of the requests (596,767 in hard copy, 68,501 in microform).

/51/. Robert H. Rea. Annual Historical Summary, 1 July 1965 to 30 June 1966. Alexandria, Va.: Defense Documentation Center, Oct. 1966. Rept. RCS DD-DSA (A) 216 (L); AD-645,500.

## REQUIREMENTS FOR INFORMATION SYSTEMS

In this section, the author undertakes to discuss three fundamental components of systems:

hardware,  
software, and  
people. /52/

The author claims no expertise in hardware or software design or development. Though the behavioral scientist frowns, sometimes, on others invading his realm, in a sense all individuals have some expertise based on their experience as members of the set. In a similar sense, information systems are not the exclusive province of systems specialists. Each man, each group of men, is a system or one of many subsystems, depending on context and point of view. This section relies on experts in their areas of expertise. The author tacitly assumes the prerogative of a reviewer.

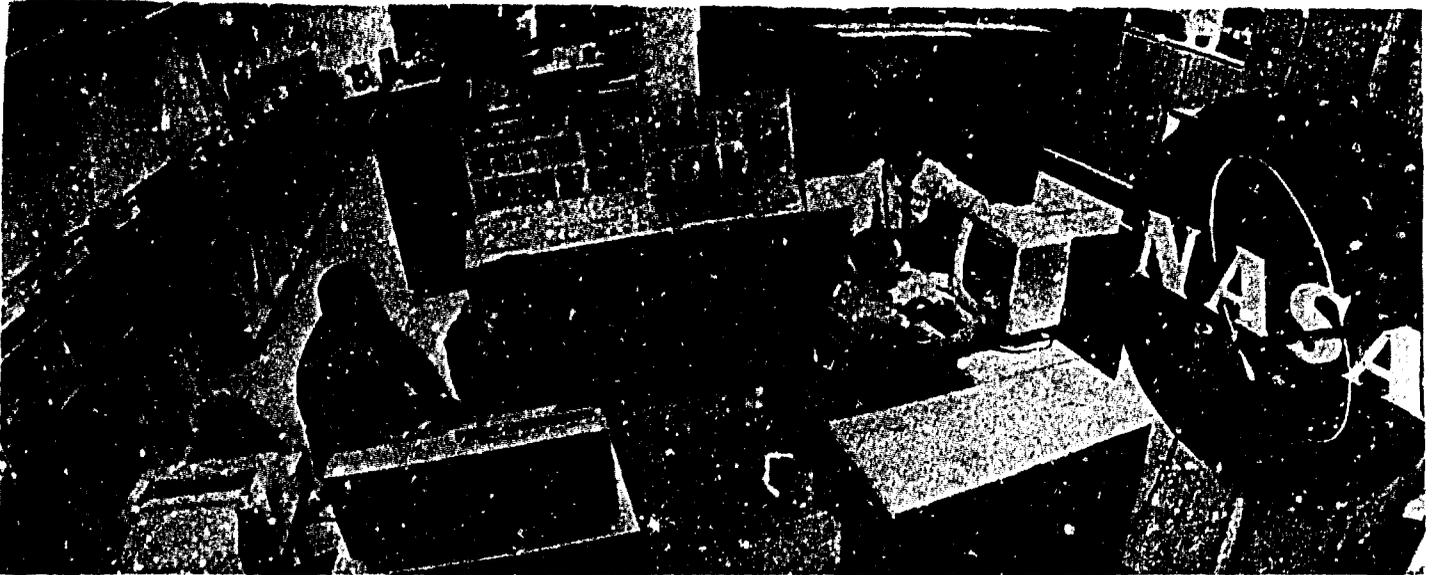
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The photograph in Figure 10 is intended to take the place of the proverbial thousand words. It is not included here for the inference that a super-computer can be anyone's tool, or that the 360/91 is an ultimate in super-computers /53/. Its cost (about \$1.5 million for the 2-megabyte core, \$1.5 million for the central processing unit) exceeds the budgets even of

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/52/. There is a fourth component -- planning. This could be part of required "software" for a system but, although software, as it should be conceived, takes account of the objectives of the system and, thus, the environment, its examination of factors in the environment is relatively superficial. Planning is, or should be, antecedent to any systems work. Its purview is, thus, different, and it appears important, therefore, to consider it separately. This is done in the next section on "Payoffs from Information Systems."

/53/. The other 91's to be delivered may, in fact, be 95's, with memory cycle times of 120 nanosec. compared with the 91's 780 nanosec. The Control Data Corp.'s "super," the 7600, with a central processing unit price of \$5 million, may be twice as fast as the 95. See "Goddard Starts Up the First Model 91" and "Look Ahead," Datamation, vol. 14, no. 3 (March 1968) p. 99, 101 and 17, respectively. The Goddard article gives other performance data for the 91 and compares it with other "supers."



Inner workings of the universe and problems of space exploration will be studied by the largest computer in user operation, the IBM System 360/Model 91, according to NASA. Recently installed at NASA's Goddard Space Flight Center in Greenbelt, Maryland, the Model 91 will explore theoretical astronomy, sub-atomic physics, global weather forecasting, and questions on the precise structure and environment of the earth. Now in full operation, the 91's test performance exceeded NASA specifications, according to IBM officials. With a maximum rate of 13.6 million additions a second, the new computer has up to 50 times the arithmetic capability of the IBM 7090. In addition to its speed, the 91 has a number of other features, including

a main memory which is subdivided into 16 storage elements from which the processor can fetch information in an overlapped mode. Each subdivision has a storage-protection "combination lock" using monolithic circuits to prevent accidental cancelling of data in memory. Estimates are that each day the computer will solve more than 1,000 problems involving about 200 billion calculations. From its inception, the Model 91 has been a limited IBM program. It was developed to advance the state of the computer art and serve a relatively small number of users. IBM is no longer accepting new orders, but has scheduled delivery of all systems now on order within 17 months.

Figure 10. "Super-Computer Serves NASA." Data Systems News, vol. 9, no. 3 (Feb. 1968) p. 3.

many who could use it. This insert, rather, is meant to emphasize to late adopters (see item 5, p. 3 above) that today's hardware is sophisticated and is becoming more so. The implications of hardware on software are discussed in the subsection below.

With the advent of third-generation computers and inexpensive mass storage devices in 1962-1963, the concept of computer-based information storage and retrieval passed from the hypothetical to the possible. Future hardware developments, such as larger internal memories, more parallelism of internal operations by the use of cheaper and simpler electronic components, and higher speeds suggest a reversal of recent trends toward general-purpose machines. Hardware, rather than software, may determine the appropriateness of a machine for business or scientific applications. A third class of machines, for information retrieval, can now be introduced /54/.

Lawrence Berul recently surveyed the peripheral equipment available for information retrieval applications /55/. These, associated with computers, facilitate man-machine interaction and the inexpensive production of a variety of information outputs. Terminals with cathode-ray-tube displays and keyboards enable input, editing, and searching at remote stations and on-line (i.e., in "conversation" with the computer). High-speed printers, equipment for photoreducing printouts, and devices converting magnetic tape records to microfilm are streamlining the production of announcement media /56/. Photocomposers (Photon, Mergenthaler's Linotron, RCA's Videocomp) yield printed products of graphic arts quality. Inexpensive (e.g., Xerox's Magnavox Telecopier renting for \$35/month) but slow speed (6 min. for an 8½ x 11-in. page) facsimile equipment can deliver graphic material to remote locations over standard voice-grade telephone lines /57/. Roll and unit-record microfilm are low-cost means of providing back-up files containing full texts of documents. Thus, subsystems for input, output, and remote access, shown in Figures 11 and 12, are state-of-the-art. /58/.

Berul's five-year projections include:

- computer stores of up to 20 million bytes at 2-10 cents/bit
- segmentable mass random-access memories
- extensive software tailored to information storage and retrieval
- \$1000 - \$2000 terminals (today's cost \$5000 - \$10,000)
- \$1000 - \$5000 automated microfilm retrieval systems (simplified access-by-address-only systems)
- greater use of unit-record microfilm (aperture cards, microfiche)
- somewhat wider use of "fax"

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/54/. Charles Fanwick. Trends in Computer Hardware. Santa Monica, Calif.: System Development Corp., March 1966. Rept. SP-2393; AD-632,477.

/55/. Lawrence H. Berul. "Survey of IS&R Equipment." Datamation, vol. 14, no. 3 (March 1968) 27-32.

/56/. National Cash Register's Photo-Chromic Micro-Image System (PCMI) reduces up to 3200 pages to a single 4 x 6-in. microfiche at a rate of 1000 pages per hour. Duplicate microfiche can be produced in quantity at 50¢ to \$1 per copy. Viewers rent for \$10 - \$15 per month; attachments can provide hard copy.

/57/. High-speed equipment, such as Xerox's Long Distance Xerography, that transmits up to 8 pages/min, requires monthly rentals of \$550 and \$650 for the scanner and printer, respectively, with surcharges of 2¢ and 3¢ per foot, respectively.

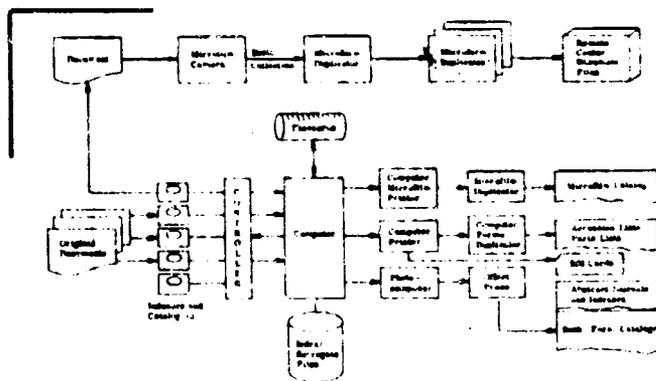


Figure 11. Computer-Based Input-Output System

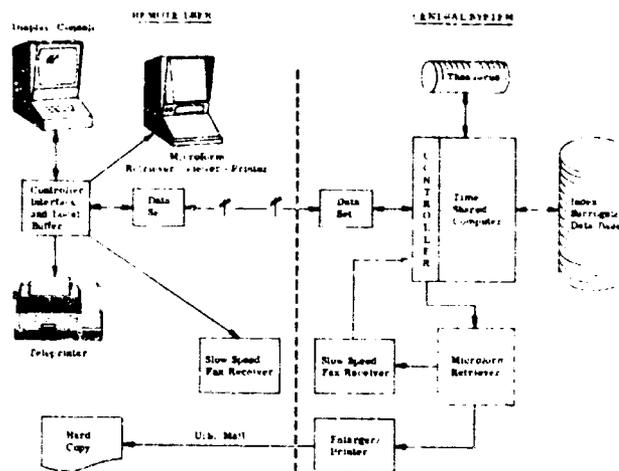


Figure 12. Computer-Based Remote User System

/58/. Four technical reports, that probably were behind the state-of-the-art by the time they were published, are cited here because of their comprehensive and critical analyses of computer and peripheral equipment performance and cost:

Warren O. Erickson. An Analytic Cost Comparison of Computer Operating Systems. Santa Monica, Calif.: System Development Corp., June 1967. AF Contract F19628-67-C-0004. Rept. TM-3525; AD-661,983.

Donald J. Pizzicara. Computers and Displays/Controls, State-of-the-Art Technology Studies. Woodland Hills, Calif.: Litton Systems, Inc., Feb. 1966. Contract Nonr-4951(00); Rept. 4902; AD-631,663.

George B. Bernstein, et al. Technical Data Handling Survey. Vol. I. Review of Projected Navy User Requirements and Current Vendor Capabilities. Washington, D.C.: Planning Research Corp., Aug. 1967. Contract N00500-67-C-0999. Rept. PRC R-1029; AD-661,789. (See particularly Section III and Appendix B)

Ronald A. Zuckerman. Optical Scanning for Data Collection, Conversion and Reduction. Los Angeles; Calif.: Los Angeles County Public Library, Aug. 1967. Sponsored by Council on Library Resources, Inc.

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Software must serve three masters: the user, the hardware, and itself. Software is the package of procedure- and computer programs that translate the user's requirements into formats acceptable to the machine. The degree to which this can be efficiently accomplished depends, in part, on characteristics of the software that has been used. Extensive and imaginative effort has been applied to creating software, both for effective management of the machine's components (operating systems) and for the convenience of the user (specific processors and "higher level" (user-oriented) programming languages). /59/ The programmer has designed assembly languages for himself and compilers that make particular languages "understandable" to various machines.

Though software becomes more important to system operation, performance, and cost with increasing hardware complexity, flexibility, and size, no methods exist for definitively evaluating a given software package. There are no standard measures of performance. Tools for evaluation are inadequate. Performance is difficult to predict, much less guarantee, before or during development /60/. In his description of the evaluation guide developed by The Rand Corp. to assess candidate systems, J. D. Tupac gives reasons for this situation /61/. Software evaluation usually weighs functional capabilities against performance, at a time when neither hardware nor software is available and job mixes are not determinable. Needs of users are not conveniently generalizable. Even viewpoints of software experts differ. Tupac illustra-

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/59/. Various estimates place the number of user-oriented languages that have been developed at 350 to 500. Eighteen languages are analyzed in:

Bertram Raphael. Survey of Computer Languages for Symbolic and Algebraic Manipulations. Menlo Park, Calif.: Stanford Research Institute, March 1967. Contract AF 49(638)-1752. Rept. AFOSR 67-0811; AD-649,401.

/60/. The development of standards and methods of evaluating software are among the major objectives of the National Bureau of Standards' Center for Computer Sciences and Technology under the directorship of Dr. Herbert R. J. Grosch. See Data Processing Management in the Federal Government. Hearings before a Subcommittee of the Committee on Government Operations, House of Representatives, 90th Congress, 1st Session, July 18-20, 1967, p. 69-106.

/61/. J. D. Tupac. An Approach to Software Evaluation. Santa Monica, Calif.: The Rand Corp., April 1967. Rept. P-3581; AD-651,812.

tes with the question: "What is a 'good' compiler?" Should the criterion be speed, efficient object code production, minimum storage, diagnostic and debugging features, powerful language features, or ease of use? Software, though significant, is only one element in system selection. Rand's guide, with about 125 items distributed within four main categories, each with sub-categories, includes the following:

- Hardware
- Software
  - Supervisor
  - Language processors
  - Data management
  - Other programming support
- Conversion considerations
- Manufacturer support

The weighting of each differs for different users and different environments. Rand weighted software slightly higher than 50%, the subcategories listed above in Rand's order of decreasing weight.

Software tailored for information retrieval is lagging because of difficulties designers face with language and other problems noted above (p. 28-29). When items can be identified, such as elements in bibliographic records and descriptor terms, programs can be developed for manipulating them. This kind of processing differs little from that of inventory control. All items are pre-selected and all relationships among items are pre-determined by the man in the system. Languages for pattern recognition, problem solving, and analyzing natural language that may give machines more sophisticated processing capabilities are presently research novelties /62/.

The new and coming hardware could influence software approaches to information retrieval. Cheaper, smaller, and faster circuitry in central processing units will introduce economic parallel processing. Extensive low-cost circuit redundancy may become feasible. Large, inexpensive memories and cheap, repetitive circuitry may permit the direct design of large associative

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/62/. See Current Research and Development in Scientific Documentation, No. 14. Washington, D.C.: National Science Foundation, 1966. Rept. NSF-66-17.

or content-addressed memories, thus alleviating the need for complex data arrangements and complex programming for rearrangement or search. Sophisticated query languages may be replaceable by simpler content-addressing schemes. The growth of internal storage capacities suggests the possibility of larger machine words and more common use of wired double-precision half words. Small input/output buffers with data handling and memory facilities could reduce the requirements on software for formatting and transfer. Operations can be centralized for large groups of users who share the same data base, though their information needs and programs differ. Alternatively, "personal"-size computers may be competitive with large central units for given programs in given languages. An ultimate goal is a single language or a small number of languages for specifying various storage and retrieval operations. Charles Fanwick, considering these portents, recommends that hardware and software designers abandon competitiveness in favor of collaboration, with systems analysts, for the realization of optimal allocations of hardware and software in future systems /63/.

\* \* \* \* \*

Too often, preoccupation with the complexities of hardware and software obscures the role of man in information systems. The intellectual operations he must continue to perform in the selection of input and the formulation of search strategies share priorities with hardware and software as subjects of research. Above all, the value of the products of a system to its human users measures the *raison d'être* of the system. This subsection considers activities directed toward aiding man at both the input and the output ends.

As noted above (p. 31, 32), language and classification problems are barriers to the representation of concepts for storage and subsequent retrieval. A variety of statistical methods are being explored for their applicability to the machine processing of natural language strings /64/.

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/63/. Charles Fanwick. Trends in Computer Hardware, op. cit. (ref. 54).

/64/. A fairly comprehensive review of these statistical techniques appears in Don Charles Stone. Word Statistics in the Generation of Semantic Tools for Information Systems. Philadelphia, Pa.: University of Pennsylvania, Dec. 1967. Contract AF 49(638)-1421. Moore School Rept. 68-23; AFOSR 68-0237; AD-664,915.

Results suggest that statistical procedures can accomplish much of the work involved in constructing a vocabulary and in generating relationships among terms in the vocabulary. Single word distribution measures may be able to provide estimates of the generality or specificity of terms. Statistical association measures may yield classification tables.

Whether terms are processed manually or mechanically, however, their usefulness depends on their interpretation to the man in the system. To examine people's difficulties in associating terms with concepts and in establishing relationships, Morris Rubinoff et. al. presented 513 substantive terms selected from programming textbooks and manuals to 78 graduate students and computer engineers. Each person was assigned twenty terms and was asked to designate synonymic and generic-specific relationships for each of the twenty with the rest of the vocabulary. The experiment permitted a comparison of the decisions of three individuals for each term. The responses showed a lack of consistency among individuals in recognizing synonymy, and misunderstanding or confusion about hierarchic-generic relationships. Directional biases were observed, i.e., a person, given a term A, recognized its synonymy with B but, given B, did not perceive its synonymy with A. Relating such terms as "column sort" and "radix sort" with the generic "sort" gave no confusion, but relating "grammar" with "language" did. /65/. Thus, the ability of machines to generate arrays of terms is paced by methods of achieving man-man communication.

How man formulates his information needs and proceeds to satisfy them has escaped the attention of most information retrieval specialists /66/. These questions are of concern, however, to industrial engineers,

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/65/. Morris Rubinoff, Winifred Franks, and Don C. Stone. Description of an Experiment Investigating Term Relationships as Interpreted by Humans. Philadelphia, Pa.: University of Pennsylvania, June 1967. Contract AF 49-(638)-1421.

/66/. Of over 1000 research projects current in 1966 in the field of information storage and retrieval, only 5-10% were directly behavior related. About 50% of the reports of these projects are characterized as "low grade" with respect to research methods or experimental design. See Melvin R. Marks. Behavior-Related Research in Information Storage and Retrieval. Rochester, N.Y.: University of Rochester, Nov. 1966. NSF Grant GN-398.

psychologists, and communications scientists. An analysis of the behavioral characteristics of man as an information seeker describes the search process as one that

must be learned,  
is stable over long periods,  
develops according to traditional stimulus-response learning theory,  
and that cognitive decisions are based on subjective expected utilities. 167/

For current awareness, by contrast, that occurs more frequently and is not aimed at finding a particular piece of information, activities are often discontinued when they don't readily reward. Man exhibits long delays in learning to use the information services available to him in his environment, depicted in Figure 13. Researchers Albert Rubenstein and Gustave Rath comment that "changing fields or organizations should lead to a much greater source of new experiences, but these new experiences require time before they change one's information-seeking behavior." People prefer short search sequences to long ones. They generally proceed from simpler (personal contact, telephone calls) to more complex techniques (use of libraries, written inquiries), though the first step varies with the information being sought (e.g., the use of libraries or letters to obtain specific documents). In an experiment that supplied X-ray crystallographers with services they reported directly applicable to their needs but had not previously heard about, 52% of the service packets were not opened; only 19% were used.

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167/. Albert H. Rubenstein and Gustave J. Rath. "Some Preliminary Experiments and a Model of Information-Seeking Style of Researchers." Proceedings, 20th National Conference on the Administration of Research, Miami, Fla., Oct. 1966. At p. 93-108.

This study is part of an extensive program at Northwestern University on research on the management of research and development. In its eighth year, this program includes projects on idea flow in R & D; strategies for the organization and diffusion of research in developing countries; and transition and interface problems between phases of research, development, and application. See Program of Research on the Management of Research and Development, Annual Report, 1965-1966. Evanston, Illinois: Northwestern U., Sept. 1966. Rept. AD-658,897.

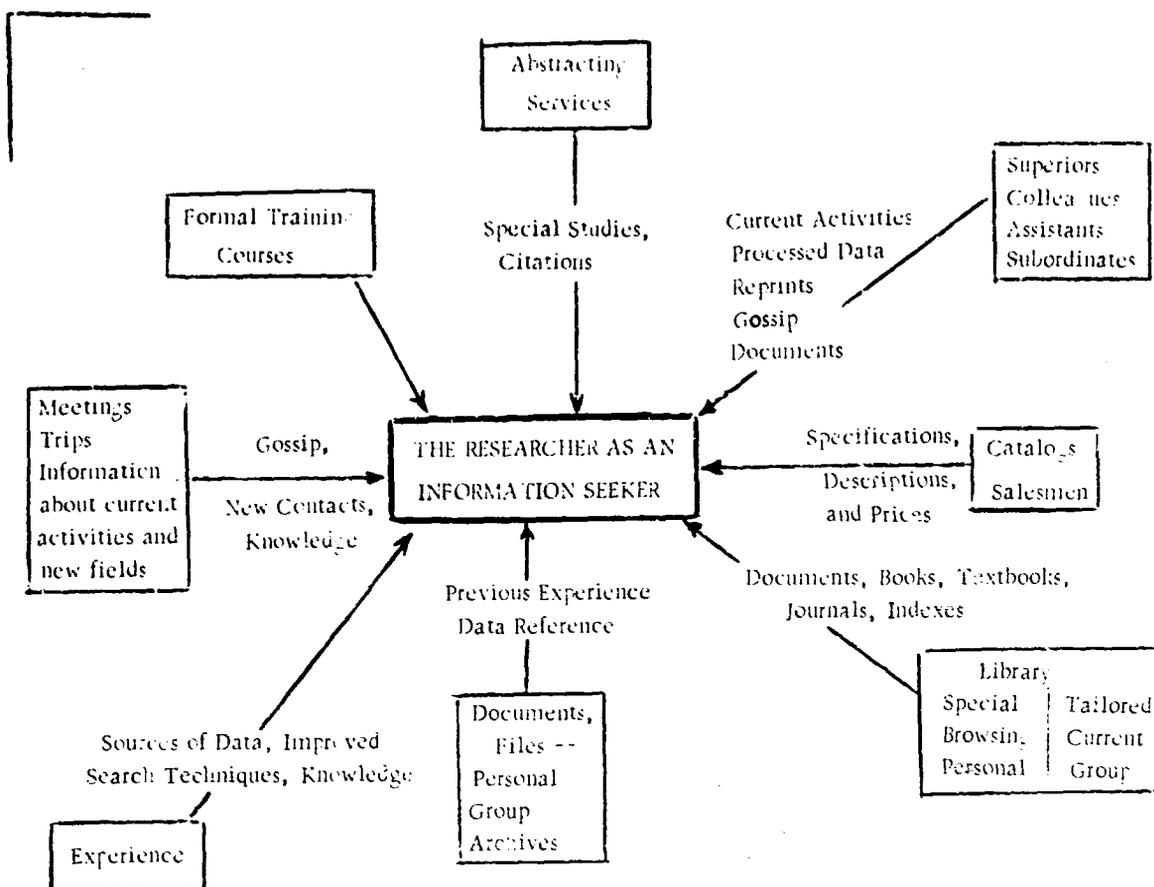


Figure 13. The Information Search Environment

Studies of reading habits confirm the Rubenstein-Rath findings. A poll of 2200 scientists and engineers (1765 responses) in two industrial organizations disclosed that 75% spent less than one hour per week on contract reports, 65% spent one to five hours weekly on technical magazines, 40% spent one to five hours weekly on professional journals, and less than 50% read review journals /68/.

In an empirical study of information flow that queried 2000 scientists and engineers in 13 establishments of 4 corporations and 1200 members of the Institute of Electrical and Electronics Engineers, Richard Rosenbloom and Francis Wolek report that 55% of information transfer occurs through inter-

/68/. J. M. Lufkin. "The Reading Habits of Engineers - A Preliminary Survey." *IEEE Transactions on Education*, vol. E-9, no. 4 (Dec. 1966) 179-182.

personal communication /69/. They show the following acquisition patterns for 1523 corporate respondents:

	Scientists	Engineers
N	633	890
Interpersonal comm'n, local source	18%	25%
Interpersonal comm'n, elsewhere in corp.	9%	26%
Interpersonal comm'n, external to corp.	16%	11%
Written, corporate documents	6%	12%
Trade publications	9%	11%
Professional documents	42%	15%

Differences among fields within science and engineering were small in comparison with the aggregate data, though life scientists and chemists showed greater use of the formal literature than physicists and mathematicians in data processing. Slightly fewer than half the acquisitions resulted from specific search; one-third were contributed by volunteers. In one-sixth of the instances, recognition of need occurred after the information was acquired, principally because it was pointed out by the volunteer (40% derived from "competence-oriented" activity such as browsing, reviewing new developments). Among individuals in the same corporation, those in research laboratories relied more on external interpersonal communication and on professional documents than those in operating divisions. Of special interest, respondents in an advanced development division of a data corporation had extensive interpersonal communication with members in other parts of the corporation, probably reflecting their mission. Rosenbloom and Wolek tentatively suggest a relation between an individual's productivity and his commitment to advancing his professional skills through education, professional memberships, and the reading of professional periodicals. They conclude that "informal media for information transfer should be recognized as valid and effective mechanisms" and that "the organization within which the technical

/69/. Richard S. Rosenbloom and Francis M. Wolek. Technology, Information, and Organization, Information Transfer in Industrial R & D. Boston, Mass.: Harvard University, June 1967. NSF Grant GH-305.

work is performed is, of itself, a principal mechanism for information storage and its transfer to operational purposes." /70/

These studies of human information processing behavior make evident some of the reasons why today's formal information systems can satisfy only part of man's information needs. Are additional mechanisms possible that can overcome communication barriers and instill both efficiency and effectiveness into naturally occurring information flow processes?

The experience of agricultural extension services and change agents furnishes much guidance for the promotion of information transfer. Additional to these, formal schemes for the transfer of technological information having been flourishing since the early 1900's. Specialized information centers that have appeared in the United States and elsewhere over the past fifteen years /71/ are but a recent type of service organization. Germany's Handwerkskammern or Artisan Trade Associations were founded in 1900, the Copenhagen Technological Institute in 1906, and the European Productivity Activity in 1953 /72/. Thus, the information transfer activities (visits to clients, identification of knowledge gaps, etc.) of Battelle's Transducer Information Center personnel (p. 18 above) are part of a tradition that already has a history. Beneficial refinements are presumably being sought through the continued establishment of other organizations. For example, a main purpose of the Office of Technology Utilization of the National Aeronautics and Space Administration and its regional dissemination centers is to "assess the most effective means for channeling new technologies into promising directions, including civilian industries" /73/. Another U. S. government program, that of the Office of State Technical Services in the Department of Commerce established in 1965, is to achieve "wider diffusion

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/70/. Ibid, p. 124, 127.

/71/. Some of these services are summarized in: Directory of Selected Specialized Information Services, Ad-Hoc Forum of Scientific and Technical Information Analysis Center Managers, Directors, and Professional Analysts, Battelle Memorial Institute, Columbus, Ohio, November 9-11, 1965. Oak Ridge, Tenn.: USAEC Division of Technical Information Extension, 1965. Rept. CONF-651131 (App.); TID-4500.

/72/. Joseph E. Stepanek. Small Industry Advisory Services, An International Study. Glencoe, Illinois: The Free Press, 1960.

and more effective application of science and technology in business, commerce, and industry." Its second annual report estimates that some services reached 35,000 firms and 100,000 individuals through about 1200 units organized during Fiscal Years 1966 and 1967 /74/. In the United States, technical service men from material and equipment suppliers have been information transfer agents par excellence. A 1956 Small Business Administration publication advises users as follows:

"Technical service men are sent out to provide all the information necessary for the customers to understand the manufacturer's new product, and to discuss with the customers their reactions and possible new developments using the new product. In many instances, the supplier will actually work out new developments for companies that do not have a sufficiently large or well-staffed research organization to do this work for themselves.

"Technical service of this kind is made available free of charge by the major suppliers, so that they can increase their sales. But generally, technical service involves a fair exchange -- the more information the small company can provide as to its requirements, the more willing and able the supplier will be to offer assistance. Then both will be able to benefit later from expanding markets. In the same way, the small company will find that by furnishing technical service to its customers in turn, so far as possible, sales will increase. In fact, it is at this level that technology will be of greatest immediate benefit to the small company. (emphasis by this author)

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/73/. Richard L. Leshner and George J. Howick. Assessing Technology Transfer. Washington, D.C.: National Aeronautics and Space Administration, 1966. Rept. NASA SP-5067.

/74/. Office of State Technical Services, Annual Report, Fiscal Year 1968. Washington, D.C.: U.S. Dept. of Commerce, 1968.

See also State Technical Services Newsletter published by the OSTIS. This informative bimonthly (the March - April 1968 issue is vol. 4, no. 3) announces new grants and describes the activities of on-going programs (including technology transfer experiences). It also contains abstracts of reference literature in the technology transfer field and abstracts of NASA Technology Survey reports.

"The basic thought behind technical service is that 8 out of 10 uses for a new product are developed by its users -- not by its producers. But new products are introduced into today's markets so frequently, and there is so much technical knowledge now available to industry that the consumers must rely on the specialists for aid. And this is readily available to the small business operator through technical service." /75/

The next section, "Payoffs From Information Systems," discusses profits that have been realized through organized information transfer services. These data substantiate the following observation that ends this section. Existing knowledge about requirements for information handling systems is not scarce. What appears to be lacking is the exploitation of this knowledge in new enterprises, and a willingness to cope with difficult, basic problems in new research undertakings.

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/75/. Technology and Your New Products. Washington, D.C.: Small Business Administration, 1956.

## PAYOFFS FROM INFORMATION SYSTEMS

The U.S. Navy defines "systems performance effectiveness" as "a measure of the extent to which a system can be expected to complete its assigned mission within an established time frame under stated environmental conditions" /76/. For quantitative measurement, an evaluation method is needed that specifies requirements, performance variables, and decision criteria. This author has found no quantitative methodology for information systems beyond procedures that assess the efficiency of operations in terms of staff, equipment, and facility costs compared with numerically determinable volume flows. In their survey of criteria for determining the effectiveness of library services as distinguished from the efficiency of library operations, C. J. Wessel and B. A. Cohrssen conclude that conceptualizations have not developed beyond vague notions of maximal response to service or product demands /77/. James Schlesinger of The Rand Corp. questions emphasis on models of cost effectiveness that divorce systems from such environmental realities as the quality of their data bases, their non-quantifiable and changing objectives, and socio-economic and political factors with which they interrelate. "Far too much attention ... has been wasted in this strange dialectical tilting ground." /78/.

Sales of a product on a free market are a measure of the product's worth to customers. This viewpoint has limitations because of buyer ignorance and trade-offs between the cost of search for a better, cheaper product and needed returns /79/. Nevertheless, the success of many commercial

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/76/. Navy Systems Performance Effectiveness Manual. Washington, D.C.: Headquarters, Naval Material Command, May 1967. Rept. NAVMAT P3941; AD-660,413.

/77/. C. J. Wessel and B. A. Cohrssen. Criteria for Evaluating the Effectiveness of Library Operations and Services. Phase I - Literature Search and State of the Art. Washington, D.C.: John I. Thompson & Co., Feb. 1967. Contract DA-28017-AMC-3483 (A); ARLIS Rept. 10; AD-649,468.

/78/. James R. Schlesinger. Systems Analysis and the Political Process. Santa Monica, Calif.: The Rand Corp., June 1967. Rept. P-3464; AD-657,313.

/79/. George A. Stigler. "The Economics of Information." Journal of Political Economy, vol. 69, no. 3 (June 1961) 213-225.

information service ventures (see ref. 40) attests to some customer satisfaction. Occasionally, savings can be directed related to the possession of items of information. For example, weather forecasts, tailored by services from Weather Bureau data to a particular client's operations, permit a comparison of gains vs. losses, given an item of information, with the cost of obtaining it /80/. Cost accounting, however, is difficult to apply to systems that enhance the diffusion of ideas. Historical dependencies were examined in a study that traced events in the discovery of the DNA (deoxyribonucleic acid) code through bibliographic citation data. Topological network diagrams show 65 "nodal" papers written by 89 investigators; only 11 of the papers did not cite earlier nodal work. A weighting assigned to each node determined by the number and type of citation connections to and from the node properly identified key papers /81/. The diagrams enable factual conjecture on effects of the absence of particular nodes on subsequent work. If an information system were desired to collect bibliographic data to emphasize significant nodal papers and thereby stimulate the exploitation of their results, what criteria should be established for the system? What are permissible bounds on performance variables? How should value be ascribed to discoveries like that of the genetic code? What variables can reliably predict discoveries from present networks that enable the computation of estimates for anticipated system effectiveness?

Despite the absence of direct cost/benefit data, systems enjoy government and private support based on an attitude to economic growth that emerged after World War II. This attitude postulates that progress can be guided and accelerated through deliberate action and planning. Traditional economic-growth models that emphasized capital accumulation have been su-

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/80/. Richard W. Nelson and Sidney G. Winter, Jr. A Case Study in the Economics of Information and Coordination, The Weather Forecasting System. Santa Monica, Calif.: The Rand Corp., Sept. 1963. Rept. P-2788; AD-417,335.

/81/. Eugene Garfield, Irving H. Sher, and Richard J. Torpie. The Use of Citation Data in Writing the History of Science. Philadelphia, Pa.: Institute for Scientific Information, Dec. 1964. Contract AF 49(638)-1256. Rept. AFOSR 65-1317; AD-466,578.

See also: David Allison. "The Growth of Ideas." International Science and Technology, no. 67 (July 1967) 24-32.

perseded by those showing that technical progress is responsible for up to 90% of increases in real product per person employed, and crediting education with 42% of the increase in real national income per person employed /82/. If innovations basic to economic growth do emanate from fundamental research, then information systems are an essential link between research and development activities. Indeed, one prestigious group of experts attributes the differential growth of technologically based enterprises in Boston and Philadelphia primarily to superiority of communication -- scientific and technical between entrepreneurs and universities, and financial between entrepreneurs and banks /83/.

In the late 1950's, C. F. Carter and B. R. Williams surveyed various British firms and found that technical progressiveness is related to financial success. They developed a checklist of characteristics for distinguishing firms. These items are:

1. Good information sources.
2. Readiness to seek information and knowledge of practice from external sources.
3. Willingness to share knowledge - technical, managerial, and commercial.
4. Willingness to acquire knowledge on license and to enter joint ventures.
5. Effective internal communication and co-ordination.
6. Deliberate surveying of potential ideas.

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/82/. Christopher Freeman, M. Raymond Poignant, and Ingvar Svennilson. Science, Economic Growth and Government Policy. Paris, France: Organisation for Economic Co-operation and Development, 1963.

/83/. Robert A. Charpie, et al. Technological Innovation: Its Environment and Management. Washington, D. C.: U.S. Department of Commerce, Jan. 1967. Rept. PB-174,103.

See also: Albert Shapero, Richard P. Howell, and James R. Tombaugh. The Structure and Dynamics of the Defense R & D Industry; The Los Angeles and Boston Complexes. Menlo Park, Calif.: Stanford Research Institute, Nov. 1965. DDR&E Contract SD-758. This report is one of the Institute's R&D Studies Series in its Technology Management Program. It examines the interrelationships among qualitative, quantitative, and structural data of the R&D industry, and industry response to Department of Defense and other national needs.

7. Consciousness of costs and profits in research and development departments (if any).
8. Routine procedure for costing projects for investment decisions.
9. Good management techniques (work study, methods study, budget control systems, production planning).
10. High status of science and technology in firm (when relevant).
11. Scientists and technologists on Board of Directors.
12. High quality in chief executive(s).
13. Able to attract talented people.
14. Sound policy of recruitment for management positions.
15. Willingness to arrange for effective training of managerial and technical staff.
16. Adequate provision for intermediate managers.
17. Good quality in intermediate management.
18. Ability to stimulate managers.
19. Effective selling policy.
20. Good technical service to customers.
21. Ingenuity in adapting to material and equipment shortages.
22. Readiness to look ahead; policy for anticipated developments.
23. High rate of expansion (rate of increase of assets).
24. Rapid replacement of machines. /84/

Their data gave little support to the following items:

25. Industry has strong scientific or technical background.
26. Adequate buildings or site.
27. Scientific or technical training of top management.
28. Resistance to innovation on shop floor.
29. Adequate financing.

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/84/. C. F. Carter and B. R. Williams. "The Characteristics of Technically Progressive Firms." Journal of Industrial Economics, vol. 7, no. 2 (March 1959) 87-104.

They found technically progressive firms among non-science-based industries. Old buildings did not preclude the use of modern methods. A significant number of high-quality executives were not scientists. Few firms encountered problems arising from the conservatism of foremen and operatives. Financial shortage was only an occasional problem. They conclude that "technical progressiveness is related to the general quality of the firm." "The use of science is not an optional extra to be attached to the firm, but an expression of the whole attitude of the firm." They observed that attention to general quality, reflected in the above characteristics, not only preceded technical change, but often was a necessary condition for making it.

The advisory services discussed in the preceding section have helped many groups broaden their technological base. The assistance, and the results, vary in type and magnitude. Payoffs include:

- Elimination of research duplication -- a search for information by the Danish Council on Scientific and Technical Research before starting research on workman's clothing saved \$14,000 appropriated for a study and brought a clothing manufacturing industry to Denmark. /85/
- A new industry -- research in a Burmese institute on a U.S. rice bran oil extraction process adapted it to the tropical climate and local solvent supplies for local manufacturers. /86/
- A higher level of industrialization -- technical assistance and accompanying capital loans totaling under \$1 million increased gross value of production by \$21 million in less than ten years under a rural industrialization program in Mysore, India. /87/
- A new product -- research by the Copenhagen Technological Institute for a small firm yielded a method of manufacturing adhesive cellulose tape. /88/
- A new industry -- development by the Copenhagen Institute's experimental station of a new method of extracting tannin from Danish trees was put into production. /89/

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/85/. Joseph E. Stepanek, op. cit. (ref. 72), p. 101.

/86/. Ibid., p. 105.

/87/. Ibid., p. 127.

/88/. International Labour Office, op. cit. (ref. 19), p. 98.

/89/. Ibid., p. 99.

- Better productivity -- recommendation by the Swedish Government Handicrafts Institute of a more efficient machine saved a paint manufacturer 7,000 crowns per year. /90/
- A new product -- Collaboration of the Swedish Institute with an inventor resulted in the realization of his invention at a cost of 10,000 crowns in lieu of an equipment purchase for 60,000 crowns. /91/

Payoffs, however, should be viewed with caution. They give advisory services useful feedback and justify sponsors' support, but they are only gross indicators of the information milieu that is needed to produce them. Specialists in the diffusion process, advisory services, and human information processing behavior agree that success in information transfer requires an environment rich in a variety of information sources. The following kinds of information facilities, operating collaboratively, appear necessary for an effective transfer environment:

- Information documentation facilities -- with active acquisition and dissemination programs.
- Research, development, and testing (RD&T) facilities -- for in-house and as-requested work, including the development of standards.
- Counseling facilities -- for technical, managerial, and financial advice and guidance.
- Training facilities -- primarily for the documentation and counseling facilities.
- An administrative facility or facilities -- primarily for focusing activities pertaining to coordination, quality control monitoring, and systems development.

It is the nature of information transfer work that payoffs to users and the economy are visible mainly through counseling activities. When counselors need specialists for the solution of particular problems, the results of RD&T contributions can be directly assessed. Sometimes payoff can be traced to information obtained through abstracting services, technical bulletins, and exhibits produced by documentation facilities, or trade

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/90/. Ibid, p. 61.

/91/. Ibid, p. 62.

fair and mass media announcements of counseling facilities. These latter occurrences are windfall profits. Information packages that are prepared for group audiences create awareness, stimulate thought but, except when they are detailed "how-to" texts, require follow-up by generalists from the counseling facilities or specialists from the RD&T facilities to promote implementation. Training facilities must be content to base their effectiveness on the performance of those whom they recruit and prepare for information roles. Administrative facilities, often the sine qua non for efficient operations, rarely share in payoff glory.

The author has found no proposal to examine the above facilities from a total system point of view, as components of an interactive information transfer network. Developments in some nations (e.g., Japan, the Netherlands, Denmark) and among some groups (e.g., Europe's productivity centers) reflect system planning. Several appeals have been voiced for an international structure. Taizo Ishizaka, chairman of the Federation of Japanese Economic Organizations, suggests an international exchange for technical information. This, combined with international movements of personnel, could "speedily translate scientific discoveries into improved living standards for the people of the world" /92/. Rapidity of achievement is questionable. Several Pugwash Conference working groups addressed the problem of an international system, Group 5 at the Thirteenth Conference in 1964 proposing a World Center for Scientific Information for "systematic, co-ordinated and, as far as possible, integrated effort." Why, Bentley Glass inquires, has this proposal lagged? /93/

The experience of advisory services provides many answers. The attainment of interactive, productive relationships with user groups is a gradual, up-hill process, mostly because of man-man communication problems and the lack of adequately trained personnel, rather than financial or other insufficiencies. Communication difficulties that impede the development of information storage and retrieval structures were discussed in the

/92/. Joseph E. Stepanek, op. cit. (ref. 72), p. 108.

/93/. Bentley Glass. "Pugwash Interest in Communications." Science, vol. 159, no. 3821 (March 1968) 1328-1331.

preceding section. Other types of man-man problems also loom large. Counselors often must probe to discern and separate real from imagined users' needs. Both parties must adapt in the transfer process, the counselor to the user's constraints and the user to the counselor and to the counselor's resources. Human resistance must be overcome to accepting externally generated information, and new attitudes must be stimulated for the adoption of new procedures. Change agents capable of performing these varied tasks are in short supply. The European Productivity Activity estimates that one counselor cannot adequately serve, through direct contact (the most effective interaction), more than 75 firms annually. Statistics on practice in Europe in 1959-1960 disclosed a ratio closer to 1:5,000 /94/. Moreover, the planning and implementation of any particular facility are sufficiently demanding to preclude a facility's assumption of responsibilities beyond those relevant to immediate objectives /95/.

No systems approach should be expected to materially affect any facilities operations over a short range. If employed, however, particularly in regions where facilities are already close knit or are not far advanced, tangible payoffs in more effective use of personnel, financial, and material resources should begin to be realizable within three years /96/. A consensus among specialists on information transfer is the indivisibility of the information needs involved in transfer. Technical information, marketing information, financial information, and management information are all interrelated for the industrial exploitation of knowledge. If informa-

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/94/. Joseph E. Stepanek, op. cit. (ref. 72), p. 159.

/95/. An excellent guide for planners is: Eugene Staley and Richard Morse. Modern Small Industry for Developing Countries. New York: McGraw-Hill Book Co., 1965. Staley and Morse discuss both program planning in the large and realistic stepwise strategies for transfer facilities and users.

/96/. Three years is the author's guess based on reported experience of periods required for planning, training, and initial start-up. Three years is a short time, but newcomers can circumvent much faulty trial and error by availing themselves of a wealth of existing knowledge that many organizations offer to share.

One guide to sources of information is: Donald R. Liggett. Small Industry Development Organizations, A Worldwide Directory. Glencoe, Illinois: The Free Press, 1959. Grouped by country, various kinds of facilities and their publications and services are described.

tion handling and dissemination facilities assume this viewpoint, the whole of their efforts can be more than the sum of the parts.

## EPILOGUE

This paper has not explicitly related its contents to Israel and to the Information Processing Association of Israel for whom it was written. This is the purpose of this section.

Israel, this year, celebrates her Twentieth Anniversary. Israel's immigration policy is responsible for a "unique dualistic situation," an environment ranging from highly sophisticated levels of development to patterns prevalent in undeveloped societies /97/. Israel subscribes to the thesis that education and exploitation of scientific and technical knowledge are essential to her social and economic well-being. She has begun, under government and private sponsorship, to establish institutions to implement this thesis. Her experiments and achievements in education are well known /98/. The government, through the Ministry of Development, makes technical and economic studies to aid large- and small-scale industries. The Israel Institute of Productivity, founded in 1951, maintains an advisory service and conducts surveys and training programs for industry. Other organizations give management and financial assistance /99/. Private groups, such as Yeda in Rehovoth, have begun to link the research potential of Israel's scientists with industry /100/. Currently, a large-scale assessment of

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/97/. Mordechai Bar-On. Education Processes in the Israel Defence Forces. Tel Aviv, Israel: Israel Defence Forces, 1966.

/98/. Randolph L. Braham. Israel, A Modern Education System. Washington, D.C.: U.S. Dept. of Health, Education and Welfare, 1966. (Prepared under Contract OS-63-79 with The City College, New York, N.Y.) Rept. OE-14125.

/99/. Small Industry Development Organizations, op. cit. (ref. 96)

/100/. Scientific Activities 1966. Rehovoth, Israel: The Weizmann Institute of Science, 1966.

Israel's economic position is under way. In preparation for an Economic Conference held in Jerusalem during the first week in April, 1968, a number of informative reports were issued /101/. These, together with a recent review, for UNESCO, of Israel's science policy and research and industrial structure /102/, are valuable reference materials for planners and designers of information systems and services.

It is not the object of this paper to review Israel's information handling activities. These have been made evident. Contributions of scientists in areas of theory and critical analysis are reflected in the literature /103/. Israel's information resources (special libraries, information facilities) are being documented /104/. Since 1961, a Center of Scientific and Technological Information, an agency of Israel's National Council for Research and Development, has been investigating and developing information services for industry. Israel's small but maturing information processing

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/101/. See, for example:

Ka'et- Israel Communications Inc. Israel Investors' Manual. Jerusalem, Israel: Government of Israel Investment Authority, 1968.

Natural Resources and Power. Jerusalem, Israel: Ministry of Development, Feb. 1968.

Summary Data on Manufacturing Industries in Israel (Preliminary Survey). Jerusalem, Israel: Prime Minister's Office, Ministry of Commerce and Industry, Nov. 1967.

/102/. National Science Policy and Organization of Research in Israel. Jerusalem, Israel: Prime Minister's Office, National Council for Research and Development, Oct. 1967.

See also: Shlomo Gonen, ed. Scientific Research in Israel. Tel Aviv, Israel: Prime Minister's Office, National Council of Research and Development, 1968.

/103/. See, for example:

Asa Kasher. "Data Retrieval by Computer. A Critical Survey." In Manfred Kochen, ed. The Growth of Knowledge, Readings in Organization and Retrieval of Information. New York: John Wiley & Sons, Inc., 1967, p. 292-324.

Y. Bar-Hillel, A. Kasher, and E. Shamir. "Measures of Syntactic Complexity." In A. D. Booth, ed. Machine Translation. Amsterdam: North-Holland Publishing Co., 1967, p. 31-50.

/104/. L. Vilentchuk. Directory of Special Libraries in Israel (Excluding Humanities). Tel Aviv, Israel: Center of Scientific and Technological Information, 2d ed., 1964. Guides to Sources of Information Series, Directory No. 1.

community is represented in the International Federation of Information Processing and has begun to build a software industry for home and export markets /105/. Universities, government installations, and private firms are planning and augmenting computer sciences curricula and software training courses.

This paper has the object, rather, of complementing the foregoing activities. In recounting the experiences of others with respect to information systems and services, some of the characteristics of human information processing behavior, limitations inherent in present systems, and expectations for future systems, this paper is intended as a guide and reference aid. The author is convinced that effective information systems and information services can be achieved, and that they are necessary elements of modern industrial societies. Successful systems most assuredly presuppose adequate operating budgets. However, the import of this paper is that money alone cannot buy systems. Payoff is a function, first and foremost, of the quality of the people in the system. Willingness to learn; ingenuity in adapting knowledge and experience to environment; forethought in planning; skill in implementation -- these are the human requirements and the pacemakers. The field of information systems and services offers challenge and opportunity to people of large and small countries, alike, who are capable of applying their own resources to the exploitable commodity, information.

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/105/. Software Opportunities in Israel. Jerusalem, Israel: Prime Minister's Office, Feb. 1978.

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This document describes, in considerable detail, publications of the various agencies and their information facilities and services.

Annotated Bibliography on Systems Cost Analysis (P. A. DonVito). Santa Monica, Calif.: The Rand Corp., March 1967. Rept. RM-4848-1-PR; AD-810,910.

Bibliography of 1966 Publications of University Bureaus of Business and Economic Research. Vol. XI. Eugene, Oregon: University of Oregon, 1967.

This is a continuing bibliography, vol. I covering 1950-1956 publications. References are grouped by institution and by subject.

Bibliography on Automation and Technological Change and Studies of the Future (Annette Harrison). Santa Monica, Calif.: The Rand Corp., March 1967. Rept. P-3365-2, AD-650,074.

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In view of the growing need for and interest of computer sciences personnel in information systems, and activities in most advanced and developing countries in computer sciences curricula, the following reference is added:

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13. ABSTRACT 8-9 Apr 68 Jerusalem, Israel.  > This paper examines information systems from the viewpoint of implementations based on current knowledge and experience. It reviews studies that report on how information has been and can be communicated for its exploitation. It discusses various types of systems and schemes that have been developed to aid the information transfer process, including the specialized information center, large-scale documentation centers, selective-dissemination-of-information systems, commercial information services, and small-group communication channels. The role of machines in information processing is considered with respect to current and potential hardware and software. Limitations and constraints imposed on formal information-transfer mechanisms by man's information processing behavior are postulated as requiring human interfaces to effect optimal use of information. An information facilities network is suggested as a structure for providing necessary documentation, transmission, and use of information. The network includes facilities for acquisition and control; advisory and counseling services; training of documentalists and information specialists; research, development, and testing support; and administration and coordination. Information activities are related to payoff, particularly with respect to technologically developing societies and potential small-industry users.			

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