LBJ Panel Urged Curb on 'Oligopoly'

By Morton Mintz
Washington Post Staff Writer

A secret Johnson Administration task force has recommended radical new legislation to establish and preserve competition throughout the economy.

The task force report—released by the Justice Department yesterday without comment—recommended laws:

- To drastically restructure industries in which a few firms are dominant—autos, steel and computers being leading examples—by reducing the market share of an "oligopoly firm" to 12 per cent.

Currently, General Motors has about 54 per cent of the auto market, United States Steel about 25 per cent of the steel business, and IBM 70 to 80 per cent of the computer business.

- To make the conglomerate merger movement procompetitive by prohibiting a very large firm from acquiring any leading company in an industry in which the four leaders have 50 per cent of the market.

Generally, the task force—made up of a philosophic cross-section of 12 professors of law and economics and members of the antitrust bar—viewed the conglomerate movement with far less concern than entrenched concentration.

- To overhaul the Robinson-Patman Act to eliminate features "that unduly restrict the free play of economic forces." The Act was intended to abolish price discrimination that gives unwarranted advantages to large buyers and favors national over local sellers.

- To require holders of patents to license all qualified applicants if they believe any. Under existing law a patentholder is permitted to restrict his monopoly to one or two licensees.

In a letter to President Johnson that accompanied the report last July 5, task force chairman Phil C. Neal, dean of the University of Chicago Law School, touched on the patent recommendation with this comment:

"We have not dealt specially with the drug industry, an item mentioned int he letter of appointment of the Task Force, but we believe that the changes recommended by us in the patent field would have significant beneficial effects in that industry."

Numerous complaints about high prices for trade-named prescription drugs have focused on companies that have aborted possible price competition by licensing no other firms or only one or two.

- To repeal provisions of the Miller-Tydings and McGuire Acts, which allow resale price maintenance, that encourage "anti-competitive practices."

Other Recommendations

In additional recommendations, the task force proposed steps to "improve the quality and reliability" of data needed to formulate antitrust policy.

As to enforcement under existing laws, the group said that "more can be done about concentration than has been done under existing law. We recommend that the Attorney General be encouraged . . . to bring carefully selected" test cases.

The task force was one of 50 to 70 set up by President Johnson to get uninhibited advice—without regard to political feasibility—from the academic community and other experts outside the Federal bureaucracy. Even the existence of the units was secret.

Partly because of erroneous accounts of the true content of the report of the antitrust task force, its members favored release of the paper.

In an exclusive interview in last Sunday's Washington Post, Assistant Attorney General Richard W. McLaren, head of the Justice Department's Antitrust Division, made the surprise disclosure that release of the report was imminent.

Until yesterday, only a few members of the group had been identified. Two members—Robert H. Bork of Yale Law School and Richard E. Sherwood of the Los Angeles law firm of O'Melveny & Myers—dissented sharply from the legislative proposals concerning existing concentration, conglomerate mergers and patents.

Another member, economist Paul W. MacAvoy of the Massachusetts Institute of Technology, had a alternative to new legislation in the conglomerate area: creation of a presidential commission to study the issue.

The report's most controversial proposal is for a Concentrated Industries Act. Its target would be the persistant rigid pricing and other noncompetitive behavior that is beyond the reach of the antitrust laws because it results from an oligopolistic structure—one in which each of a small number of sellers has a large share of the market.

Draft Provision

A draft of the legislation—included in the report as an appendix—says that once an oligopoly has been found through investigation by the Justice Department and Federal Trade Commission, proceedings shall be begun under which a Special Antitrust Court can require divestitures by very large firms that do not undertake them voluntarily.

In urging new legislation on conglomerates, the task force said that as things stand, some potentially anti-competitive mergers escape attack, some mergers that will not harm competition are prohibited, and business has inadequate guidance.

The other members of the task force, appointed in December, 1967, were:

Law professors William F. Baxter of Stanford, Carl H. Fulda of the University of Texas, William K. Jones of Columbia and James A. Rahl of Northwestern; economists James W. McKie of Vanderbilt and Lee E. Preston of the University of California at Berkeley.

Also, Dennis G. Lyons of Arnold and Porter, Washington, and George D. Reycraft of Cadwalader, Wickersham and Taft, New York City, and Kane, Schulman and Schlei, Washington. The staff director was S. Paul Posner of the Kane, Schulman firm.

Italian Vintner Admits Wine Theft

ASCOLI PICENO, Italy, May 21 (UPI)—Winemaker Fabio Lanciotti confessed today he stole Exhibit "A" in one of Italy's biggest criminal cases, all 28,120 barrels of it.

He said he got into the locked cellars where allegedly adulturated wine was stored, siphoned it off through the ventilation holes in the barrels and sold it for $240,000. Then, he said, he panicked when he heard police were on his trail, tore up the money into little pieces and threw it all away.

The wine was the state's prime evidence against 270 persons, including Lanciotti, who have been on trial since last July accused of manufacturing adulterated wine containing everything from banana skins to ox blood.

Colombia Jetliner

HAVANA, May 21 (AP)—Colombian jetliner hijacked [to] Cuba yesterday was releas[ed] after only a few hours on t[he] Communist island and [re]turned to Colombia.

It was the 26th airliner [di]verted to Cuba this year.

TB: WH for Board

Text of IRS Software Memorandum

The New York regional office of the Internal Revenue Service has decided that software should be capitalized (see story on page 1). Below is the text of the memorandum issued by the New York office.

UNITED STATES GOVERNMENT
Memorandum
To: All Revenue Agents
Date: January 15, 1969
SUBJECT: Capitalization of "Software"

Request has been made of the national office whether or not "Software" should be capitalized. It may be some time before technical advice is received because taxpayers in every district will be affected and in some instances the tax effect of capitalizing would be very substantial.

Pending receipt of advice, examinations should not be delayed or set aside. Instead "Software" *should be capitalized* where significant, and the taxpayer advised that the "Software" issue will be suspensed, but that all other issues will be resolved to the extent possible.

"Hardware" is the machine – the computer and all its components. "Software" is the Program – developmental costs, etc.

THAT NIGHTMARE, SOFTWARE

What is Software?

Software is the name for the programming needed to make computers operate. The [New York] District is taking the stand that Software, or programs that last longer than one year, are intangible assets that should be written off over their useful lives. (National Office technical advice has been requested but may be delayed. Pending receipt, examinations will be completed. Software will be capitalized and the issue suspensed per

(Continued on Page 21)

(Continued from Page 20)

my memorandum of January 15, 1969.)

Where can the cost of Software be found in the taxpayer's records?

If the taxpayer has purchased Software then the expenditure is recognizable in the taxpayer's records. If the programs have been developed by the taxpayer's own personnel and the costs have been identified, there is no problem. If, however, the costs have not been identified, they will be reflected in the payroll for:

1. Systems Analysts
2. Programmers
3. Coders
4. Key punch operators
5. Other data processing personnel

To these costs should be added a proportionate share of the taxpayer's overhead expenses. It should be noted, however, that systems analysts, programmers, and coders are also occupied maintaining programs. Maintenance of programs as distinguished from the development of new programs is expense and not capital. The key punch operators and other data processing personnel spend most of their time processing data and not in developing programs. A small proportion of their salaries would be involved in the cost of new programs.

If the cost of new programs cannot be determined directly from the taxpayer's records, then the statistical data shown below may be used to develop the costs indirectly.

What is the average life of a computer program?

This will have to be determined from the taxpayer's own experience bearing in mind that programs can outlast computer hardware since they can be compatible with the more advanced equipment.

What about an investment credit on Software?

Since Software is made up of intnagible [sic] assets, no investment credit is allowable.

Distribution of Computer Costs in the Absence of Detailed Cost Records

Hardware (Cost or Rental)	35%
Software	20%
Maintenance	15%
Operation	30%
Total Cost	100%

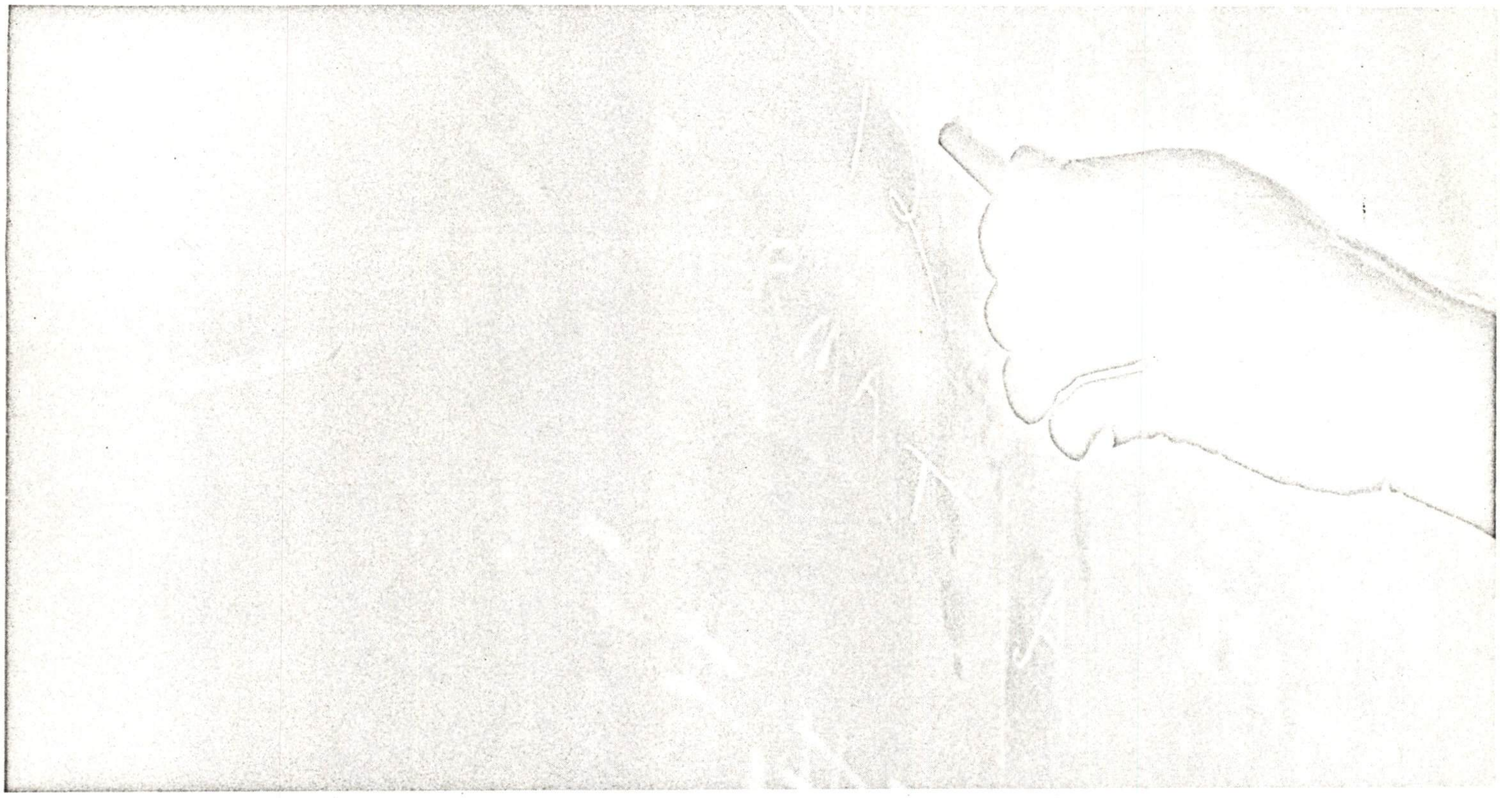
Staff costs in relation to Hardware average between 185 — 190%.

Example: (Based on 185%)	Hardware cost		$ 80,000
	Staff cost		148,000
	Software	20%	45,600
	Maintenance	15%	34,200
	Operation	30%	68,400

In any given situation the percentages may vary and are subject to determination by the agent and the taxpayer.

Distribution:
All Revenue Agents

SP-3315



COMPUTERS AND PRIVACY IN SOCIAL SCIENCE DATA ARCHIVES

Robert C. Brictson

17 March 1969

SP-3315

SP *a professional paper*

COMPUTERS AND PRIVACY
IN SOCIAL SCIENCE DATA ARCHIVES

BY

Robert C. Brictson

17 March 1969

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SDC

ABSTRACT

This paper is a revised version of the talk which introduced the Panel on Privacy at the Council for Social Science Data Archives (CSSDA) 1968 Annual Conference. A framework for inquiry into issues of computers and privacy is reviewed and categories of concern are suggested. Some criteria for evaluation of the use of archives, a brief inventory of protective measures, standards, and limitations of use are summarized. Finally, some concepts, examples, and programs that relate to Social Science Data Archives (SSDA) and manipulation of aggregate data are discussed.

Computers and Privacy in Social Science Data Archives*

Robert C. Brictson

Strong concern has been voiced about the necessity to protect the privacy of the individual citizen from the possibility of invasion by illegal, unethical, or inept users of information stored in various records systems. In the recent California primary election a candidate for U.S. Senator urged a Bill of Rights for the computer age. His four-point program to protect citizens included: 1) the right of every person to inspect his own records; 2) the right to know who else has inspected the records and for what purposes; 3) the right to challenge and correct inaccuracies; and 4) the right to control release of information by limiting access to responsible officials with a specific legal purpose.[1]

Further controversy has been expressed in national hearings conducted by Congressman Gallagher and Senator Long, in the courts, by private organizations (e.g. the American Civil Liberties Union), in universities, and in the popular press. Gallagher emphasized, "The invasion of privacy, on the scale a computer makes possible, would drastically change the structure of American society and quite possibly destroy the American democracy. We cannot do without the computer. We must learn to live with it, and we must learn to control its use and potential abuse."[2] Studies also are under way by Harvard's Program on Technology and Society, The American Academy of Arts and Sciences project on "The Social Implications of the Computer," the National Academy of Sciences's Computer Science and Engineering Board, and at various other universities such as Iowa State, Lehigh, and George Washington.[3]

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* Paper presented at 4th Annual Council of Social Science Data Archives (CSSDA) Convention, as part of the Panel on Privacy which the author chaired at the University of Pittsburgh, June 13, 1968.

1. L.A. Times, May 21, 1968. This is an outgrowth of a program recommended by John McCarthy in "Information," Scientific American, Vol. 215:3 (September 1966). An additional suggestion was that the government should not ask a person for information it already has.

2. EDP Weekly, May 27, 1968.

3. News Release, Cornelius E. Gallagher, M.C., "Gallagher Hails Increasing Concern Over Computer Privacy," March 6, 1969.

Because technology consistently outpaces man's ability to incorporate innovations into his society without some turmoil, citizens' apprehensions are stirred by new devices, techniques or philosophies that jeopardize societal stability. Although change is part of progress, its handmaiden is uncertainty, and doubts about relative merit are justified if not essential. By fully understanding the possible uses of the computer as a tool many of its hazards are controlled. Safety regulations appropriate for users may be established and categories where most effective use can be made may be defined and demarcated. On this panel we will discuss some of the implications for privacy of the use of archives in the study of public policy issues and perhaps suggest some ways in which both availability of information and privacy can be facilitated.

Panel discussion will follow review of a framework for inquiry developed in an earlier paper[4] which suggests categories of concern. Criteria for evaluation of the use of archives and a brief inventory of protective measures were presented before covering the benefits, standards, and limitations of use. Some concepts, examples, and programs that relate to Social Science Data Archives and manipulation of aggregate data will also be discussed.

Dr. Merton Kahne from the Department of Psychiatry at M.I.T. will consider the fallacy of misplaced emphasis where the stepping stones offered by a quantitatively easy task frequently lead investigators into paths of social irrelevance. Ignoring previous assumptions implicit in data may also lead to unwarranted conclusions. Dr. Kahne's previous concern with ethics in behavioral science research sets an appropriate background for his commentary.

Next, Dr. James Laue from the Community Relations Service of the Department of Justice[5] will describe some of his experiences and provide a governmental perspective conditioned by his sociological training and his extensive work in the field of civil disorder. Among the problems he has encountered is the use of social information collected from various communities which must be treated as sensitive because of its role in planning and implementation of social programs which might be jeopardized by premature disclosure. The issue of inter-and intra-agency cooperation in use of social data also is important in his work.

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4. Brictson, R.C., Computers and Privacy--Implications of a Management Tool, SDC document SP-2953/001/00, March 1968.

5. Now Lecturer in Sociology, Laboratory of Community Psychiatry, Harvard Medical School.

Finally, Dr. Albert Biderman, Senior Research Associate at the Bureau of Social Science Research, will discuss privacy in the purpose and organization of statistics. His creative work in the fields of social indicators, evaluation of national criminal statistics, including victimization rates, and freedom in research for the American Sociological Association contribute to his insights. His findings suggest the necessity for single organizations to collect widely varying data to cope with special requirements of different echelons, e.g. special needs of planners, workaday administrators, and operational field units.

The diverse fare offered by the speakers should provide provocative points for discussion and further profitable reflection. One working assumption for purposes of our discussion is that concern for privacy essentially refers to data that can be identified with specific persons rather than records which are aggregated beyond some minimal point where definition of specific identity is possible. Certainly this point varies with the type of statistics utilized.

Preliminary investigation at System Development Corporation regarding social implications of computers and privacy yielded a set of guidelines which structured the field with respect to concepts, context, and specific issues.[6]

The concepts covered include: 1) acquisition of information, 2) access, 3) dissemination, 4) retention, 5) revision (including updating, rejoinder, and redress), 6) destruction, and 7) time-cycles. General context developed includes: 1) historical developments which have led to current circumstances, 2) retrospective/prospective analysis (Considering current knowledge, how might society avoid problems associated with computers and privacy developments?), 3) implications for individuals, organizations and society, 4) technical and legal issues, 5) information systems--ethics and society, philosophy, morality and practice in relation to computers and privacy, and 6) futures--projected contingencies in information systems and possible future worlds for succeeding generations of men and computers.

Privacy associated with computer usage also relates to many specific areas: personnel and employment; manpower and human resources, commerce and industry, insurance, credit, consumer behavior and recreation, economy, law enforcement, law, legislation, private investigation, security, education and training, public health and medicine, social welfare, mass media, national government (including urban planning), taxation, elections and the electorate, civil liberties, economic and social indicators, and research.

A brief inventory of countermeasures to protect privacy of data includes: 1) access control such as passwords and authorization, 2) processing restrictions, including storage protection and tenure of access rights, 3) threat monitoring, including logs and audits, 4) privacy transformation, allowing only

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6. R. C. Brictson, *op. cit.*

approved transfer among data sets, 5) integrity management for hardware (by alarms), software (by retrospective analysis), and for personnel (through selection, recruitment and confidentiality agreements), and assigned data security officers for each user agency.[7]

Because our discussion topic is social data and social policy, the implications of this privacy framework are obvious. Examples proliferate in each of the areas mentioned. We must show concern for privacy in practice with data and make enlightened use of new computer tools if we are to optimize the benefits provided by a data-rich civilization,[8] avoid some of the possible hazards, and enjoy dividends for social policy planning, scholarly secondary analysis, and academic instruction.

From the standpoint of societal impact, the field of economic and social indicators provides a good example. Information on the basic institutions of society is included and implicit in all data archives. Nations and people display inordinate sensitivity to such data as revealed in a mounting collection of diplomatic white papers, periodical exposes, and legal suits. Educational accomplishments are expressed in transcripts. Law enforcement systems house data on crime, prosecution, criminals, and corrections. Other data repositories provide detail on occupations and earning power. Health and medical records include facts on length and type of patient care as well as hospital administration. Similar indicators assess the quality and extent of subsistence, nutrition, and shelter, as well as related logistics.

Use of the 25 archives suggested in the catalog of CSSDA for 1967 are only a beginning. Issues of availability, protection, expansion, and coupling of archives to provide useful links for research of higher societal value are other vital concerns.

Topics of acquisition, processing, maintenance, and required services also relate to the aforementioned inquiry framework. Such issues and topics must be considered when one recalls some of the broad problems that archives seek to solve: 1) refine data designed for specific use or particular analysis, 2) "clean" data according to varied sources, collection techniques, dissemination patterns, 3) organize for integration or combination of data by standard coding, 4) provide varied users' resources--hardware/software, 5) afford unique capabilities for collection/conversion of data, 6) incorporate data maintenance to assure completeness and current accuracy.[9]

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7. S. Gibben, File Security Procedures, unpublished manuscript submitted to California State Subcommittee on Privacy and Confidentiality, Intergovernmental Board on Electronic Data Processing, October 18, 1968.

8. H. D. Lasswell, "Policy Problems of a Data-Rich Civilization" in Proceedings of the 1965 Congress-FID-International Federation for Documentation, Vol. II, Washington: Spartan Books, 1965).

9. R. Bisco, "Social Science Data Archives: Progress and Prospects," Social Sciences Information, VI: 1 (February 1967) and Social Science Data Archives in the United States 1967.

A critical problem influencing access to data produced by the government is the imperative need to protect confidentiality of respondents.[10] Similar safeguards are required for dealing with privately produced data, especially when proprietary interests are involved. For example, updating of information is imperative if records are to continue to be of value. This depends on accurate data collected regularly--hopefully, with the cooperation of respondents who have confidence in the integrity and competence of investigators.

Both private and public organizations have understandable and legitimate interest in the activities and behavior of their members or citizens as reflected in their past, present, and future expectations and actions. In many ways the viability and the service of such organizations are dependent on such data. However, a delicate balance between autonomy of the individual and authority of the organization must be maintained--a balance that considers the functions and necessity of privacy, the need for and utility of information, as well as their interrelationship.[11]

Threats to privacy have been considered in an ever-increasing accumulation of documents with much space devoted to hardware protection and software safeguards. The strictures and admonitions of politicians, lawyers, government committees, and professional groups must be considered if proper access, effectiveness, and economy are to be expected in work with data archives. Perhaps these are best accomplished by precise definitions of study goals, accurate formulation of required data including statements of minimum levels of aggregation and adoption of standards formulated by organizations such as the Council, which in practice will demonstrate the value of the research and the circumspection of the investigators. These tenets are in accord with conclusions and recommendations of the Panel on Privacy and Behavioral Research of the President's Office of Science and Technology.[12]

Certainly norms regarding divulgence of information are in the process of change. Perhaps a movement from strategies of privacy to strategies of insight will occur; i.e., a change from emphasis on limitation of information and the maintenance of <u>status quo</u> to concern with larger social values of inquiry and full scale sharing of objective information.[13] But at present the controversy persists and the direction remains uncertain.[14]

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10. ibid., p. 70.

11. A. Simmel, "Privacy," <u>in</u> D. L. Sills (ed.), <u>International Encyclopedia of the Social Sciences</u>, Vol. 12, (New York: Free Press, 1968) pp. 480-487.

12. "Privacy and Behavioral Research," <u>Science</u>, (February 3, 1967), pp. 535-538.

13. Lasswell, <u>op. cit.</u>

14. H. Kalven, Jr., "The Problems of Privacy in the Year 2000," <u>Daedalus</u>, (Summer 1967), pp. 876-882.

From a sociological standpoint the studies of archival material appear to be facilitated because of the usefulness of aggregate data. In this case only file control would be necessary, but other behavioral science goals such as psychological studies require considerably more individual focus in data manipulation, where confidentiality must be safeguarded by proper coding and authorization of access (i.e., datum control/protection). For example, study of criminal justice systems is facilitated by such data management systems as the New York State Identification and Intelligence System (NYSIIS), where large data banks serve many agencies. In the New York system, over 3600 agencies are associated with law enforcement functions across a 6-fold spectrum including police, prosecution, courts, probation, parole, and correctional institutions. Use of aggregate data for secondary analysis and training would be possible without coding linked to individual identities. However, such assurances of confidentiality must be actively incorporated into data sets delivered for the use of archive researchers. Understandably, studies of recidivism can still be meaningful without identification of persons, but effective criteria for insulating material must be established. This is the job of professional committees on standards and ethics such as that of CSSDA.[15]

Similarly, studies of urban violence can acquire data related to early warning, community reaction, perceived needs, and degree of involvement with current issues reflecting mounting or subsiding dissatisfaction.[16] The use of aggregated indexes of satisfaction can give insight into potential for disorder and possibly assist in the timing and extent of positive preventive programs designed to ameliorate conditions and reduce dissatisfaction. Of more immediate use are social indicators acquired from urban observatories and used for operational/tactical programs designed to cope with existing emergencies. A final example of aggregate data use is the analysis of stratified groups within societies in longitudinal panel reactions to conditions. Surveys at periodic intervals might explore the opinions of elite groups including political leaders, government officials, intellectual-academic groups, and different classes or occupational strata to determine a composite societal reaction. If controls are established, such responses can be effectively coded to avoid individual identities without compromising information.

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15. American Association for Public Opinion Research, "Code of Professional Ethics and Practices," Public Opinion Quarterly, Vol. 24, (Fall 1960).

16. Jiri Nehnevajsa, Elements of a Theory of Internal War, SDC document SP-3055, February 1968.

Appropriate criteria have been recommended for evaluating archives.[17] A reasonable beginning might include: 1) substantial relevance, 2) methodological adequacy, 3) purposive concern regarding standards of privacy assuring circumspection by investigators, confidentiality of records, rights of revision and redress in open ended data files. Standards also must be established that apportion responsibility among investigators, institutions for whom they work, and sponsoring agencies.

Many technical improvements in hardware and software can be anticipated. Future plans for expansion of archives include more effective cross-indexing, incorporation of cross-cultural materials, simplification, new techniques for storage, machine readability of data, use of optical scanners, magnetic ink for inputs, time-sharing and the possibility of wide scale computer utilities. However, these concerns are more technical and would presume consensus on standards by archive members and authorized users.

Development of computer programs for analysis of aggregate data has also been impressive. Many of these programs, particularly in time-sharing modes, require identification for access and manipulation of data. File protection devices are incorporated and further improvements are expected. Three such programs at SDC are SPAN, IDEA and TRACE. SPAN has been used in association with the Bay Area Transportation Study Commission to deal with certain aspects of transportation study data management. SPAN includes standard file manipulation and data reduction capabilities, matrix operation, statistical processes, plotter display capabilities, and report generation. Originally designed to support the Penn-Jersey Transportation Study, SPAN was completed in support of the Bay Area Study.

The system operates on the IBM 7094 computer and includes a library of generalized programs for file processing, statistical analysis, and graphic display. These programs operate on data supplied to them and the specific elements of each operation are defined by parameters. The parameters are provided through an English-text job control language which includes the ability to specify data transformation algorithms and data stratification rules. A SPAN application consists of a sequence of job steps, each invoking a particular processing capability in an arbitrary order determined by the user. The data structures upon which SPAN operates are self-defining so that the required information about data format and coding is automatically communicated from module to module of the system.

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17. R. E. Mitchell, "Information Services," "Information Storage and Retrieval," in D. L. Sills (ed.), International Encyclopedia of the Social Sciences, Vol. 7, (New York: Free Press, 1968).

A time-shared routine for analysis classification and evaluation (TRACE) was developed at SDC in connection with bargaining and negotiation research. TRACE is a system of computer programs that operates interactively with a user under time-sharing. This system, which performs many of the functions normally assigned to a data clerk, is organized to handle a data base whose structure is tailored to the kinds of manipulations that are appropriate to experimentally derived information. It differs from typical data management systems in that the primary objective is to derive new variables from existing ones, rather than being concerned primarily with data retrieval. It differs from standard analysis programs in that the manipulation capability is primarily logical and algebraic, rather than statistical; i.e., the system constructs and maintains the data base and consequently does not impose rigid formatting requirements on the user. By thus giving the experimenter the ability to manipulate his data freely without specific programs, and by permitting him to defer a decision about the next manipulation until he has seen the results of the preceding one, TRACE can serve as an inductive aid in discovering underlying regularity and relations that otherwise would be difficult to uncover.

Another powerful tool which has been developed at SDC is the IDEA (Inductive Data Exploration and Analysis) Program. IDEA helps the investigator to overcome the limitations and restrictions of pure machine induction by allowing him to collaborate with a programmed library of heuristics in the process of uncovering and representing the structure in his data. It provides a process for deriving decision trees and has been used tentatively to analyze data on a wide array of situations, including civil disorders and characteristics of underdeveloped areas.

However, concern for technical developments is not of primary interest here, so further examples are unnecessary. Nevertheless, some knowledge of how generic standards apply to specific cases is useful. Several desiderata for standards emerge to allay apprehensions over archive use: 1) specification of benefits, 2) definition of potential risks, 3) expression of preventive safeguards and controls, 4) delineation of countermeasures, and 5) index of penalties and sanctions. Both in the anticipated development of a federal data center and in the use of existing segmented archives, standards are necessary to assure advantage without the possibility of detrimental effects because of compromise of confidentiality of respondents.[18]

Three possible operational applications exist for any potential user. First, an inventory of protective methods with associated costs and limitations should be explicated. Secondly, effective design of new systems should plan for

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18. Bisco, *op. cit.*

built-in protection. Finally, for existing systems, experts should be sought who are capable of retrofitting systems without adequate protection and troubleshooting those that malfunction. Since absolute protection is unlikely because of the many complexities involved, a pragmatic conclusion is that the cost of penetration or securing information should exceed the value of information acquisition. Finally, perhaps through the Council itself or through EDUCOM--a consortium of universities interested in data processing techniques and use of computers--more wide scale availability of programs that adequately protect privacy will provide experience and increasing capability for the field of social science data archives.

Send to Home

7

letter from Edinburgh

The computer in Europe

Nations and firms struggle to catch up in the field that symbolizes the technology gap

More than any other single non-military item, the computer has become the symbol for Europe of the so-called technology gap separating it from the United States. Despite the expanding European computer industry, American computer technology and marketing are still major forces here, and the 4,000 delegates from 40 countries meeting for the third Congress of the International Federation of Information Processing were aware of the slim prospects of catching up.

Such one-sidedness was not always the case. During the decade or so following World War II, British development of computers also was substantial. The British Government sponsored the design and development of computers for scientific testing, measuring and making mathematical calculations. The technology was competitive. But when computers leaped into the commercial market in 1960, Britain, like the rest of Europe, was left behind.

In 1960 International Business Machines produced its "1400" second-generation series, which signaled the take-off of commercial computers in contrast to the smaller-scale scientific machines. Taking advantage of its broad research base, as well as of its already-existing network of U.S. subsidiaries in Europe, IBM (soon to be followed by other American firms) established a lead which it has never come close to relinquishing.

Currently, IBM is estimated to fill more than three-fourths of the world market in computers, and seven other American manufacturers have substantial shares in the remainder. The U.S. is the richest market, and seems a greater inspiration to corporate growth. More than 42,000 computer systems were in use in the U.S. by the end of 1966, compared to fewer than 8,000 in Western Europe and the United Kingdom combined.

This does not mean that the non-U.S. computer industry is sitting on its hands.

By far the widest area of discussion at the IFIP meeting was new computer applications—a particularly vital topic to the European industry as it seeks to enlarge its market. A special panel was convened to discuss the interaction among users, designers and manufacturers, a problem on a continent of small nations trying to spread technology back and forth across national borders.

The realization of the need for expanded computer development is not new. In 1964, Britain's newly-established Ministry of Technology selected computation as one of four areas for concentrated development. A National Computer Center at Manchester and three regional centers were set up, and mergers within the industry were not only tolerated, but actively encouraged.

When English Electric-Leo-Marconi joined Eliott Automation, the resulting billion-dollar concern was, and still is, the most formidable computer contender in Western Europe.

From here, computer marketers are looking to the east. Czechoslovakia alone has already ordered more than $3.6 million worth of hardware. (Some observers, in fact, believe that Czechoslovakia may have gone so far as to shelve its own infant industry and accept instead dependence on British computers.) Britain has also made significant inroads into Poland and Bulgaria, with sales totalling some $16.8 million and expected to climb.

East Germany, on the other hand, has struck a more nationalistic pose. The country produces one of the more sophisticated computers in Eastern Europe, the Robotron 300. Yet the machine is considered relatively slow, especially for a second-generation design. East Germany seems content to ignore this, and plans to market the 300 not only at home but in the rest of Eastern Europe as well.

The true potential of computers, however, many at the meeting feel, will be realized by broadening their applications and by enhancing the art of programming. Development of software might also offer Europe the means of improving her position vis-a-vis the U.S. In France, for example, at least half a dozen software concerns are operating in the million-dollar bracket. More importantly, they are gathering vital experience in systems programming, in new kinds of compilers and in better usage of real time systems through development of such techniques as process control and message switching procedures.

Many European groups are concentrating on time-sharing, or multi-access systems, believing this to be the key to the next phase of computer development. The University of Edinburgh, for example, is working toward enabling computers to handle tasks for more than 200 remote terminals.

Political, technological and economic barriers will have to be overcome to give Europe the computer boost it needs. As the IFIP conference vividly demonstrates, efforts in this direction are becoming increasingly vigorous. The political problem remaining, however, is that each nation has pursued an independent determination of priorities, resulting in fragmentation of effort. To present a successful counterpoise to the U.S., Europe will have to cohere these fragments more effectively than it has. Without cooperation, the Continent may fall even farther behind.

The solution, Europeans feel, can't come too soon.

Pauline and Leonard Schwartz

40

6-24-69
Copy to Norm Doelling
Richard May
From Ken Olsen

Feasibility Study and Recommended Plan

for

Establishing an Institute for Information Systems in Higher Education

prepared for

National Science Foundation

Associated Universities, Inc.
Washington, D.C.

June 1969

PROJECT ISE

STUDY REPORT

INFORMATION SYSTEMS IN HIGHER EDUCATION

prepared for

THE NATIONAL SCIENCE FOUNDATION

by

Associated Universities, Inc.
Washington, D.C.

1 June 1969

NSF Grant GJ-58

NATIONAL ACADEMY OF SCIENCES

Computer Science and
Engineering Board

The full report is available in the CS&E office. If you wish a copy please let me know.

Karen

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PREFACE

For twenty years we have witnessed remarkable progress in understanding the nature of information and how it can be processed. The computer has been at the very center of this development. Those who became intimate with the computer -- in universities, in government, in industry -- achieved a new level of competence. The sheer bulk of information that could be handled and the complexity of the problems which could be solved influenced enormously the productivity and contributions of those having effective access to computer based information systems.

Nevertheless, today the computer still remains remote, physically and intellectually, from the daily lives of most people.

During the next twenty years computer based information systems will reach deeply into all aspects of society. It will be an era of sharply reduced costs, greatly improved ease of physical access, and much simpler communication modes between users and the computer. Since the computer is a machine for amplifying the power of man's intellect, its widespread availability will have particularly deep implications for higher education. Without question, computer based information systems fundamentally will change the content and processes of learning and research.

To date relatively few students in higher education have had exposure to the computer. Bringing similar advantages to a large percentage of all students -- undergraduates, graduates, and post-doctoral scholars -- is an immediate and difficult task. Much more difficult, however, will be the initiation of those steps necessary to achieve full potential of the computer in all aspects of the learning process. This undertaking will be one of great complexity since it involves an elaborate information system, including internal supervisory and user software as well as powerful computer hardware. The task is further complicated by the varied nature and ability of the user -- from the advanced worker in computer science to the freshman in economics, each working in an environment devoted to stimulate learning but in which little is known of how learning takes place.

Closely related to campus instruction and research is the administration of institutions of higher education. Here the problem centers on more effective use of campus resources -- on the best possible deployment of faculty, facilities and dollars to achieve economical, high quality education. The need for well designed and operated information systems to support decision making at all organizational levels on the campus is urgent.

A number of colleges and universities are doing work important to the needed developments suggested above. Such effort by individual institutions must be continued at increasing levels and with careful avoidance of needless duplication.

There exist, however, important problems requiring solutions which must be implemented, not on just one campus, but nationwide by many of the 2,300 institutions of higher learning. Dealing with many of these problems will require long-range and large-scale efforts. Project ISE has concerned itself with these more sizable issues.

This project, of one year's duration, has profited from consultation with many people in higher education and in the computer sciences community. The Advisory Committee, in particular, devoted many hours of spirited effort. Associated Universities, Inc. rendered valuable services as sponsor and host for the staff. The National Science Foundation, in cooperation with the U.S. Office of Education, provided the funding. Recognition must also be given to Charles Blair, the Associate Director of Project ISE, for his skilled and thoughtful contributions to all of the major issues addressed; to Lloyd Slater, Assistant to the President of AUI, whose great interest in the project and writing talents gave expression to much of the final report; to Mrs. Shirley Hamilton, who not only typed the final report manuscript, but contributed heavily to the coordination of project activities from the very beginning; and to Mrs. Lois Chew, who edited the final report.

Finally, I acknowledge gratefully the contributions made by the Chairman of the Advisory Committee, Dr. T. Keith Glennan, who was primarily responsible for the launching of this project and has served as a "prime mover" throughout. Both Dr. Glennan's and my own interest and concern for the problems addressed in this study have grown out of our shared experiences in higher education over much of the past twelve years -- he as President and I as Provost of Case Institute of Technology.

While much of the credit for what may prove of value belongs to others, I must, as Director of the project, assume full responsibility for errors, for omissions, and for treading in certain problem areas where the footing is soft and the direction to move is unclear.

John A. Hrones

John A. Hrones
Director, Project ISE

Provost for Science and Technology
Case Western Reserve University

Washington, D. C.
4 April 1969

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PART 2 -- WORKING PAPERS

SUMMARY STATEMENT

This report is of a study of national needs for computer based information systems in higher education and offers specific recommendations for a program of actions to meet these needs. The study was limited to those large-scale and long-range problem areas which might best be solved through more central and cooperative effort between institutions.

The report is developed into two major parts:

PART 1 ... is a relatively terse description of the complete study; how it was made, what its findings are, and the actions that are recommended.

PART 2 ... deals more extensively with five major problem areas in the application of computers in higher education -- in administration, resource sharing, instruction, research and the library. It is presented in the form of "working papers" which were developed, shaped, and reshaped in the course of the study. Many of the findings and recommendations presented in PART 1 are more exhaustively treated in PART 2.

Findings of the Study

The study determined that two areas -- administration and resource sharing -- are in critical need of immediate and major research and development effort which should be national in character. Other important areas -- in instruction, the library, and in research in computer science -- also were found to require important effort, but the actions necessary are clearly less well defined than those for administration and resource sharing.

Recommendations

The recommendation for immediate action is:

> Establishing a non-profit Institute for Information Systems in Higher Education to undertake immediately programs in administrative systems and in resource sharing among many institutions.

Recommendations for further study:

- Inaugurating a feasibility study for design and implementation of a regional unified library automation system.

- Organizing an inter-institutional facility for study of large-scale and long-range research projects in the information and computing sciences in the near future.

- Undertaking a large-scale effort to establish economical use of the computer in instruction; to be organized and launched within the next decade.

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NEEDS FOR A NATIONAL POLICY

Among shortcomings to be faced are projects that burden the National Science Foundation, rising costs of graduate science education, lack of coördination in attacks on social problems, and the poor flow of information from scientists to Congress.

EMILIO Q. DADDARIO

THIRTY YEARS AGO research in physics in the United States was a remote concern of government. Graduate students in this then pure science were the original do-it-yourself leaders and had to become as adept at begging and borrowing as they were in making equipment. Then came the discovery of fission, the second world war and the nuclear chain reaction. You well know the rest of the story. Congress was so impressed with the enormous new power derived from the science of physics that it enacted one of the most extraordinary laws in our history—the Atomic Energy Act of 1946.

Trends in funding

The decades following the war saw Congress loosen the drawstrings of the public purse to pour out unstinting financial support for research and development. So generous was this support that the annual increase in the level of funding averaged 15% during the Eisenhower years and 16.5% during the Kennedy years. It slowed to 3–4% during President Johnson's administration. However, keep in mind that 3–4% of this enlarged science budget still represented a substantial number of dollars each year.

For many years scientists have assumed that the federal support for science would continue its exponential growth. Only four years ago Harvey Brooks, in responding to questions posed to the Committee on Science and Astronautics,[1] observed that university requirements rise at a minimal rate of 13–15% a year. The economist Carl Kaysen likewise called for continued growth of federal funds for research. We heard similar testimony in hearings that preceded rewriting the National Science Foundation Act.

How large has this funding become? The latest NSF report on federal funding for science-related activities in universities and colleges estimates some $3.3 billion for 1967. Of this amount $2.3 billion was for academic science and $1.3 billion, or about 40% of the total, was for research and development as such.

I see signs that federal funding for university research is following the familiar S-shaped logistic or growth curve. Figure 1 illustrates the point with data on federal obligations for research in the physical and environmental sciences. Table 1 gives the details. I found it refreshing last year to see this recognized by the National Research Council's Committee on Support of Research in the Mathematical Sciences, which observed that growth of federal financial support can not go on forever. Speaking of its recommendation of increased support for research in mathematics, the committee said:

> An 18-percent-a-year increase means doubling every four years. A 10-percent annual increase means doubling in less than 10 years. Such doubling cannot continue indefinitely. Not only mathematical science, but all science and all technologies with growing research sectors must face the need for an ultimate tapering off. Neither the fraction of gross national product that can be devoted to research nor the number of people potentially capable of becoming research investigators can increase indefinitely.

Compounding the funding problem is the increasing cost of research that has approximately doubled in the past decade. This doubling is due to an annual cost-increase rate of about 7%, which includes the efforts of inflation at approximately 3% plus the higher costs from increasing complexity in research processes. The impact of this factor is all too apparent in figure 2.

This question of funding is one that my Subcommittee on Science, Research and Development has followed ever since it was established.

How does the situation for scientific research, for university research, look from Capitol Hill?

I see storm signals flying. The pressures of rising expectations affect scientists and engineers as well as ghetto dwellers. Our people's commitment to science is an act of faith that carries with it the dangers of disappointed expectations. Don Price recently wrote in *Science*[2]:

> I suspect that the current attacks on science come less from those

Emilio Q. Daddario (D-Conn) is a member of the House Committee on Science and Astronautics and chairman of its Subcommittee on Science, Research and Development. A major legislative review of the National Science Foundation and authorship of legislation passed and signed into law in 1968 to revise and bring this arm of government up to date have been his responsibilities. Daddario is a veteran of two wars, has been a representative since 1959, is married and has three sons.

who have always feared it than from those who were frustrated when they tried to put too much faith in it. To them, it was another God that failed.

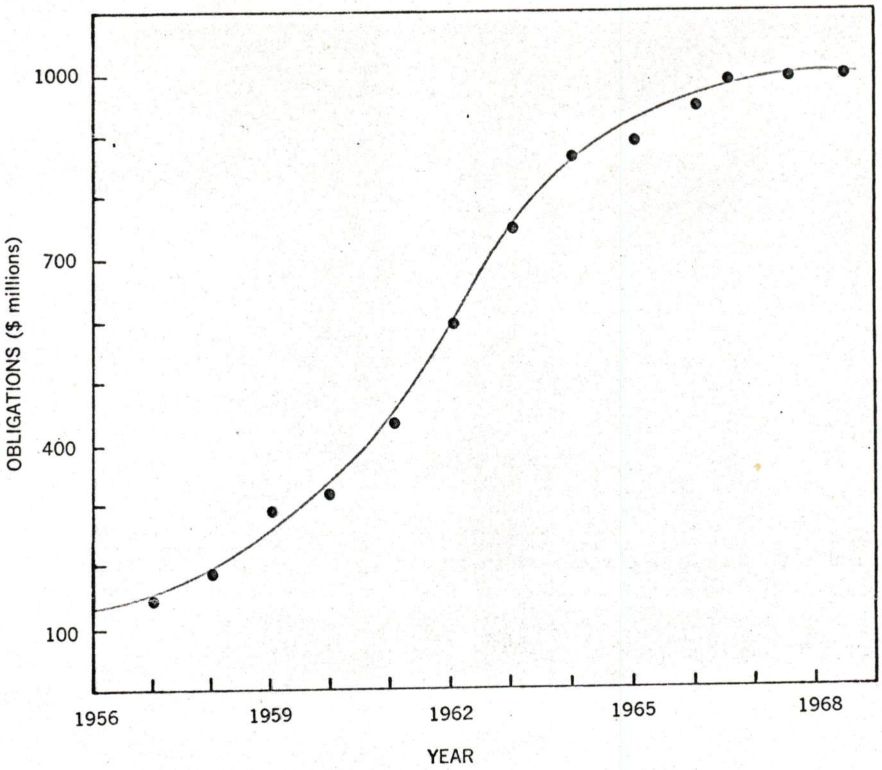
I conceive as one responsibility of my subcommittee the effort to keep expectations in balance with the potentialities of science.

Four policy issues

Now I will discuss four matters of priority in shaping public policy for science. Each poses subordinate questions that merit the attention of our scientific organizations. Each raises questions of priorities for use of limited national resources.

The issues are:

- Are mission agencies abdicating their responsibility for academic research?
- How shall the nation sustain its institutions of higher education in science and technology?
- How should multidisciplinary research on the problems of society be fostered?
- How can Congress obtain an improved input of information and ideas from the scientific community?



FEDERAL OBLIGATIONS for university research in the physical and environmental sciences. These data for 1956–68 follow the S-shaped growth curve. —**FIG. 1**

Are mission agencies abdicating their responsibility for academic science?

After the second world war many federal agencies began to substantially support scientific research in colleges and universities. Many a scientist owes a long-standing debt of gratitude to the Office of Naval Research for its support of academic research after the wartime Office of Scientific Research and Development was terminated and during the legislative effort that finally led to the formation of NSF in 1950. During the four years it took to establish NSF, other mission agencies also moved into the vacuum. The Atomic Energy Commission, the Air Force and the Army, all began to put money into research on campus. Later the Advanced Research Projects Agency and the National Aeronautics and Space Administration did likewise. So it happened that a de facto science policy came about through which individual mission-oriented agencies assumed a responsibility to replenish the pool of scientific knowledge and understanding upon which they drew in implementing their missions. The consequent pluralism in federal support for academic research in the sciences has become one of the strengths of our nation's science, and many attribute to it our leadership in many fields of science.

ONR money paid for the research of the Fermi Institute in nuclear physics at the University of Chicago after the second world war. ONR support made the Nevis Laboratory of Columbia University a leader in meson physics. ONR money established the nuclear-physics group at Notre Dame as a national center of excellence. More recently, ARPA funds paid for construction and operation of the radio-astronomy installation at Arecibo and installed the finest world-wide network of seismographs ever known.

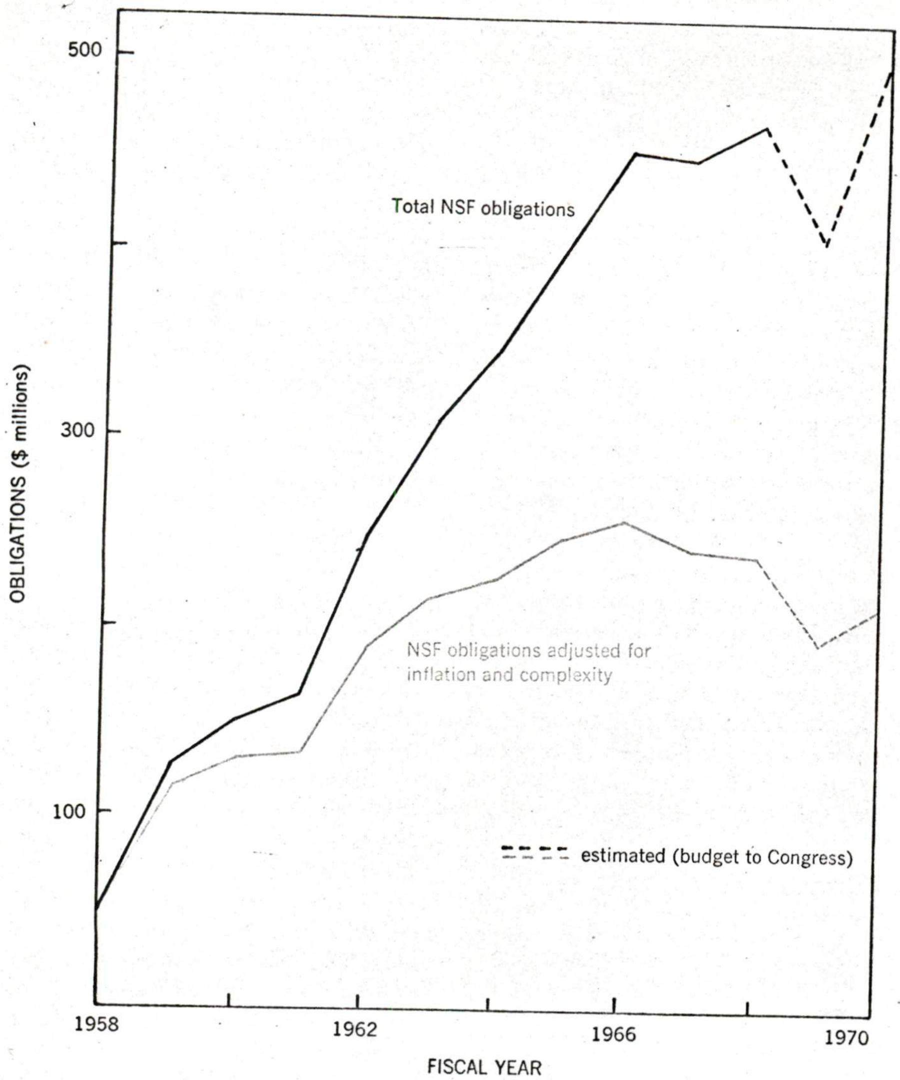
The pluralistic system that supported such excellence worked well as long as there were regular increases in federal funding for research and de-

Table 1. Federal Obligations for Basic Research in Physical and Environmental Sciences, 1956–1969*

Year	*Obligations* (*$ millions*)	*Year*	*Obligations* (*$ millions*)
1956	120	1963	767
1957	147	1964	874
1958	192	1965	902
1959	291	1966	962
1960	319	1967	1034
1961	443	1968	1087
1962	604	1969	1116†

*Before 1967 no distinction was made between obligations for physical-science research and that for environmental sciences. Thus one should add to the figures for 1967 and afterward those for environmental sciences to make them comparable to the preceding data. The source is *Federal Funds for Research, Development, and Other Scientific Activities, Fiscal Years 1967, 1968, and 1969*, National Science Foundation report 68-27, vol. 17, table C-92, p. 225.

† This 1969 figure is still an estimate.



INFLATION AND INCREASING COMPLEXITY. Total NSF obligations (black) are compared with the same data adjusted for increasing costs during 1958–70. —FIG. 2

velopment. This enabled the mission agencies to extend their interests to new fields of academic research, sometimes not immediately related to agency interests, and to support continuing projects as well. These were the days when we were treated to the sight of much of the nation's most fundamental work in high-energy physics riding on the coattails of an essentially military atomic-energy program. Parenthetically, I have read Craig Hosmer's remarks at the recent particle-accelerator conference, in which he proposed that the funding for AEC's high-energy physics be set off separately from AEC's authorization, thus cutting off that coattail.

Now that funds for research and development are tighter and the growth rate is not much ahead of inflation, we are seeing signs of strain. And with this change has come what appears to me as a flight by some agencies from their long-standing de facto responsibility for academic research. Federal agencies now appear to be redirecting their support for basic research into fields that they apparently believe are more visibly related to their missions and thus are more easily defensible. Some appear to be retreating from support of basic research they once initiated with the lame excuse that this is now the function of NSF.

Dumping onto NSF

Think back to the examples I just mentioned. Each of these projects was dropped or so severely curtailed by the originating agency that NSF has felt impelled to pick them up. Every project so supported by NSF has preëmpted funds that otherwise could have gone to new investigators with new ideas, with new experiments to try. What we are seeing in my opinion, approaches a cynical dumping of well established, productive research groups onto NSF. One reason is that this is an easy alternative for the mission agencies that are now feeling budget pressures. Another is that this is easier than making the case for continued support to those members and committees of Congress who may have questioned such mission-agency support. I am very much concerned about this flight from responsibility by the mission agencies. And I am sure that their budget requests have not been reduced by the amounts shifted to NSF. Moreover, what assurance have we that projects of less quality, less productivity do not continue to receive mission-agency support while first-rate ones are cast adrift.

Recently Leland Haworth, then director of NSF, summed up for our committee his work with the foundation. He spoke of NSF as providing the basis for science upon which mission agencies should build, rather than acting to fill gaps between areas of research supported by mission agencies. And as this dedicated man spoke his hopes for NSF, I could not help thinking how different its situation might be today. What if the scientific community had been less adamant about the organization of NSF as first proposed in Congress? What if there had been compromise so that President Truman would not have felt compelled to veto the first NSF Act of 1947? Those three years until the act was passed in 1950 cost NSF and academic science dearly. In that interim the mission agencies moved in with big money, and NSF never caught up. Now some of these same agencies are looking towards NSF and saying, "Here, catch!" as they have second thoughts about the nature and extent of their responsibilities for academic research. In this time of financial constraint, NSF finds real obstacles in getting funds not for new research but to take care of orphans of the fiscal storms.

If ever there was a matter that requires national policy, this is it.

Now that we have dragged this unmentionable subject out into the open, let us look at it more closely.

Since 1965 NSF has chosen to pick up the support of 20 large research groups, mainly from the physical sciences, whose support was reduced or ended by mission agencies. The cost of this research for fiscal year 1970 is estimated at $11.8 million. Now this may not sound much to the big spenders, where a single project may spend that and more in a single year. But compare this with the total of $195 million requested for *all* NSF project support and with the $29 million for all physics project grants for fiscal 1970. For the current fiscal year alone NSF has picked up seven large projects whose costs come to $3.5 million. This includes $1.6 million for Arecibo as the Department of Defense blithely withdraws much of its support for radio astronomy. And did you know that DoD, which puts only 3% of its research and development into universities, estimated their university spending at $223 million for fiscal 1968? Compare that with NSF's total of $170.1 million for project grants for that same year! Table 2 gives the information since 1965.

What of fiscal 1970? Will the dumping go on? NSF anticipates it may pick up another 48 projects now supported by mission agencies in physics, chemistry, biology, engineering and social sciences. If it does, the additional cost will be $2.9 million. Every one of those dollars will be removed from the competition among new scientists with new ideas.

This dumping can not go on.

My subcommittee has no intention of permitting NSF to become a relief agency for now unwanted research. Mission agencies must recognize their responsibility for funding academic research that they have begun. If a group becomes unproductive, if its subject is mined out and exhausted, I would expect the mission agency to end its support. But if the group is productive, it should not be left on NSF's doorstep; it should not be abandoned by the delinquent agency with a plaintive note pleading that NSF take care of the agency's offspring.

NSF is not a relief agency

That this dumping may be acute in the physical sciences is suggested by Haworth's reply to a question during the hearings on the NSF authorization bill. I had asked about the withdrawal of agency support in various fields of science and the competition of the abandoned projects with others for NSF funds. Haworth said:

> It is not surprising that a large proportion of major particle-physics and nuclear-physics projects formerly supported by the Department of Defense agencies will survive this competitive evaluation . . . Being first on the scene and working with limited resources, the DoD agencies supported the very strongest groups . . . Subsequently, the continued support of these groups together with the superiority of their facilities insured that the scientific faculty remained strong. . .

His reply shows how DoD's withdrawal of funds for basic research in some fields of science puts the old pros in those fields into competition with the rookies. The outcome must be evident to all. There is no contest. Perhaps we will have to learn from horse racers how to handicap the well established, winning groups in the competition for funds so that the newcomers will not be lost in the dust.

There is a corollary to the idea I have just outlined. Pluralism in funding of academic research implies that some such support will continue to come from the defense agencies. In turn this means that the academic community may have to forego the intellectual luxury of condemning defense-supported research simply because it disagrees with certain of the nation's defense policies.

On this matter, I note that the President's science adviser, Lee DuBridge, has spoken twice, at the University of Chicago and in a letter to the *New York Times*, to make the point that DoD support of basic research of the sort that universities themselves think appropriate and educationally valuable should be continued.

Returning to our theme, it seems to me that one matter of immediate priority is to reëstablish agency responsibility for support of academic research and thus to sustain our pluralis-

Table 2. Projects Taken Over from Other Agencies by NSF since 1965*

Institution	*Former support agency*	*Year taken over*	*NSF expenditure fiscal 1969 ($ thousands)*
ATOMIC AND MOLECULAR PHYSICS			
Stanford	NASA	1968	112
ELEMENTARY-PARTICLE PHYSICS			
Johns Hopkins	AFOSR	1967	269
Chicago	AFOSR	1969	110
California, Berkeley	ONR	1966	125
Syracuse	ONR	1969	170
Cornell	ONR	1965	2800
Stanford	ONR	1969	1630
Michigan	ONR	1969	305
Princeton	ONR	1969	130
NUCLEAR PHYSICS			
Chicago	ONR	1966	1560
Columbia	ONR	1966	1262
Cal Tech	ONR	1968	880
Notre Dame	ONR	1968	310
Illinois	ONR	1969	260
Indiana	ONR	1965	358
RADIO ASTRONOMY			
Illinois	ONR	1968	120
California, Berkeley	ONR	1968	180
Michigan	ONR	1968	120
RADIO ASTRONOMY AND IONOSPHERIC PHYSICS			
Arecibo Ionospheric Observatory	ARPA	1969	900
GEOPHYSICS			
Worldwide seismic network	ARPA	1968	283

* Source. *1970 National Science Foundation Authorization. Hearings before the House Committee on Science and Astronautics, Subcommittee on Science, Research, and Development, 91st Congress, first session*, 1969, vol. 1, pp. 524–5.

tic system. If we do not do so, the only alternative may be to create a single agency to oversee the funding of all basic research and to assure the proper implementation of national—not agency—priorities.

How shall the nation sustain its institutions of higher education in science and technology?

My second issue is the precarious financial position of many of our centers of excellence for education and research in science and the absence of coördinated federal policy and action to cope with the situation.

American science and engineering have achieved great strength, which we believe to be vital for the future of our country. Yet our institutions of graduate education, one major source of this strength, have had to make financial decisions and commitments without the guidance of an explicit national policy. Some even now are risking their financial health to give us time to shape and apply such a policy, and, I should add, we are not yet shaping and applying one.

This is a future-oriented issue. Responding to the new responsibility put upon it by Congress last year, the National Science Board has advised us that graduate education will soon be the fastest growing and most expensive part of the educational process. The number of graduate students is expected to double and reach 1.3 million by 1980. The cost of their education is expected to quadruple to an annual rate of $20 thousand million by then. At present some 200 000 graduate students are in science and engineering. This number is expected to exceed 400 000 by 1980.

These figures take on special pertinence when we look at the high unit cost of graduate education in the sciences. Philip Handler testified before my subcommittee last February[3] that the expenditures per graduate student in the natural sciences "very substantially exceed those for the graduate student in mathematics or the humanities, with the expenditures for social sciences somewhere in between." Northwestern University estimates that a graduate student in the physical sciences costs about $21 000 a year in comparison with $4000 a year in the humanities. Moreover, records show that a doctoral student in chemistry there can cost $40 000 a year. If we subtract those costs recouped from federal sources, we find that a university such as Northwestern may be putting in $11 000 a year for each graduate science student in comparison with about $3700 a year per graduate student in the humanities.

How long can a university afford so disproportionate an allocation of its resources among fields of graduate education?

Consider the predicament of US universities that are caught between their desire to respond to the American dream of education for each person to the limits of his intellectual ability on one hand and the spiraling costs of graduate education and research on the other. Some universities are dipping into their capital endowment funds, robbing their future to pay for the present. This year Duke is about $2.5 million in deficit. Within a few years an annual deficit of $10 million is projected at one major university in the Northeast, while a $2 million annual deficit is expected shortly at another major university in the near Midwest.

Real and urgent problems

Early in March I visited the West Coast with some other members of Congress to obtain firsthand information about effects on universities there of constraints on federal funds. I returned to Washington convinced there is a real and urgent problem. Part of it stems from the response by the universities to federal policies that called for establishing new centers of excellence. Just as these new centers began to take off, just as they were recruiting graduate students and faculty, there came the NSF cut, the cutback on the National Defense Education Act, NASA, AEC and National Institute of Health fellowships, and the belt tightening on mission research support. The final crunch came with the Expenditure Control Act of last year.

I saw visible evidence of real injury to our scientific enterprises on campus. People were being fired. Major equipment purchases were delayed or canceled. Institutions such as the Scripps Institution of Oceanography were tying up their oceanographic boats and firing the specially trained crews—which will be expensive and difficult to replace in the future.

How long can deficit financing by universities continue before they are inescapably caught in the downward spiral leading to reduced enrollments, reduced quality and even bankruptcy? What is the future for those universities that in good faith responded to the need for new centers of excellence, centers that we will need very much in the coming years, only to suddenly find to their sorrow that federal policy and federal funding were different things? How much longer can our universities wait for concerted national policy and action? Are we by default abandoning the American dream that each citizen be educated to the limits of his intellect rather than to the size of his purse?

Deficit spending by universities is not their only financial problem. Financial support for graduate education comes in part from academic research funded by mission agencies. But the narrow interpretations of their missions has led to incomplete coverage of graduate science education and science, both by discipline and among institutions. Although mission agencies have strengthened specific fields of science and technology, they have not correlated their support with long-range national needs for graduate scientists and engineers. I submit that it is poor policy to hope for an accidental confluence of mission-agency interests in academic research and education that will produce the kinds of manpower we will need. This is not to say I favor total state planning and control, which is just as bad at the other extreme. It is time to think much harder about the responsibilities of mission agencies in relation to our institutions of graduate education. My Subcommittee on Science, Research and Development has good reason to consider carefully the recommendation of the National Science Board that the federal government accept a continuing responsibility for a significant share of the total cost of graduate education and to assist in the implementation of a national policy to this end.

To deal with these issues in graduate science education Chairman George P. Miller of the House of Representatives Committee on Science and Astronautics and I introduced H. R. 35, a bill to provide institutional grants to our universities. This would authorize the appropriation of $400 million for fiscal 1970 to supplement other forms of financial support to universities and to provide stable, long-range funding for research and instruction in the sciences. I will not go into that bill in detail, but I hope many readers of PHYSICS TODAY will give it careful attention. You can write to my office for a copy of the bill and of the hearings on it. It is enough for now to say that H. R. 35, if enacted, will be an important step towards meeting the grave financial threat to the future of our universities and their ability to produce the educated men and women whom we will so urgently need in the years to come.

How should multidisciplinary research on the problems of society be fostered?

A third priority matter for national science policy has to do with multidisciplinary research on the problems of society. By this I mean research that combines the intellectual and informational resources of the life, physical and social sciences and engineering. Multidisciplinary research holds out the hope of better—note I do not say complete—understanding of the complex issues that perplex us today. We must further experiment with ways to marshal the interests and talents of our scientists and graduate students. At the moment, such multidisciplinary research is still a novelty. NSF estimates there are only about 40 such groups in existence or coming into existence at universities. The International Biological Program and the NSF weather-modification programs are good examples of an approach that is both multidisciplinary and multi-institutional. How well such groups can adapt to the highly individualistic traditions of university science remains to be seen. Whether the scientific community itself will accord multidisciplinary research full recognition is also an open item. These questions will remain moot, however, if we do not encourage such groups to show what they can do and to recognize there will be disappointments as well as successes.

I bring up multidisciplinary research for another reason. Multidisciplinary research offers to our young science faculty and their graduate students, who are intensely concerned about social problems of the day, an opportunity to connect, to tie their professional development to resolving problems of the real world. It can bring the rigorous criticism of science to bear upon the often emotionally loaded questions we face.

Given these reasons for multidisciplinary research, what is being done about it?

My answer has to be, "Precious little." Agencies with specific functions naturally concentrate upon the short-term, applied problems, often to the exclusion of longer-range anticipation of and preparation for the future. They have little authority, time, funds and inclination to develop a basis for understanding the ever changing complex questions of our day that demand solution. I would hope that federal policy could set out a responsibility for mission agencies to invest in some interdisciplinary research that may solve some problems.

Consider for a moment the International Biological Program. This international, interdisciplinary scientific venture seeks to obtain the baseline information so urgently needed to assess the effect of man's excesses upon his environment—upon the air *you* breathe, the water *you* drink and swim in, the foods *you* eat and the land that *you* would enjoy. With prodding and urging by Congress, the Executive is slowly responding. If this response is what we hope it will be, the program will be an outstanding example of large-scale multidisciplinary research that will include systems analysts, meteorologists, land-management scientists, geneticists, pathologists, nutritionists and professionals of many other disciplines.

We also have before us the proposal from NSF for a new program of multidisciplinary research with an initial budget of $10 million for fiscal 1970. It is interesting to me that NSF included this item upon the recommendation of its Engineering Advisory Committee. Part of this money would help existing, or forming, multidisciplinary groups to firm up their thinking and plan the kind of research they would propose. Part would fund multidisciplinary ventures that are ready to move off. Some examples mentioned by NSF include research into cultural and social consequences of changes in technology, structure of urban environment, and environmental quality of modern society.

We are interested in this proposal. One thought that occurs to us is that perhaps other institutions with a proven ability in multidisciplinary research should be permitted to share in this effort. For example, Oak Ridge National Laboratory already has included political and other social scientists in some of its research projects. We should be thinking about ways to bring that expertise residing in our federal laboratories to bear on this multidisciplinary approach to the problems of our society.

How can Congress obtain an improved input of information and ideas from the scientific community?

My fourth item for immediate priority in national science policy is the question of improved communications with the Congress by the scientific community. We do have some advisory groups now. Our experience, however, convinces me that much remains to be done to improve the content, timing and targeting of advice on scientific matters. Now let me be clear. I am not suggesting a science lobby. Rather I am calling for legitimate and needed inputs in their fields of expertise from the societies and individual scientists who make up our scientific community. In particular we need inputs that look beyond the needs of one particular specialty and compare the needs and opportunities of various fields of science. The Committee on Science and Public Policy (COSPUP) report to the Committee on Science and Astronautics by George B. Kistiakowsky's panel is a good beginning in addressing some of these thorny questions. This would help us in Congress to substitute reasoned advice for hunches and off-the-cuff responses.

I realize full well that we in this country would be the poorer were we to forget that science has become a prime means of enriching our lives through the generation of knowledge. Man has an inborn desire to know, a curiosity that propelled him up the chain of evolution. I think we need this intellectual stimulation just as much as we need food, shelter and health.

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REPORT

ON

THE APPLICATION OF COPYRIGHT ON COMPUTER USAGE

NATIONAL ACADEMY OF SCIENCES
WASHINGTON, D.C.

December 1, 1967

National Academy of Sciences Panel
on the
Application of Copyright on Computer Usage

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I. SUMMARY OF MAIN FINDINGS

It is the general opinion and finding of the panel that:

1. Computer information processing is of growing importance, and in a multitude of ways involves dealing with what is copyrightable material.

2. The copyright revision bill does not deal directly with many vital aspects of computer information processing. We feel that enacting it into law in its current form could lead to difficulties of interpretation.

3. We recommend further study of the copyright issue, and support in general the proposal to create a study commission on copyright law. We find that the Panel is divided on the advisability of enacting the present bill in its current form, pending the outcome of the Commission's study.

In the body of this report, a general discussion is presented which gives in more detail the background information upon which these findings are based. A final section deals with a number of specific problems which we foresee could result from the passage of this bill.

II. GENERAL DISCUSSION

1. Computers are a New and Growing Business

The importance of computers to the activities of the scientific and technical community, and the great size and astonishing growth rate of the computer industry make it essential to consider carefully any legislation which might affect the constructive contribution of computers to the progress of science and technology. There are now more than 28,000 computers in the United States, and the electronic data processing and computer industry is valued at $6 billion, and has a growth rate of 20% per year.*) Industry, governmental agencies, educational institutions, and other organizations in both the public and private sector use computers in a variety of ways. They can be used to improve many different kinds of operations by adding new capabilities and by performing routine tasks more efficiently. In the scientific area they can be used to perform calculations which are impossible to do by hand and to analyze large quantities of data with great speed and efficiency. We can confidently predict that the computing area will continue to grow in importance, not only to the scientific and technical community, but also to society at large. While its present importance is great, its importance in the future will be even greater. Impending legislation which may affect computers and their usage should be carefully considered to make sure that the effect will be to stimulate growth and encourage experimentation.

Before discussion other aspects of computers, we must establish what we mean by the term "computers". The term can be construed, and is frequently used, in the narrow sense of a central electronic processor. Such a

*"Thinking Big," Barron Report, October 2, 1967, p. 3 and following.

device, when operated in conjunction with ancillary equipment, is capable of receiving information, manipulating it, and putting out processed data. However, in this report, we shall use the term "computers" to mean:

> The complex of newly available technology by means of which information can be processed and communicated in a variety of ways with great speed, can be stored for future use, displayed in both ephemeral and permanent forms, and can be reproduced at nearby or remote locations.

It is very clear that in this broad sense the computer is having, and in the future will have, an even stronger impact on traditional means of disseminating information to the scientific and technical community, as well as other segments of our society.

The computer is a new development; before World War II capabilities of this type did not exist. Therefore, its effect on traditional means of information dissemination is only beginning to be felt. But as new applications are developed, it is safe to assume that its impact will be a permanent one and that some of our current methods of disseminating information will become obsolete.

2. <u>The Use of Computers Involves "Copyrightable" Materials</u>

Computers can make use of materials that are "copyrightable" in the traditional sense.

The first use of computers was to replace the desk calculator, and the programs that were used to generate the solution of the problems were not of a nature that had been traditionally copyrightable. The computer basically expressed solutions to problems in a form which could be interpreted as a translation into machine language of a method of solution that was either already known, or would be obvious to experts in the field.

Subsequently computers were used in a way more analogous to a special-purpose device; for example, in process control. Here the computer program residing in the machine may be a replacement for, or a simulation of, electrical circuits that could have been specially constructed. Some such programs may have the originality and inventive character that would make them analogous to new devices—devices which would normally be considered for patent protection. It may not be possible to make a general statement about which of these programs should—and which ones should not—be afforded such protection, just as it is not possible to make a general statement about which device should be patented.

A third utilization of computers is the manipulation of textural materials; for example, basic files of physical data of the type accumulated in handbooks, tables of mathematical functions similar to those occurring in handbooks of mathematical tables, teaching programs aimed at providing instruction at various levels, etc. Here the materials contained in and disseminated by the computer are quite similar to those contained in elementary textbooks. It is possible for computers to transform and edit material, such as music, or to derive concordances of literary materials. There are in existence computer programs which generate music, which write poetry, and which draw cartoons. Most of these programs are on a highly experimental basis at the present time, but it is not unlikely that practical and widespread uses will be made of such programs in the not too distant future. Those programs which instruct the computer to create the music or to draw the cartoons might be programs which would have been provided patent protection in the traditional sense; and the result of applying these programs is to produce music, poetry, or cartoons which are normally copyrighted.

In summary, therefore, it appears that computers may take in copyrightable materials as input for processing. They may generate material as their output which is copyrightable, and in some cases the programs that control the machine may be copyrightable, or entitled to some other kind of protection.

3. Computer Usage can be Expected to Grow Rapidly

The use of computers in all facets of contemporary life has grown at an explosive rate, and we can expect this growth to continue far into the future. This utilization of computers has been likened to the industrial revolution, and properly so. The computer is a new tool, a symbol-manipulating tool whose full capabilities are not yet known.

One of the factors that distinguish man from beast is his ability to abstract and to symbolize. Man has learned to represent many of his ideas in terms of symbols. Mathematics has given us the capability of deriving relationships between symbols and carrying out transformations on these symbols. The printing press was a means of recording and transmitting man's symbols. The computer provides a tool for manipulating or rearranging and transforming the symbols. The hand axe was perhaps man's first mechanical tool, and the invention of the lever in the form of a handle on the hand axe gave great manipulative power to this tool and led to subsequent inventions of more complex tools. One might compare the printing press with the hand axe, and the computer to the lever. Figuratively speaking, the computer has put a handle on our symbol manipulating capability.

Computers are now a powerful aid in solving engineering, physics and mathematical problems; and more powerful methods are being discovered every day which will lead to greater uses in solving scientific problems. The use of a computer as a simulator of other devices is growing. The equations which govern the control of a process can be programmed in a computer and the computer then becomes a process-control device. A computer is, of course, a superb handler of information, and can provide many of the facilities of a library. Utilization of machines for storage and retrieval, and for searching of data, will certainly increase manyfold. As we solve more and more of the problems of man-machine communication, the computer will become a powerful tool in teaching, scheduling, report writing, editing, and other simple clerical functions.

New uses for computers are being uncovered rapidly, and new methods are being developed that will permit exploitation of the computer in completely new areas. It is apparent that the future of computers and their usage cannot be predicted with any certainty—except for the positive statement that so far we have only explored a small fraction of the vast number of possibilities.

4. Computers are Used by All Sections of Society

Computer technology has found application in many phases of our life. Computers are used by many different organizations—large and small, private and public. They are used to solve mathematical problems of an abstract nature. They are used to solve engineering problems for very specific uses. They are used to analyze data, to accumulate and store information, to disseminate data and information, and as aids to teaching.

In these various forms, computers are of great value to governmental operations (both scientific and administrative); and in private business they are used to improve efficiency and overall productivity.

There is little doubt that the advent of the computer age has had enormous beneficial effects upon society. But even more important is the fact that these uses can be expected to multiply in the future. If we are to achieve the optimum use of computers, it is important that their growth be encouraged.

The computer is being applied to tasks of ever greater complexity and importance in our society—management information systems, scientific and technical information retrieval, governmental data banks, military command and control, etc. Unfortunately, the present knowledge about the problems in applying the computer to such applications is almost nonexistent. Extensive experimentation with the computer is, therefore, particularly important to ensure that the computer is indeed used to the best advantage of society. Such experimentation should be encouraged.

5. Computer Coverage under the Proposed Copyright Legislation

Under the proposed copyright revision bill, computer usage will basically be covered by general provisions restating conventional concepts of copyright law. The bill does not include provisions specifically written with the computer in mind.

We believe that this subject deserves the most careful consideration so that legislation can be enacted which will have a constructive effect on this most important matter.

6. The Proposed National Study Commission on Copyright

In our opinion, the copyright problems raised by the computer are so novel and complex that the technical and scientific communities would benefit from an intensive study by a governmental body specially designated for the purpose.

Accordingly, we support the idea of the recent proposal to establish a National Study Commission.

III. SPECIFIC PROBLEMS

Several potential problem areas were brought into focus during the discussions of our Panel. For illustrative purposes, several of these are described in more detail below in order to suggest the possible impact of the bill. Discussion is limited to the problems that are associated with computers and related technologies.

Because the subsequent legal interpretation of the proposed bill will depend not only on the language of the bill itself, but also on the spirit and intent of the legislation as expressed in the records of the committee hearings and reports, this report makes reference to the background reports. The main sources used in this study are:

S. 597	U.S. Congress. Senate. A bill for the general revision of the Copyright Law, title 17 of the United States Code, and for other purposes. S. 597, 90th Congress, 1st session. Jan. 23, 1967. Introduced by Sen. McClellan.
H.R. 2512	U.S. Congress. House of Representatives. A bill for the general revision of the Copyright Law, title 17 of the United States Code, and other purposes. Passed by House of Representatives April 11, 1967.
H. Rept. 2237	U.S. Congress. House. Committee on the Judiciary. Copyright Law Revision. 89th Congress, 2nd session. House Report No. 2237, Oct. 12, 1966. Submitted by Mr. Kastenmeier.
H. Rept. 83	U.S. Congress. House. Committee on the Judiciary. Copyright Law Revision. 90th Congress, 1st session. March 8, 1967. Submitted by Mr. Kastenmeier.

Copyright Law Revision Part 6	U.S. Congress. House. Committee on the Judiciary. Copyright Law Revision Part 6, Supplementary Report of the Register of Copyrights on the General Revision of the U.S. Copyright Law: 1965 Revision Bill; report to accompany HR. 4347 and S. 1006. 89th Congress, 1st session, May 1965.

These reports are cited in their brief form in the discussions that follow.

1. <u>The Question of According Copyright to Computer Programs</u>

The production of computer programs in this country currently is estimated to involve an expenditure of over a billion dollars per year. By 1970, an estimated one-half million people will be employed in programming activities. (Ref. Barron's article cited earlier). Many of the completed programs have been made freely available for others to use by such means as publication in technical journals, reports, and instructional manuals; by information distribution; and by distribution through organized clearinghouses of program information (e.g., SHARE) established by the many users of computer equipment. For many types of programs the authors (personal and corporate) are interested in making the programs available for all parties to study and use.

In contrast, there are many programs that are closely controlled as proprietary investments or trade secrets. One example would be an extremely efficient file sorting program written by a computer service bureau that would enable its customers to sort their files in half the time and cost required at another service bureau. There could definitely be lost revenue for the firm that wrote this program if a competitor could freely obtain and use the same program. Another example would be the program written by an oil company for the computer control of a petrochemical refinery at a considerable improvement in efficiency and cost over prior methods of control. This oil company would lose some competitive edge if the program were made available to a competing oil company.

Protection might also be sought for programs because they contained some key elements of information such as stock market or election prediction rules, or ingredients and control for the manufacture of proprietary products (e.g., soft drinks or camera film emulsions) or because they contained large amounts of useful reference information that might otherwise be used without compensation for the developer (e.g., Dun and Bradstreet statistical and financial data for 100,000 major U.S. companies).

There appears to be considerable disagreement, both within the industry and between the users, on the question of whether programs should be protected. One of the reasons for the disagreement is that there are so many facets of the use of the developments for computers that very few people can look at all aspects. There is also disagreement regarding the form of protection that might be provided (patent, copyright, other new form).

In May 1964, the Copyright Office agreed to accept programs for copyright registration under the existing legislation*) if the programs constitute works of original authorship. The Copyright Office made it clear that this policy does not mean that all or any programs are copyrightable. Those questions must be resolved by the courts.

The proposed bill is broad enough to cover computer programs in some sense. Thus Section 102 (S.597 and HR.2237) includes among "original works of authorship" capable of copyright, "literary works," and these are further defined by Section 101 as "works expressed in words, numbers, or other verbal or numerical symbols or indicia, regardless of the nature of the material objects, such as books, periodicals, manuscripts, phonorecords, or films, in which they are embodied." The Report of the Register of Copyrights (RC pt. 6, p. 67) says, "The definition of literary works . . . is broad enough to

*Copyright Office Circular 31D, January, 1965.

cover every possible form of verbal or numerical expression including, for example, computer programs fixed on punch cards, magnetic tape, or any other media."

But there are a number of remaining questions. What kinds of programs would be covered? As programming languages become more machine-independent and general in form, syntax, and vocabulary, we will reach the point where programs approach statements of general concept. What kind of protection can be given to a program when it is written as a general statement or approach?

What would be the effect of the availability of copyright on the publication of programs in books, journals, and other sources, and on the use of programs so published? Some observers think that if it were possible to copyright simple mathematical routines, scientific problem-solving could be seriously hampered, and scientific uses of computers curtailed. On the other hand, copyright would provide some form of protection for organizations whose programs represent considerable investments and make possible systems of program leasing and selling. In this way, one can argue that scientific problem solving would benefit from the availability of copyright.

The advent of copyrighted programs may cause administrative difficulties for computer centers as they must determine, and later keep track of, which items in their program library are copyrighted and require special handling. Such centers might also be put in the position of having to check each user's intended application to see whether or not he was a legitimate exempt user. This, however, is hardly a serious criticism because one of the principal advantages of a computer is its ability to handle problems of a bookkeeping nature.

2. The Question of the Reach of a Copyright on Computer Programs: Would it Cover the Plan, Concept, Theorem, Process, etc.?

There are instances in which the first appearance of a new technique may be in a specific computer program. This technique may represent a novel work or invention. It may be:

- of a mathematical nature (e.g., a new method to solve a particular type of equation), or
- of a linguistic nature (e.g., a new method to perform machine language translation), or
- logical (e.g., a method of computer internal control that replaces a hardware circuit with a programmed equivalent or virtual circuit), or
- other non-mathematical nature (e.g., a new method to sort records into alphabetic sequence).

The developers of such programs can justifiably argue that their contribution should be rewarded with some form of copyright or limited monopoly.

In some instances the number of methods for solving a particular problem may be relatively small; e.g., computing the area of a circle or converting binary to decimal numbers. Under such circumstances other programmers might develop identical or similar programs even though they had never seen the original. This might be awkward because it would place a burden upon the second programmer to prove that his work was original with him and was not copied from the first programmer. It is possible that in order to avoid this kind of dilemma later, programmers might choose to carry out their work in more clumsy ways rather than to risk disproof of a charge of copying.

There appears to be some confusion as to whether or not the copyright for a computer-operator process would cover the process itself, as well as the program of the computer. Actually it would cover neither, but merely the expression of the program or of the ideas or information on which it is based. To extend protection to processes would be contrary to copyright tradition, and raises questions as to the relationship of copyright to patent protection. It should be noted that in this case protection would run for about 75 years, in contrast to the 17 years of the present patent law.

The President's Commission on the Patent System recently advised against the patenting of computer programs, saying ". . . a 'program' shall not be considered patentable."*) However, the stated basis for the recommendation was the practical fact that reliable patent searches would not be feasible or economic because of the tremendous volume of prior art being generated, and without this search the patenting of programs would be tantamount to mere registration.

3. <u>The Question of Input Copying in a Machine-Language Representation</u>

Every program and method of computer processing requires that the data to be processed must be first converted to a machine-language representation before they can be processed. The data cannot be handled by the computer unless they can first be sensed by such means as character recognition devices, punched paper tape or card readers, or magnetic record readers. There are innumerable cases where it will be necessary or desirable to convert copyrighted material into machine-readable form for subsequent processing by the computer.

Where is the proper point of control for such uses? Should copyright protection apply at the point of input—the point where the copyright material

*Report of the President's Patent Commission, Senate Document No. 5, 90th Congress, 1st Session, 1967.

is converted into machine-readable form, or would it be more desirable to apply controls at the output of the computer—the point where the copyrighted material is put to some human use?

There are two strong schools of thought on this issue. The proponents of "input" control believe that this is the only possible point at which protection can be guaranteed because once the information is in the computer, many people will have access to it for any purpose. The proponents of "output" control believe that copyright protection should apply only to the ultimate use of the information, thereby encouraging experimentation on the whole subject of information storage, retrieval and use.

This problem is further complicated by the concepts of "fair use" and exemptions.

Section 106 says that ". . . the owner of copyright . . . has the exclusive [right] . . . (1) to reproduce the copyrighted work in copies or phonorecords; . . . ."

HR.83 states that, "Under the bill it makes no difference what the form, manner, or medium of fixation may be—whether it is in words, numbers, notes, sounds, pictures, or any other graphic or symbolic indicia, whether embodied in a physical object in written, printed, photographic, sculptural, punched, magnetic or any other stable form, and whether it is capable of perception directly or by means of any machine or device 'now known or later developed'." (p. 15). And further, ". . . unless the doctrine of fair use were applicable, the following computer uses could be infringements of copyright under section 106: reproduction of a work (or a substantial part of it) in any tangible form (paper, punch cards, magnetic tape, etc.) for input into an information storage and retrieval system; reproduction of a work or substantial part of it, in copies as the 'print-out' or output of the computer; . . . ." (p. 25).

HR.83 provides arguments on both sides of the question of copyright protection on computer input, and makes the summary statement, ". . . section 106 preserves the exclusive right of the copyright owner with respect to reproductions of his work for input or storage in an information system." (p. 25).

RC Pt. 6 states that, "It seems clear . . . that the actual copying of entire works (or substantial portions of them) for 'input' or storage in a computer would constitute a 'reproduction' under clause (1), whatever form the 'copies' take: punchcards, punched or magnetic tape, electronic storage units, etc." (p. 18).

Proponents of the input restriction argue that: (1) because of the potential for duplication and display, computers have the potential to destroy or damage the hard-copy market of authors and publishers; and (2) the publisher may want to market his product in machine-language form, and an unrestricted privilege of conversion to machine-language form would reduce his market.

Opponents of input control argue that the copyright owner is not damaged by input alone, and that the controls should be placed on the subsequent printing or distribution of copies. They argue that if it is not a violation of law for a student to look through a series of articles to find ones that are relevant, why should it be a violation for a computer to do this? Proponents of input control reply that it is not "the looking through" the copyrighted material that concerns them, but the possibility inherent in the computer of unlimited multiplication of copies at an unlimited number of locations which would seriously impair the publisher's economic ability to publish.

The bill also excludes machine-language storage for archival purposes. Section 108 says that it is not an infringement for a nonprofit institution with archival custody of unpublished works to reproduce them "in facsimile copies" for purposes of presentation or security. But HR.83 says that, ". . . a repository could make photocopies . . . by microfilm or electrostatic process, but could not reproduce the work in 'machine-readable' language for storage in an information system." (p. 37).

This has an impact on both the user and the manufacturer. Advances in digital image storage may make it possible for future systems to store and process images in digital form (in a manner similar to the now familiar pictures transmitted from the moon). The digital data could be stored in a number of ways (e.g., optically on film, or magnetically on a magnetic medium). Such digital storage means would be of value to the archivist. The images could also be stored in a video form, but video storage and retrieval systems are not exempt under the proposed language. The exclusion of a machine-language form may also cause difficulty for the archivist who wishes to use computer techniques for further operations to help him organize and use a collection (e.g., file searching on a manuscript text, machine indexing, concordance construction, literary criticism, and tests of authorship).

Input control may also have a large impact on people concerned with the computer processing of text material. As examples:

A. Organizations currently running a computerized Selective Dissemination of Information (SDI) system in which journal titles, abstracts or text are compared with a list of keywords or other indicators that characterize the subject interests of a staff member. There are an estimated 40 to 50 such systems in operation today in this country, some of them serving as many as 1000 users.

B. Organizations currently using computers to process or scan text material. Examples of this use are: file searching of text; automatic indexing or abstracting; machine translation; concordance or work list construction. Unless permitted by fair use, the preparation of such material might constitute a derivative work.

C. Organizations storing text in computers for use with display equipment. Examples of this use are on-line display of requested items and computer-assisted instruction.

It is, of course, true that the potential user can obtain the necessary permissions and licensing from the copyright holders. Commercial publishers have become accustomed to the handling of such requests, and some of them currently process several thousand requests per year as part of their normal business activity. Therefore, it may not be too difficult or time consuming for the user to obtain the necessary release from many of the major publishers. Furthermore, it is quite possible that the major publishers would be willing to make blanket approvals for more kinds of experimental work by researchers.

4. The Question of On-demand Distributing Libraries

In contrast to the practices of circulating or lending requested material to library users, a number of organizations and individuals have proposed a practice of making and furnishing expendable copies for distribution, with no copies to be returned to the libraries. From a technological viewpoint, it is possible and practical to do this under certain circumstances. Several publishers are already working in this manner, and many libraries and information centers have assumed this mode of operation for the majority of their inter-library loan traffic. The National Library of Medicine in 1959, for example, distributed approximately 75,000 copies of articles requested by other libraries. The ERIC information centers supported by the U.S. Office of Education expect to distribute thousands of copies of articles per year to interested users. Large distribution centers have been planned by other organizations. This copying of individual articles has grown to a considerable volume, and will probably continue to grow. Many professional societies, and publishers in some cases, have generally recognized the usefulness of copying techniques to scientists, and have endeavored to develop this type of usage for the mutual benefit of all concerned. A 1962 study sponsored by the NSF reported that there were no indications at that time of any significant financial damage to publishers because of copying practices.*) One government spokesman was recently reported as saying that only 17 out of the top 100 journals requested by NLM (National Library of Medicine) loans were from profit-oriented publishers. However, that situation seems to be changing, and some publishers indicate that they see real evidence of loss of subscriptions (particularly where there are multiple subscriptions to the same organization); they feel that this is directly due to the practice of copying the material by the subscriber.

The applicability of the fair use provision is unclear. No specific exemption is given to educational organizations for hard copy as it is for certain displays and performances (section 110). HR.83 says that, ". . . the Committee does not favor special fair use provisions dealing with the problems of library photocopying . . .", and again that, "Any educational uses that are fair use today would be fair use under the bill." (pp. 37, 31). There have been some suggestions that the practical interpretation of fair use could be accomplished by some kind of regulatory commission.

The bill needs study insofar as it may affect the development of library file collections. With the present technology, an on-demand or distributing library is more practical if the main file exists in microfilm, video tape recording, or some form other than the original hard copy. This would permit significant economies to be achieved in the duplication, storage, and material handling processes. Except for the limited fair use provision, the present

*Survey of Copyrighted Material and Reproduction Practices in Scientific and Technical Fields, George Fry and Associates, Chicago, 1962.

bill does not permit microform (e.g., microfilm, microfiche, video tape recording) copies to be made without permission of the copyright holder.

Mechanized equipment is available now (e.g., IBM Cypress, Ampex Videofile, Magnavox Magnavue) which can store the entire contents of a library in microform, and provide microform or viewing copies on demand. Some libraries in the future may become interested in replacing their copyrighted journals, books, proceedings, etc., with an equivalent microform for the machine file.

One solution may be to obtain the microform from the present licensed distributors (e.g., subscriptions are available to the microfilm editions of the New York Times and Chemical Abstracts). However, much of the library material may not be available in microform. HR.83 says, "A key, though not necessarily determinative, factor in fair use is whether or not the work is available to the potential user. If the work is 'out of print' and unavailable for purchase through normal channels, the user may have more justification for reproducing it than in the ordinary case, but the existence of organizations licensed to provide photocopies of out-of-print works at reasonable cost is a factor to be considered." (p. 34).

To summarize, existing copyright restrictions might make it difficult to convert library collections into forms other than the original hard copy, or to implement an on-demand distributing library. It would affect the present and planned operation of many information services. Suitable means should be provided to accomplish these goals.

5. The Question of Computer-Assisted Instruction Systems

Computer-Assisted Instruction (CAI) is the name given to the type of system in which a computer program is written to permit a student-machine instructional dialogue to take place. These programs may concentrate on a particular subject field (e.g., freshman courses in psychology or American history, fourth grade arithmetic or spelling courses). Over 20 different programs have already been developed. The systems typically work with some form of display device, such as a typewriter or cathode ray tube terminal, and some mechanism that permits the student to enter information into the computer from the terminal. Usually, the programs display some body of text or information for the user to read, then present a series of questions for the student to answer. A program includes appropriate responses to all possible answers, and leads the student through a sequence of correction and tutorial statements before re-testing. The student has finished the course when he has successfully passed through all of the quizzes. CAI may constitute the entire instruction of the course, or it may be used as an exercise to augment teaching by conventional means. A considerable amount of effort is required in the present CAI systems to plan the sequence of instruction, develop the tests and dialogue, and write the program.

CAI systems are currently being developed at more than 20 institutions across the country, and are being used on an experimental basis in classroom work in several schools. The University of California at Irvine, for example, is using over 14 terminals for the instruction of pupils in 24 different classes, for a total of 1500 terminal hours per month. Grades 3 to 6 in Brentwood Public School in Palo Alto, California, are using CAI techniques developed at Stanford University to help teach mathematics and English, with the aid of 8 teletype terminals from a computer system in another part of town. Each student uses a terminal once per day for 5 to 10 minutes. The same computer system is also being planned for experimental use with classes on the East Coast. In another experimental situation, some students at Harvard have been taking computer-assisted courses with a terminal linked to a computer 3000 miles away in Santa Barbara, California. In one of the most extensive installations, New York City will be starting a system in early 1968 with 196 terminals in 15 schools, grades 2 through 6, for arithmetic drill and practice, and later for spelling and reading. Similar development work is being done at the University of Illinois, Pennsylvania State University, University of Pittsburgh, University of Michigan, University of Texas, Florida State University, and University of California at Santa Barbara.

Various types of material may be displayed in a CAI system. It appears that few, if any, of the CAI programs used to date have incorporated any copyrighted or previously published material. The programs are generally developed anew, for each subject and installation, by the individual who is preparing the course. Thus there does not seem to be a significant problem yet in requiring clearance to use copyrighted material for these systems. However, this picture may change, especially if an institution with a CAI system wishes to incorporate previously published workbooks or portions of standard texts into its system, using one copy where it might otherwise have bought several hundred. This could be accomplished by arrangements between educational publishers and computer manufacturers, such as evidenced by the acquisitions of Science Research Associates and Random House by IBM and RCA, respectively, and by recent agreements whereby the computer manufacturers would use the programs developed by other publishers.

Section 110-(2) permits ". . . display of a work by or in the course of transmission by a governmental body or other non-profit organization, if: (A) the . . . display is a regular part of the systematic instructional activities of . . . a nonprofit educational institution; and (B) the radius of the area normally encompassed by the transmission is no more than 100 miles; and (C) the transmission is made primarily for: (i) reception in classrooms or similar places normally devoted to instruction . . . ; and (D) the time and content of the transmission are controlled by the transmitting organization and do not depend on a choice of individual recipients in activating transmission from an information storage and retrieval system or any similar device, machine, or process; . . . ."

HR.83 says that, "The transmission must not cover a radius of more than 100 miles, . . . and its time and content must be controlled by the transmitting organization, thus excluding transmissions of instructional material to individual users by means of computers and the like." (p. 5).

Most CAI systems would not be exempted under the bill because the student is the one who initiates the transmission and display by his choice. In addition, the 100-mile limit may constitute a difficulty.

In the bill, several conditions have been imposed on exempt displays of copyrighted material in order to protect the copyright owner from widespread on-demand use of a single copy of his material. Some observers argue that CAI systems will be handicapped by the lack of an educational exemption.

On the other hand, the general provisions of the bill would permit the actual CAI programs, text, and dialogue material to be copyrighted as a protection to the authors or developers. In the years to come, the development of a CAI program will be analogous to today's effort by the course instructor to develop a text for his course. He will probably have an interest in obtaining the corresponding royalties and recognition for his effort. Under the bill, organizations that are developing their own CAI programs and text will be able to use them without restrictions as to distance, mode and timing of transmission, volume or type of output, or number of users. Furthermore, they will be able to copyright these programs for their own benefit. This appears to be an important point with the developers of the programs who argue that a considerable amount of money may be invested in a program (reportedly over $400,000 for one of the major CAI programs), and that the developer must have some protection and incentive. They argue, further, that without copyright protection, the independent developer or publisher would have no incentive, and the field would be left to the equipment manufacturers and the government; this would not provide the diversity of instructional materials that the schools require.

Thus, we see a vagueness of objectives, and some sharp differences within the educational field regarding the needs of CAI and the merits of the proposed bill with regard to CAI.

6. The Question of Computer Preparation of Derivative Works

Computers are able to prepare many types of derivative works that would be possible, but relatively difficult, to prepare manually. Consequently the machines may be used more and more extensively for this task. A question is raised whether the bill does not place conditions on the preparation of derivative works that may make it difficult to exploit the full machine capability.

Section 101 says that, "A 'derivative work' is a work based upon one or more pre-existing works, such as a translation, musical arrangement, dramatization, fictionalization, motion picture version, sound recording, art reproduction, abridgment, condensation, or any other form in which a work may be recast, transformed, or adapted. A work consisting of editorial revisions, annotation, elaborations, or other modifications which, as a whole, represent an original work of authorship, is a 'derivative work'." Section 106 provides that the owner of copyright has the exclusive right "to prepare derivative works based upon the copyrighted work."

Examples of secondary works which can now, or may in the future, be prepared with computers are: translations or transliterations; concordances, indexes or catalogs; abstracts or extracts, statistical summaries. Whether, or to what extent, the several kinds of secondary works should be given legal status as derivative works with the consequence of vesting extensive control in the owner of the primary work, is a basic and difficult question in itself.

Since the early 1960's, major concordances have been prepared by computer processing of the full natural text, instead of being prepared manually. This will surely continue to be the case in the future. Computer techniques have also been used to prepare indexes to individual journals, as well as to entire collections of journals for a given subject field. Most of the major indexing and abstracting services (e.g., Chemical Abstracts, Index Medicus, Biological Abstracts) already use computer programs to construct some of the indexes to the articles they cover.

It is possible that the bill would be interpreted in such a way that organizations interested in using machine techniques to develop derivative works as research tools for local or widespread use would be prevented from doing so without permission of the copyright holder. A literary scholar, for example, who wanted to compile a detailed index or concordance to the writing of Hemingway, would be unable to do so without permission unless covered by the doctrine of fair use. The restriction on conversion to machine-language would apply, even if there were no restrictions on derivative works. However, the requirement that a researcher get permission from the copyright holder for the preparation of concordances, indexes, etc., does not seem to be an undue hindrance.

As a second example, an organization interested in scanning copyrighted printed matter (e.g., technical journals and articles) with a page reader in order to use a computer to prepare a brief abstract or detailed index, either for local or widespread use, might be unable to do so without permission.

Derivatives from derivatives pose some interesting questions. Would it be possible for an individual to take a magnetic tape corresponding to all of the citations of Chemical Abstracts, and extract a specific subsection to make a separate publication, such as Abstracts of Soviet Chemistry, without restrictions? How is this different from performing literature searches (for personal use or for profit) using Chemical Abstracts? Is it permissible to prepare an index to footnote citations (as done in the present citation indexes) without permission of the original authors? Should the author have the exclusive right to prepare indexes or concordances to his own books—but, in the public interest might he be required to let others do it if he does not do it within some specified time-period after publication?

Is it permissible to translate a program written in ALGOL programming language into a FORTRAN program without permission? Is it permissible to prepare a detailed flow chart for another person's program without permission? Is a programming language a language?

7. The Question of Property Rights in the Results of Computer Programs

We have already discussed the question of copyright in computer programs, but what rights should be allowed in the results of the use of a program? For example, computer programs have been written which compose music (there are some copyrighted works from an Illiac Computer program) and write poetry (published in early 1960's), given some initial data and starting conditions. Would all the future output of a program fall within the ownership of the holder of the program copyright?

As a second example, computer programs are now being used in some movie studios to compute and draw intermediate cartoon frames in a cartoon film sequence by interpolating between two given cartoon frames that are closely related. That is, an artist manually draws every-other-frame of the cartoon, but the computer program is used for smoothing and interpolation to generate the frames between the manually-drawn frames. Does the holder of the program copyright also have a share of the ownership of the cartoons? A similar situation might arise with computer programs used to generate patterns and designs for tapestries, garments, and other furnishings.

Reflections by the Chairman on the Strategy and Exploratory Contacts of the Computer Science and Engineering Board

The discussions of the objectives and organization of the Board presented in the Planning Group's report to the President of the Academy stopped short of suggesting a strategy for attacking the questions described in that report, although some strategy decisions are implicit in the priority ranking attached to objectives.

It would appear that the Board has two basic courses open to it. One is to raise its own questions; the other is to respond to requests for advice. Obviously these two approaches are not mutually exclusive. Nonetheless, in practice the Board will, I believe, find it necessary in many instances to make a choice. By concentrating exclusively on self-generated questions the Board may gain perspective for itself and open wider intellectual horizons for others, but this will probably be accomplished at the risk of irrelevance to current issues and of general impotence. By responding unselectively or exclusively to requests for advice, the Board may, on the other hand, acquire relevance and effectiveness at the price of losing perspective and of channeling all its energies into searches for immediate solutions under the same pressures and with the same forced lack of perspective which the need for immediate decision-making imposes on those who may seek the Board's advice.

The choice between these approaches cannot be made solely on intellectual grounds. The pattern of funding in the Academy necessarily enters the decision process. The Academy is unable to sustain a major or prolonged effort out of its endowment or other general income. The Board, like all other organs of the Academy, is therefore dependent almost entirely on external funding. At this stage, the resources at the Board's disposal include a $10,000 unrestricted grant from the American Federation of Information Processing Societies. We believe the Board will also be funded at the rate of $100,000 a year for the period of three years by the Advanced Research Projects Agency of the Department of Defense. The terms of the latter funding are reflected in the Academy's proposal to ARPA of which you have a copy. You will note in Section 3 of that proposal that the terms of the contract with ARPA will leave the Board considerable latitude in the selection of problems of broad general interest as well as responding to specific requests that may originate within the Department of Defense. On the other hand, any other major studies that may be addressed primarily to interests of other branches of the government may require additional and separate funding.

Thus, while the Board in principle has considerable latitude it is clear that the current funding level and our initial manpower resources will scarcely lend themselves to a buckshot approach. To be effective, the Board will have to choose carefully among problems of the highest priority.

To the extent that circumstances permit, it would be desirable to combine the advantages of both basic approaches. For example, the Board might choose to extrapolate the trends in the development of computing five or ten years forward to identify intellectual or technical bottlenecks and suggest education and research strategies to help eliminate these. The undertaking of such a broad inquiry could gain in specificity and focus through a combination of specific case studies of current critical issues confronting ARPA, the FCC, or other agencies. A general study of educational requirements in computer science could fruitfully be coupled with fact-finding and with analysis of specific problems confronting ARPA, the Office of Science and Technology, and the Office of Education in allocating their limited resources to efforts most likely to pay off in advancing the state of the art and the effectiveness of computer applications.

General studies could therefore provide the Board with guidelines for selecting specific projects. Evidence gathered in specific concrete studies could help anchor the general studies in reality.

The listing of exploratory contacts made in the course of the Planning Group's work illustrates the range of specific projects which the Board might address. The Planning Group's report suggests certain general questions or areas for the Board's examination. Our initial efforts might therefore be directed toward, on the one hand, enlarging both lists in the light of the interests and experience of members of the Board and then getting down to work on appropriate subsets of these. The selection of initial committee members should proceed concurrently.

Report of the Planning Group
Computer Science and Engineering Board
to the
President of the National Academy of Sciences

In view of the rapid evolution of the field of Computer Science and Engineering, the National Academy of Sciences has decided to establish a Computer Science and Engineering board comprised of a distinguished group of experts in the field of computer and information science and related areas. The Board will be available to provide advice to federal agencies and to other organizations which may have problems in which the Board can be helpful. This step is in keeping with the official role of the National Academy of Sciences to provide advisory assistance to the federal government in matters of science and engineering.

Since the field of computer science and technology is developing rapidly, the Board will have a special and continuing obligation to keep itself well informed. It should be capable of perceiving the current state and the future prospects of Computer Science and Engineering, and of its professional practices in order to advise the government concerning the intellectual capital and the manpower resources necessary to insure continuing U. S. leadership in Computer Science and Engineering. It should be able to evaluate in technical terms the true meaning of the enormous and somewhat heterogeneous growth of information processing technology as it affects the public and private sectors of our nation. It should, in general, be capable of assessing the implications of advances in this branch of science and technology for the national welfare.

The Board should therefore take a broad view of this subject and of its applications to research and education in other branches of science and engineering as well as to the workaday needs of government, commerce, industry and education. Consequently, it should interact with other boards or committees under the various subdivisions of NAS/NAE/NRC.

The Organization of the Board

This view of the Board's broad role implies a need to set priorities among areas of potential interest by weighing the importance attached to these areas.

The following recommendations on organization and priorities reflect the thought the Planning Group and its guests have given to these questions.

To function with a balanced and broadly representative group of individuals without losing the working efficiency of smaller groups, the Planning Group recommends that the Board organize itself into several committees, each subsuming panels created to meet specific needs.

Between plenary sessions of the Board, the committees would meet on schedules tailored to the work of the panels or working groups under their wing. These panels or working groups should be created as needed, often on a temporary basis. They should be chaired by a member of the parent committee and staffed for appropriate competence and breadth of representation by members of committees other than the parent committee and also by the most competent individuals in the nation representing significant points of view whether or not they belong to any committee of the Board.

Specific capabilities the Board should have at its inception were studied by panels of the Planning Group. The initial areas spelled out by these panels can be covered by starting the Board with the following three committees:

1. Education
2. Research and Development
3. National Programs

The interests and responsibilities of these three committees clearly overlap. The committees should therefore have overlapping membership. This mechanism for insuring balanced coverage of all significant points of view can be supplemented by the creation of joint panels to deal with specific subjects. The staffing and the mission of such panels would be determined by recommendations of the affected committees to the chairman of the Board, who would be responsible for assuring broad and balanced representation. Since competence and partiality often go hand in hand, broad and balanced representation should be interpreted as assurance of full and free expression of contending professional points of view.

Committees of the Board

The Committee on Education should be prepared to advise on educational questions, for example how to overcome the prevalent shortage of personnel in Computer Science and Engineering. This committee very likely will need a panel on data-gathering to make recommendations about adequate statistics for describing manpower needs.

This committee should perform for education in computer science and engineering in a continuing, comprehensive and nationally representative fashion the role that the earlier committees chaired by Rosser (in NAS) and Pierce (in OST) could perform only for a limited time under restrictive charters.

The Research and Development Committee should be concerned with assessing the current state of the art and perceiving future directions for research and development. Three principal panels recommended for initial creation under the Research and Development committee would study (a) the application of computers (b) the science of machines and programs (c) systems directions.

The first panel may advise on research policy leading to better applications methodology for extending current computer applications and for developing new application areas.

The second panel may advise on the development of a formal theoretical foundation for the developing science of machines and programs.

The panel on systems directions may foster the development of new systems concepts and organizations. The systems problems continue to be of the most difficult type, heightening the importance to be attached to great improvements in the depth of understanding and of skills for tackling the wide variety of such problems which confront all levels of organization, both government and private. Panels concerned with specific functional areas, e.g. data retrieval, can be formed in cooperation with the Committee on National Programs.

Under the Committee on National Programs, panels dealing with specific requests by governmental organizations would be formed as needed.

The Committee on National Programs should perceive and assess developments in Computer Science and Engineering that affect national programs providing direct support to policy formulation and policy execution. It should advise on how human, equipment, and methodological resources may be combined to maximize the effectiveness and efficiency of federal, state and local governmental organizations.

The implications of the current state and future prospects of Computer Science and Engineering on the formulation of government policy affecting Computer Science and Engineering and related fields should also be a prime concern of this Committee.

Staffing of Committees

The initial organization of the Board into three major committees leads to natural emphases on staffing in the three corresponding areas. For example, the Education Committee should include people representing the universities, the schools, the professional societies, and such industrial organizations or government agencies as are concerned with education and training. Lay members should be included to assure satisfactory representation of other significant points of view.

The Research and Development committee should include the individuals most knowledgeable of affected substantive areas without regard for the institutional character of their primary affiliation.

The National Programs Committee should include among its members people chosen primarily for their familiarity with relevant aspects of national civilian or military programs as well as experts in Computer Science and Engineering.

Liaison groups should be established to inform other organizations within NAS/NAE/NRC of the discussions and plans of the Computer Science and Engineering Board and to keep the Board informed of the needs of computer users in various areas of science and technology. As the need arises, more formal joint panels can be created in conjunction with other NAS/NAE/NRC boards or committees.

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THE MISSIONS OF THE EDUCATION COMMITTEE OF CSEB

1. Education cures all the ills of a society (!) and education in computers is to be anti-toxin[1], therapeutic[2], and conditioner[3] for some of these ills: "Give me data and I will move the world."

We must distinguish among the following roles of computers in which education is required:

(i) As a device enhancing the educational process in general.

(ii) As a tool to be used in the work of other disciplines.

(iii) As a universal plastic for modeling ourselves, e.g., representations for our abstractions.

(iv) As a tool in which (i) to (iii) can be combined in unlimited ways.

These roles can be studied, in principle, at every educational level from grade-school to graduate school.

2. The roles of CSEB with respect to education.

Naturally there are many roles for the CSEB committee to study. Principally, tensions (and reinforcements) arise in making a choice because the Board must serve both the scientific community and the Federal Government.

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1) An understanding of computers and their role will prepare man to understand and hence resist the onslaughts on him by organized complexities of one sort or another, or put another way computer education is survival education. Thus how do we teach this technical subject in a non-technical way to the non-scientist?

2) Those educated in computers can drive away these ills by intelligent use of the computer in, e.g., organization of data, transmittal of the right data and burial of the wrong data, reorganization of resources, and the creation of universal euphoria from planned use of inspiring inventions.

3) Armed for the next crisis.

Within the scientific community CSEB must not only serve the established sciences but must emphatically support the establishment of computer science. For the Federal Government it must expose which of its problems can be helped by education in the computer. These problems arise both in the government's operations and its desires to improve society. In all cases CSEB must determine how gains and improvements are to be brought about.

CSEB involvement in any problem--at least in its first stages--cannot be total. Initially CSEB should focus on those problems which are important and are not being adequately studied elsewhere. CSEB should be careful not to concentrate its energies and the talents of its members and panels on audits of studies done elsewhere and on patches to solve specific problems in the Federal Government.

At some later date additional studies will need to be made evaluating work now going on elsewhere but which CSEB cannot now concern itself with.

3. Specific CSEB education studies which are proposed for immediate attention.

(1) Graduate education in computer science.

(2) Undergraduate education in software engineering.

4. Graduate education in computer science.

Computer science is a new and real discipline. Graduate programs exist and others are being born. Their output will populate all levels of computer education in the future. No complete study of this topic has yet been made and it is unlikely that any other Federal Board or Agency will do this study for CSEB.

This study should include:

(1) Definition: What is an adequate (excellent) graduate program in computer science at the Ph.D. and the M.S. level? How does it

relate to other graduate programs in allied fields like mathematics and electrical engineering and the social sciences?

(2) Resources (people): How many adequate (excellent) programs exist? How many are needed? What are the bottlenecks which will delay achievement of the need? What is (should be) the ouput of these programs and how does (should) it filter through the general computer education program? At what stage should undergraduate computer science programs be begun?

Resources (money): How much money is required to adequately support and give birth to these programs? How much of this money should be Federal? Industrial? University? Philanthropic?

(3) Interaction: How will graduate programs in computer science affect the use of computers by other scientists, e.g., in increasing efficiency and even through better understanding of their own problems?

5. Undergraduate education in software engineering.

Whereas computer science is concerned with increasing our understanding of concepts, software engineering focuses on things, albeit abstract ones, which are designed, constructed, documented, maintained, improved, and above all used. We refer to programs which are the central elements of computer systems. There are several central questions which must be answered before examining the details of the education program.

(1) What's all the fuss about?

Software is becoming more intricate. After all so are the computers and so are the interesting problems.

The software base required for useful computer systems is growing.

The software base for software development is also increasing both in size and complexity.

Furthermore, delays in production, inability, to accurately predict completion times and cost, are seriously prejudicing future developments in the entire computer and user industry.

(2) Is it really engineering?

Perhaps what is required is not modern engineering which is ever drawing closer to science and is more akin to classical engineering. However new engineering subjects may have to develop from "trades" as did their predecessors. However it is certainly the spirit and discipline of engineering that is needed in the development and manufacture of software.

(3) Are trained people needed?

Finding system programmers of proven competence with a predictable productivity is a principle difficulty and bottlenceck in systems programming. Integrating programmers into teams is exceptionally difficult. Managing such teams is nightmarish being somewhat as in baseball without contracts and the reserve clause. (It's game time and the thirdbaseman leaves except nobody on the team knows how to play the position!)

What, then, are the major issues in this area before the committee? Clearly they are precisely the same logistic issues as raised for computer science. However we note that there are <u>no</u> university programs in software engineering in existence now. The definition of a program is going to be considerably more difficult. Perhaps the committee will find that a first step will be the delineation of undergraduate options or minors in electrical engineering, which, however, will be somewhat different than the propositions put forward for the computer science education within electrical engineering.

6. Reasons for rejecting other studies now.

(1) Computer aided instruction.

This important area--of potential value in education--is being supported by several agencies and studied by psychologists, educators, and computer scientists. While a future study will undoubtedly be of value, there is no immediate pressure for studies at this time comparable to those outlined.

(2) Enhancing the use of the computer in other disciplines.

The very universality of the computer makes this kind of study important. The importance of the user disciplines and their problems, the extremely important and expensive research programs which phase their development on the results of computation all make this a most important role of computers. Nevertheless many in these fields have long experience in computation and their own professional societies have been aiding considerably in improving their use of the computer. Several previous studies have been made on the computer needs of these disciplines (The Rosser report). There are also ongoing educational efforts to intensify the educational use of the computer within these disciplines. Here, too, a study will be required eventually, but there is no pressing need at this time for CSEB to supervise one.

7. Recommended personnel for the committee and panels.

The following people are suggested for membership in the two committees:

(1) The committee on computer science

G. Forsythe (Stanford)
J. Hartmanis (Cornell)
B. Rosen (Wisconsin)
S. Conte (Purdue)
J. Carr (Pennsylvania)
R. Hamming (BTL)
A. VonDam (Brown)
W. Clark (Washington U.)
H. Goldstine (IBM)
F. Brooks (U. N. Car.)
B. Lampson (U.Cal)

(2) The committee on software engineering

E. David (BTL)
T. Cheatham (ADR)
L. Zadeh (University of California)
F. Corbato (MIT)
S. Rosen (Purdue)
E. McCluskey (Stanford)
J. Snyder (Illinois)
R. Spinrad (SDS)
W. Acheson (University of Maryland)
A. Opler (Computer Usage)
J. Schwartz (SDC)
V. Vyssotsky (BTL)
G. Culler (U.Cal., S.B.)
B. Gilchrist (IBM)
D. Knuth (Stanford)
R. Jones (ADR)
M. Conway (Univac)

8. Timetable

General organizational meeting:	late September for establishment of panels.
Draft reports	January
Final reports	March

Alan J. Perlis
September 10, 1968

REPORT FOR THE COMMITTEE ON NATIONAL PROGRAMS

J. Barkley Rosser

There is no difficulty about finding problems of importance and urgency. They crowd upon one. The question of government imposed standards for computers and their use, nationwide data banks (how to be efficient and also safeguard privacy), copyright problems connected with computer use, national computer laboratories, how to hasten relaxation of secrecy restraints from important new hardware advances, and the pressure upon nationwide communication channels posed by new computer systems and utilities are amongst those that come readily to mind. A somewhat orderly approach to a couple of these will be reported, but events have forced our hands in some other areas.

An urgent call involving a highly classified area led to the hurried formation of an ad hoc Panel consisting of Carter, Griffith, House, Oettinger, Rosser and about three others who are not members of the Board. This Panel has met once with the interested agency, and further meetings are expected. Carter has made inquiries about possible additional Panel members. I shall attend a meeting on October 14 at another agency which should provide a lot of background information. When the Board has a classified meeting, more details can be disclosed.

An even more urgent call led to the even more hurried formation by the Vice-Chairman of an Advisory Panel which met on July 23 to make a preliminary survey of controls upon the export of computers. The Panel consisted of Fernbach, Griffith, and Pierce, with nine other members from OST, Commerce, CIA, IDA, State, the Bureau of Economic Affairs, and OSD. A member of the Panel has since been working on such matters as a draft list of critical technical points bearing on the computer export problem. I have not seen a report, but I understand that one is to be presented at the Executive Session on September 10.

At the time of the formation of the Board, I was concerned that the Brooks Bill seemed to call for the formation at the Bureau of Standards of a National Computer Institute, one of whose responsibilities would be to set computer standards. This seemed to allow the possibility of some serious consequences, and so I set this as first priority. I visited NBS, and later NIH (to which NBS furnishes some computer services), and Carter and I visited the Department of Commerce. At the July 12 meeting of the Board, Dr. Grosh spoke in his capacity as Director of the Center for Computer Sciences and Technology of NBS, and I talked afterwards with Ernie Baynard of Congressman Brooks' staff. As I indicated in a recent communication to the Board, Brooks' intentions for NBS are quite reasonable. A national computer laboratory (if there is to be one) is a wholly separate matter. The matter of NBS now seems sufficiently clearcut that it may be advisable to set up a Panel to consider whether to push for some of Brooks' ideas, and if so, how best to do so. There exists an Advisory Panel to NBS for computation, and I have attached a list of members at the end of this report. All seem excellently qualified to serve on a Panel of the Board, and there might be some advantages in interlocking Panels. Other possible members might be Norman Ream, past Director of the NBS Center for Computer Sciences and Technology, and George Forsythe, chairman for some years earlier of the NBS Advisory Panel.

In 1961 the Bureau of the Budget commissioned a feasibility study for the centralization and computerization of the many personal records now residing in individual agencies of the Federal Government. It was chaired by Richard Ruggles, Professor of Economics at Yale University. In 1965 they issued the "Ruggles Report," recommending "that the Bureau of the Budget .... immediately take steps to establish a Federal Data Center." Two subsequent reports were developed upon request by the Bureau of the Budget: the "Dunn Report" by Edgar S. Dunn, Jr., of Resources for the Future, Inc., and the "Kaysen Report" by Dr. Carl Kaysen, Chairman of the Institute for Advanced Study. Both endorsed and expanded the "Ruggles Report."

Congressman Gallagher, Chairman of the Special Subcommittee on Invasion of Privacy of the Committee on Government Operations, took a dim view of these developments. He held hearings and apparently stalled BoB temporarily. However, on June 20, BoB sent to contractors a Request for Proposals for a two year study of how to install a system embodying something very like a Federal Data Center.

The Federal Statistics Users' Conference, composed of over 160 member corporations, unions, and universities, is now in the second year of a study of the National Data Bank. Executive Director Aiken has said that one possible conclusion might be that the present system suffices, and there is no need for a centralized data center system.

Congressman Gallagher says that if BoB comes back with a request for Congressional approval of a National Data Center, he will request formation of a panel to study all the problems and potentialities, and will withhold approval at least until the panel has thoroughly investigated all aspects of the problem.

Should the Board attempt to enter such a donnybrook? A study by Lance J. Hoffman (a student of Bill Miller) seems to indicate that as yet computer experts have not really looked thoroughly at the problem of protection of privacy. The password system in common use in time sharing systems does fairly well for the purposes it is used for, but could easily be circumvented if the inducement were great. A D. K. Hsiao just this summer got a Ph.D. at the Moore School on a system for giving much better protection against invasion of privacy. I spoke to his thesis director, Professor Noah Prywes, who says that Dr. Hsiao now has his protection procedure in operation within a larger problem solving system that Professor Prywes is developing. Dr. Hsiao will stay at the Moore School next year to continue work with Professor Prywes.

Professor Alan Westin, a member of our Board, is the author of "Privacy and Freedom." He states, and I agree, that protection of privacy can be assured only by controls on the operators as well as constraints within the computers. However, with suitable constraints within the computers, imposition of controls on the operators will be facilitated.

A properly constituted Panel might be able to find a practical combination of computer constraints and controls on humans that would assure even Congressman Gallagher of protection of privacy. One thing that would almost certainly have to be done would be licensing of computer operators, perhaps after the fashion of CPA's. I talked to Donn B. Parker, Chairman of the Professional Standards and Practices Committee of ACM. He says that plans have been proposed for requiring statements of intent to be signed by state-employed programmers in California.

Any of the people mentioned in this discussion might be prospects for members of the Panel, namely Ruggles, Dunn, Kaysen, Aiken, Hoffman, Miller, Hsiao, Prywes, Westin, Parker (perhaps even Congressman Gallagher!). In addition, Launor Carter, Ithiel Pool, Paul Armer, and Paul Baran are experienced in the area.

With two Panels now in operation, and two under consideration, I have not given much thought to areas for further Panels. The FCC has just had a course of instruction in computer lore from a group appointed by ACM, so that perhaps the problem of communications is not currently urgent. The revision of the copyright laws was recently postponed for a year or two, pending further study. We should check if ACM has an active committee ready to supply testimony; if so, a separate Panel of our Board would likely not be needed. The discussion at the September 10 Executive Session may cast light on the urgency of considering a National Computer Institute. The question of relaxation of secrecy restraints on hardware advances is probably contingent upon export controls for computers. Perhaps it can be fielded to that Panel, or perhaps that Panel can be reorganized for the purpose if it finishes its study of export controls fairly soon.

NATIONAL ACADEMY OF ENGINEERING-NATIONAL RESEARCH COUNCIL

Advisory Panel to
Center for Computer Sciences and Technology
Institute for Applied Technology
National Bureau of Standards

*Chairman's Final Report of 1967-68 Panel

This Panel, as constituted in February 1967, after some delay occasioned by the departure of the first Center Director, Mr. Norman J. Ream, comprised the following:

Dr. William W. Eaton, Chairman
1523 L. Street, N. W.
Washington, D. C. 20005

Mr. John Diebold, President
The Diebold Group, Inc.
430 Park Avenue
New York, New York 10022

Professor Robert Fano**
Director, Project MAC
Massachusetts Inst. of Technology
Boston, Massachusetts 02139

Mr. Robert B. Forest
Editor, DATAMATION
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Professor Walter Frese
Harvard Business School
Harvard University
Cambridge, Massachusetts 02138

Mr. James D. Gallagher, Vice Pres.
McCall Information Service
McCall Corporation
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Dr. Cuthbert C. Hurd
Chairman, Board of Directors
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Dr. Adrian McDonough
Professor of Industry
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Dr. Jack Moshman, Managing Dir.***
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Graduate School of Business Admin.
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Los Angeles, California 90007

Professor John Tukey
Department of Mathematics
Princeton University
Princeton, New Jersey 08540

Dr. Willis H. Ware
The RAND Corporation
1700 Main Street
Santa Monica, California 74089

*NOTE: Time did not permit checking this report with the Panel members.
**Dr. Fano resigned as of June 29, 1967.
***Now Vice-President, LEASCO Documentation.

RECEIVED
SEP 1 8 1968
KENNETH H. OLSEN

The RAND Corporation
1700 MAIN ST. • SANTA MONICA • CALIFORNIA 90406

21 June 1968 L-12082

Mr. Warren House
Executive Secretary
Computer Science and Engineering Board
National Academy of Sciences
2101 Constitution Avenue
Washington, D.C.

Dear Mr. House:

Professor Anthony Oettinger asked me to send you permission to distribute copies of my manuscript, "Social Research and the Evolution of Laws," to the members of the Computer Science and Engineering Board of the National Academy of Sciences. I am glad to grant permission but with one request, since I am preparing to revise the manuscript. Could you please add the following note to the title page, wherever there is space:

"CRITICAL COMMENTS WELCOMED:
c/o Mathematics Department
The RAND Corporation — until 1 September 1968
1700 Main Street
Santa Monica, California 90406

Adams House G-31
Harvard University — after 1 September 1968
Cambridge, Massachusetts 02138

Thank you very much.

Sincerely,

Joel E. Cohen

Joel E. Cohen

JEC:mbh

W.H.: PLEASE Distribute to COSEB (only if Cohen gives permission) Thanks! [signature]

For Prof. Oettinger (I'll appreciate criticism) Joel

3

6288

SOCIAL RESEARCH AND THE EVOLUTION OF LAWS

Joel E. Cohen

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Government 260 | Harvard University

Seminar: Science and Public Policy | April 1968

DRAFT ONLY: PLEASE DO NOT CITE OR QUOTE WITHOUT PERMISSION

SOCIAL RESEARCH AND THE EVOLUTION OF LAWS

SOCIAL RESEARCH AND THE EVOLUTION OF LAWS

SUMMARY

One of the clearest and most useful pictures in the vast literature on the dealings of a government with scientists is due to Don K. Price. The scientists in his picture of four estates are mostly natural scientists, however, and the change in government due to the discoveries of the natural scientists is slow enough at any particular moment that the government may be taken as static and given.

When social scientists join their natural colleagues, they immediately make the government itself an object of study. Like Keynesian economics, certain developed or embryonic social theories may affect radically the procedure and even the goals of the government which supports or encourages the development of these theories. These theories deal, for example, with cost-benefit accounting, manpower flows, election predictions, and social and demographic effects of technological change.

If theoretical inventions in these social areas are analytical and predictive in form, are based on adequate data, and involve variables which are accessible to control or influence, then, unlike many inventions in the natural sciences, these theories (1) can affect directly and immediately virtually any other research, development, or action program in which people are involved; (2) can affect the structure, performance, and

purposes of the very organization, the government, which allots the resources for their own future development; and (3) can take massive effect relatively quickly. The potency of social as compared to other kinds of technological inventions within cultural change is something like the potency of Lamarckian as opposed to Darwinian evolution in a gene pool.

At present the United States Congress both expects social sciences to help solve some of its most urgent problems and fears the potential power of social technologies. Congress is as suspicious of the possible use of social science to produce a "socialized, integrated, scientific world organization" as the scientist J. D. Bernal was hopeful of that use and outcome. However, no credible social theory is now comprehensive enough to pronounce universally in favor of monolithic unification as opposed to decentralized diversification.

The existence of certain social theories potent in effecting social change does suggest picturing the functional relations among scientists and government and Price's other estates as a nested set of feedback loops in which the different sciences affect and are affected by the shape of government at different rates. From a certain point of view, this functional picture includes Price's picture of constitutional responsibilities, which emphasized the natural sciences. The practical effect of this enlarged picture is to suggest how intimately involved adequate social theories can and increasingly must be in aiding laws, as determined by government, to guide society.

PRICE'S FOUR ESTATES

In his book on The Scientific Estate, Don K. Price distinguishes four broad functions in government and public affairs--the scientific, the professional, the administrative, and the political. (See Figure 1.) These functions, Price says,

> are by no means sharply distinguished from one another even in theory, but fall along a gradation or spectrum within our political system. At one end of the spectrum, pure science is concerned with knowledge and truth; at the other end, pure politics is concerned with power and action. But neither ever exists in its pure form.[1]

Of the estates between pure science and pure politics, Price says,

> The professions (for example, engineering and medicine) make tremendous use of the findings of the sciences, but they add something more: a purpose. . . . Each is organized around a combination of a social purpose and a body of knowledge, much of it drawn from science. . . . [The general administrator's responsibility] is not restricted to some special aspect of an organization's affairs that is related to a special body of knowledge or a special type of training, and it is more difficult for him to define a sense of obligation to a professional purpose that to some degree transcends the purposes of his employer. He is obliged to deal with all aspects of the concrete problems that his organization faces, and for that reason his education--no matter how thorough and useful it may be--cannot be reduced to a specific discipline or a restricted field.[2]

Price formulates a twofold principle of freedom and responsibility which is partly descriptive but also partly prescriptive of the constitutional relations among the four

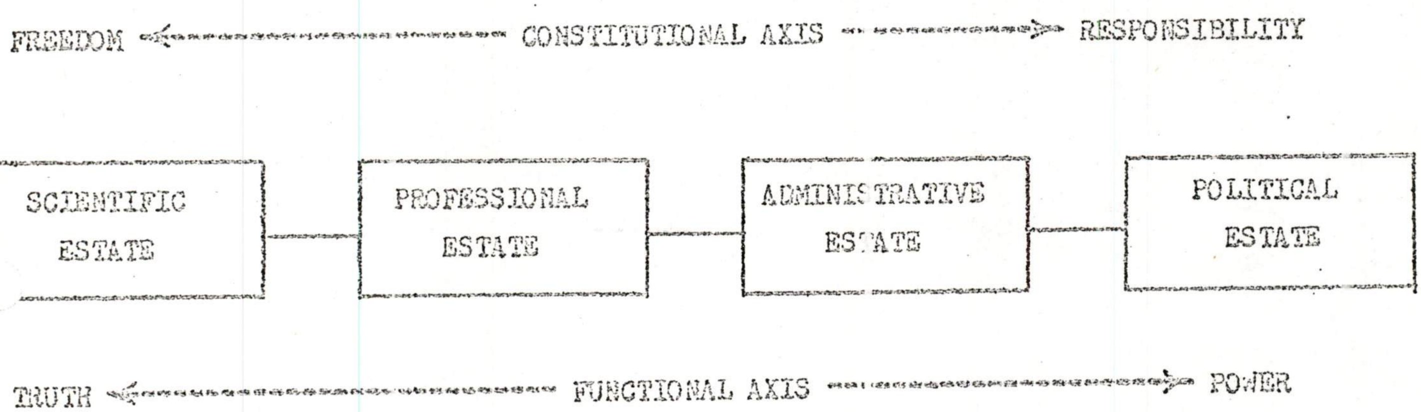

Figure 1. Sketch of Price's schema of the four estates.

estates in the United States. It runs as follows:

> (1) [T]he closer the estate is to the end of the spectrum that is concerned solely with truth, the more it is entitled to freedom and self-government; and (2) the closer it gets to the exercise of power, the less it is permitted to organize itself as a corporate entity, and the more it is required to submit to the test of political responsibility, in the sense of submitting to the ultimate decision of the electorate.[3]

Price claims that the four estates will be found in any technologically advanced country because they are functions which the government must fulfill. Their respective quotas of freedom and responsibility in America are, Price says,

> plausible only on the basis of certain historic political assumptions.[4] . . . although the way in which scientific knowledge is related to political purpose seems to require the existence of something like our four estates, it by no means requires the relationship among them that is conventional in the Western constitutional tradition.[5]

DOMINANCE OF THE NATURAL SCIENCES

Price talks primarily about physical and biomedical science, with the emphasis on the former. The relatively greater scientific maturity of the natural sciences, their recent roles in support of national security, prestige, and welfare, and their contributions through technology to methods of production easily account for the predominance of the natural sciences in academic and political thinking about the social roles of science.

Thus, J. D. Bernal discoursing in 1939 on The Social Function of Science declared: "The indirect effect of science through its inexorable influence on productive methods is now, and is likely for long to remain, its most important form of influence."[6] And, as recently as 1967, Eugene B. Skolnikoff could write in Science, Technology, and American Foreign Policy: ". . . the focus of interest in this analysis is the interaction of the physical and life sciences with foreign affairs. . . . Accordingly, the term science is not intended to include the social sciences." There is only one index reference to the social sciences in the book. (While Skolnikoff, himself a social scientist, could leave aside the social sciences, he didn't want to talk himself out of the picture. So on the very next page he writes: "For this analysis, scientists are considered to be those individuals engaged in basic or applied research . . . The term will be meant to encompass not only scientists in physical and life science fields, but also those in the social sciences."[8])

ENTER THE SOCIAL SCIENCES

I think the rise of the social sciences may require a further development of Price's picture of the interactions among the four estates of government. It is not Price's description of the constitutional relations among the four estates—their allotments of freedom and responsibility—but his account of how the estates function together that I want to reconsider.

In his history of Science in the Federal Government, Duprée records that "[o]ne change during the 1920's affected the government's scientific establishment out of all proportion to the money spent. The social sciences for the first time appeared as a distinct entity animating whole research activities."[9] Duprée cites the Bureau of the Census, the Bureau of Labor Statistics, and the Bureau of Agricultural Economics as early social science agencies. Immediately, Duprée observes, one of the main effects

> of the rise of the social sciences on the federal establishment was the beginning of the systematic study of that structure as an object in itself. In the past, natural scientists closely associated with the government had speculated in a random way--sometimes with great acuteness--on research as a function of the state and on the forms in which it might be organized. The social scientists had begun to make their appearance among those interested in parts of the federal research structure by the time Irving Fisher issued his report on National Vitality in 1909. But only after World War I did the social science of the country muster enough personnel, technical ability, and interest to tackle the federal government as an institution worthy of systematic study.[10]

The full history of science in the federal government since 1940, when Duprée's study stops, has yet to be written. When it is written, it will have to signalize one event which Bernard Brodie has described as "of critical importance." After World War II, the Air Force set up the RAND Corporation.

> The initial interest of the Air Force in the RAND Corporation was no doubt primarily for the sake of technological advice,

> and thus the physics division and the several kinds of engineering divisions were basic. But those who organized RAND included in it at the outset a division of mathematics and within two years divisions also of economics and social science.[11]

The critical importance of including the economists, Brodie says, was that they developed the methods of cost-effectiveness analysis which were crucial to strategic choices of weapons systems.

Those methods of cost-effectiveness analysis may also be crucial in ways closer to the hearts of the RAND Corporation and the other social scientists who developed and refined them. Just as the early social scientists studied the government, so now the government returns the compliment by suggesting that the economists' methods of cost-benefit analysis be applied to the government's research and development programs. In 1966, the House Committee on Government Operations reported its recommendations on the decision-making process in federal research and development programs. One of the Committee's recommendations was that the Executive Office should use the cost-benefit approach, wielded so successfully by the Pentagon, in evaluating major research and development proposals and "should initiate studies by economists and scientists to work toward improved cost-benefit analysis of research and development, both within programs and among competing programs."[12] Further, said the Committee on Government Operations,

> In addition to its failure systematically to consider the costs and benefits of major R. & D. proposals, the Executive Office has done little to assess the costs (in relation to

> benefits) to the Nation of maintaining a high concentration of Federal R. & D. in the defense, space, and atomic energy programs. Informed and distinguished critics have long called attention to these costs, but they remain largely unanswered.[13]

Called upon to evaluate the House recommendations, the Committee on Science and Public Policy of the National Academy of Sciences responded with 1967 with a very nicely argued explanation of the limitations of "optimizing" basic research by cost-benefit analysis.[14]

Reluctant as the natural scientists were to be overrun by a sorcerer's apprentice of the social scientists" devising, a number of the most distinguished of the natural scientists had already, in another context, raised the question of the conscious and purportedly rational allocation of research resources. The 1965 study by the Office of Science and Technology of Biomedical Science and its Administration at the National Institutes of Health flatly declared:

> It is not clear to us that the approximate 2:1 funding ratio between mental health and neurology, or the 6:1 ratio between arthritis and dental science, for example, are so related both to national need and to scientific opportunity as to maximize the benefits of the over-all expenditures in terms of improved health and longevity.[15]

This story of cost-benefit analysis reveals what engineers call a feedback loop. The government discovers in World War II that it needs the results of large-scale, institutionalized scientific research. It sets up a research institute. The researchers there provide the government with a tool for evaluating and comparing programs. Since one set of its programs is research, the government wants to apply that tool to research. If cost-benefit analysis is applied to research and development activities, some discoveries will be made which might not have been made otherwise, and other discoveries will remain unmade which might have seen light under a different allotment of research resources. Among the discoveries which are made may be some which, when again cycled through the government, may again return in one way or another to affect or guide the discoverers.

An important characteristic of cost-benefit analysis as an invention is that it is a procedure for manipulating symbols (not, like a computer, a mechanization of that procedure) which is based on and provides insight into the operation of a complicated system. It is not a solid-state device, or a clever miniaturization of circuits, a weapon or a cure.

Keynesian economic theory is another such invention. It indicates quantitative relations among social variables and points to those which are important for measurement and control.

SOCIAL THEORIES WITH POSSIBLE FEEDBACK EFFECTS

Some examples of less well known social theories will emphasize the potency of such inventions in a feedback loop with government.

Doctoral education. Bolt, Koltun, and Levine[16] developed a model for the flow of men holding doctorates in science and engineering between and out of the two broad functional categories, or "estates," of graduate education and other professional activities. They showed how future stocks of doctorates in educational and professional functions could be predicted from difference equations involving as parameters (1) the rate of return of new doctorates into colleges and universities for employment; (2) the average productivity by faculty holding doctorates of new doctorates; (3) the rate of flow of faculty holding doctorates to employment outside colleges and universities; and (4) the rate of attrition in the stock of doctorates due to retirement, death and other causes. They estimated values for these parameters from recent American data and displayed the different strategies available to a policy-maker who wanted the country to be able, say, to produce twice as many doctorates per year in ten years as it does now. These strategies depend on influencing appropriately the values of the four parameters.

Analysis showed, for example, in the case of doctorates in mathematics, that influencing the rate of return of new doctorates to universities for employment could not possibly lead to the desired level of doctoral production, but that other strategies were available.

The model is sufficiently convincing, and easy enough to present to nontechnical people, that it has been adopted as a background for policy judgments within the government. While the model links previously fragmentary and unrelated manpower data, it also emphasizes gaps in those data. Bolt et al. conclude that "this and similar dynamic models of social systems can serve not only to aid in the development of policy but also to guide the collection of statistical information necessary to undergird policy with a solid factual base."[16]

Here the feedback loop is again clear. Bolt, the creator of the analytical model, is a former physicist turned M.I.T. political scientist. Working in and with the National Science Foundation, he does a piece of research which, through the government, affects strongly the future training of men in just those analytical skills which make his invention possible.

Voting predictions. Much has been said and written on the possible effects of publishing polls and predictions about election results. An announcement that 49 percent of voters say they will vote for candidate A and 51 percent say they will vote for candidate B may reverse an election's outcome if substantial sympathy for the underdog results, or may misleadingly widen A's margin of loss if voters jump on B's bandwagon. The problem has worsened lately with the use of computers to tabulate election returns on the day of the election and to project final outcomes before all votes are in. Since the television and radio networks broadcast the East Coast tabulations and projections to the West Coast, where voting stations remain open several hours later, the West Coast votes may be substantially affected. This problem, which has been especially acute in recent presidential elections, has generated much Congressional and judicial discussion about possible remedies.[17]

Unnoticed in the discussion is a bit of theory by Herbert A. Simon[18] which points to exactly the information needed to pick a proper policy (presumably one that assures that elections turn out the way they would have without the interference of polls, predictions, and projections). Simon proves by the use of a mathematical result known as a fixed-point theorem that if the net effect of publication of a prediction or projection may be characterized as a bandwagon effect or an underdog effect (increasing or decreasing the actual percentage voting for the candidate predicted to win in comparison to the percentage voting for him without the poll's publication) then it is always possible to adjust the prediction before its publication so that the published prediction will in fact be correct. If a bandwagon effect is the consequence of publishing a prediction, Simon proves, then publication can have no effect on the (win-loss) outcome of the election, although alteration of the published prediction can but need not alter the outcome of the election. On the other hand, if an underdog effect is the consequence of publishing a prediction, failure to adjust the published prediction to take account of that effect can actually reverse the outcome of the election, while such an adjustment (accurately done) cannot reverse the outcome of the election.

From Simon's analysis, it obviously becomes crucial to know whether the effect on the American voting public of publishing predictions is bandwagon or underdog. If publication causes a bandwagon effect, then it causes no harm (in two-way elections, though it might in three-way elections). If publication causes an underdog effect, either publication must be banned or a sufficiently accurate knowledge of the reaction function of the public must be obtained to enable prior adjustment of the prediction so that it is in fact confirmed. The latter course may seem risky to those familiar with the uncertainties of measuring and predicting mass behavior, and perhaps less desirable than a few-hour restriction on the press (in spite of the First Amendment). At least Simon's analysis makes clear the kind of information needed to formulate policy; and survey and opinion research centers exist at American universities to gather just such information.

Technological change and human ecology. A theory which linked economic and sociological changes consequent to the introduction of a new technology would be another area of theory of enormous potential importance. Harold A. Thomas, Jr. has developed such theory for a tribe of hunter-gatherers in southern Africa.[19] On the basis of data on the !Kung tribe gathered by Richard Lee,[20] Thomas constructs a production function of food. The two parameters of the production function refer to (1) efficiency of work, and (2) areal productivity of land. Thomas estimates the shift in the production function which follows from the introduction of iron arrow tips. Assuming the tribesmen optimize a utility function which depends linearly only on their population size, their rate of work, and the average productivity of their work, Thomas predicts approximately the increase in food production, the decrease in the rate of work and the increase in tribal population.

Better diet and greater longevity require calculable adjustments in the frequency of child-bearing (which is already rigidly controlled by abstinence, abortion and infanticide) if the population is to remain stable at its new level. Thus Thomas moves from arrowheads to sex life with an analytical model and a reasonable hope of prediction.

It remains to be seen whether further data on the !Kung will confirm the details of Thomas's analysis and, more importantly, whether his procedures generalize to vastly more complicated interactions of technological innovation with human ecology. What is important in his attempt is its clear analytical style and its demonstration that such calculations are possible. Obviously, such calculations, were they reliable, would be crucial in guiding a government in the choice of large-scale technologies for support and development.

Two more examples of areas in which useful analytical theory is still more embryonic but of enormous potential importance are first, bureaucratic and administrative behavior and organization, and second, persuasion and influence, whether of individuals, small groups, or masses. The techniques of persuasion a government uses to build popular support for its space or welfare programs might also influence popular support for research, even research on the subject of persuasion. And the techniques might be most effectively employed by a bureaucracy whose structure was based on some fundamental understanding of bureaucratic structure. Beginnings are being made in these directions.[21]

The theories that exist or are called for in these areas are what Merton[22] calls theories of the middle range, but they differ crucially from the verbal theories that seem pandemic in sociology. The variables involved in the theories mentioned above are not only measurable in the sense that their magnitudes can be inferred from some observations, but, unlike those of many current sociological explanations, they are, or will have to be, at least partially accessible to control.

In a polite but effective indictment of the utility of some sociological theories, a professor of public health looking for guidance as to the social etiology and ecology of disease found that

> If public health were to act upon the information thus obtained [from sociology], it would, among other things, have to upgrade social class, eliminate status incongruity and occupational stress, selectively control both geographic and social mobility, make cities into country farms, improve family incomes, shepherd groups through culture change, maximize the individual's acceptance of his life situation, prevent social isolation, and provide a value basis for choosing whether one's parents should or should not be church-going people.[23]

Mouthwash will not take the place of usable theory. Neither will sheer statistics. The necessity to develop social theory along with social information and "social indicators" is clearly appreciate by Raymond A. Bauer:

> General models of social systems exist, as do models of the American social system. It is safe to say, however, that all of them require considerable development and refinement before one could use them to plan developments in the noneconomic sector with any degree of precision.[24]

HOW SOCIAL SCIENCES (AND SOCIAL THEORIES) CAN AFFECT GOVERNMENT

The familiar feedback loop between a thermostat and a home furnace which keeps the house at a steady temperature is stable. The information from the thermostat returns the temperature to some constant state. The feedback loop between social science research and government is destabilizing. The information from government-supported or government-adopted research alters the structure and behavior of the government, which alters the research that gets supported or adopted, and so on, around and around.

An understanding of social operation may not only condition the success or failure of social programs, but may condition the goals of those programs. If it is ridiculous to pass a law against material objects attracting each other with a force that varies inversely as the square of their distance, it is equally ridiculous to pass a law against people liking the sight of nubile girls in cigarette advertising. An understanding of social mechanisms, implicit or explicit, must accompany any successful effort at control (barring pure luck).[25] Today the understanding of the practicing politician, the administrator, and the scientist attempting to influence government policy, is mostly implicit; as their goals become increasingly complicated and conflicting, their understanding will have to be more explicit.[26]

Three characteristics of the examples given in the preceding section are outstanding. First, the social scientific findings can affect directly and immediately a broad range of other research, development, and action programs. Second, they can affect the structure and performance of the very organization, the government, which allots the resources for their own future development. Third, they can take effect relatively quickly, so that a man's discoveries can return to influence his own future discoveries well within his working lifetime.

The other sciences in which the government is involved, the kinds in Price's scientific estate, do not seem to share all three of these characteristics. For example, the government's investment in land-grant colleges and agricultural research in the nineteenth century has, it is true, removed the problem of producing enough food in this country and freed most of the population from the soil, thereby making available resources for other programs; but this agricultural success has not determined the shape of other programs, has released resources to them only over a long period of time, and has not greatly affected the procedure by which future decisions regarding agricultural research are made.

Similarly, the discoveries in the physical sciences and technologies have affected a broad range of other research, development, and action programs for the most part indirectly or obliquely. Alvin Weinberg[27] has listed a number of ingenious "technological fixes" to social problems: for example, using atomic power to desalt ocean water to irrigate land to provide more food to sidestep or allay an exploding population.

Such a device, Weinberg admits, is mainly good for buying time; and since time may be important in convincing people that they want to limit the number of children they have, such a device may be crucial. Yet this technological approach does not say what is a desirable range of population sizes, nor how to convince people to have less children during the time that it buys; nor does it affect, except through providing time, the ways a government makes decisions about its population control or atomic energy programs.[28] The influence of the knowledge of the laws of physics on the structure of the social institutions which apply those laws is very indirect.

17.

A BIOLOGICAL ANALOGY

A biological analogy may be suggestive. An animal species, such as man, and its environment, including other species, form a coupled system. The environment selects certain members of the species to survive long enough to reproduce and influences the way the species will evolve. But the species also affects the way the environment will change by what it does to the other species, what it puts into or extracts from the atmosphere, the soil and the seas. Ordinarily, this interaction is rather slow-paced and indirect, because according to Darwinian theory and much evidence the environment's only means of affecting evolution is by determining who reproduces and who does not. Think how much faster change could occur if, as Lamarck supposed, animals could adapt within their lifetimes and pass on their adaptations to their offspring. Anthropologists are familiar with the cliché that man has progressed from biological evolution to cultural evolution, that man's tremendous capacity to learn and to transmit culture over generations enables him to modify his life faster than Darwinian selection ever could. Within the the process of cultural change, I suggest, the action of physical laws on the social structures which apply them is usually of the Darwinian sort; whereas the action of an understanding of social functioning is more likely to be of the Lamarckian sort.

PRESENT RELATIONS OF GOVERNMENT AND SOCIAL SCIENCE

In order to speculate on possible future relations between government and social science in this country, it seems reasonable to start with some view of their present relations. Among the many aspects of those relations which the following sketch will exclude are those relating to the founding of a National Social Science Foundation,[29] the roles of social scientific findings in judicial decisions on the Constitutionality of racial segregation and tracking (segregation by performance on standardized tests) in public schools, and the roles of many recent "social scientific" reports in prompting, or failing to prompt, executive action on social problems. Massive case studies of each of these and other excluded aspects would, I think, reinforce the general conclusions drawn below.

In the second progress report (1966) of the Subcommittee on Science, Research, and Development of the House Committee on Science and Astronautics, the members of Congress manifested a curiously ambivalent lusting after the favors of social science and a fear of her power. On the positive side, the subcommittee noted with pride that it had

> recommended adequate representation of industry, nonprofits, small colleges, and social scientists on the National Science Board [of the National Science Foundation]. . . . Dr. Ralph W. Tyler, director for advanced studies in the behavioral sciences at Stanford University, was elected as Vice Chairman of the Board, representing the first time in the Board's history that a social scientist has held that post.[30]

Further, in its statement of requirements on government in the future, the subcommittee concluded:

> We are further convinced that governmental effectiveness in coping with the big issues of the future will require two special attributes:
>
> (1) An ability on the part of the Government, and particularly the Congress, to see and cope with each problem in its entirety--to deal with each as a complete system and to treat the entire syndrome rather than isolated phases of it. A current example is pollution, a large ecological systems problem, which must depend for its solution not only on science and technology, but on political considerations, judicial and legal situations, economic and tax factors, public relations, interstate and international cooperation and industrial evolution, together with the involvement of social scientists in certain preliminary stages of planning.
>
> (2) A willingness to encourage and support approaches to the problems of the future which will join the social sciences

> with physical sciences and engineering, and which will make use of their combined powers. The necessity for this appears obvious when one looks closely at the difficulties facing modern society. Few of them will be eliminated by the application of technology alone. In many instances, in fact, we need to know a great deal more about the behavior and motivations of humanity--individually and collectively--than we now know in order to apply our growing technology with accuracy and maximum results.[31]

Six pages later, the same subcommittee looked at another side of the social sciences:

> We are concerned about the inroads against personal liberty which may be inherent in [the] application [of social sciences and electronic techniques of observation]--and about their constantly increasing potential for the invasion of personal privacy. This means more than invading the person or the senses. It also means invading the mind and personality by unconscious exposure to or direction by the machine or certain social science techniques. . . . one must be wary of the day when a magnetic public personality, provided with sufficient funds to place his image electronically before the populace as often as the psychologically programed computers dictate, will automatically be guaranteed election. Somehow we must not let technology deaden our capacity for thought, for perception, for reason and understanding.[32]

BERNAL'S VIEW

That is the United States Congress speaking. Its hopes for, and fears of, the social sciences reflect a very strong and potentially influential appreciation of what the social sciences can do for and to government. Like the U. S. Congress, J. D. Bernal also hoped society would take advantage of science's integrating and systematizing power when he wrote:

> It is the function of science to study man as much as nature, to discover the significance and direction of social movements and social needs. The tragedy of man has too often lain in his very success in achieving what he imagined to be his objects. Science, through its capacity for looking ahead and comprehending at the same time many aspects of a problem, should be able to determine far more clearly which are the real and which the phantastic elements of personal and social desires.[33]

But the attitudes of the U. S. Congress and the Marxist Bernal toward the political framework within which the social sciences will best come to fruition are vastly different. The members of Congress would not easily accept Bernal's claim that "Only in a socialized economy effectively concerned with providing maximal welfare can the full development of the social sciences be expected, for there they needs must become in practice and theory an integral part of the machinery of communal life."[34] Not all the members of Congress might favor this assertion by Bernal:

> The freedom of the nineteenth century was a seeming thing. It was an absence of a knowledge of necessity. Its basis lay in social relations through a market. In liberal theory every man should be free to do what he liked with his own, buy or sell, work or idle. In fact he was tied by the iron laws of economics; laws socially produced but taken as laws of nature because they were not understood. In an integrated and conscious society this conception of freedom is bound to be replaced by another--freedom as the understanding of necessity.[35]

The Congress may often vote the tax changes suggested through the President by the Keynesians in the Council of Economic Advisers, but it prefers to exercise choice without thinking of "iron laws of economics." Certainly in the domain of social laws and social control, the Congress is not attracted by the prospect of central integration through the social sciences that so attracts Bernal: "Science implies a unified and coordinated and, above all, conscious control of the whole of social life . . . Henceforth society is subject only to the limitations it imposes on itself. . . . The socialized, integrated, scientific world organization is coming."[36] Bernal here assumes in advance that social science will show that globally coordinated unification is the best social organization for all future political choices.

If the Congress supports the development of the social sciences, must it also acquiesce to a society so centrally integrated that the freedoms of the citizen and of the Congress are endangered? No credible social theory yet exists to answer that question. For certain purposes, decentralized political choice and scientific research may be highly desirable. A diversity of societies and cultures, and a diversity of social scientific endeavors coupled to them is, for example, the evolutionary version of not putting all your eggs in one basket; and this is often a better strategy than monolithic uniformity in a rapidly and unpredictably changing environment.[37] But in insisting that social life and social organization be approached more self-consciously, Bernal desires the inevitable, if political choice and social sciences continue to be coupled.

A FLOW CHART OF INFLUENCE

Evolutionary biologists and comparative cultural anthropologists know that species and so-called primitive societies solve apparently similar ecological problems in a variety of ways. If an extrapolation to more complex societies has any validity, it is likely that technologically advanced societies can arrange the relations between their natural and social scientific endeavors and their political functioning in more than one way. Here it is necessary to return to Price's picture of the four estates.

When Price labels the axis from science to politics as the axis from freedom to responsibility, it is clear that he wants to describe informally the constitutional arrangement, that is, the assignment of social responsibility, of the four estates in the United States. He makes explicit that this allocation of social responsibility is in no sense necessary, and points out that other, notably socialist, countries have very different constitutional arrangements.

When Price relabels the line from science to politics as moving from truth to power, he seems to suggest a sort of epistemological or functional schema, according to which quantities of truth and influence move in the proper directions from one estate to the next.

The examples gives above suggest that the strong coupling of political choice and the social sciences into a feedback system makes a linear picture inadequate to represent the system of mutual influence.

In a picture (see Figure 2) fully as rough and approximate as Price's, imagine a circular loop with arrows pointing in a clockwise direction. At the 12 o"clock position stands the political estate. At the 3 á'clock position stands the administrative estate, which translates what the political estate wants to understand to the scientific estate (standing at 6 o'clock) and supplies it with resources to find out. The scientific estate investigates where resources are available and feeds the results directly back to the government, as in the case of cost-benefit analysis.

Around this first circle is a larger circle tangent to it as the 12 o'clock position, thus going through the same political estate. At the 3 and 6 o'clock positions are respectively administrative and scientific estates, as in the first loop, but in addition at the 9 o'clock position is the professional estate. If the social applications of the science generated in this loop are clear in advance, the new findings are forwarded immediately to the professional estate and put into practice: as, for example, when someone at NIH finds a cure for a disease and passes the word to the medical profession. The findings of the scientists at 6 o'clock affect the purposes and forms of politics at 12 o'clock through the activities of the professionals. The engineers who made possible the massive pollution of the East Coast and the physicians who contributed to the public expectation of reasonable health, including clean air, were among the forces producing new interstate political alliances to control pollution.[38]

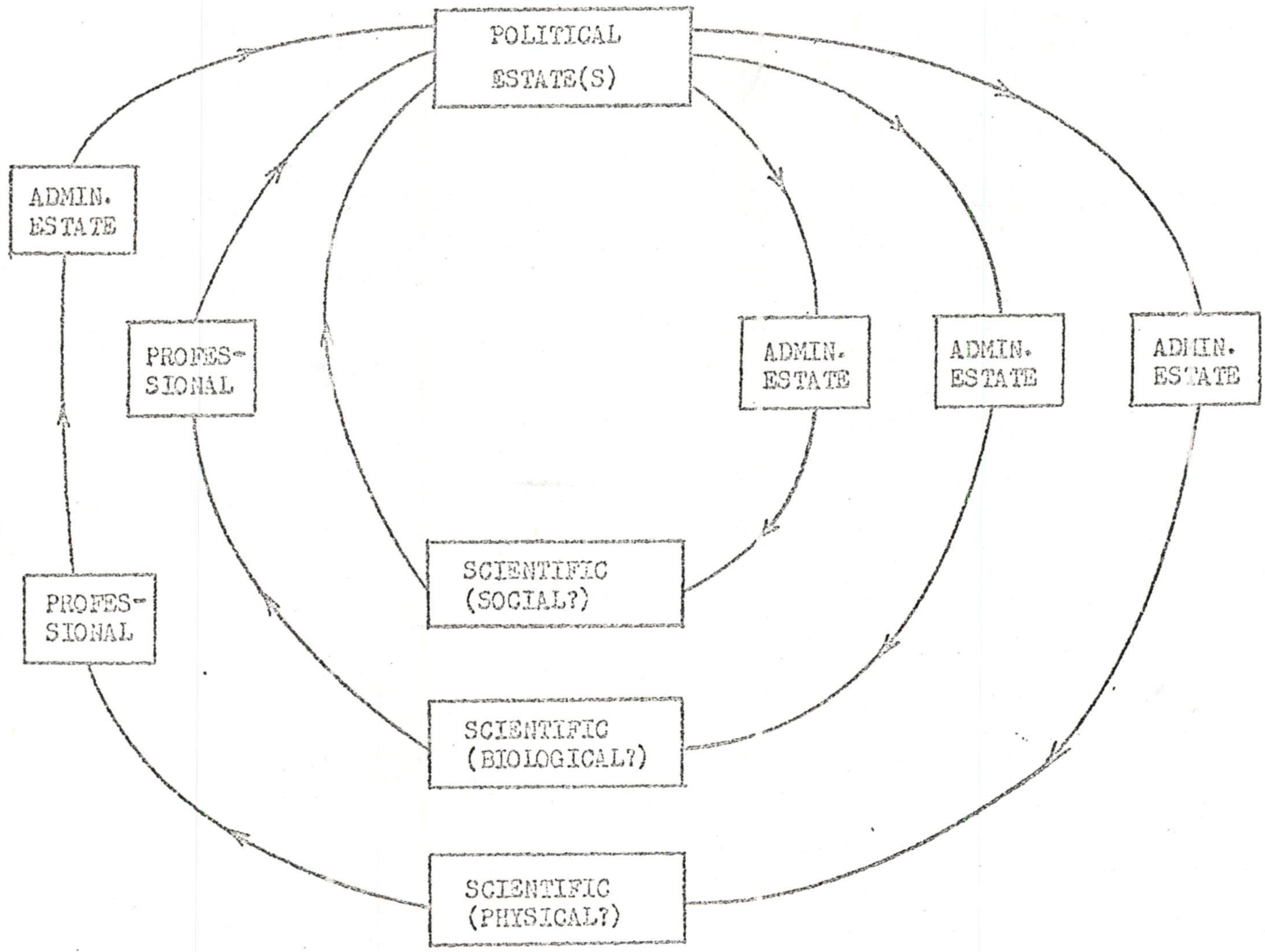

Figure 2. Proposed functional schema: a nested set of feedback loops.

Around both of these circles is a still larger one tangent to both of them at the 12 o'clock position, again going through the same political estate. Administration and science have their usual posts at 3 and 6 o'clock. At 8 o'clock are the professions, and, at 10 o'clock, another bunch of administrators again. From the point of view of the scientist at 6 o'clock in this loop, the 3 o'clock administrators are afferent, or input, affecting which problem areas will get support, while the 10 o'clock administrators are efferent, or output, determining how his scientific findings and the skills of the professionals will be used to carry out the initial political purposes.

The point of view of the politician in this outer loop is not quite so simple, for the administrators on both sides of him are supposed to carry out his purposes. The 3 o'clock administrators facilitate large scale changes in basic understanding. The administrators at 10 o'clock carry out purposes with the principles and skills made available by the scientists and professionals. The administrators at 10 o'clock produce large-scale changes in the society and influence the political framework in which future choices are made.

In the science of this outer loop belong, I think, most of the physical scientific and technological research that Price has in mind for his scientific estate. I put it on the outside to suggest that the time this science requires to effect a change in the structure and purpose of the political estate may be relatively longer than that of the science on the inner loop, and that its influence is mediated through other estates.

(This is the Darwinian kind of selection mentioned earlier.) In the science of the inner loop I would place the social sciences, including economics, whose effects can be most immediate.

To show how nonrigorous this assignment of sciences to inner and outer loops is, here are two counterexamples. The discovery by physical scientists of new means of detecting violations of a test ban treaty immediately opened new political possibilities to the American and Russian negotiators of a test ban treaty. Here is physical science on the inside loop. (It could also be argued that since the discovery did not really alter the ultimate intent or procedure of the negotiators, it still belongs on the outside loop.) On the other hand, if government-supported studies of public education affect differentially who gets educated and with what quality, within a generation or two there will be a differential effect on the personnel in the government and on the kind of scientific and action programs they are inclined to support. (There will also, incidentally, be a differential effect on the pool of people from whom educational sociologists are drawn.) Here is a slow (outer loop) effect of social science.

The separation of activities into these three loops is not meant to suggest that there are basic functional differences among them, but only differences in subject matter, time scale, and degree of institutional differentiation. Whereas a social scientist may be a fundamental researcher, interpreter to politicians, and administrator of a resulting project, these jobs are perhaps more often divided among different men on the outer loop.

The lumping of the entire political estate into one box is not meant to deny that there are camps within the politicians, some of whom have NASA as their preferred clients and some of whom have NIH as theirs, and some of whom have no taste for science or scientists.

Finally, the suggested allotments of different kinds of sciences to different loops is not meant to deny that biology can be directly affected by advances in physics and chemistry, and that social and behavioral sciences can be directly affected by the progress of biology, without the intervention of politicians. The reason for neglecting this interaction here is that it is scientifically "in-house"; the political estates benefit from it, but don't have to deal with it directly.

From the theory of control systems it is known that in a nested set of feedback loops the rate of change of the whole system is limited by the rate of change in the slowest-changing loop. Before the rise of the social sciences, and to a considerable extent even now, the rate of change of the inner loop was nearly zero, so that the inner loop was invisible and the government was nearly static in its interactions with estates on the outer loop.

Once the inner loop picks up enough steam scientifically to surpass the outer loops in rate of substantial change (a distant prospect) then the physical sciences set the limits on the society's rate of change. This arrangement is entirely reasonable if the physical sciences are viewed as mediating between the society and its physical environment, as the principal shaper of its ecology, and if the society can adapt to its environment much more rapidly than the environment can change. At the moment such adaptation is far from common; social change is in fact the prime limitation on the system. Adequate social sciences offer a possibility of improving the situation.

If an administrator moves far off to the right in the 3 o'clock direction in Figure 2, the outer semicircle from science to politics on the left appears to lose its curvature and approximates the spectrum from truth to power of Price. I would guess that Price wrote from this point of view (the social sciences then being virtually invisible), and combined that aspect of the functional schema with what he clearly saw was the constitutional schema. Unless there is some social scientific finding to the contrary, there is no obvious reason why all the administrators performing various functions in various loops in this functional schema cannot be given the apportionment of freedom and responsibility described by Price; similarly for the scientists, professionals, and politicians.

One surprising (to me) aspect of this schema is the preponderance of administrative functions. I can imagine friends of mine in pure research asking, "What politician and what administrator supported the thinking of a Swiss patent clerk that led to the theory of relativity?" I can only answer, "None," and readily admit that the schema is incomplete in at least two major respects. First, science will probably always benefit from the gratuitous discoveries of men free to think for themselves. Another way of saying this is that politicians (like scientists) don't always know what they want to understand, and sometimes it is only after a fundamental advance in understanding that they realize that it was just what they wanted. Moreover, the terms and contexts in which scientists couch their understanding may be very different from those in which the politicians state their problems. It seems fair to estimate, though, that the fraction of all scientific activity in America which is described by this schema has been steadily increasing. Second, political choice will probably always be conditioned by things other than knowledge of the direct and indirect implications of natural and social laws. But as the inner two loops of this schema are filled in, the fraction of all political choices conditioned, if not determined, by the natural and social sciences will, I would guess, rise spectacularly.

LEGAL EVOLUTION

In conclusion, what practical or concrete difference does my picture of the functional relations of the sciences and other estates make? In the social and behavioral sciences there are urgent and difficult problems of individual privacy, experimentation with humans, and computer-integrated national personnel files.[39] The general views presented here do not suggest ready solutions to these problems, but point to the need for a greater understanding of the likely consequences of the possible policy choices. Greater knowledge will not necessarily solve the problems but it can make the alternatives broader and the restrictions on choice clearer.

This conception of the marriage of the social and other sciences with the political and other estates of government has grander goods to offer beyond the immediate present. In an article called "The Speech of Justice,"[10] Learned Hand stated "[t]wo conditions [which] are essential to the realization of justice according to law. The law," he wrote

> must have an authority supreme over the will of the individual, and such an authority can arise only from a background of social acquiescence, which gives it the voice of indefinitely greater numbers than those of its expositors. . . . The pious traditionalism of the law has its roots in a sound conviction of this necessity; it must be content to lag behind the best inspiration of its time until it feels behind it the weight of such general acceptance as will give sanction to its pretension to unquestioned dictation. Yet with this piety must go a taste for courageous experiment, by which alone the law has been built as we have it, an indubitable structure, organic and living. It is in this aspect that the profession of the law is in danger of failing in times like our own when deep changes are taking place in the convictions of men. It is not as the priests of a completed revelation that the living successors of past lawmakers can most truly show their reverence or continue the traditions which they affect to regard. If they forget their pragmatic origin, they omit the most pregnant element of the faith they profess and of which they would henceforth become only the spurious and egregious descendants. Only as an articulate organ of the half-understood aspirations of

living men, constantly recasting and adapting existing forms, bringing to the high light of expression the dumb impulses of the present, can they continue in the course of the ancestors whom they revere.[41]

I think that the social sciences can and will play a growing role in assuring the fulfillment of the conditions essential to the realization of justice according to law. The social sciences can assist, perhaps to a frightening extent, in producing and sustaining the social acquiescence which gives authority to the law. But the social sciences will be able to continue indefinitely to aid the authority of the law only if, far more importantly, they also, in Learned Hand's phrase, aid in bringing to the high light of expression the dumb impulses of the present. Perhaps it is in this elucidating role that the social sciences can contribute most effectively to the marriage of the laws of nature and the laws of men.

NOTES

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3. Ibid., p. 137.

4. Ibid., p. 138.

5. Ibid., p. 139.

6. J. D. Bernal, The Social Function of Science (London: George Routledge and Sons, 1939). p. 386.

7. Eugene B. Skolnikoff, Science, Technology, and American Foreign Policy (Cambridge, Mass.: M.I.T. Press, 1967). p. 18.

8. Ibid., p. 19.

9. A. Hunter Duprée, Science in the Federal Government (Cambridge, Mass.: Harvard University Press, 1957). p. 335.

10. Ibid., p. 336.

11. Bernard Brodie, "The Scientific Strategists," in Robert Gilpin and Christopher Wright (eds.) Scientists and National Policy Making (New York: Columbia University Press, 1964). p. 246

12. U. S Congress. House 89:2 Committee on Government Operations, Federal REsearch and Development Programs: The Decision-Making Process (Washington: GPO, 1966). p. 4.

13. Ibid , p. 34.

14. U. S. Congress. House 90:1 Committee on Government Operations, Federal Research and Development Programs: The

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15. U. S. Office of Science and Technology, NIH Study Committee, Biomedical Science and Its Administration (a report to the President) (Washington: GPO, 1965). pp. 11-12.

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17. Thomas H. D. Mahoney, "Computers, Congress, the Constitution, and the Courts: the Problems of Early Broadcasting of Reports, Projections, and Declarations." Harvard University Seminar on Science and Public Policy, mimeo, 1967.

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20. Richard B. Lee, "Subsistence Ecology of !Kung Bushmen." Ph.D. dissertation, University of California, Berkeley, 1965.

21. For attempts to understand large organizations, see Beatrice and Sydney Rome, "Leviathan," System Development Corporation Magazine 8(4):17-25, April 1965. The presence in the 1966 Arts of Persuasion in Litigation Handbook of a monograph called "Persuasion and Behavioral Change" by James V. McConnell,

a psychologist whose research has primarily been in the area of persuading flatworms, may indicate a nascent awareness of the social potential of theoretical understanding of persuasion.

22. Robert K. Merton, On Theoretical Sociology (New York: Free Press, 1967). Chapter 2: "On Sociological Theories of the Middle Range."

23. Edward S. Rogers, "Public Health Asks of Sociology . . ." Science 159:506-508, 2 February 1968.

24. Raymond A. Bauer, "Application of Behavioral Science," in Applied Science and Technological Progress (a report to the Committee on Science and Astronautics, U. S. House of Representatives, by the National Academy of Sciences, June 1967) (Washington: GPO, 1967). p. 134.

25. "Technical knowledge is a necessary but not a sufficient requisite for the scientist who seeks to play the catalyst in the conversion of scientific discovery to social action." By itself medical evidence on the effects of smoking failed to produce appropriate legislative response. The quote is from Stanley J. Reiser, "Smoking and Health: the Congress and Causality," in S. A. Lakoff (ed.), Knowledge and Power (New York: Free Press, 1966). pp. 293-311. See also Kingsley Davis, fn. 28 below.

26. See John W. Finney, "Institute Set Up To Aid the Cities," New York Times, 27 April 1968, p. 1. ~~Mayor John Lindsay's recent hiring of the RAND Corporation to find out what is happening in New York may be the first of many examples of this sort.~~

27. Alvin M. Weinberg, "Social Problems and National Socio-Technical Institutes," in Applied Science and Technological Progress, pp. 415-434.

28. "The study of social organization is a technical field; an action program based on intuition is no more apt to succeed in the control of human beings than it is in the area of bacterial or viral control. Moreover, to alter a social system, by deliberate policy, so as to regulate births in accord with the demands of the collective welfare would require political power, and this is not likely to inhere in public health officials, nurses, midwives, and social workers. To entrust population policy to them is 'to take action,' but not dangerous 'effective action.'

"Similarly, the Janus-faced position on birth-control technology represents an escape from the necessity, and onus, of grappling with the social and economic determinants of reproductive behavior." Kingsley Davis, "Population Policy: Will Current Programs Succeed?" Science 158:730-739, 10 Nov. 1967.

29. Luther J. Carter, "Social Sciences: Where Do They Fit in the Politics of Science?" Science 154:488-491, 28 Oct. 1966.

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31. Ibid., p. 20.

32. Ibid., p. 26.

33. Bernal, op. cit., p. 411.

34. Ibid., p. 342

35. Ibid., p. 381.

36. Ibid., p. 409.

37. In a study of "Scientific Productivity and Academic Organization in Nineteenth-Century Medicine," Joseph Ben-David attributed the rise in productivity of medical science in Germany and America in the last half of the 19th century to the presence of academic decentralization and competition, and the simultaneous fall in productivity in France and England to de facto or de jure academic centralization. In Bernard Barber and Walter Hirsch (eds.), Sociology of Science (New York: Free Press, 1962). pp. 305-328.

38. For a brilliant intimation of the long-term social implications of biology, see Robert S. Morison, "Where is Biology Taking Us?" Science 155:429-433, 27 January 1967.

39. See e.g. Chapter 5, "Future Problems," in Commission to Study the Organization of Peace, The United Nations and Human Rights (New York: The Commission, August 1967), pp. 40-44.

40. Harvard Law Review 1916, pp. 617-621.

41. Ibid., pp. 618-619.

NAS PRIVILEGED

DRAFT REPORT

NATIONAL ACADEMY OF SCIENCES'

STUDY OF

COMMUNICATIONS/INTERCONNECTION

as of

1 April 1970

PRIVILEGED

NAS PRIVILEGED

SECTION 1

BACKGROUND AND CONCLUSIONS

SUMMARY OF THE STUDY

Origin

The "Carterphone Decision" was widely recognized as potentially leading to a fundamental change in communications carrier/user relationships.[1]

By this decision, the FCC ordered the American Telephone and Telegraph Company to delete general prohibitions against interconnection and foreign attachments from its interstate message toll tariffs. In compliance, the AT&T, after consultation with representatives of the independent telephone companies, filed the following new tariffs: #259 - "Wide Area Telecommunications Service"; #260 - "Private Line Service"; #263 - "Long Distance Message

[1] Section 2 - COMMUNICATIONS BACKGROUND, pp 23-27

Telecommunications Service." These new tariffs specify and define certain key limiting signal characteristics and "access arrangements" believed necessary to protect the telephone service and the telephone system, as well as those who come in contact with the system as employees or users.[1]

The FCC allowed these proposed tariffs to go into effect and requested comments from interested parties. It received a considerable number and range of responses. The technical portions of these responses varied from complete acceptance, to challenges as to the basis of determination of harm, to complete rejection.

Since the new tariffs are based upon the "Public Harm" issue, it was determined essential that a competent and objective study be made of the technical factors involving interconnection and user-provided attachments. The

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[1] Section 3, TRANSMISSION AND PROTECTION CONSIDERATIONS, pp 12-30

National Academy of Sciences (NAS), through its Computer Science and Engineering Board (CSEB), accepted the responsibility of carrying out such a study. The objective was to evaluate and report on the issues of harm and protection of the telephone network from harm, as well as to develop and evaluate the possible alternative arrangements or procedures available to avoid harm.

The Panel broadly considered and evaluated alternative methods of interconnection. Among the more important considerations were:

(a) Whether the existing tariffs unduly restrict the user wishing to interconnect.

(b) The possible hazard to carrier personnel and property and impairment of network service from uncontrolled interconnection.

(c) The costs and practicability of alternative methods.

(d) The impact of interconnection on the introduction of new equipment and service.

The charter of the Panel and the urgency of the problems of voice-band interconnection necessitated that this report be concentrated on the technical aspects of those problems, to the exclusion of other significant consequences of interconnection such as:

(a) The distribution of costs of interconnection among carriers, the general non-interconnected user, and the interconnected user.

(b) The reliability or adequacy of service obtained by a user from his own interconnected equipment.

(c) The effect on service to a user with carrier-provided equipment on calls to or from a user with his own interconnected equipment.

Final judgment by the FCC as to courses of action must, of course, include, in addition to the technical factors, such questions as rates, costs, legal implications and basic economic policy. In this connection, it should be noted that future changes in costs or rates by the carriers for interconnection devices could have a significant impact on the interconnection situation[1]. This factor could not be evaluated.

The principles which underlie the conclusions in this report may be applicable to other types and circumstances of interconnection.

Principal Conclusions

The principal conclusions arrived at by the Panel are as follows:

> Uncontrolled interconnection can cause harm to network performance and to personnel and property.[2], [3]

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[1] Section 8, COSTS

[2] Section 3, TRANSMISSION AND PROTECTION CONSIDERATIONS, pp 31-57

[3] Section 4, NETWORK CONTROL SIGNALING, pp 2-6

Present tariff criteria and carrier-provided connecting arrangements are an acceptable way of assuring protection for network personnel and property.(1)

An acceptable alternative way of assuring protection is through enforced certification of equipment and personnel.(2) Enforced certification requires:

> that authority for the certification program reside with the Federal Regulatory Agency;(3)
>
> that the program be uniformly applied to all classes of users;(4)

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(1)Section 5, PROTECTIVE DEVICES, pp 3-8

(2)Section 6, CERTIFICATION PROGRAM

(3)Section 7, RESPONSIBILITY

(4)Section 1, BACKGROUND AND CONCLUSIONS, pp 30-32 that the enforced certification procedures be taken as a whole -- they represent an integrated system;

that a carefully planned and timed step-by-step effort be set up to ensure the successful implementation of the program.[1]

Self-certification by manufacturers or users cannot assure an acceptable degree of protection.[2]

Innovation by carriers will not be significantly impeded by the certification program. Innovation by users may be promoted.[3]

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[1] Section 6, CERTIFICATION PROGRAM, pp 27-30

[2] Section 6, CERTIFICATION PROGRAM, pp 15-18

[3] Section 9, INNOVATION

Organization structures should be established to promote the exchange of information among carriers, users, and suppliers.[1]

STUDY PLAN

Organization

An initial analysis indicated that a broad range of experience was necessary for the Panel. The technical coverage included the following subjects:

- Switching Systems
- Transmission Systems
- Standards - Development and Use
- Equipment Manufacturing
- Privately-Owned and Operated Communications Systems
- Communications-Oriented Computer Systems.

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[1] Section 11, INFORMATION AND ORGANIZATION

In order to obtain the necessary first-hand technical knowledge, it was necessary that Panel members be drawn, to a large measure, from organizations that are "interested" parties. A careful effort was made to select individuals of high technical competence and integrity to assure the objective required by the NAS and FCC. The Panel operated under NAS rules of a privileged relationship, wherein those addressing the Panel were assured that proprietary information would be protected. Additionally, the chairman of the Panel was chosen from the not-for-profit community. The Panel, whose names and affiliations are shown in Annex 1, consisted of fourteen members with diverse backgrounds. The members were selected on the basis that they were well-recognized as technically-qualified people. They acted as individual technical experts only and did not represent the organizations with which they were associated.

Procedures

A review was made of the FCC files concerning interconnection and foreign attachments and plans were prepared for accumulating the necessary data for analysis. Facts and opinions were accumulated from parties who expressed their interest to the FCC and directly to the NAS Panel as a result of announcements, publicity, and direct solicitations. Additional organizations with knowledge of, and experience in, subjects of particular interest to the Panel were also contacted directly.(1) Among the organizations providing data were:

Communication Common Carriers

Telephone Equipment Manufacturers

Computer Manufacturers

Terminal Equipment Manufacturers

Organizations with Private Communications

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(1) Section 10, APPLICABLE EXPERIENCE

Regulatory Agencies

U. S. Government Agencies

Standards Agencies

Foreign Communications Agencies

Testing Laboratories

Computer Service Organizations

Installation and Service Organizations

Trade Associations

In all, fifty parties presented written technical submissions and of these, twenty-five, by Panel invitation, made oral presentations and submitted to intensive questioning at closed panel sessions. During these sessions, the Panel operated on an informal basis, in that free questioning on all aspects of a presentation was allowed to the satisfaction of the questioner as long as it was, in the opinion of the chairman, in a technical vein and on the subject. Since the information was provided to the NAS on a privileged basis, the Panel cannot reference or acknowledge the source of specific information used in our analysis.

As a result of this data gathering effort, the Panel believes that it has collected as complete an information base as is possible at the present time. The available information, together with the collective engineering judgment of the Panel, was adequate to arrive at the conclusions and recommendations which follow.

The cooperation of all participants and the detailed work carried out by them in their submissions and appearances was essential to this study. The participants all displayed a positive and constructive attitude and demonstrated that all of them had a stake in a well-functioning telephone system.

EFFECTS OF INTERCONNECTION ON THE PERFORMANCE OF THE NETWORK

The objective of the Panel has been to determine how much freedom of interconnection can be allowed without impairment of service to users of the network, generally. In its approach to this objective, the Panel has considered how harm can be caused to the network and has then considered how this harm can be prevented.

Harmful Effects

Harm may arise through the introduction into the network of (a) voltages dangerous to human life, (b) signals of excessive amplitude or improper spectrum, (c) improper line balance, or (d) improper control signals.[1]

INCREASED EXPOSURE TO HAZARDOUS VOLTAGES CAN RESULT FROM UNCONTROLLED INTERCONNECTION[2]

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[1] Section 2, COMMUNICATIONS BACKGROUND

[2] Section 3, TRANSMISSION AND PROTECTION CONSIDERATIONS, pp. 31-57

Uncontrolled availability and installation of customer-owned terminal devices involving the use of 115v AC and other hazardous voltages, can involve risks to telephone company installation and maintenance personnel. It is a necessary condition that maintenance and expansion of telephone service be carried on without interruption of existing service. It is standard and efficient practice for cable and exchange plant workers to work barehanded on pairs and junctions in the immediate proximity of hundreds of others which are in normal use. To avoid increasing the hazard, it is mandatory that stringent measures be taken to ensure that hazardous voltages not be applied at points of interconnection.

SIGNALS WHICH VIOLATE THE CRITERIA IN TARIFFS 260 AND 263 CAN CAUSE HARM BY INTERFERING WITH SERVICE TO OTHER USERS.[1]

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[1] Section 3, TRANSMISSION AND PROTECTION CONSIDERATIONS, pp 10-30

The non-linear characteristics of transmission components, which are widely used in the telephone plant, require that input signal powers be limited. The signal powers specified in the tariffs represent reasonably optimized values for voice and data usage. There are no limiting functions in the carrier systems which can accomplish the required limiting. The limits on in-band signal power spectrum are specified to avoid the possibility of interference with internal network signaling. The "out-of-band" power limits are based upon limitations of local cable plant and requirements for minimum interference with present and expected greater than voice band services. The telephone plant does not now supply this protection.

Signal criteria which are specified in the tariff must be observed for both voice and data services, but when transmitting data, the user has an incentive to exceed the signal power criteria in order to reduce his error rate despite possible degradation of service to others.

LINE BALANCE IS CRITICAL TO NETWORK PERFORMANCE[1], [2]

Imbalance in line terminations will render ineffective the careful electrical balance built into the pairs in the cables connecting users and the telephone company central offices. The resultant unbalances can cause loss of privacy and increased interference, not only to the unbalanced pair, but to other pairs in the cable as well. Terminal imbalance can occur due to poorly-built equipment, improper installation, or inadequate maintenance.

IMPROPER NETWORK CONTROL SIGNALING CAN IMPAIR TELEPHONE SERVICE AND INCREASE COSTS.[1], [3]

Network control signaling must be properly performed for correct system operation and message accounting. For example, in a telephone set, these signals are produced by the switchhook and the rotary dial or the

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[1] Section 1, COMMUNICATIONS BACKGROUND, pp 9-10, 14-15

[2] Section 3, TRANSMISSION AND PROTECTION CONSIDERATIONS, pp 57-64

[3] Section 4, NETWORK CONTROL SIGNALING

touch-tone pad. Mechanisms for producing these signals, if not carefully designed, manufactured, installed, and maintained, can, in conjunction with the varying characteristics of the telephone loops, cause improper signals to be received at the central offices. Central offices vary in their tolerance to distorted control signals and in their ability to correct such signals before retransmission into the network. In particular, dial pulse signaling of poor quality can cause significant harm by the generation of wrong numbers, causing annoyance to others, wasteful use of central office equipment and transmission facilities and improper billing. On the other hand, improper signals generated by touch-tone pads are inherently less harmful since, if a signal is out of tolerance, the central office equipment will not complete the call.

Protecting the Network

Three alternative approaches for protecting the public telephone network were considered. They are:

(a) Operation under present tariffs which call for common-carrier ownership, installation, and maintenance of connecting arrangements.

(b) A program of enforced certification of equipment and personnel, with appropriate standards for safety and network protection. This approach would allow user ownership, installation, and maintenance of protective coupling units or complete terminal equipment. Assurance of protection without carrier-provided connecting arrangements is the objective.

(c) A program of user self-certification based upon published standards for safety and network protection.

PRESENT TARIFF CRITERIA AND CARRIER-PROVIDED CONNECTING ARRANGEMENTS ARE AN ACCEPTABLE WAY OF ASSURING NETWORK PROTECTION[1]

The present tariffs specify signal criteria for electrical, accoustic and inductive coupling, and specify that the carrier provide connecting arrangements and network control signaling. The signal criteria limits the signal inputs to the network to those which are considered to be

[1] Section 3, TRANSMISSION AND PROTECTION CONSIDERATIONS
Section 5, PROTECTIVE DEVICES

A question has been raised as to the need for some of the protective features. Analyses of the presently-available connecting arrangements indicates that they provide a degree of protection in the way of voice signal limiting that, in some cases, is unnecessary. Present carrier-provided coupling units are, in some instances, complicated and marginally effective and may degrade performance. The uncertainties regarding protective features can be attributed to the rapid introduction of the connecting arrangements and the lack of experience on which to base judgments. Continued development should produce more effective units. For the present, they do provide a substantial portion of the protection required. The sudden demand for interconnection and the need for time to determine the features required by a large number of users is at the root of the present problem. Many desired connecting arrangements are not yet available.

THE ESTABLISHMENT OF STANDARDS AND THE ENFORCED CERTIFICATION OF EQUIPMENT AND PERSONNEL, FORM AN ACCEPTABLE ALTERNATIVE WAY OF ASSURING NETWORK PROTECTION.[1]

The standards to be established cover only network protection aspects such as personnel safety, signal criteria, transmission, and network signaling.

Despite some variability from installation to installation, there has been enough experience with the telephone network to allow standards to be prepared for network protection. A standards development program, as mentioned, requires the resources of a qualified standards organization. The purpose here is to provide coordination, structural guidance, and staff services to those writing the standards. Such organizations exist within both private industry, and government. Within this frame-

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[1] Section 6, CERTIFICATION PROGRAM

work, the standards can be written by qualified representatives of the carriers, suppliers, and users. A definition of the interface between the user-owned equipment and the network, so far as protection is concerned, is a part of standardization.

Finally, although general standards can be written to cover interconnection with various types of central offices and loops, each individual installation is, to some extent, customized.

Interconnected equipment must be provided with proper adjustme[illegible] features to deal with individual case-by-case variatio[illegible] The necessary adjustments must be worked out cooperatively at the time of installation between the carrier and the user. Cooperative guideline procedures should be formalized.

Type certification of equipment must be done by testing laboratories independent of the equipment manufacturers. It must include evaluating and monitoring each manufacturer and its specific products. Qualified independent test laboratories exist which are capable of performing these functions in related fields. They could expand their resources to qualify for the program which is envisaged. With a significant volume of work, costs of this program should not be prohibitive. Certification can be applied to couplers, to protective sections of larger equipment, or to the protective characteristics of entire units of equipment.

Equipment type certification alone is not sufficient to protect the telephone network. This equipment must be installed and maintained by certified technicians. In addition, the standards must make provisions for assurance that the network protection is maintained by documented periodic inspection.

It remains to certify the installation and maintenance of interconnected equipment. This will require a program of personnel training, the development of tests and test equipment, and the licensing of installation and maintenance personnel. On the last point, the Panel has the opinion that a nucleus of support personnel exists in the servicemen and organizations who now install and service communications and computer equipment. These people can be certified (and licensed) by examination, following procedures which form part of the overall certification program. Each certification (or license) would be endorsed as applicable to equipment of one or more classes.

SELF-CERTIFICATION BY MANUFACTURERS OR USERS CANNOT ASSURE AN ACCEPTABLE DEGREE OF NETWORK PROTECTION.[1]

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[1] Section 6, CERTIFICATION PROGRAM, pp 15-18

A self-certification program allows the manufacturer or user to test and approve his own equipment, installation, and maintenance. On the other hand, an enforced certification program separates the responsibility for certification from the organizations having a direct financial involvement in the production or use of interconnected equipment. The competence and earnest sense of responsibility of many users is apparent to the Panel and is acknowledged by the carriers. The question, however, is not whether some users will exercise care, but whether all users can be depended upon to do so.

Self-certification requires the user to procure and use equipment considered harmless and to operate in accordance with the tariffs. In the absence of some control system, it is inevitable that equipment which is marginal will make its way to the market and usage outside of the rules will take place. Monitoring to ensure compliance with the signal criteria by the carriers could possibly be developed and utilized. However, the hazards of safety, imbalance, and incorrect signaling could not be protected against by a program of monitoring.

<u>Party Lines Represent a Serious Hazard</u>[1]

The Panel has concluded that the probability of harmful effects due to interconnection is materially greater, and more serious, where interconnection involves party-line users. Party-line operation substantially increases the risks of false charging and of harm to the service of others, especially, of course, others sharing the party line.

The Panel is not satisfied that the proposed procedures of certification will be applicable or effective if party-line operation is permitted.

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(1) Section 4, NETWORK CONTROL SIGNALING, p. 3

Requirements for an Enforced Certification Program

AUTHORITY FOR A NATION-WIDE CERTIFICATION PROGRAM MUST RESIDE WITH THE FEDERAL REGULATORY AGENCY RESPONSIBLE FOR THE TARIFFS.[(1), (2)]

The certification program must be recognized in the tariffs. The Federal regulatory agency, which approves these tariffs, must assume the responsibility for authorizing implementation of the overall certification program. This agency should develop and publish rules and procedures and propose timetables and sequence of applications.

Plans should be developed under control of the Federal agency for the selection of the organization or organizations which will coordinate the preparation of standards, the procedures for the qualification of technicians, and the organizations which are to be given the authority to certify equipment.

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(1) Section 6, CERTIFICATION PROGRAM, p 31

(2) Section 7, RESONSIBILITY, pp. 5, 10, 14, 15

Uniformity in standards and certification procedures for equipment and in personnel qualifications throughout the country is necessary. Installation and maintenance may be supervised and inspected locally. Therefore, co-ordination by federal and state agencies is necessary to establish policies which will permit the nationwide use of certified equipment and procedures for the certification of technicians[1].

THE PROPOSED INTERCONNECTION REGULATIONS, WHICH ARE INTENDED TO ASSURE NETWORK PROTECTION, MUST BE APPLIED UNIFORMLY TO ALL CLASSES OF USERS

The Panel endeavored to classify users, including utilities, right-of-way companies, agencies of the federal government, etc., in an effort to show that one or more classes

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(1) Section 7, RESPONSIBILITY

might be permitted unrestricted interconnection without serious risk of impairment to the operation of the network as a whole. The result of this careful consideration was a firm conviction to the contrary. Classifications such as membership in an association, employment by the government, subjection to regulation, possession of particular kinds of equipment -- none of these provide assurance of both competence and responsibility among all users who are members of that class.

In a certification program which enables any user to qualify on reasonable terms, there is no technical basis, in the opinion of the Panel, for any class or group of users to be exempted from conforming.

The Panel recognizes that certain classes of users have, in the past, directly interconnected with the network without significant impairment to service generally.

Widespread interconnection, on the other hand, creates a new and different environment in which all existing variances from the proposed rules must eventually be corrected. The committee is not, however, in a position to recommend specific time allowances.

THE ENFORCED CERTIFICATION PROCEDURES MUST BE TAKEN AS A WHOLE.

The Panel wishes to emphasize that, in recommending the development of standards and a program of certification as a workable alternative to present tariff controls, it is proposing a complete system of control, which will not be effective unless all elements of the system, as described in the report, are adopted. For example, the development of standards alone is inadequate. Certification of equipment without certification of installation, testing and maintenance will be ineffective in protecting personnel, facilities, services, etc. The Panel's approval of standardization and certification as an alternative is contingent on the adoption of the total plan.

A CAREFULLY PLANNED AND TIMED STEP-BY-STEP EFFORT IS NECESSARY TO ASSURE THE SUCCESSFUL IMPLEMENTATION OF A CERTIFICATION PROGRAM.[1] THE FIRST STEP SHOULD INVOLVE A MODERATELY COMPLEX INTERCONNECTION PROBLEM.

Experience with interconnection is limited and has, for the most part, been with users having extensive experience and resouces. There is little applicable experience involving smaller, less sophisticated users or with large-scale public interconnection. The certification program is something new to the telephone industry and to many of the major user industries. Existing laboratories are

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[1] Section 6, CERTIFICATION PROGRAM, pp. 27-30

not equipped to test and certify communications equipment in the quantities envisioned. The personnel needed by all parties for this kind of operation are in short supply.

There is much to be learned. If a start is made promptly, and if all concerned assign the task a high priority, there should be a reasonably rapid implementation which will produce the necessary certification programs and guidelines for qualifying personnel.

The same effort should produce both standards for equipment and guidelines for qualifying personnel. Thereafter, when the personnel program has started to function, the certification of interface devices and equipment will permit their installation and operation by users according to the new standards.

The Panel recommends that first applications be to equipment with moderately complex interconnection problems and for which a knowledgeable technical base for manufacture, installation, and maintenance now exists. Once started, application of the standards to one service (such as PBX, for example), can proceed while standards are set for another (such as data modems). Numerous and seemingly simple applications should await actual experience in more complex applications where trained personnel are already working. Since the standards program is an iterative process, requiring procedures for continuous reconsideration and renegotiation of specifications, it is important that an organizational mechanism be set up to gather data and evaluate the progress of the program.

EFFECTS OF INTERCONNECTION ON INNOVATION

THE PROPOSED CERTIFICATION PROGRAM SHOULD NOT SIGNIFICANTLY IMPEDE INNOVATION BY THE CARRIERS AND MAY PROMOTE INNOVATION BY USERS THROUGH INCREASED FLEXIBILITY.[1]

Several opinions have been expressed to the Panel regarding the potential impact of interconnection on innovation.

The carriers have said that widespread interconnection will tend to impede innovation in the network, because, among other things, users will tend to oppose changes by the carriers that make the users' equipment obsolete or require it to be modified. They have also said that direct interconnection without carrier-owned interconnecting arrangement will further impede their innovation because

[1] Section 9, INNOVATION

it removes the carrier-controlled buffer with known characteristics between the network and the interconnected equipment.

Some users, especially the large ones and those in rapidly developing fields such as computer time-sharing, have expressed the opinion that, with the necessarily deliberate rate of innovation expected in the network, there will be no major problems in keeping up with the network innovation. They do not agree with the carriers' concerns regarding the need for a carrier-controlled buffer.

Some suppliers of equipment and services have expressed the opinion that the presence of the carrier-owned interconnecting arrangement will impede innovation on the user side of the interface where the goal is to optimize the users' system or use of equipment. Further, and perhaps more importantly, they question the ability of the carrier to respond rapidly enough to new situations where new interconnection arrangements are required.

While there are limited data on which to base conclusions, it is the opinion of the panel that:

(a) The advent of widespread interconnection itself, regardless of how it is implemented and controlled, may indeed have some effect on the rate of innovation by carriers, suppliers and users. In some cases, it may impede innovation in the network and in others, it could conceivably promote innovation because of the pressures of demand

INFORMATION INTERCHANGE

THE PANEL BELIEVES THAT ORGANIZATIONAL STRUCTURES SHOULD BE ESTABLISHED TO PROMOTE THE EXCHANGE OF INFORMATION AMONG CARRIERS, USERS, AND SUPPLIERS.[1]

As stated earlier, the Panel was continually reminded of the need for improved communications among the parties concerned. There were instances where incorrect interpretations of conditions of use of the network by user and manufacturers caused unnecessary confusion at both the technical and administrative levels. There was a firm expression on the part of the carriers of the need for more direct communications and a more comprehensive picture of user requirements. With the anticipated acceleration in innovation affecting data systems and

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(1) INFORMATION AND ORGANIZATION

APPENDIX

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SECTION 2

COMMUNICATIONS BACKGROUND

TELEPHONE SYSTEM

In discussions of the interconnection situation, it is convenient to consider separately, the exchange and long distance parts of the telephone plant.

Exchange System

In its very simplest form this consists of a telephone, a "loop" to the central office, the automatic telephone exchange, and, perhaps, trunks running from the nearest central office either (a) to other central offices nearby; or (b) extending into the toll telephone network.

The Telephone

The subscriber interfaces with the telephone system at the telephone instrument. From the network control viewpoint, the subscriber is really a highly adaptable logic and memory system which responds to incoming calls, initiates calls, and reacts reasonably predictably to a variety of situations encountered in using the telephone. The mechanisms he uses to exert this control in the simplest form of telephone, are the switchhook and the dial. Lifting the handset closes electrical contacts in the switchhook to signal the central office. These switchhook signals play an important role in subsequent operations. (One of them is establishing, for charging purposes, the times at which the call was initiated and terminated.) On receiving dial tone (which the subscriber distinguishes from several other tones produced for his use), the subscriber responds by operating the rotary dial or set of push buttons to correspond to the number he desires to reach, as read from the telephone directory or taken out of his memory (not always accurately). The subscriber takes certain actions depending on whether, subsequently, he hears the voice of the wanted party, receives busy tone, continues to hear an unanswered audible ringing signal, reaches the wrong telephone, etc. At times he may hear a voice-recorded announcement and react accordingly, or he may reach an intercept operator with whom he converses. The subscriber, in short, by manipulating the telephone instrument, plays a crucial role in the network control signaling function of the telephone system. The telephone instrument, its controls, and the various signals from the system beyond the instrument to which the subscriber responds, are chosen in recognition of experience with the subscriber's capabilities, limitations and behavior patterns. The same is true of the quantity of switching equipment at the central office, which is chosen to fit the customer's habits as to calling frequency, duration of message, etc.

The various systems' solutions arrived at for the subscriber/telephone combination at the point of access to the network may not necessarily be the same, certainly not necessarily equally optimal, where the combination is replaced in part or completely by machine or computer. When so replaced, the machine or computer, with or without interface devices, must reproduce in some form most or all of the logical and memory operations now performed by the subscriber. It may be conjectured that the machine is more accurate and more rapid, though not necessarily as versatile.

The primary function of the telephone instrument, of course, is to transmit and receive speech. The statistical distributions of levels and waveforms sent into the telephone system depend on the characteristics of both the subscriber and the telephone instrument. The loops and long distance trunks are designed to handle the range of levels encountered, without introducing crosstalk between pairs in multi-paired cable, or overloading the long-distance multiplexed system with its common amplifiers. To this end, there are limits both as to the output at the subscriber station and the input to the trunks.

The telephone instrument is being used with increasing frequency to handle signals other than human voice, the telephone subscriber's voice and ear being replaced by an acoustically or inductively-coupled data set, cardiograph machine, facsimile machine, etc. Again, replacement of the subscriber by a machine implies compromises. Specifically, the machine-generated signal levels and waveforms must be chosen to be both (a) effective, and (b) non-interfering. This is accomplished in part by specification. In acoustic coupling, the signals are first converted to specified audible sounds and the telephone handset is fitted into a specified holder where these sounds are picked up. In inductive coupling, the electrical circuits within the handset pick up electromagnetic signals from the attached device. In both cases, the exact details of telephone instrument design are important. Small changes in the telephone instrument may obsolete acoustic and inductive coupling arrangements. Coordination between the designers of telephone instruments and the designers of acoustic and inductive couplers is required to avoid this.

A third function of the subscriber's telephone installation is to protect the user, telephone employees, and the rest of the telephone system against harm. The telephone instrument and installation is insulated against contact with electric power sources. The telephone instrument contains a "click reducer" to eliminate the hazard of acoustic shock, etc. It is designed to maintain careful balance to ground on both sides of telephone line, avoiding noise and cross-talk effects. It contains non-linear devices which limit energy levels, particularly on short loops to the central office, etc.

Where the subscriber telephone system is replaced by a machine, with or without interfacing equipment, the three basic functions of network control, transmission, and protection must all be preserved.

Finally, these basic functions must be handled without mutual interference. Specifically, the network control signaling function must be protected against interference from speech or other signals. For example, room noise picked up in the handset must not interfere with Touch-Tone audible signaling. As will be pointed out later, this consideration sets additional limits on the level and waveform of signals that can be transmitted throughout the system from the telephone.

The Loop

The "loop" connecting the telephone to the central office (or "trunk" connecting the PBX to the central office) is of less complexity and somewhat less significance to interconnection although it is one of the major elements of total telephone plant investment. The loop, for our purposes, includes the interior wiring on the customer's premises, the "drop" from the premises to the point of attachment to the cable running to the central office, and a selected pair of wires in that cable, either assigned wholly for the use of the subscriber or shared with other users. Important characteristics of the loop are its length and the size of the copper conductors. Since a minimum of direct current, at least, must be drawn over these conductors to supply the microphone in the telephone and 20-cycle alternating current must be fed over them to ring the telephone bell, there are upper limits on length of loop and fineness of conductor gauge. Similarly, there are limits connected with the attenuation of voice signals and the deformation of the direct current signals used for switchhook supervision and dial pulsing. If considerations of limiting loop length and gauge are identical when the subscriber/ telephone subsystem is replaced by a machine, there need be no changes in loop design and layout. If not, some changes may eventually be indicated.

Loops and short-haul trunks are derived from copper wire pairs in cables carrying several hundred or several thousand pairs. In order for crosstalk between services carried over these pairs to be held at a minimum, there is strict control in cable manufacture to avoid structural imbalance. The effect of this careful control can be destroyed if improperly designed or improperly installed equipment is connected to the ends of the pairs. One of the basic requirements for any device connected to the telephone network, therefore, is that it not introduce imbalance in impedance to ground from the two wires of the pair at the point of connection.

Crosstalk can also be created if excessively high levels are applied. To avoid crosstalk from this source, limits are set on the output levels from the subscriber's station. Finally, crosstalk in cables increases with frequency. Since paired cables are used increasingly to handle communications involving higher frequencies (e.g., PICTUREPHONE), the limits on levels into these cables are set differently for frequency bands above the voice range.

Key Telephones and PBX's

Not all telephone instruments are connected directly to the central office over loops, particularly non-residence telephones for business, Government, or professional use. In this case, additional switching systems are interposed between the telephone instrument (extension telephone) and the central office. These are manually-operated Key Telephone systems and automatic (or sometimes manual) PBX's or PABX's (two acronyms for essentially the same thing). Some of these systems are of a size and complexity comparable to a telephone central office. In the meetings of this Panel, there has been extensive discussion of when, where, and under what conditions customer-owned and maintained PBX's should be interconnected into the telephone network. There has been no specific discussion of the interconnection of customer-owned and maintained key telephone systems.

PBX's are sometimes, but not always, located on the customer's premises. In recent years there has been increasing use of Centrex service. In Centrex service, the PBX's switching may be done either on the customer's premises, or in the telephone central office. In Centrex service, PBX extensions are reached directly by dialing from the telephone network (Direct Inward Dialing). The telephone extension number becomes part of the nationwide numbering system. On outward calls from approved extensions, the called telephone is reached without the intervention of the PBX operator (Direct Outward Dialing). The extension in some cases is identified automatically for billing purposes.

The Central Office

Dial central offices are of the step-by-step or progressive control type, or of the common control type (crossbar and most recently electronic switching). In a step-by-step office, the subscriber more or less directly controls the switches in the central office when he operates the dial mechanism. Since these switches are mechanical devices with definite speed limitations, the dial return mechanism is equipped with a speed governor, as a kind of buffer against an impatient user. In common control offices, operation of the dial controls the condition of groups of relays or solid state electronic circuits, which are made available for the subscriber's sole use, simultaneously with his receipt of dial tone. These relay or electronic circuit combinations then control the central office switches to set up the desired connection. In general, these latter arrangements are faster. In some cases this is taken advantage of by doubling the speed of the dial mechanism from 10 to 20 pulses per second.

Except for this, however, the same type of telephone instruments are used for all types of dial central offices. Push-button or Touch-Tone control will be referred to later.

Exchange and Toll Trunk Carrier Systems

Telephone switching offices are interconnected into a nationwide switching plan or hierarchy in which the local central office is at the lowest hierarchical level. The switching centers of the hierarchy are interconnected over short- and long-haul trunk circuits. These circuits are of voice-bandwidth (approximately 3200 cycles) and handle two kinds of signals: 1) the message signal itself -- voice, data, etc.; and 2) the network control signals used in setting up and taking down connections, controlling switches, start of billing, and, in general, what is known as inter-office "handshaking," (exchange of call status information between switching offices). It is important to good service that the message signals not produce false network control signals. This can happen. For example, "talk-off" is a condition where an unusual voice sound deceives the signaling equipment into thinking that a signal has been received indicating that the subscriber has hung up. When the system is used for other than voice, restrictions on energy level and waveform are imposed to avoid "talk-off" and other adverse effects. In certain trunk systems, a separate channel is used for network control signals and these precautions are not required. The majority of trunks, however, use a single channel for both purposes.

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Restrictions on energy level and waveform are also required to avoic crosstalk and noise among services sharing the same facilities.

Multi-channel carrier systems carry 12, 60, 600, and more voice channels through common amplifiers over paired cables, coaxial cables, microwave radio relay and (internationally) submarine cable and satellites. These common amplifiers can handle only certain limited total levels of energy. Beyond this point they overload. The effect of overloading is to introduce noise and crosstalk among the voice channels. The total available load capacity of the amplifiers must be shared evenly by all the channels, whether they are handling voice or other communications. Specifications for individual channel loading have been established. The established loadings are intended to be an optimum compromise between low levels where underlying system noises dominate and the higher levels where intermodulation noise and crosstalk prevail.

Other Uses of the Telephone System

One of the uses of the telephone network for purposes other than switched message telephoning has been mentioned -- acoustic or inductive coupling to the telephone instrument for handling data, picture transmission, etc. This is only one of many non-telephone uses.

Leased Services

In fact, uses of the telephone system fall into two broad categories: 1) leased services; and 2) services which involve the switched network. From almost the beginning, the loops and trunks of the telephone network have been leased out to other services, operated by large users of communications, Western Union, the railroads, large industries, Government, etc. In some cases these leases have involved interconnection between leased lines and equipment owned and maintained by the telephone companies, but operated by the customer (for example, the 81-type teletype store-and-forward switching system). In other cases, Western Union for example, circuits only are leased out; the customer attaches his own equipment.

The possibility of interference into message telephone services, injury to personnel and facilities, etc., always exists as a theoretical possibility. Some of these problems arise as a result of the inherent susceptibility of the telephone system and its many points of exposure. Others come about because of unusually severe customer situations (high voltage sources, for example). However, some of the users of leased service are well-experienced in communication matters, have competent planning, operating, installation and maintenance staffs, and have problems of avoidance of harm and injury similar to those of the telephone company itself.

Non-Telephone Services Involving the Switched Network

The use of the switched telephone network for other than message telephone service goes back at least to the 30's with the use of acoustic couplers by press photographers to transmit spot news photographs from nearby telephones, using portable telephotograph equipment. The present situation with respect to acoustic couplers has already been covered.

Touch-Tone Services

There are over 1,000,000 telephone installations in which the rotary dial has been replaced by a 10- or 12-button "Touch-Tone" combination. This mode of network control signaling is unique, in that the Touch-Tone signals, unlike the rotary dial signals, can be used not only to control the setting up of the connection, but also, after the connection has been set up, can be used to transmit data. DIVA is an acronym for Digital Inquiry Voice Answerback, a telephone company-provided service in which customer-owned equipment connected to a telephone company-provided data set receives Touch-Tone inquiry signals from a remote subscriber and responds with recorded voice announcements. Like other non-telephone signals, the Touch-Tone signals have been chosen to avoid interference with and false operation of the internal system's network control signals.

Data-Phone Service

The development of Data-Phone service started in the late 50's. This was and is a telephone company-offered service over the switched telephone (or leased telephone) network. The customer leases a Data-Phone station (there are some 20 basic varieties to choose from and many variations of each), which is installed, attached to the telephone system, and maintained by the telephone company. There are now upwards of 100,000 of those in service. Most or all of these Data Phones, where connection with the switched telephone network is involved, include a telephone handset, dial and illuminated keys where the attendant can set up the connection, monitor and to be sure the called machine is reached, and at the right moment, operate the keys to connect the machines together. Data-Phone equipments in leased service do not have telephones. Where Data-Phone interfaces with customer's equipment, detailed interface standards (number of leads, voltages, etc.) have been worked out between the Electronic Industries Association and the telephone companies.

Speeds available over Data Phone service via the switched network range from 100 bits to (most recently) 50 kilobits per second. In the latter case, of course, specially treated loops and wideband trunk circuits are used. Also, there are special 50 kilobit switching units, "slaved" to regular switching units in the central office (meaning that the same common control guides the operation of both switches).

Various modulation methods are employed: multi-frequency, frequency shift, 4-phase, multi-level, etc. Waveforms and levels have been selected for transmission effectiveness and compatibility with telephone system electrical characteristics (e.g., delay distortion and noise) and again, avoidance of interference into network control signaling.

Interconnection and Attachment

The demand for more and different forms of interconnection with the switched message telephone and leased telephone plant has led to extensive discussions and controversy over the business and technical conditions under which interconnection is to be offered by the carriers. The original tariff provisions, for example, did not allow computer service bureaus to lease facilities for their use in switching messages. The Chief of the FCC Common Carrier Bureau referred to this as a "tariff inhibition" which "is a continuing source of irritation to the computer industry."*

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*Telecommunication Report, October 24, 1966.

The Carterfone Company manufactures a coupling device for interconnecting privately owned and operated mobile radio systems with the public network. This became an issue between this company and the Southwestern Bell Telephone Company, the latter considering this a violation of tariffs.

Other cases involve interconnection of private microwave radio relay systems with telephone company facilities.

The Common Carrier Bureau of the FCC* concluded, and recommended it as an FCC position, that Carterfone would not impair the operation of the telephone system. More broadly, the Bureau recommended

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*Telecommunication Report, August 7, 1967 that the telephone company "be ordered to set forth in its tariffs in clear and specific language, reasonable standards and requirements that any such customer-provided equipment, apparatus, circuits or devices, must meet in order to protect telephone company employees, facilities, the telephone system and the public from adverse effects."

The telephone company position has been that "the only safeguard we urge is that we be allowed to provide suitable interfaces or buffer devices, so that the various types of attached equipment will not put something into the network that could adversely affect or interfere with the service other customers are getting."*

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*Mr. H. I. Romnes, quoted in Telecommunication Report, March 25, 1968

In late June 1968, the Commission ordered AT&T to delete from its message toll tariffs (No. 263) general prohibitions against interconnection and foreign attachments, and if the carrier chose, to submit new tariffs. In compliance with this order, AT&T, in September 1968, applied for permission to file new tariffs which "while opening up the network to all sorts of customer-owned devices (would) protect its switching and signaling functions." It is these tariffs (there are three of them: No. 259, "Wide Area Telecommunications Service"; No. 260, "Private Line Service"; and No. 263, "Long Distance Message Telecommunications Service") which are now under discussion. Under particular discussion are the tariff provisions which require the use of telephone company-provided interfacing devices.

The Common Carrier Bureau of the Federal Communications Commission is holding discussions concerning the legal and regulatory provisions of the tariffs. The Bureau has requested the National Academy of Sciences to examine the technical considerations involved in simultaneously: a) protecting the network, its customer, employees, and services; and b) opening up the use of the network to new services.

SECTION 3

TRANSMISSION AND PROTECTION CONSIDERATIONS

INTRODUCTION

This Section of the Report discusses the rationale behind the carrier's tariff restrictions on the power and waveform of signals sent over the telephone networks (signal criteria).

THE PANEL HAS CONCLUDED THAT THE SIGNAL CRITERIA IN THE TARIFFS ARE REASONABLE. SIGNALS WHICH VIOLATE THESE CRITERIA CAN CAUSE HARM BY INTERFERING WITH SERVICE TO OTHER USERS.

The Section discusses next, the sources and effects of harmful voltages on personnel and plant, the exposures of the telephone system to these voltages, and the additional risks introduced by user-provided equipment.

THE PANEL CONCLUDES THAT INCREASED EXPOSURE TO HAZARDOUS VOLTAGES CAN RESULT FROM UNCONTROLLED INTERCONNECTION.

The Section discusses finally, the subject of cross-talk, and how this undesirable effect may be produced by unbalanced (to ground) attachments to telephone lines.

THE PANEL CONCLUDES THAT THE MAINTENANCE LINE BALANCE IS CRUCIAL TO GOOD SERVICE. LINE BALANCE CAN BE IMPAIRED IF POORLY DESIGNED OR IMPROPERLY INSTALLED AND MAINTAINED EQUIPMENT IS ATTACHED TO THE SYSTEM.

The following paragraphs introduce the technical background appropriate to the later, more detailed discussion of signal criteria, protection criteria and line unbalance.

TECHNICAL FACTORS TO BE CONSIDERED IN THE INTERCONNECTION OF USER-OWNED TERMINALS TO THE PUBLIC NETWORK

The public telephone network has been engineered, necessarily on a statistical basis, to provide a variety of services to a large number of residential, commercial, military, etc., users with different service requirements; voice, data, etc. The numbers and duration of the calls placed by these users cover a wide range.

Users are served by many types of telephone facilities at a range of distances from their serving central offices.

The trunks that tie these offices into the long distance portions of the network also vary statistically in type and length. Resultant ranges in transmission parameters of the loops and trunks produce variations in the overall end-to-end characteristics of switched connections through the network. The alternate routing of calls which allows the automatic adjustment of traffic patterns to meet changing load requirements can increase or decrease the number of links used in setting up successive calls between the same two locations. In short, both the service and the plant can only be understood and treated on a statistical basis.

Because the numbers involved in telephone network are large, it is always possible to provide service to a small number of identified users whose requirements depart from the statistics in terms, for example, of the nature of signals to be transmitted. Special treatment might, for example, involve the selection of suitable pairs in local cables to minimize crosstalk. It is clearly not economic, however, nor in some cases even possible, to provide special treatment to a very large portion of the total subscribers since the bulk of the service provided must match the capabilities of the bulk of the serving facilities. If, in addition, users whose signals depart from normal are not identifiable, there is no way to provide them with special treatment.

If the network is to accommodate large numbers of customer-owned terminal equipment, it follows that signal amplitude, waveform and energy distribution with this equipment must continue to conform to the parameters used in the overall network design. Even a single user, whose signals are such as to cause crosstalk or interference in multi-pair cable systems or cause overload in broadband carrier systems can cause serious deterioration of service to a group of users.

Motivation is one factor in the determination of the likelihood that customer-generated signals will exceed the spectral power handling capability of telephone facilities. Where voice transmission is involved, there is generally no motivation. In data communication, however, it is to the user's advantage to increase the signal transmission level in order to improve his own performance, albeit at the expense of degraded performance of other users. It is necessary, therefore, in this case, to have effective controls for ensuring that signals applied to the network by customers do not exceed the transmission capabilities of the telephone facilities.

In addition to control of signal levels and waveforms, the interconnection of user-provided terminals involves other considerations. The first of these is the risk of hazardous voltages to personnel and to the network. The most important problem, of course, is the danger to telephone installation and maintenance personnel. Installation and maintenance must be carried on without interruption of existing service. It is, therefore, the practice for cable and exchange plant workers to work on cable pairs and junctions in the immediate proximity of hundreds of other pairs and junctions which are in normal use. It is clearly impractical to disconnect all terminal equipment before a worker contacts the wires in a cable or works on a distribution frame. Measures, therefore, must be taken to ensure that harmful voltages not be applied at any terminal at any time. With the anticipated increase in user-owned terminal devices using 115V AC and/or high DC voltages, the possibilities of harm due to poor initial design, improper installation, and/or inadequate maintenance are significant and must be faced in the interconnection of user-owned equipment.

Another situation where service to other subscribers may be impaired is where the telephone line, normally well-balanced, becomes unbalanced when a poorly-designed, installed or maintained device is attached to it. Tightly-packed wire pairs in telephone cables are very carefully manufactured to minimize unwanted pickup of interference -- either from other telephone circuits or from nearby power systems. It is necessary to maintain this longitudinal balance at all times on all pairs. If this balance is degraded by some attached equipment, not only will interference be present on the unbalanced pair, but other pairs in the same cable will be disturbed as well. Again, adequate provision must be made to ensure that user-owned terminals meet and maintain the longitudinal balance that is fundamental to maintaining the quality of network service, as do carrier-provided terminals.

Signal criteria, protection, and line balance, are discussed in detail in the following paragraphs.

SIGNAL CRITERIA

The signal criteria set limits on both "in-band" and "out-of-band" power. Criteria for in-band (below 3995 Hz) power signal levels are set to optimally load the frequency-division multiplex carrier systems which furnish most long-haul voice grade services.

Criteria for out-of-band power signal levels are set to avoid interference into communications sharing the same cable, but operating on other pairs in the cable, at frequencies above 3995 Hz. The mechanism here is crosstalk between cable pairs which increases at higher frequencies. The problem here is somewhat analogous to the FCC problem of management of the radio spectrum to the end that all users may not suffer service degradation because of signals spurious transmitted outside the allocated frequency band.

A third category of signal criteria sets limits on signal power in a specific region of the in-band range (2450 to 2750 Hz). The purpose here is to safeguard the operation of the 2600 Hz in-band signaling system, which is almost universally used in long distance telephone service. False operation of the in-band signaling system has serious results: improper billing, intermittent interruptions, insertion of a band elimination filter in the transmission path, or even complete disconnection of a call.

The derivations of the three classes of signal criteria, as set forth in the tariffs, are discussed under the following three subsections.

In-Band Signal Power Criteria

The tariff requirements on in-band power* are as

*In-band power is defined as the total power in the band below 3995 Hz.

follows: FCC 259, FCC 263 -...... the power of the signal at the central office not exceed 12 dB below one milliwatt when averaged over any three second interval. *

FCC 260 -...... the power of the signal which may be applied by the user-provided equipment to the Telephone Company interface located on the user's premises will be specified by the Telephone Company for each application to be consistent with the signal power allowed on the telecommunications network.

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*There is also a requirement that the signal applied to the loop plant not exceed 0dBm, but this is redundant for the network, since loops never exceed 12 dB loss. However, it is a factor in determining safe private line power levels.

The above requirements on in-band power are based on interference considerations of long-haul* frequency division multiplex carrier systems. These systems include coaxial cable carrier systems with capacities ranging up to 3600 channels and microwave radio carrier systems with up to 1800 channel capacity. Virtually, all voice grade services longer than about 200 miles use these types of facilities. As of December 1968, there were over 68,000,000 circuit miles** on coaxial cable carrier systems and over 172,000,000 circuit miles on microwave radio in the Bell System alone.

These systems are designed to handle a per channel load of -16 dBm long-term average power as measured

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*The term long-haul is used here to designate transmission systems longer than about 200 miles

**A circuit mile is defined as one mile of facility suitable for two-way voice grade transmission.

at a network reference transmission level point*. The -16dBm0 power is the maximum average power per 4kc channel that can be permitted without incurring a noise penalty (increase in total system noise power). Below -16dBm0 per channel average signal power, the noise is predominantly thermal (or random) noise. In addition to this thermal noise (which is independent of total signal power), the broadband systems are also subject to intermodulation noise. At these low levels, this increases proportionately with signal power and at -16dBm0 average signal power per channel, the intermodulation noise and thermal noise are equal. At signal power above

*Commonly referred to as the zero transmission level point (OTLP). Signal powers referenced to OTLP are normally designated with an "O" suffix (i.e., -16dBm0).

-16dBm0, the noise is predominantly intermodulation noise, this increases at a faster rate than the signal power. Maximum signal-to-noise ratio is obtained with average signal power at -16dBm0.

Since both directions of transmission normally are not used simultaneously and not all channels are active at the same time, it has been determined that an average power limit of -13dBm0 applied to all users of a system is consistent with the long-term loading objective of -16dBm0. In developing the tariff criteria, this -13dBm0 three-second average power limit was translated to refer to a specific physically identifiable location. The selected location was the serving central office and the usual loss between this point and the equivalent network reference transmission level point is 1dB. Thus, the maximum signal power that may be permitted at the central office is -12dBm when measured over any three-second interval.

When this power level is exceeded, the effect on other users of voice and data services is increased noise and interference. Depending upon the nature of the excessive signal, this noise and interference may appear in the following forms:

1. Increased background noise or hiss on the channel.

2. Crackling or static on the channel.

3. Crosstalk of other people's conversations into the channel. This crosstalk may be either intelligible of merely bursts of garbled speech.

4. Increased error rates on data channels.

5. Complete loss of service caused by catastrophic overload of line facilities.

The network of long distance facilities to which the in-band power criterion is applicable is used on almost all long distance connections (over 200 miles in length). This network provides many diverse paths over which voice and dataphone calls may be carried. Network management techniques plus dynamic alternate routing plans vary the specific path (and specific broadband facility) that a particular point-to-point call will use. Similar changes in routing also occur on private line services particularly when a facility failure requires an alternate facility for service restoration. This need for facility flexibility necessitates that all channels be operated at equal signal levels. Hence, an equal apportionment of system power handling capability to all channels is appropriate.

Out-of-Band Signal Power Criteria

The tariff requirements on out-of-band* power are as follows: FCC 259, FCC 260, FCC 263 -...... the signal which is applied by the customer-provided equipment to the Telephone Company interface located on the customer's premises meet the following limits:

1. The power in the band from 3995 Hz to 4005 Hz shall be at least 18dB below the stipulated maximum in-band signal power.

2. The power in the band from 4000 Hz to 10,000 Hz shall not exceed 16dB below one milliwatt.

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*The out-of-band region is defined as those frequencies greater than 3995 Hz.

In many ways, the most dangerous source of potentially fatal currents is the 110 or 220 volt power line. The major danger of this source stems from its ubiquity around users' premises and the fact that the protective devices that are connected to telephone lines will usually not operate if the line is crossed to 110 volts. Yet the presence of the cross is potentially lethal to personnel who come in contact with that line.

Extension of the protector block technique to 110 volt exposure is not feasible for several reasons. In the first place, air-gap devices are not practical in this region. More important, however, ringing voltages used in the telephone system have higher peaks than 110V AC and these voltages must be allowed to pass. A suitable shunt protector would have to limit well below the amplitude of ringing voltage and consequently would prevent the use of standard 20 Hz ringing. Use of a simple series fuse-type device would incur the same type of problem. Normal loop current, such as those present in the low voltage, low resistance telephone circuits are in the 25 to 150 ma range which is above the lethal level. Fuses that would pass this level of current would be of no help.

In sum, simple fusing or voltage breakdown devices cannot protect the human being because legitamately present currents and voltages, that are themselves not potentially lethal, exceed the thresholds to which protective devices would have to be adjusted in order to protect against sources of potentially fatal currents.

Extent of Personnel Exposure

As explained, the telephone companies provide service to customers by means of physical conductors in the exchange plant. Each time service is installed, removed or repaired, telephone craftsmen make physical contact with wire pairs and terminals at one or more points in the station equipment or at the terminal appearances of the wire pairs on customer premises in outside manholes or on poles, and in the central office building.

In general, the work operations require a hands-on type contact. The size of the wires, the terminal sizes and spacings, and the dexterity required, generally preclude the use of protective clothing or devices such as rubber gloves. This is not to say that rubber gloves are never worn. They are prescribed for many construction operations, particularly when working on joint use poles shared with power companies. But they are inappropriate for such tasks as splicing together multi-conductor, fine gauge cables.

The conductors which fan out from a wire center (or central office building) are carried in densely-packed cables, ranging from as few as 6 to 2700 pairs of conductors per cable, and they are spliced together and terminated on closely-spaced terminals in cross-connection boxes and in sealed splices along the routes.

Therefore, craftsmen working on a single pair are exposed not only to that one pair at terminal field appearances, but also to additional pairs which are connected to adjacent terminals.

Effects of Interconnection on the Harmful Voltage Problem

The direct electrical connection of user-provided equipment and communications systems to telephone company lines add an additional source for the introduction of potentially harmful voltages into the telephone plant. This source is different from the sources discussed in the previous paragraphs. It is also unique in that it is perhaps the easiest source to protect against in that the telephone line exposure occurs specifically at the point of interface with the user equipment. A simple protective coupler at the interface can provide suitable protection in both direction, i.e., protect the user from foreign voltages on telephone lines and protect the telephone company from foreign voltages introduced by user-provided equipment or systems. The question here is not the need for protection but whether or not there are alternative means for achieving this same protection in which one may place a high degree of confidence. The question is whether or not the interconnecting users can provide the same degree of protection from lightning and electric power sources of harmful voltages that is now achieved through adherence to present carrier practices and the joint power-telephone cooperation outlined above. The achieve this degree of protection would require that all the interconnecting users have:

- trained installation and construction craftsmen to ensure proper installation in regard to exposure to sources of harmful voltages;

- properly-designed and manufactured equipment and wiring meeting properly-enforced electric code requirements.

- trained maintenance personnel and a continuing maintenance program, including inspection and repair procedures and practices to ensure continuance of safe exposure conditions and proper operability of protective devices;

- cooperative agreements with the power utilities, continuously observed.

Conclusions

Attachments are a source of exposures potentially hazardous to people and property. Protection from such exposures require trained personnel, close and continuous coordination and cooperation, and the development and continuous updating of construction, maintenance and protection standards, procedures and practices. These standards, procedures and practices, to be effective, must be rigorously and continuously applied and enforced throughout the service life of the plant equipment involved.

Increased exposure to hazardous voltages can result from uncontrolled interconnection. The need for protection means that controls must be provided to ensure that hazardous voltages are not inadvertently connected to the telephone system. These controls are a necessary condition for interconnection.

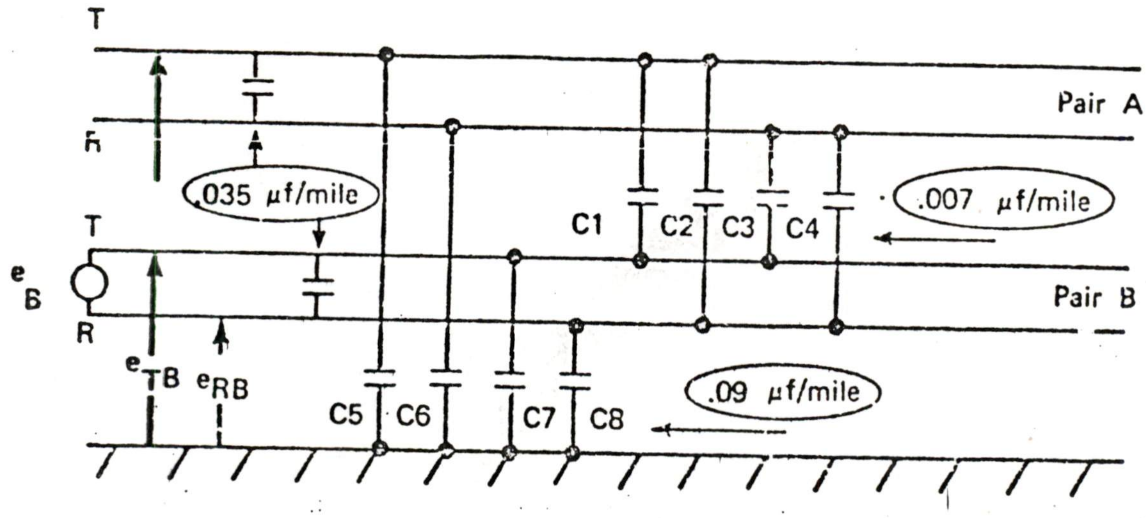
Loop Balance

Connections between customer premises and central offices are normally made by individual wire pairs in multi-paired cables. The wires, because of the close proximity to each other, have mutual capacitive and inductive coupling effects. Mutual coupling results in crosstalk from adjacent wires, which, if not controlled, will interfere with the desired signal. Crosstalk, in aggravated instances, can produce interfering signals of an intelligible nature which may lead the user to believe that his security has been violated. -- a most undesirable situation.

Technology for Reducing Crosstalk

To minimize electrical interactions among individual wire pairs within the cable, the pairs are twisted and balanced to ground. Twisting of the wire pairs cause equal and opposite currents to be induced from adjacent pairs and reduces the effects of magnetic coupling to an insignificant factor. Capacitive coupling is, however, still a factor and has to be carefully controlled.

The figure on the following page showing coupling capacitances between two pairs in a cable will be used to explain the crosstalk mechanism.



A voltage generator, e_B, is shown connected to one pair. Setting aside, for the moment, the effects of the wire-to-ground capacitances, C5, C6, C7, and C8, we can assume that the voltage-to-ground of the T conductor of Pair B, e_{TB}, is equal in magnitude but opposite in polarity to voltage e_{RB}. If C1 equals C2, then the voltage coupled to the T conductor of Pair A from T of B through C1 would exactly cancel the voltage coupled from R of B through C2. Similarly, the voltages coupled to the R conductor of Pair A through capacitors C3 and C4 would also cancel. Hence, no net voltage would be developed on either the T and R conductors of Pair A. These pair-to-pair capacitances are controlled quite carefully in manufacture and the difference among the capacitances associated with any two pairs (or as it is called, the pair-to-pair capactive unbalance) is typically less than .0001 microfarads per mile.

The capacitance of the wires to ground, however, is not as closely controlled in manufacture. Hence, C7 does not equal C8 and e_{TB} and e_{RB} are not exactly equal and opposite. Therefore, the voltages coupled to the conductors of Pair A are not completely cancelled, and a net voltage is induced in Pair A. (Similarly, differences between C5 and C6 also cause noncancellation of the coupled voltages.)

The factors that control crosstalk between any two pairs in a cable are: (1) the magnitude of the interpair capacitance, C1, C2, C3, and C4, which is a function of the proximity of the two pairs within the cable; (2) the amount of unbalance (or difference) among them; and (3) the amount of unbalance (or difference in impedance to ground) of the individual pairs.

The longitudinal balance in cables is controlled so that the coupling loss between pairs is generally well over 100dB with about one per cent of pairs having coupling losses of 80dB or less at 1000 Hz. Since this coupling is primarily capacitive, the coupling loss will decrease (hence crosstalk will increase) with increasing frequency at the rate of 6dB per octave. Tests have shown that if one conductor of one pair is grounded, crosstalk will be worsened by 20dB, and if one conductor of both pairs is grounded, it will be worsened by as much as 60dB. Therefore central office circuits and telephone station equipment and wiring in the telephone network are designed, installed, and maintained to ensure a high degree of balance to ground.

Problem

Cables are designed and controlled in manufacture to maintain balance and reduce crosstalk, but these controls become ineffective if equipment attached to the cable pairs is itself improperly designed, installed or maintained. Crosstalk will result if user-provided equipment is unbalanced to ground. This can occur if:

1. Equipment is designed poorly initially. Tying into unbalanced single ended circuits is a typical way of causing trouble.

2. Equipment is improperly installed so as to apply a ground to one side of the line. This may occur accidentally through insulation being scraped away or with nails or staples cutting through wires.

3. Equipment can fail in service. A component can break down and cause unbalance on the line.

Crosstalk can be insidious and difficult to locate because the malfunction is partial rather than total. The user may not be aware that he is causing trouble to other parties especially if his service appears normal. Thus, the deteriorated performance can exist for a long period before diagnosis and correction.